Software Configuration Guide, Cisco IOS Release 15.2(6)E (Catalyst 2960-L Switches)

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Preface

This book describes configuration information and examples for on the switch.

Document Conventions

This document uses the following conventions:

Convention	Description
^ or Ctrl	Both the ^ symbol and Ctrl represent the Control (Ctrl) key on a keyboard. For example, the key combination **^D** or **Ctrl-D** means that you hold down the Control key while you press the D key. (Keys are indicated in capital letters but are not case sensitive.)
bold font	Commands and keywords and user-entered text appear in **bold** font.
Italic font	Document titles, new or emphasized terms, and arguments for which you supply values are in *italic* font.
`Courier` font	Terminal sessions and information the system displays appear in `courier` font.
`Bold Courier` font	**`Bold Courier`** font indicates text that the user must enter.
[x]	Elements in square brackets are optional.
...	An ellipsis (three consecutive nonbolded periods without spaces) after a syntax element indicates that the element can be repeated.
|	A vertical line, called a pipe, indicates a choice within a set of keywords or arguments.
[x | y]	Optional alternative keywords are grouped in brackets and separated by vertical bars.
{x | y}	Required alternative keywords are grouped in braces and separated by vertical bars.

Convention	Description
[x {y | z}]	Nested set of square brackets or braces indicate optional or required choices within optional or required elements. Braces and a vertical bar within square brackets indicate a required choice within an optional element.
string	A nonquoted set of characters. Do not use quotation marks around the string or the string will include the quotation marks.
< >	Nonprinting characters such as passwords are in angle brackets.
[ ]	Default responses to system prompts are in square brackets.
!, #	An exclamation point (!) or a pound sign (#) at the beginning of a line of code indicates a comment line.

Reader Alert Conventions

This document may use the following conventions for reader alerts:

Note Means *reader take note*. Notes contain helpful suggestions or references to material not covered in the manual.

Tip Means *the following information will help you solve a problem.*

Caution Means *reader be careful*. In this situation, you might do something that could result in equipment damage or loss of data.

Timesaver Means *the described action saves time.* You can save time by performing the action described in the paragraph.

Warning IMPORTANT SAFETY INSTRUCTIONS

This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. Use the statement number provided at the end of each warning to locate its translation in the translated safety warnings that accompanied this device. Statement 1071

SAVE THESE INSTRUCTIONS

Obtaining Documentation and Submitting a Service Request

For information on obtaining documentation, submitting a service request, and gathering additional information, see the monthly *What's New in Cisco Product Documentation*, which also lists all new and revised Cisco technical documentation, at:

http://www.cisco.com/c/en/us/td/docs/general/whatsnew/whatsnew.html

Subscribe to the *What's New in Cisco Product Documentation* as a Really Simple Syndication (RSS) feed and set content to be delivered directly to your desktop using a reader application. The RSS feeds are a free service and Cisco currently supports RSS version 2.0.

CHAPTER 1

Using the Command-Line Interface

Information About Using the Command-Line Interface

Note Search options on the GUI and CLI are case sensitive.

Command Modes

The Cisco IOS user interface is divided into many different modes. The commands available to you depend on which mode you are currently in. Enter a question mark (?) at the system prompt to obtain a list of commands available for each command mode.

You can start a CLI session through a console connection, through Telnet, an SSH, or by using the browser.

When you start a session, you begin in user mode, often called user EXEC mode. Only a limited subset of the commands are available in user EXEC mode. For example, most of the user EXEC commands are one-time commands, such as **show** commands, which show the current configuration status, and **clear** commands, which clear counters or interfaces. The user EXEC commands are not saved when the switch reboots.

To have access to all commands, you must enter privileged EXEC mode. Normally, you must enter a password to enter privileged EXEC mode. From this mode, you can enter any privileged EXEC command or enter global configuration mode.

Using the configuration modes (global, interface, and line), you can make changes to the running configuration. If you save the configuration, these commands are stored and used when the switch reboots. To access the various configuration modes, you must start at global configuration mode. From global configuration mode, you can enter interface configuration mode and line configuration mode .

This table describes the main command modes, how to access each one, the prompt you see in that mode, and how to exit the mode.

Table 1: Command Mode Summary

Mode	Access Method	Prompt	Exit Method	About This Mode
User EXEC	Begin a session using Telnet, SSH, or console.	`Switch>`	Enter **logout** or **quit**.	Use this mode to • Change terminal settings. • Perform basic tests. • Display system information.
Privileged EXEC	While in user EXEC mode, enter the **enable** command.	`Switch#`	Enter **disable** to exit.	Use this mode to verify commands that you have entered. Use a password to protect access to this mode.
Global configuration	While in privileged EXEC mode, enter the **configure** command.	`Switch(config)#`	To exit to privileged EXEC mode, enter **exit** or **end**, or press **Ctrl-Z**.	Use this mode to configure parameters that apply to the entire switch.
VLAN configuration	While in global configuration mode, enter the **vlan** *vlan-id* command.	`Switch(config-vlan)#`	To exit to global configuration mode, enter the **exit** command. To return to privileged EXEC mode, press **Ctrl-Z** or enter **end**.	Use this mode to configure VLAN parameters. When VTP mode is transparent, you can create extended-range VLANs (VLAN IDs greater than 1005) and save configurations in the switch startup configuration file.

Mode	Access Method	Prompt	Exit Method	About This Mode
Interface configuration	While in global configuration mode, enter the **interface** command (with a specific interface).	`Switch(config-if)#`	To exit to global configuration mode, enter **exit**. To return to privileged EXEC mode, press **Ctrl-Z** or enter **end**.	Use this mode to configure parameters for the Ethernet ports.
Line configuration	While in global configuration mode, specify a line with the **line vty** or **line console** command.	`Switch(config-line)#`	To exit to global configuration mode, enter **exit**. To return to privileged EXEC mode, press **Ctrl-Z** or enter **end**.	Use this mode to configure parameters for the terminal line.

Understanding Abbreviated Commands

You need to enter only enough characters for the switch to recognize the command as unique.

This example shows how to enter the **show configuration** privileged EXEC command in an abbreviated form:

```
Switch# show conf
```

No and Default Forms of Commands

Almost every configuration command also has a **no** form. In general, use the **no** form to disable a feature or function or reverse the action of a command. For example, the **no shutdown** interface configuration command reverses the shutdown of an interface. Use the command without the keyword **no** to reenable a disabled feature or to enable a feature that is disabled by default.

Configuration commands can also have a **default** form. The **default** form of a command returns the command setting to its default. Most commands are disabled by default, so the **default** form is the same as the **no** form. However, some commands are enabled by default and have variables set to certain default values. In these cases, the **default** command enables the command and sets variables to their default values.

CLI Error Messages

This table lists some error messages that you might encounter while using the CLI to configure your switch.

Table 2: Common CLI Error Messages

Error Message	Meaning	How to Get Help
`% Ambiguous command: "show con"`	You did not enter enough characters for your switch to recognize the command.	Reenter the command followed by a question mark (?) without any space between the command and the question mark. The possible keywords that you can enter with the command appear.
`% Incomplete command.`	You did not enter all of the keywords or values required by this command.	Reenter the command followed by a question mark (?) with a space between the command and the question mark. The possible keywords that you can enter with the command appear.
`% Invalid input detected at '^' marker.`	You entered the command incorrectly. The caret (^) marks the point of the error.	Enter a question mark (?) to display all of the commands that are available in this command mode. The possible keywords that you can enter with the command appear.

Configuration Logging

You can log and view changes to the switch configuration. You can use the Configuration Change Logging and Notification feature to track changes on a per-session and per-user basis. The logger tracks each configuration command that is applied, the user who entered the command, the time that the command was entered, and the parser return code for the command. This feature includes a mechanism for asynchronous notification to registered applications whenever the configuration changes. You can choose to have the notifications sent to the syslog.

Note Only CLI or HTTP changes are logged.

Using the Help System

You can enter a question mark (?) at the system prompt to display a list of commands available for each command mode. You can also obtain a list of associated keywords and arguments for any command.

SUMMARY STEPS

1. **help**
2. *abbreviated-command-entry* **?**
3. *abbreviated-command-entry* <Tab>
4. **?**
5. *command* **?**
6. *command keyword* **?**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**help** **Example:** `Switch# help`	Obtains a brief description of the help system in any command mode.

Step 2	*abbreviated-command-entry* **?**
	Example:
	`Switch# di?`
	`dir disable disconnect`
		Obtains a list of commands that begin with a particular character string.

Step 3	*abbreviated-command-entry* <Tab>
	Example:
	`Switch# sh conf<tab>`
	`Switch# show configuration`
		Completes a partial command name.

Step 4	**?** **Example:** `Switch> ?`	Lists all commands available for a particular command mode.
Step 5	*command* **?** **Example:** `Switch> show ?`	Lists the associated keywords for a command.

Step 6	*command keyword* **?**
	Example:
	`Switch(config)# wireless management ?`
	`certificate  Configure certificate details`
	`interface    Select an interface to configure`
	`transfer     Active transfer profiles`
	`trustpoint   Select a trustpoint to configure`
		Lists the associated arguments for a keyword.

How to Use the CLI to Configure Features

Configuring the Command History

The software provides a history or record of commands that you have entered. The command history feature is particularly useful for recalling long or complex commands or entries, including access lists. You can customize this feature to suit your needs.

Changing the Command History Buffer Size

By default, the switch records ten command lines in its history buffer. You can alter this number for a current terminal session or for all sessions on a particular line. This procedure is optional.

SUMMARY STEPS

1. **terminal history** [**size** *number-of-lines*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**terminal history** [**size** *number-of-lines*] **Example:** `Switch# terminal history size 200`	Changes the number of command lines that the switch records during the current terminal session in privileged EXEC mode. You can configure the size from 0 to 256.

Recalling Commands

To recall commands from the history buffer, perform one of the actions listed in this table. These actions are optional.

Note The arrow keys function only on ANSI-compatible terminals such as VT100s.

SUMMARY STEPS

1. **Ctrl-P** or use the **up arrow** key
2. **Ctrl-N** or use the **down arrow** key
3. **show history**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**Ctrl-P** or use the **up arrow** key	Recalls commands in the history buffer, beginning with the most recent command. Repeat the key sequence to recall successively older commands.
Step 2	**Ctrl-N** or use the **down arrow** key	Returns to more recent commands in the history buffer after recalling commands with **Ctrl-P** or the up arrow key. Repeat the key sequence to recall successively more recent commands.
Step 3	**show history** **Example:** `Switch# show history`	Lists the last several commands that you just entered in privileged EXEC mode. The number of commands that appear is controlled by the setting of the **terminal history** global configuration command and the **history** line configuration command.

Disabling the Command History Feature

The command history feature is automatically enabled. You can disable it for the current terminal session or for the command line. This procedure is optional.

SUMMARY STEPS

1. **terminal no history**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**terminal no history** **Example:** `Switch# terminal no history`	Disables the feature during the current terminal session in privileged EXEC mode.

Enabling and Disabling Editing Features

Although enhanced editing mode is automatically enabled, you can disable it and reenable it.

SUMMARY STEPS

1. **terminal editing**
2. **terminal no editing**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**terminal editing** **Example:** `Switch# terminal editing`	Reenables the enhanced editing mode for the current terminal session in privileged EXEC mode.
Step 2	**terminal no editing** **Example:** `Switch# terminal no editing`	Disables the enhanced editing mode for the current terminal session in privileged EXEC mode.

Editing Commands Through Keystrokes

The keystrokes help you to edit the command lines. These keystrokes are optional.

Note The arrow keys function only on ANSI-compatible terminals such as VT100s.

Table 3: Editing Commands

Editing Commands	Description

Ctrl-B or use the **left arrow** key	Moves the cursor back one character.
Ctrl-F or use the **right arrow** key	Moves the cursor forward one character.
Ctrl-A	Moves the cursor to the beginning of the command line.
Ctrl-E	Moves the cursor to the end of the command line.
Esc B	Moves the cursor back one word.
Esc F	Moves the cursor forward one word.
Ctrl-T	Transposes the character to the left of the cursor with the character located at the cursor.
Delete or **Backspace** key	Erases the character to the left of the cursor.
Ctrl-D	Deletes the character at the cursor.
Ctrl-K	Deletes all characters from the cursor to the end of the command line.
Ctrl-U or **Ctrl-X**	Deletes all characters from the cursor to the beginning of the command line.
Ctrl-W	Deletes the word to the left of the cursor.
Esc D	Deletes from the cursor to the end of the word.
Esc C	Capitalizes at the cursor.
Esc L	Changes the word at the cursor to lowercase.
Esc U	Capitalizes letters from the cursor to the end of the word.
Ctrl-V or **Esc Q**	Designates a particular keystroke as an executable command, perhaps as a shortcut.
Return key	Scrolls down a line or screen on displays that are longer than the terminal screen can display. **Note** The More prompt is used for any output that has more lines than can be displayed on the terminal screen, including **show** command output. You can use the **Return** and **Space** bar keystrokes whenever you see the More prompt.
Space bar	Scrolls down one screen.
Ctrl-L or **Ctrl-R**	Redisplays the current command line if the switch suddenly sends a message to your screen.

Editing Command Lines That Wrap

You can use a wraparound feature for commands that extend beyond a single line on the screen. When the cursor reaches the right margin, the command line shifts ten spaces to the left. You cannot see the first ten characters of the line, but you can scroll back and check the syntax at the beginning of the command. The keystroke actions are optional.

To scroll back to the beginning of the command entry, press **Ctrl-B** or the left arrow key repeatedly. You can also press **Ctrl-A** to immediately move to the beginning of the line.

Note The arrow keys function only on ANSI-compatible terminals such as VT100s.

The following example shows how to wrap a command line that extends beyond a single line on the screen.

SUMMARY STEPS

1. **access-list**
2. **Ctrl-A**
3. **Return** key

DETAILED STEPS

	Command or Action	Purpose

Step 1	**access-list**
	Example:
	`Switch(config)# access-list 101 permit tcp`
	`10.15.22.25 255.255.255.0 10.15.22.35`
	`Switch(config)# $ 101 permit tcp 10.15.22.25`
	`255.255.255.0 10.15.22.35 255.25`
	`Switch(config)# $t tcp 10.15.22.25 255.255.255.0`
	`131.108.1.20 255.255.255.0 eq`
	`Switch(config)# $15.22.25 255.255.255.0 10.15.22.35`
	` 255.255.255.0 eq 45`
		Displays the global configuration command entry that extends beyond one line.
		When the cursor first reaches the end of the line, the line is shifted ten spaces to the left and redisplayed. The dollar sign ($) shows that the line has been scrolled to the left. Each time the cursor reaches the end of the line, the line is again shifted ten spaces to the left.

Step 2	**Ctrl-A**
	Example:
	`Switch(config)# access-list 101 permit tcp`
	`10.15.22.25 255.255.255.0 10.15.2$`
		Checks the complete syntax.
		The dollar sign ($) appears at the end of the line to show that the line has been scrolled to the right.

Step 3	**Return** key	Execute the commands. The software assumes that you have a terminal screen that is 80 columns wide. If you have a different width, use the **terminal width** privileged EXEC command to set the width of your terminal. Use line wrapping with the command history feature to recall and modify previous complex command entries.

Searching and Filtering Output of show and more Commands

You can search and filter the output for **show** and **more** commands. This is useful when you need to sort through large amounts of output or if you want to exclude output that you do not need to see. Using these commands is optional.

SUMMARY STEPS

1. {**show** | **more**} *command* | {**begin** | **include** | **exclude**} *regular-expression*

DETAILED STEPS

	Command or Action	Purpose

Step 1	{**show** | **more**} *command* | {**begin** | **include** | **exclude**} *regular-expression*
	Example:
	`Switch# show interfaces | include protocol`
	`Vlan1 is up, line protocol is up`
	`Vlan10 is up, line protocol is down`
	`GigabitEthernet0/1 is up, line protocol is down`
	`GigabitEthernet0/2 is up, line protocol is up`
		Searches and filters the output.
		Expressions are case sensitive. For example, if you enter **| exclude output**, the lines that contain **output** are not displayed, but the lines that contain **output** appear.

Accessing the CLI Through a Console Connection or Through Telnet

Before you can access the CLI, you must connect a terminal or a PC to the switch console or connect a PC to the Ethernet management port and then power on the switch, as described in the hardware installation guide that shipped with your switch.

If your switch is already configured, you can access the CLI through a local console connection or through a remote Telnet session, but your switch must first be configured for this type of access.

You can use one of these methods to establish a connection with the switch:

Procedure

- Connect the switch console port to a management station or dial-up modem, or connect the Ethernet management port to a PC. For information about connecting to the console or Ethernet management port, see the switch hardware installation guide.
- Use any Telnet TCP/IP or encrypted Secure Shell (SSH) package from a remote management station. The switch must have network connectivity with the Telnet or SSH client, and the switch must have an enable secret password configured.
  - The switch supports up to 16 simultaneous Telnet sessions. Changes made by one Telnet user are reflected in all other Telnet sessions.
  - The switch supports up to five simultaneous secure SSH sessions.

  After you connect through the console port, through the Ethernet management port, through a Telnet session or through an SSH session, the user EXEC prompt appears on the management station.

Accessing the CLI through Bluetooth

You can access the CLI through Bluetooth connectivity by pairing the switch to a computer.

Note This feature is available on Cisco IOS Release 15.2(5)E2 and higher.

1. Connect a Bluetooth dongle to the USB port on your switch and power on the switch.
2. Turn on Bluetooth on your computer and discover the switch.
3. Pair the computer to the switch.
4. Connect to the switch as an access point.
   - If you are connecting from a Windows computer: Go to *Devices & Printers*, select the switch, click on the *Connect Using* tab and select *Access point*.
   - If you are connecting from a Mac computer: On the menu bar, click the Bluetooth icon, hover over the switch name, and click *Connect to Network*.

Once a connection is established, you can open a management window and configure the switch.

PART I

Interface and Hardware

CHAPTER 2

Configuring Interface Characteristics

Information About Configuring Interface Characteristics

Interface Types

This section describes the different types of interfaces supported by the switch. The rest of the chapter describes configuration procedures for physical interface characteristics.

Port-Based VLANs

A VLAN is a switched network that is logically segmented by function, team, or application, without regard to the physical location of the users. Packets received on a port are forwarded only to ports that belong to the same VLAN as the receiving port. Network devices in different VLANs cannot communicate with one another without a Layer 3 device to route traffic between the VLANs.

VLAN partitions provide hard firewalls for traffic in the VLAN, and each VLAN has its own MAC address table. A VLAN comes into existence when a local port is configured to be associated with the VLAN, when the VLAN Trunking Protocol (VTP) learns of its existence from a neighbor on a trunk, or when a user creates a VLAN.

To configure VLANs, use the **vlan** *vlan-id* global configuration command to enter VLAN configuration mode. The VLAN configurations for normal-range VLANs (VLAN IDs 1 to 1005) are saved in the VLAN database. If VTP is version 1 or 2, to configure extended-range VLANs (VLAN IDs 1006 to 4094), you must first set VTP mode to transparent. Extended-range VLANs created in transparent mode are not added to the VLAN database but are saved in the switch running configuration. With VTP version 3, you can create extended-range VLANs in client or server mode. These VLANs are saved in the VLAN database.

Add ports to a VLAN by using the **switchport** interface configuration commands:

- Identify the interface.

- For a trunk port, set trunk characteristics, and, if desired, define the VLANs to which it can belong.
- For an access port, set and define the VLAN to which it belongs.

Switch Ports

Switch ports are Layer 2-only interfaces associated with a physical port. Switch ports belong to one or more VLANs. A switch port can be an access port or a trunk port. You can configure a port as an access port or trunk port or let the Dynamic Trunking Protocol (DTP) operate on a per-port basis to set the switchport mode by negotiating with the port on the other end of the link. switch ports are used for managing the physical interface and associated Layer 2 protocols and do not handle routing or bridging.

Configure switch ports by using the **switchport** interface configuration commands.

Access Ports

An access port belongs to and carries the traffic of only one VLAN (unless it is configured as a voice VLAN port). Traffic is received and sent in native formats with no VLAN tagging. Traffic arriving on an access port is assumed to belong to the VLAN assigned to the port.

The types of access ports supported are:

- Static access ports are manually assigned to a VLAN (or through a RADIUS server for use with IEEE 802.1x.
- VLAN membership of dynamic access ports is learned through incoming packets. By default, a dynamic access port is not a member of any VLAN, and forwarding to and from the port is enabled only when the VLAN membership of the port is discovered. Dynamic access ports on the switch are assigned to a VLAN by a VLAN Membership Policy Server (VMPS). The VMPS can be a Catalyst 6500 series switch; the switch cannot be a VMPS server.

You can also configure an access port with an attached Cisco IP Phone to use one VLAN for voice traffic and another VLAN for data traffic from a device attached to the phone.

Trunk Ports

A trunk port carries the traffic of multiple VLANs and by default is a member of all VLANs in the VLAN database.

The switch supports only IEEE 802.1Q trunk ports. An IEEE 802.1Q trunk port supports simultaneous tagged and untagged traffic. An IEEE 802.1Q trunk port is assigned a default port VLAN ID (PVID), and all untagged traffic travels on the port default PVID. All untagged traffic and tagged traffic with a NULL VLAN ID are assumed to belong to the port default PVID. A packet with a VLAN ID equal to the outgoing port default PVID is sent untagged. All other traffic is sent with a VLAN tag.

Although by default, a trunk port is a member of every VLAN known to the VTP, you can limit VLAN membership by configuring an allowed list of VLANs for each trunk port. The list of allowed VLANs does not affect any other port but the associated trunk port. By default, all possible VLANs (VLAN ID 1 to 4094) are in the allowed list. A trunk port can become a member of a VLAN only if VTP knows of the VLAN and if the VLAN is in the enabled state. If VTP learns of a new, enabled VLAN and the VLAN is in the allowed list for a trunk port, the trunk port automatically becomes a member of that VLAN and traffic is forwarded to and from the trunk port for that VLAN. If VTP learns of a new, enabled VLAN that is not in the allowed list for a trunk port, the port does not become a member of the VLAN, and no traffic for the VLAN is forwarded to or from the port.

Routed Ports

A routed port is a physical port that acts like a port on a router; it does not have to be connected to a router. A routed port is not associated with a particular VLAN, as is an access port. A routed port behaves like a regular router interface, except that it does not support VLAN subinterfaces. Routed ports can be configured with a Layer 3 routing protocol. A routed port is a Layer 3 interface only and does not support Layer 2 protocols, such as DTP and STP.

Configure routed ports by putting the interface into Layer 3 mode with the **no switchport** interface configuration command. Then assign an IP address to the port, enable routing, and assign routing protocol characteristics by using the **ip routing** and **router** *protocol* global configuration commands.

Note Entering a **no switchport** interface configuration command shuts down the interface and then re-enables it, which might generate messages on the device to which the interface is connected. When you put an interface that is in Layer 2 mode into Layer 3 mode, the previous configuration information related to the affected interface might be lost.

The number of routed ports that you can configure is not limited by software. However, the interrelationship between this number and the number of other features being configured might impact CPU performance because of hardware limitations.

Switch Virtual Interfaces

A switch virtual interface (SVI) represents a VLAN of switch ports as one interface to the routing or bridging function in the system. You can associate only one SVI with a VLAN. You configure an SVI for a VLAN only to route between VLANs or to provide IP host connectivity to the switch. By default, an SVI is created for the default VLAN (VLAN 1) to permit remote switch administration. Additional SVIs must be explicitly configured.

Note You cannot delete interface VLAN 1.

SVIs provide IP host connectivity only to the system. SVIs are created the first time that you enter the **vlan** interface configuration command for a VLAN interface. The VLAN corresponds to the VLAN tag associated with data frames on an ISL or IEEE 802.1Q encapsulated trunk or the VLAN ID configured for an access port. Configure a VLAN interface for each VLAN for which you want to route traffic, and assign it an IP address.

You can also use the interface range command to configure existing VLAN SVIs within the range. The commands entered under the interface range command are applied to all existing VLAN SVIs within the range. You can enter the command **interface range create vlan** *x* - *y* to create all VLANs in the specified range that do not already exist. When the VLAN interface is created, **interface range vlan** *id* can be used to configure the VLAN interface.

When you create an SVI, it does not become active until it is associated with a physical port.

EtherChannel Port Groups

EtherChannel port groups treat multiple switch ports as one switch port. These port groups act as a single logical port for high-bandwidth connections between switches or between switches and servers. An EtherChannel balances the traffic load across the links in the channel. If a link within the EtherChannel fails, traffic previously carried over the failed link changes to the remaining links. You can group multiple trunk ports into one logical trunk port or multiple access ports into one logical access port. Most protocols operate over either single ports or aggregated switch ports and do not recognize the physical ports within the port group. Exceptions are the DTP, the Cisco Discovery Protocol (CDP), and the Port Aggregation Protocol (PAgP), which operate only on physical ports.

When you configure an EtherChannel, you create a port-channel logical interface and assign an interface to the EtherChannel. For Layer 2 interfaces, use the **channel-group** interface configuration command to dynamically create the port-channel logical interface. This command binds the physical and logical ports together.

Power over Ethernet Ports

A PoE-capable switch port automatically supplies power to one of these connected devices if the switch senses that there is no power on the circuit:

- a Cisco pre-standard powered device (such as a Cisco IP Phone or a Cisco Aironet Access Point)
- an IEEE 802.3af-compliant powered device

A powered device can receive redundant power when it is connected to a PoE switch port and to an AC power source. The device does not receive redundant power when it is only connected to the PoE port.

Using the Switch USB Ports

The switch has two USB ports on the front panel — a USB mini-Type B console port and a USB Type A port.

USB Mini-Type B Console Port

The switch has the following console ports:

- USB mini-Type B console connection
- RJ-45 console port

Console output appears on devices connected to both ports, but console input is active on only one port at a time. By default, the USB connector takes precedence over the RJ-45 connector.

Note Windows PCs require a driver for the USB port. See the hardware installation guide for driver installation instructions.

Use the supplied USB Type A-to-USB mini-Type B cable to connect a PC or other device to the switch. The connected device must include a terminal emulation application. When the switch detects a valid USB connection to a powered-on device that supports host functionality (such as a PC), input from the RJ-45 console is immediately disabled, and input from the USB console is enabled. Removing the USB connection immediately reenables input from the RJ-45 console connection. An LED on the switch shows which console connection is in use.

USB Type A Ports

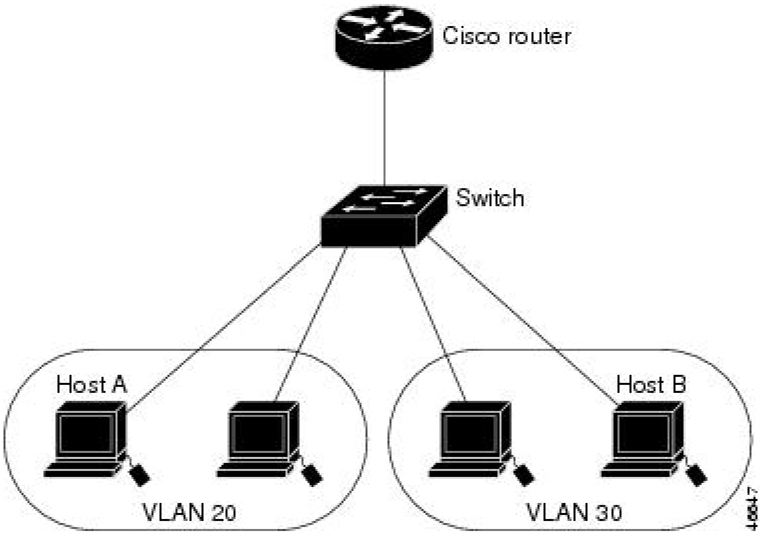
The USB Type A ports provide access to external USB flash devices, also known as thumb drives or USB keys. The switch supports Cisco 64 MB, 256 MB, 512 MB, 1 GB, 4 GB, and 8 GB flash drives. You can use standard Cisco IOS command- line interface (CLI) commands to read, write, erase, and copy to or from the flash device. You can also configure the switch to boot from the USB flash drive.

Interface Connections

Devices within a single VLAN can communicate directly through any switch. Ports in different VLANs cannot exchange data without going through a routing device.

In the following configuration example, when Host A in VLAN 20 sends data to Host B in VLAN 30, the data must go from Host A to the device, to the router, back to the device, and then to Host B.

Figure 1: Connecting VLANs with the Switch



With a standard Layer 2 switch, ports in different VLANs have to exchange information through a router.

Note The Catalyst 3560-CX and 2960-CX switches do not support stacking. Ignore all references to stacking throughout this book.

Interface Configuration Mode

The switch supports these interface types:

- Physical ports—switch ports and routed ports
- VLANs—switch virtual interfaces
- Port channels—EtherChannel interfaces

You can also configure a range of interfaces.

To configure a physical interface (port), specify the interface type, module number, and switch port number, and enter interface configuration mode.

- Type—Gigabit Ethernet (gigabitethernet or gi) for 10/100/1000 Mb/s Ethernet ports, or small form-factor pluggable (SFP) module Gigabit Ethernet interfaces (gigabitethernet or gi).
- Module number—The module or slot number on the switch (always 0).
- Port number—The interface number on the switch. The 10/100/1000 port numbers always begin at 1, starting with the far left port when facing the front of the switch, for example, gigabitethernet0/1 or gigabitethernet0/8. For a switch with 10/100/1000 ports and SFP module ports, SFP module ports are numbered consecutively following the 10/100/1000 ports.

You can identify physical interfaces by physically checking the interface location on the switch. You can also use the **show** privileged EXEC commands to display information about a specific interface or all the interfaces on the switch. The remainder of this chapter primarily provides physical interface configuration procedures.

Default Ethernet Interface Configuration

This table shows the Ethernet interface default configuration, including some features that apply only to Layer 2 interfaces.

Table 4: Default Layer 2 Ethernet Interface Configuration

Feature	Default Setting
Operating mode	Layer 2 or switching mode (**switchport** command).
Allowed VLAN range	VLANs 1– 4094.
Default VLAN (for access ports)	VLAN 1.
Native VLAN (for IEEE 802.1Q trunks)	VLAN 1.
802.1p priority-tagged traffic	Drop all packets tagged with VLAN 0.
VLAN trunking	Switchport mode dynamic auto (supports DTP).
Port enable state	All ports are enabled.
Port description	None defined.
Speed	Autonegotiate. (Not supported on the 10-Gigabit interfaces.)
Duplex mode	Autonegotiate. (Not supported on the 10-Gigabit interfaces.)
Flow control	Flow control is set to **receive: off**. It is always off for sent packets.
EtherChannel (PAgP)	Disabled on all Ethernet ports.
Port blocking (unknown multicast and unknown unicast traffic)	Disabled (not blocked).

Feature	Default Setting
Broadcast, multicast, and unicast storm control	Disabled.
Protected port	Disabled.
Port security	Disabled.
Port Fast	Disabled.
Auto-MDIX	Enabled. **Note** The switch might not support a pre-standard powered device—such as Cisco IP phones and access points that do not fully support IEEE 802.3af—if that powered device is connected to the switch through a crossover cable. This is regardless of whether auto-MIDX is enabled on the switch port.
Power over Ethernet (PoE)	Enabled (auto).
Keepalive messages	Disabled on SFP module ports; enabled on all other ports.

Interface Speed and Duplex Mode

Ethernet interfaces on the switch operate at 10, 100, or 1000 Mb/s and in either full- or half-duplex mode. In full-duplex mode, two stations can send and receive traffic at the same time. Normally, 10-Mb/s ports operate in half-duplex mode, which means that stations can either receive or send traffic.

Switch modules include Gigabit Ethernet (10/100/1000-Mb/s) ports and small form-factor pluggable (SFP) module slots supporting SFP modules.

Speed and Duplex Configuration Guidelines

When configuring an interface speed and duplex mode, note these guidelines:

- Do not disable Auto-Negotiation on PoE switches.
- Gigabit Ethernet (10/100/1000-Mb/s) ports support all speed options and all duplex options (auto, half, and full). However, Gigabit Ethernet ports operating at 1000 Mb/s do not support half-duplex mode.
- For SFP module ports, the speed and duplex CLI options change depending on the SFP module type:
  - The 1000BASE-*x* (where -*x* is -BX, -CWDM, -LX, -SX, and -ZX) SFP module ports support the **nonegotiate** keyword in the **speed** interface configuration command. Duplex options are not supported.
  - The 1000BASE-T SFP module ports support the same speed and duplex options as the 10/100/1000-Mb/s ports.

Note Catalyst 2960-L Switches do not support GLC-T and GLC-TE at speed 10/100 Mb/s.

- If both ends of the line support autonegotiation, we highly recommend the default setting of **auto** negotiation.
- If one interface supports autonegotiation and the other end does not, configure duplex and speed on both interfaces; do not use the **auto** setting on the supported side.
- When STP is enabled and a port is reconfigured, the switch can take up to 30 seconds to check for loops. The port LED is amber while STP reconfigures.
- As best practice, we suggest configuring the speed and duplex options on a link to auto or to fixed on both the ends. If one side of the link is configured to auto and the other side is configured to fixed, the link will not be up and this is expected.

Caution Changing the interface speed and duplex mode configuration might shut down and re-enable the interface during the reconfiguration.

IEEE 802.3x Flow Control

Flow control enables connected Ethernet ports to control traffic rates during congestion by allowing congested nodes to pause link operation at the other end. If one port experiences congestion and cannot receive any more traffic, it notifies the other port by sending a pause frame to stop sending until the condition clears. Upon receipt of a pause frame, the sending device stops sending any data packets, which prevents any loss of data packets during the congestion period.

Note The switch ports can receive, but not send, pause frames.

You use the **flowcontrol** interface configuration command to set the interface's ability to **receive** pause frames to **on**, **off**, or **desired**. The default state is **off**.

When set to **desired**, an interface can operate with an attached device that is required to send flow-control packets or with an attached device that is not required to but can send flow-control packets.

These rules apply to flow control settings on the device:

- **receive on** (or **desired**): The port cannot send pause frames but can operate with an attached device that is required to or can send pause frames; the port can receive pause frames.
- **receive off**: Flow control does not operate in either direction. In case of congestion, no indication is given to the link partner, and no pause frames are sent or received by either device.

Note For details on the command settings and the resulting flow control resolution on local and remote ports, see the **flowcontrol** interface configuration command in the command reference for this release.

How to Configure Interface Characteristics

Configuring Interfaces

These general instructions apply to all interface configuration processes.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**interface**
	Example:
	`Switch(config)# interface gigabitethernet 0/1`
	`Switch(config-if)#`
		Identifies the interface type and the number of the connector.
		Note You do not need to add a space between the interface type and the interface number. For example, in the preceding line, you can specify either **gigabitethernet 0/1**, **gigabitethernet0/1**, **gi 0/1**, or **gi0/1**.

Step 4	Follow each **interface** command with the interface configuration commands that the interface requires.	Defines the protocols and applications that will run on the interface. The commands are collected and applied to the interface when you enter another interface command or enter **end** to return to privileged EXEC mode.
Step 5	**interface range** or **interface range macro**	(Optional) Configures a range of interfaces. **Note** Interfaces configured in a range must be the same type and must be configured with the same feature options.
Step 6	**show interfaces**	Displays a list of all interfaces on or configured for the switch. A report is provided for each interface that the device supports or for the specified interface.

Adding a Description for an Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **description** *string*
5. **end**
6. **show interfaces** *interface-id* **description**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the interface for which you are adding a description, and enter interface configuration mode.
Step 4	**description** *string* **Example:** `Switch(config-if)# description Connects to Marketing`	Adds a description (up to 240 characters) for an interface.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**show interfaces** *interface-id* **description**	Verifies your entry.

	Command or Action	Purpose
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a Range of Interfaces

To configure multiple interfaces with the same configuration parameters, use the **interface range** global configuration command. When you enter the interface-range configuration mode, all command parameters that you enter are attributed to all interfaces within that range until you exit this mode.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface range** {*port-range* | **macro** *macro_name*}
4. **end**
5. **show interfaces** [*interface-id*]
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**interface range** {*port-range* | **macro** *macro_name*}
	Example:
	`Switch(config)# interface range macro`
		Specifies the range of interfaces (VLANs or physical ports) to be configured, and enter interface-range configuration mode.
		• You can use the **interface range** command to configure up to five port ranges or a previously defined macro.
		• The **macro** variable is explained in the section on *Configuring and Using Interface Range Macros.*

	Command or Action	Purpose
		• In a comma-separated *port-range*, you must enter the interface type for each entry and enter spaces before and after the comma. • In a hyphen-separated *port-range*, you do not need to re-enter the interface type, but you must enter a space before the hyphen. **Note** Use the normal configuration commands to apply the configuration parameters to all interfaces in the range. Each command is executed as it is entered.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show interfaces** [*interface-id*] **Example:** `Switch# show interfaces`	Verifies the configuration of the interfaces in the range.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring and Using Interface Range Macros

You can create an interface range macro to automatically select a range of interfaces for configuration. Before you can use the **macro** keyword in the **interface range macro** global configuration command string, you must use the **define interface-range** global configuration command to define the macro.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **define interface-range** *macro_name interface-range*
4. **interface range macro** *macro_name*
5. **end**
6. **show running-config | include define**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**define interface-range** *macro_name interface-range* **Example:** `Switch(config)# define interface-range enet_list gigabitethernet 0/1 - 2`	Defines the interface-range macro, and save it in NVRAM. • The *macro_name* is a 32-character maximum character string. • A macro can contain up to five comma-separated interface ranges. • Each *interface-range* must consist of the same port type. **Note** Before you can use the **macro** keyword in the **interface range macro** global configuration command string, you must use the **define interface-range** global configuration command to define the macro.
Step 4	**interface range macro** *macro_name* **Example:** `Switch(config)# interface range macro enet_list`	Selects the interface range to be configured using the values saved in the interface-range macro called *macro_name*. You can now use the normal configuration commands to apply the configuration to all interfaces in the defined macro.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config | include define** **Example:** `Switch# show running-config | include define`	Shows the defined interface range macro configuration.

	Command or Action	Purpose
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Ethernet Interfaces

Setting the Interface Speed and Duplex Parameters

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **speed** {**10** \| **100** \| **1000**}
5. **duplex** {**auto** \| **full** \| **half**}
6. **end**
7. **show interfaces** *interface-id*
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/3`	Specifies the physical interface to be configured, and enter interface configuration mode.
Step 4	**speed** {**10** | **100** | **1000**} **Example:**	Enter the appropriate speed parameter for the interface: • Enter **10**, **100**, **1000** to set a specific speed for the interface.

	Command or Action	Purpose
	`Switch(config-if)# speed 10`	

Step 5	**duplex** {**auto** | **full** | **half**}
	Example:
	`Switch(config-if)# duplex half`
		This command is not available on a 10-Gigabit Ethernet interface.
		Enter the duplex parameter for the interface.
		Enable half-duplex mode (for interfaces operating only at 10 or 100 Mb/s). You cannot configure half-duplex mode for interfaces operating at 1000 Mb/s.
		You can configure the duplex setting when the speed is set to **auto**.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 7	**show interfaces** *interface-id* **Example:** `Switch# show interfaces gigabitethernet 0/3`	Displays the interface speed and duplex mode configuration.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring IEEE 802.3x Flow Control

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **flowcontrol** {**receive**} {**on** | **off** | **desired**}
4. **end**
5. **show interfaces** *interface-id*
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the physical interface to be configured, and enter interface configuration mode.

Step 3	**flowcontrol** {**receive**} {**on** | **off** | **desired**}
	Example:
	`Switch(config-if)# flowcontrol receive on`
		Configures the flow control mode for the port.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 5	**show interfaces** *interface-id* **Example:** `Switch# show interfaces gigabitethernet 0/1`	Verifies the interface flow control settings.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Shutting Down and Restarting the Interface

Shutting down an interface disables all functions on the specified interface and marks the interface as unavailable on all monitoring command displays. This information is communicated to other network servers through all dynamic routing protocols. The interface is not mentioned in any routing updates.

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **interface** {**vlan** *vlan-id*} | { **gigabitethernet***interface-id*} | {**port-channel** *port-channel-number*}
4. **shutdown**
5. **no shutdown**
6. **end**
7. **show running-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**interface** {**vlan** *vlan-id*} | { **gigabitethernet***interface-id*} | {**port-channel** *port-channel-number*}
	Example:
	`Switch(config)# interface gigabitethernet 0/2`
		Selects the interface to be configured.

Step 4	**shutdown** **Example:** `Switch(config-if)# shutdown`	Shuts down an interface.
Step 5	**no shutdown** **Example:** `Switch(config-if)# no shutdown`	Restarts an interface.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:**	Verifies your entries.

	Command or Action	Purpose
	`Switch# show running-config`	

Configuring the Console Media Type

Follow these steps to set the console media type to RJ-45. If you configure the console as RJ-45, USB console operation is disabled, and input comes only through the RJ-45 connector.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line console 0**
4. **media-type rj45**
5. **end**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**line console 0** **Example:** `Switch(config)# line console 0`	Configures the console and enters line configuration mode.
Step 4	**media-type rj45** **Example:** `Switch(config-line)# media-type rj45`	Configures the console media type to be only RJ-45 port. If you do not enter this command and both types are connected, the USB port is used by default.
Step 5	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring the USB Inactivity Timeout

The configurable inactivity timeout reactivates the RJ-45 console port if the USB console port is activated but no input activity occurs on it for a specified time period. When the USB console port is deactivated due to a timeout, you can restore its operation by disconnecting and reconnecting the USB cable.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line console 0**
4. **usb-inactivity-timeout** *timeout-minutes*
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**line console 0** **Example:** `Switch(config)# line console 0`	Configures the console and enters line configuration mode.

	Command or Action	Purpose
Step 4	**usb-inactivity-timeout** *timeout-minutes* **Example:** `Switch(config-line)# usb-inactivity-timeout 30`	Specify an inactivity timeout for the console port. The range is 1 to 240 minutes. The default is to have no timeout configured.
Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring Interface Characteristics

Monitoring Interface Status

Commands entered at the privileged EXEC prompt display information about the interface, including the versions of the software and the hardware, the configuration, and statistics about the interfaces.

Table 5: Show Commands for Interfaces

Command	Purpose
show interfaces *interface-id* **status** [**err-disabled**]	Displays interface status or a list of interfaces in the error-disabled state.
show interfaces [*interface-id*] **switchport**	Displays administrative and operational status of switching (nonrouting) ports. You can use this command to find out if a port is in routing or in switching mode.
show interfaces [*interface-id*] **description**	Displays the description configured on an interface or all interfaces and the interface status.
show ip interface [*interface-id*]	Displays the usability status of all interfaces configured for IP routing or the specified interface.
show interface [*interface-id*] **stats**	Displays the input and output packets by the switching path for the interface.
show interfaces *interface-id*	(Optional) Displays speed and duplex on the interface.
show interfaces transceiver dom-supported-list	(Optional) Displays Digital Optical Monitoring (DOM) status on the connect SFP modules.
show interfaces transceiver properties	(Optional) Displays temperature, voltage, or amount of current on the interface.

Command	Purpose
show interfaces [*interface-id*] [{**transceiver properties** | **detail**}] *module number*]	Displays physical and operational status about an SFP module.
show running-config interface [*interface-id*]	Displays the running configuration in RAM for the interface.
show version	Displays the hardware configuration, software version, the names and sources of configuration files, and the boot images.
show controllers ethernet-controller *interface-id* **phy**	Displays the operational state of the auto-MDIX feature on the interface.

Clearing and Resetting Interfaces and Counters

Table 6: Clear Commands for Interfaces

Command	Purpose
clear counters [*interface-id*]	Clears interface counters.
clear interface *interface-id*	Resets the hardware logic on an interface.
clear line [*number* | **console 0** | **vty** *number*]	Resets the hardware logic on an asynchronous serial line.

Note The **clear counters** privileged EXEC command does not clear counters retrieved by using Simple Network Management Protocol (SNMP), but only those seen with the **show interface** privileged EXEC command.

Configuration Examples for Interface Characteristics

Configuring a Range of Interfaces: Examples

This example shows how to use the **interface range** global configuration command to set the speed to 100 Mb/s on ports 1 to 4 on switch 1:

```
Switch# configure terminal
Switch(config)# interface range gigabitethernet 0/1 - 4
Switch(config-if-range)# speed 100
```

If you enter multiple configuration commands while you are in interface-range mode, each command is executed as it is entered. The commands are not batched and executed after you exit interface-range mode. If you exit interface-range configuration mode while the commands are being executed, some commands might not be executed on all interfaces in the range. Wait until the command prompt reappears before exiting interface-range configuration mode.

Configuring and Using Interface Range Macros: Examples

This example shows how to define an interface-range named *enet_list* to include ports 1 and 2 on switch 1 and to verify the macro configuration:

```
Switch# configure terminal
Switch(config)# define interface-range enet_list gigabitethernet 0/1 - 2
Switch(config)# end
Switch# show running-config | include define
define interface-range enet_list gigabitethernet 0/1 - 2
```

This example shows how to enter interface-range configuration mode for the interface-range macro *enet_list*:

```
Switch# configure terminal
Switch(config)# interface range macro enet_list
Switch(config-if-range)#
```

This example shows how to delete the interface-range macro *enet_list* and to verify that it was deleted.

```
Switch# configure terminal
Switch(config)# no define interface-range enet_list
Switch(config)# end
Switch# show run | include define
Switch#
```

Setting Interface Speed and Duplex Mode: Example

This example shows how to set the interface speed to 100 Mb/s and the duplex mode to half on a 10/100/1000 Mb/s port:

```
Switch# configure terminal
Switch(config)# interface gigabitethernet 0/3
Switch(config-if)# speed 10
Switch(config-if)# duplex half
```

This example shows how to set the interface speed to 100 Mb/s on a 10/100/1000 Mb/s port:

```
Switch# configure terminal
Switch(config)# interface gigabitethernet 0/2
Switch(config-if)# speed 100
```

Configuring the Console Media Type: Example

This example disables the USB console media type and enables the RJ-45 console media type.

```
Switch# configure terminal
Switch(config)# line console 0
Switch(config-line)# media-type rj45
```

This example reverses the previous configuration and immediately activates any USB console that is connected.

```
Switch# configure terminal
Switch(config)# line console 0
Switch(config-line)# no media-type rj45
```

Configuring the USB Inactivity Timeout: Example

This example configures the inactivity timeout to 30 minutes:

```
Switch# configure terminal
Switch(config)# line console 0
Switch(config-line)# usb-inactivity-timeout 30
```

To disable the configuration, use these commands:

```
Switch# configure terminal
Switch(config)# line console 0
Switch(config-line)# no usb-inactivity-timeout
```

If there is no (input) activity on a USB console port for the configured number of minutes, the inactivity timeout setting applies to the RJ-45 port, and a log shows this occurrence:

```
*Mar  1 00:47:25.625: %USB_CONSOLE-6-INACTIVITY_DISABLE: Console media-type USB disabled
due to inactivity, media-type reverted to RJ45.
```

At this point, the only way to reactivate the USB console port is to disconnect and reconnect the cable.

When the USB cable on the switch has been disconnected and reconnected, a log similar to this appears:

```
*Mar  1 00:48:28.640: %USB_CONSOLE-6-MEDIA_USB: Console media-type is USB.
```

Additional References for the Interface Characteristics Feature

Standards and RFCs

Standard/RFC	Title
None	--

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for Configuring Interface Characteristics

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 3

Configuring Auto-MDIX

Prerequisites for Auto-MDIX

Automatic medium-dependent interface crossover (auto-MDIX) is enabled by default.

Auto-MDIX is supported on all 10/100/1000-Mb/s and on 10/100/1000BASE-TX small form-factor pluggable (SFP)-module interfaces. It is not supported on 1000BASE-SX or -LX SFP module interfaces.

Restrictions for Auto-MDIX

The switch might not support a pre-standard powered device—such as Cisco IP phones and access points that do not fully support IEEE 802.3af—if that powered device is connected to the switch through a crossover cable. This is regardless of whether auto-MIDX is enabled on the switch port.

Information About Configuring Auto-MDIX

Auto-MDIX on an Interface

When automatic medium-dependent interface crossover (auto-MDIX) is enabled on an interface, the interface automatically detects the required cable connection type (straight through or crossover) and configures the connection appropriately. When connecting switches without the auto-MDIX feature, you must use straight-through cables to connect to devices such as servers, workstations, or routers and crossover cables to connect to other switches or repeaters. With auto-MDIX enabled, you can use either type of cable to connect to other devices, and the interface automatically corrects for any incorrect cabling. For more information about cabling requirements, see the hardware installation guide.

This table shows the link states that result from auto-MDIX settings and correct and incorrect cabling.

Table 7: Link Conditions and Auto-MDIX Settings

Local Side Auto-MDIX	Remote Side Auto-MDIX	With Correct Cabling	With Incorrect Cabling
On	On	Link up	Link up
On	Off	Link up	Link up
Off	On	Link up	Link up
Off	Off	Link up	Link down

How to Configure Auto-MDIX

Configuring Auto-MDIX on an Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **speed auto**
5. **duplex auto**
6. **end**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode
Step 3	**interface** *interface-id* **Example:**	Specifies the physical interface to be configured, and enter interface configuration mode.

	Command or Action	Purpose
	`Switch(config)# interface gigabitethernet 0/1`	
Step 4	**speed auto** **Example:** `Switch(config-if)# speed auto`	Configures the interface to autonegotiate speed with the connected device.
Step 5	**duplex auto** **Example:** `Switch(config-if)# duplex auto`	Configures the interface to autonegotiate duplex mode with the connected device.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Example for Configuring Auto-MDIX

This example shows how to enable auto-MDIX on a port:

```
Switch# configure terminal
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# speed auto
Switch(config-if)# duplex auto
Switch(config-if)# mdix auto
Switch(config-if)# end
```

Additional References

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for Auto-MDIX

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 4

Configuring LLDP, LLDP-MED, and Wired Location Service

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About LLDP, LLDP-MED, and Wired Location Service

LLDP

The Cisco Discovery Protocol (CDP) is a device discovery protocol that runs over Layer 2 (the data link layer) on all Cisco-manufactured devices (routers, bridges, access servers, switches, and controllers). CDP allows network management applications to automatically discover and learn about other Cisco devices connected to the network.

To support non-Cisco devices and to allow for interoperability between other devices, the switch supports the IEEE 802.1AB Link Layer Discovery Protocol (LLDP). LLDP is a neighbor discovery protocol that is used for network devices to advertise information about themselves to other devices on the network. This protocol runs over the data-link layer, which allows two systems running different network layer protocols to learn about each other.

LLDP Supported TLVs

LLDP supports a set of attributes that it uses to discover neighbor devices. These attributes contain type, length, and value descriptions and are referred to as TLVs. LLDP supported devices can use TLVs to receive and send information to their neighbors. This protocol can advertise details such as configuration information, device capabilities, and device identity.

The switch supports these basic management TLVs. These are mandatory LLDP TLVs.

- Port description TLV
- System name TLV
- System description TLV
- System capabilities TLV
- Management address TLV

These organizationally specific LLDP TLVs are also advertised to support LLDP-MED.

- Port VLAN ID TLV (IEEE 802.1 organizationally specific TLVs)
- MAC/PHY configuration/status TLV (IEEE 802.3 organizationally specific TLVs)

LLDP and Cisco Medianet

When you configure LLDP or CDP location information on a per-port basis, remote devices can send Cisco Medianet location information to the switch.

LLDP-MED

LLDP for Media Endpoint Devices (LLDP-MED) is an extension to LLDP that operates between endpoint devices such as IP phones and network devices. It specifically provides support for voice over IP (VoIP) applications and provides additional TLVs for capabilities discovery, network policy, Power over Ethernet, inventory management and location information. By default, all LLDP-MED TLVs are enabled.

LLDP-MED Supported TLVs

LLDP-MED supports these TLVs:

- LLDP-MED capabilities TLV

  Allows LLDP-MED endpoints to determine the capabilities that the connected device supports and has enabled.

- Network policy TLV

  Allows both network connectivity devices and endpoints to advertise VLAN configurations and associated Layer 2 and Layer 3 attributes for the specific application on that port. For example, the switch can notify a phone of the VLAN number that it should use. The phone can connect to any switch, obtain its VLAN number, and then start communicating with the call control.

By defining a network-policy profile TLV, you can create a profile for voice and voice-signaling by specifying the values for VLAN, class of service (CoS), differentiated services code point (DSCP), and tagging mode. These profile attributes are then maintained centrally on the switch and propagated to the phone.

- Power management TLV

  Enables advanced power management between LLDP-MED endpoint and network connectivity devices. Allows switches and phones to convey power information, such as how the device is powered, power priority, and how much power the device needs.

  LLDP-MED also supports an extended power TLV to advertise fine-grained power requirements, end-point power priority, and end-point and network connectivity-device power status. LLDP is enabled and power is applied to a port, the power TLV determines the actual power requirement of the endpoint device so that the system power budget can be adjusted accordingly. The switch processes the requests and either grants or denies power based on the current power budget. If the request is granted, the switch updates the power budget. If the request is denied, the switch turns off power to the port, generates a syslog message, and updates the power budget. If LLDP-MED is disabled or if the endpoint does not support the LLDP-MED power TLV, the initial allocation value is used throughout the duration of the connection.

  You can change power settings by entering the **power inline** {**auto** [**max** *max-wattage*] | **never** | **static** [**max** *max-wattage*]} interface configuration command. By default the PoE interface is in **auto** mode; If no value is specified, the maximum is allowed (30 W).

- Inventory management TLV

  Allows an endpoint to send detailed inventory information about itself to the switch, including information hardware revision, firmware version, software version, serial number, manufacturer name, model name, and asset ID TLV.

- Location TLV

  Provides location information from the switch to the endpoint device. The location TLV can send this information:

  - Civic location information

    Provides the civic address information and postal information. Examples of civic location information are street address, road name, and postal community name information.

  - ELIN location information

    Provides the location information of a caller. The location is determined by the Emergency location identifier number (ELIN), which is a phone number that routes an emergency call to the local public safety answering point (PSAP) and which the PSAP can use to call back the emergency caller.

Default LLDP Configuration

Table 8: Default LLDP Configuration

Feature	Default Setting
LLDP global state	Disabled
LLDP holdtime (before discarding)	120 seconds

Feature	Default Setting
LLDP timer (packet update frequency)	30 seconds
LLDP reinitialization delay	2 seconds
LLDP tlv-select	Disabled to send and receive all TLVs
LLDP interface state	Disabled
LLDP receive	Disabled
LLDP transmit	Disabled
LLDP med-tlv-select	Disabled to send all LLDP-MED TLVs. When LLDP is globally enabled, LLDP-MED-TLV is also enabled.

Restrictions for LLDP

- If the interface is configured as a tunnel port, LLDP is automatically disabled.
- If you first configure a network-policy profile on an interface, you cannot apply the **switchport voice vlan** command on the interface. If the **switchport voice vlan** *vlan-id* is already configured on an interface, you can apply a network-policy profile on the interface. This way the interface has the voice or voice-signaling VLAN network-policy profile applied on the interface.
- You cannot configure static secure MAC addresses on an interface that has a network-policy profile.
- When Cisco Discovery Protocol and LLDP are both in use within the same switch, it is necessary to disable LLDP on interfaces where Cisco Discovery Protocol is in use for power negotiation. LLDP can be disabled at interface level with the commands **no lldp tlv-select power-management** or **no lldp transmit / no lldp receive**.

How to Configure LLDP, LLDP-MED, and Wired Location Service

Enabling LLDP

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **lldp run**
4. **interface** *interface-id*
5. **lldp transmit**
6. **lldp receive**
7. **end**
8. **show lldp**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**lldp run** **Example:** `Switch (config)# lldp run`	Enables LLDP globally on the switch.
Step 4	**interface** *interface-id* **Example:** `Switch (config)# interface gigabitethernet 0/1`	Specifies the interface on which you are enabling LLDP, and enter interface configuration mode.
Step 5	**lldp transmit** **Example:** `Switch(config-if)# lldp transmit`	Enables the interface to send LLDP packets.
Step 6	**lldp receive** **Example:** `Switch(config-if)# lldp receive`	Enables the interface to receive LLDP packets.

Step 7	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 8	**show lldp** **Example:** `Switch# show lldp`	Verifies the configuration.

	Command or Action	Purpose
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring LLDP Characteristics

You can configure the frequency of LLDP updates, the amount of time to hold the information before discarding it, and the initialization delay time. You can also select the LLDP and LLDP-MED TLVs to send and receive.

Note Steps 3 through 6 are optional and can be performed in any order.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **lldp holdtime** *seconds*
4. **lldp reinit** *delay*
5. **lldp timer** *rate*
6. **lldp tlv-select**
7. **interface** *interface-id*
8. **lldp med-tlv-select**
9. **end**
10. **show lldp**
11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**lldp holdtime** *seconds* **Example:** `Switch(config)# lldp holdtime 120`	(Optional) Specifies the amount of time a receiving device should hold the information from your device before discarding it. The range is 0 to 65535 seconds; the default is 120 seconds.
Step 4	**lldp reinit** *delay* **Example:** `Switch(config)# lldp reinit 2`	(Optional) Specifies the delay time in seconds for LLDP to initialize on an interface. The range is 2 to 5 seconds; the default is 2 seconds.
Step 5	**lldp timer** *rate* **Example:** `Switch(config)# lldp timer 30`	(Optional) Sets the sending frequency of LLDP updates in seconds. The range is 5 to 65534 seconds; the default is 30 seconds.
Step 6	**lldp tlv-select** **Example:** `Switch(config)# tlv-select`	(Optional) Specifies the LLDP TLVs to send or receive.
Step 7	**interface** *interface-id* **Example:** `Switch (config)# interface gigabitethernet 0/1`	Specifies the interface on which you are enabling LLDP, and enter interface configuration mode.
Step 8	**lldp med-tlv-select** **Example:** `Switch (config-if)# lldp med-tlv-select inventory management`	(Optional) Specifies the LLDP-MED TLVs to send or receive.

Step 9	**end**
	Example:
	`Switch (config-if)# end`
		Returns to privileged EXEC mode.

Step 10	**show lldp** **Example:** `Switch# show lldp`	Verifies the configuration.

	Command or Action	Purpose
Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring LLDP-MED TLVs

By default, the switch only sends LLDP packets until it receives LLDP-MED packets from the end device. It then sends LLDP packets with MED TLVs, as well. When the LLDP-MED entry has been aged out, it again only sends LLDP packets.

By using the **lldp** interface configuration command, you can configure the interface not to send the TLVs listed in the following table.

Table 9: LLDP-MED TLVs

LLDP-MED TLV	Description
inventory-management	LLDP-MED inventory management TLV
location	LLDP-MED location TLV
network-policy	LLDP-MED network policy TLV
power-management	LLDP-MED power management TLV

Follow these steps to enable a TLV on an interface:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **lldp med-tlv-select**
5. **end**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch (config)# interface gigabitethernet 0/1`	Specifies the interface on which you are enabling LLDP, and enter interface configuration mode.
Step 4	**lldp med-tlv-select** **Example:** `Switch(config-if)# lldp med-tlv-select inventory management`	Specifies the TLV to enable.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Network-Policy TLV

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **network-policy profile** *profile number*
4. {**voice** | **voice-signaling**} **vlan** [*vlan-id* {**cos** *cvalue* | **dscp** *dvalue*}] | [[**dot1p** {**cos** *cvalue* | **dscp** *dvalue*}] | **none** | **untagged**]
5. **exit**
6. **interface** *interface-id*
7. **network-policy** *profile number*
8. **lldp med-tlv-select network-policy**
9. **end**
10. **show network-policy profile**

11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**network-policy profile** *profile number* **Example:** `Switch(config)# network-policy profile 1`	Specifies the network-policy profile number, and enter network-policy configuration mode. The range is 1 to 4294967295.
Step 4	{**voice** | **voice-signaling**} **vlan** [*vlan-id* {**cos** *cvalue* | **dscp** *dvalue*}] | [[**dot1p** {**cos** *cvalue* | **dscp** *dvalue*}] | **none** | **untagged**] **Example:** `Switch(config-network-policy)# voice vlan 100 cos 4`	Configures the policy attributes: • **voice**—Specifies the voice application type. • **voice-signaling**—Specifies the voice-signaling application type. • **vlan**—Specifies the native VLAN for voice traffic. • *vlan-id*—(Optional) Specifies the VLAN for voice traffic. The range is 1 to 4094. • **cos** *cvalue*—(Optional) Specifies the Layer 2 priority class of service (CoS) for the configured VLAN. The range is 0 to 7; the default is 5. • **dscp** *dvalue*—(Optional) Specifies the differentiated services code point (DSCP) value for the configured VLAN. The range is 0 to 63; the default is 46. • **dot1p**—(Optional) Configures the telephone to use IEEE 802.1p priority tagging and use VLAN 0 (the native VLAN). • **none**—(Optional) Do not instruct the IP telephone about the voice VLAN. The telephone uses the configuration from the telephone key pad. • **untagged**—(Optional) Configures the telephone to send untagged voice traffic. This is the default for the telephone.

	Command or Action	Purpose
		• **untagged**—(Optional) Configures the telephone to send untagged voice traffic. This is the default for the telephone.
Step 5	**exit** **Example:** `Switch(config)# exit`	Returns to global configuration mode.
Step 6	**interface** *interface-id* **Example:** `Switch (config)# interface gigabitethernet 0/1`	Specifies the interface on which you are configuring a network-policy profile, and enter interface configuration mode.
Step 7	**network-policy** *profile number* **Example:** `Switch(config-if)# network-policy 1`	Specifies the network-policy profile number.
Step 8	**lldp med-tlv-select network-policy** **Example:** `Switch(config-if)# lldp med-tlv-select network-policy`	Specifies the network-policy TLV.

Step 9	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 10	**show network-policy profile** **Example:** `Switch# show network-policy profile`	Verifies the configuration.
Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuration Examples for LLDP, LLDP-MED, and Wired Location Service

Configuring Network-Policy TLV: Examples

This example shows how to configure VLAN 100 for voice application with CoS and to enable the network-policy profile and network-policy TLV on an interface:

```
Switch# configure terminal
Switch(config)# network-policy 1
Switch(config-network-policy)# voice vlan 100 cos 4
Switch(config-network-policy)# exit
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# network-policy profile 1
Switch(config-if)# lldp med-tlv-select network-policy
```

This example shows how to configure the voice application type for the native VLAN with priority tagging:

```
Switchconfig-network-policy)# voice vlan dot1p cos 4
Switchconfig-network-policy)# voice vlan dot1p dscp 34
```

Monitoring and Maintaining LLDP, LLDP-MED, and Wired Location Service

Commands for monitoring and maintaining LLDP, LLDP-MED, and wired location service.

Command	Description
clear lldp counters	Resets the traffic counters to zero.
clear lldp table	Deletes the LLDP neighbor information table.
clear nmsp statistics	Clears the NMSP statistic counters.
show lldp	Displays global information, such as frequency of transmissions, the holdtime for packets being sent, and the delay time before LLDP initializes on an interface.
show lldp entry *entry-name*	Displays information about a specific neighbor. You can enter an asterisk (*) to display all neighbors, or you can enter the neighbor name.

Command	Description
show lldp interface [*interface-id*]	Displays information about interfaces with LLDP enabled. You can limit the display to a specific interface.
show lldp neighbors [*interface-id*] [**detail**]	Displays information about neighbors, including device type, interface type and number, holdtime settings, capabilities, and port ID. You can limit the display to neighbors of a specific interface or expand the display for more detailed information.
show lldp traffic	Displays LLDP counters, including the number of packets sent and received, number of packets discarded, and number of unrecognized TLVs.
show location admin-tag *string*	Displays the location information for the specified administrative tag or site.
show location civic-location identifier *id*	Displays the location information for a specific global civic location.
show location elin-location identifier *id*	Displays the location information for an emergency location
show network-policy profile	Displays the configured network-policy profiles.
show nmsp	Displays the NMSP information

Additional References for LLDP, LLDP-MED, and Wired Location Service

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for LLDP, LLDP-MED, and Wired Location Service

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 5

Configuring System MTU

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About the MTU

The default maximum transmission unit (MTU) size for frames received and transmitted on all interfaces is 1500 bytes.You can increase the MTU size to support jumbo frames on all Gigabit Ethernet interfaces by using the **system mtu jumbo** global configuration command.

How to Configure MTU

Configuring the System MTU

Beginning in privileged EXEC mode, follow these steps to change the MTU size for all 10/100 or Gigabit Ethernet interfaces:

SUMMARY STEPS

1. **configure terminal**

2. **system mtu** *bytes*
3. **system mtu jumbo**
4. **end**
5. **copy running-config startup-config**
6. **do show system mtu**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**system mtu** *bytes* **Example:** `Switch(config)# system mtu 1500`	Enter 1500, 2026 or jumbo to specify the MTU size. The MTU value of **jumbo** is 10218.
Step 3	**system mtu jumbo** **Example:** `Switch(config)# system mtu jumbo`	Enter 1500, 2026 or jumbo to specify the MTU size. The MTU value of **jumbo** is 10218.

Step 4	**end**
	Example:
	`Switch(config)#  end`
		Returns to privileged EXEC mode.

Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	Saves your entries in the configuration file.
Step 6	**do show system mtu** **Example:** `Switch# do show system mtu`	

Configuration Examples for System MTU

This example shows how to set the maximum packet size for a Gigabit Ethernet port to 1500 bytes:

```
Switch(config)# system mtu 1500
Switch(config)# exit
```

This is an example of output from the **show system mtu** command:

```
Switch# show system mtu
System MTU size is 1500 bytes.
```

CHAPTER 6

Configuring PoE

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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Information About PoE

Power over Ethernet Ports

A PoE-capable switch port automatically supplies power to one of these connected devices if the switch senses that there is no power on the circuit:

- a Cisco pre-standard powered device (such as a Cisco IP Phone or a Cisco Aironet Access Point)
- an IEEE 802.3af-compliant powered device

A powered device can receive redundant power when it is connected to a PoE switch port and to an AC power source. The device does not receive redundant power when it is only connected to the PoE port.

Supported Protocols and Standards

The switch uses these protocols and standards to support PoE:

- CDP with power consumption—The powered device notifies the switch of the amount of power it is consuming. The switch does not reply to the power-consumption messages. The switch can only supply power to or remove power from the PoE port.
- Cisco intelligent power management—The powered device and the switch negotiate through power-negotiation CDP messages for an agreed-upon power-consumption level. The negotiation allows a high-power Cisco powered device, which consumes more than 7 W, to operate at its highest power mode. The powered device first boots up in low-power mode, consumes less than 7 W, and negotiates to obtain enough power to operate in high-power mode. The device changes to high-power mode only when it receives confirmation from the switch.

  High-power devices can operate in low-power mode on switches that do not support power-negotiation CDP.

  Cisco intelligent power management is backward-compatible with CDP with power consumption; the switch responds according to the CDP message that it receives. CDP is not supported on third-party powered devices; therefore, the switch uses the IEEE classification to determine the power usage of the device.
- IEEE 802.3af—The major features of this standard are powered-device discovery, power administration, disconnect detection, and optional powered-device power classification. For more information, see the standard.

Powered-Device Detection and Initial Power Allocation

The switch detects a Cisco pre-standard or an IEEE-compliant powered device when the PoE-capable port is in the no-shutdown state, PoE is enabled (the default), and the connected device is not being powered by an AC adaptor.

After device detection, the switch determines the device power requirements based on its type:

- The initial power allocation is the maximum amount of power that a powered device requires. The switch initially allocates this amount of power when it detects and powers the powered device. As the switch receives CDP messages from the powered device and as the powered device negotiates power levels with the switch through CDP power-negotiation messages, the initial power allocation might be adjusted.
- The switch classifies the detected IEEE device within a power consumption class. Based on the available power in the power budget, the switch determines if a port can be powered. Table 10: IEEE Power Classifications, on page 60 lists these levels.

Table 10: IEEE Power Classifications

Class	Maximum Power Level Required from the Switch
0 (class status unknown)	15.4 W
1	4 W
2	7 W
3	15.4 W
4	30 W (For IEEE 802.3at Type 2 powered devices)

The switch monitors and tracks requests for power and grants power only when it is available. The switch tracks its power budget (the amount of power available on the switch for PoE). The switch performs power-accounting calculations when a port is granted or denied power to keep the power budget up to date.

After power is applied to the port, the switch uses CDP to determine the *CDP-specific* power consumption requirement of the connected Cisco powered devices, which is the amount of power to allocate based on the CDP messages. The switch adjusts the power budget accordingly. This does not apply to third-party PoE devices. The switch processes a request and either grants or denies power. If the request is granted, the switch updates the power budget. If the request is denied, the switch ensures that power to the port is turned off, generates a syslog message, and updates the LEDs. Powered devices can also negotiate with the switch for more power.

With PoE+, powered devices use IEEE 802.3at and LLDP power with media dependent interface (MDI) type, length, and value descriptions (TLVs), Power-via-MDI TLVs, for negotiating power up to 30 W. Cisco pre-standard devices and Cisco IEEE powered devices can use CDP or the IEEE 802.3at power-via-MDI power negotiation mechanism to request power levels up to 30 W.

Note The initial allocation for Class 0, Class 3, and Class 4 powered devices is 15.4 W. When a device starts up and uses CDP or LLDP to send a request for more than 15.4 W, it can be allocated up to the maximum of 30 W.

Note The CDP-specific power consumption requirement is referred to as the *actual* power consumption requirement in the software configuration guides and command references.

If the switch detects a fault caused by an undervoltage, overvoltage, overtemperature, oscillator-fault, or short-circuit condition, it turns off power to the port, generates a syslog message, and updates the power budget and LEDs.

Power Management Modes

The switch supports these PoE modes:

- **auto**—The switch automatically detects if the connected device requires power. If the switch discovers a powered device connected to the port and if the switch has enough power, it grants power, updates the power budget, turns on power to the port on a first-come, first-served basis, and updates the LEDs. For LED information, see the hardware installation guide.

  If the switch has enough power for all the powered devices, they all come up. If enough power is available for all powered devices connected to the switch, power is turned on to all devices. If there is not enough available PoE, or if a device is disconnected and reconnected while other devices are waiting for power, it cannot be determined which devices are granted or are denied power.

  If granting power would exceed the system power budget, the switch denies power, ensures that power to the port is turned off, generates a syslog message, and updates the LEDs. After power has been denied, the switch periodically rechecks the power budget and continues to attempt to grant the request for power.

  If a device being powered by the switch is then connected to wall power, the switch might continue to power the device. The switch might continue to report that it is still powering the device whether the device is being powered by the switch or receiving power from an AC power source.

If a powered device is removed, the switch automatically detects the disconnect and removes power from the port. You can connect a nonpowered device without damaging it.

You can specify the maximum wattage that is allowed on the port. If the IEEE class maximum wattage of the powered device is greater than the configured maximum value, the switch does not provide power to the port. If the switch powers a powered device, but the powered device later requests through CDP messages more than the configured maximum value, the switch removes power to the port. The power that was allocated to the powered device is reclaimed into the global power budget. If you do not specify a wattage, the switch delivers the maximum value. Use the **auto** setting on any PoE port. The auto mode is the default setting.

- **static**—The switch pre-allocates power to the port (even when no powered device is connected) and guarantees that power will be available for the port. The switch allocates the port configured maximum wattage, and the amount is never adjusted through the IEEE class or by CDP messages from the powered device. Because power is pre-allocated, any powered device that uses less than or equal to the maximum wattage is guaranteed to be powered when it is connected to the static port. The port no longer participates in the first-come, first-served model.

  However, if the powered-device IEEE class is greater than the maximum wattage, the switch does not supply power to it. If the switch learns through CDP messages that the powered device is consuming more than the maximum wattage, the switch shuts down the powered device.

  Note In interface mode, the power consumption of a device cannot exceed the power supplied to the static port.

  If you do not specify a wattage, the switch pre-allocates the maximum value. The switch powers the port only if it discovers a powered device. Use the **static** setting on a high-priority interface.

- **never**—The switch disables powered-device detection and never powers the PoE port even if an unpowered device is connected. Use this mode only when you want to make sure that power is never applied to a PoE-capable port, making the port a data-only port.

For most situations, the default configuration (auto mode) works well, providing plug-and-play operation. No further configuration is required. However, perform this task to configure a PoE port for a higher priority, to make it data only, or to specify a maximum wattage to disallow high-power powered devices on a port.

Power Monitoring and Power Policing

When policing of the real-time power consumption is enabled, the switch takes action when a powered device consumes more power than the maximum amount allocated, also referred to as the *cutoff-power value*.

When PoE is enabled, the switch senses the real-time power consumption of the powered device. The switch monitors the real-time power consumption of the connected powered device; this is called *power monitoring* or *power sensing*. The switch also polices the power usage with the *power policing* feature.

Power monitoring is backward-compatible with Cisco intelligent power management and CDP-based power consumption. It works with these features to ensure that the PoE port can supply power to the powered device.

The switch senses the real-time power consumption of the connected device as follows:

1. The switch monitors the real-time power consumption on individual ports.
2. The switch records the power consumption, including peak power usage. The switch reports the information through the CISCO-POWER-ETHERNET-EXT-MIB.

3. If power policing is enabled, the switch polices power usage by comparing the real-time power consumption to the maximum power allocated to the device. The maximum power consumption is also referred to as the *cutoff power* on a PoE port.

   If the device uses more than the maximum power allocation on the port, the switch can either turn off power to the port, or the switch can generate a syslog message and update the LEDs (the port LED is now blinking amber) while still providing power to the device based on the switch configuration. By default, power-usage policing is disabled on all PoE ports.

   If error recovery from the PoE error-disabled state is enabled, the switch automatically takes the PoE port out of the error-disabled state after the specified amount of time.

   If error recovery is disabled, you can manually re-enable the PoE port by using the **shutdown** and **no shutdown** interface configuration commands.

4. If policing is disabled, no action occurs when the powered device consumes more than the maximum power allocation on the PoE port, which could adversely affect the switch.

Maximum Power Allocation (Cutoff Power) on a PoE Port

When power policing is enabled, the switch determines one of the these values as the cutoff power on the PoE port in this order:

1. Manually when you set the user-defined power level that limits the power allowed on the port by using the **power inline auto max** *max-wattage* or the **power inline static max** *max-wattage* interface configuration command
2. Automatically when the switch sets the power usage of the device by using CDP power negotiation or by the IEEE classification and LLDP power negotiation.

Use the first or second method in the previous list to manually configure the cutoff-power value by entering the **power inline consumption default** *wattage* or the **power inline** [**auto** | **static max**] *max-wattage* command.

If you do not manually configure the cutoff-power value, the switch automatically determines it by using CDP power negotiation or the device IEEE classification and LLDP power negotiation. If CDP or LLDP are not enabled, the default value of 30 W is applied. However without CDP or LLDP, the switch does not allow devices to consume more than 15.4 W of power because values from 15400 to 30000 mW are only allocated based on CDP or LLDP requests. If a powered device consumes more than 15.4 W without CDP or LLDP negotiation, the device might be in violation of the maximum current (*Imax*) limitation and might experience an *Icut* fault for drawing more current than the maximum. The port remains in the fault state for a time before attempting to power on again. If the port continuously draws more than 15.4 W, the cycle repeats.

Note When a powered device connected to a PoE+ port restarts and sends a CDP or LLDP packet with a power TLV, the switch locks to the power-negotiation protocol of that first packet and does not respond to power requests from the other protocol. For example, if the switch is locked to CDP, it does not provide power to devices that send LLDP requests. If CDP is disabled after the switch has locked on it, the switch does not respond to LLDP power requests and can no longer power on any accessories. In this case, you should restart the powered device.

Power Consumption Values

You can configure the initial power allocation and the maximum power allocation on a port. However, these values are only the configured values that determine when the switch should turn on or turn off power on the

PoE port. The maximum power allocation is not the same as the actual power consumption of the powered device. The actual cutoff power value that the switch uses for power policing is not equal to the configured power value.

When power policing is enabled, the switch polices the power usage *at the switch port*, which is greater than the power consumption of the device. When you manually set the maximum power allocation, you must consider the power loss over the cable from the switch port to the powered device. The cutoff power is the sum of the rated power consumption of the powered device and the worst-case power loss over the cable.

We recommend that you enable power policing when PoE is enabled on your switch. For example, if policing is disabled and you set the cutoff-power value by using the **power inline auto max 6300** interface configuration command, the configured maximum power allocation on the PoE port is 6.3 W (6300 mW). The switch provides power to the connected devices on the port if the device needs up to 6.3 W. If the CDP-power negotiated value or the IEEE classification value exceeds the configured cutoff value, the switch does not provide power to the connected device. After the switch turns on power on the PoE port, the switch does not police the real-time power consumption of the device, and the device can consume more power than the maximum allocated amount, which could adversely affect the switch and the devices connected to the other PoE ports.

Note In interface mode, the power consumption of a device cannot exceed the power supplied to the static port.

For example, if you configure power supply to the port at 6000 mW (**power inline static6000** interface configuration command), do not configure power consumption by a device at 8000 mW on the same port (**power inline consumption8000** interface configuration command).

Persistent PoE

Persistent PoE provides uninterrupted power to connected devices even when the switch is booting.

Note Persistent PoE is supported on Catalyst 2960-L switches from Cisco IOS Release 15.2(5)E2 and higher.

How to Configure PoE

Configuring a Power Management Mode on a PoE Port

Note When you make PoE configuration changes, the port being configured drops power. Depending on the new configuration, the state of the other PoE ports, and the state of the power budget, the port might not be powered up again. For example, port 1 is in the auto and on state, and you configure it for static mode. The switch removes power from port 1, detects the powered device, and repowers the port. If port 1 is in the auto and on state and you configure it with a maximum wattage of 10 W, the switch removes power from the port and then redetects the powered device. The switch repowers the port only if the powered device is a class 1, class 2, or a Cisco-only powered device.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **power inline** {**auto** [**max** *max-wattage*] | **never** | **static** [**max** *max-wattage*]}
5. **end**
6. **show power inline** [*interface-id* | **module** *switch-number*]
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the physical port to be configured, and enters interface configuration mode.

Step 4	**power inline** {**auto** [**max** *max-wattage*] | **never** | **static** [**max** *max-wattage*]}
	Example:
	`Switch(config-if)# power inline auto`
		Configures the PoE mode on the port. The keywords have these meanings:
		• **auto**—Enables powered-device detection. If enough power is available, automatically allocates power to the PoE port after device detection. This is the default setting.
		• **max** *max-wattage*—Limits the power allowed on the port. The range is 4000 to 30000 mW. If no value is specified, the maximum is allowed.
		• **never** —Disables device detection, and disable power to the port.
		Note If a port has a Cisco powered device connected to it, do not use the **power inline never** command to configure the port. A false link-up can occur, placing the port into the error-disabled state.
		• **static**—Enables powered-device detection. Pre-allocate (reserve) power for a port before the switch discovers the powered device. The switch reserves power for

	Command or Action	Purpose
		this port even when no device is connected and guarantees that power will be provided upon device detection. **Note** Configure power values in multiples of 100. For example, you can configure 7400 mW, but do not configure 7386 mW or 7421 mW. The switch allocates power to a port configured in static mode before it allocates power to a port configured in auto mode.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**show power inline** [*interface-id* | **module** *switch-number*] **Example:** `Switch# show power inline`	Displays PoE status for a switch, for the specified interface.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Persistent PoE

Note Persistent PoE is supported in Catalyst 2960-L switches from Cisco IOS Release 15.2(5)E2 and higher.

To configure persistent PoE, perform the following steps:

Note You will need to configure the **poe-ha** command before connecting the PD, or you will need to manually shut/unshut the port after configuring **poe-ha**.

If you want to reload the switch, ensure that the persistent PoE configuration is first saved. This is necessary to preserve the configuration.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*

4. **power inline port poe-ha**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the physical port to be configured, and enters interface configuration mode.
Step 4	**power inline port poe-ha** **Example:** `Switch(config-if)# power inline port poe-ha`	Configures persistent PoE.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Budgeting Power for Devices Connected to a PoE Port

When Cisco powered devices are connected to PoE ports, the switch uses Cisco Discovery Protocol (CDP) or Link Layer Discovery Protocol (LLDP) to determine the *protocol-specific* power consumption of the devices, and the switch adjusts the power budget accordingly. This does not apply to IEEE third-party powered devices. For these devices, when the switch grants a power request, the switch adjusts the power budget according to the powered-device IEEE classification. If the powered device is a class 0 (class status unknown) or a class 3, the switch budgets 15,400 mW for the device, regardless of the CDP-specific amount of power needed. If the powered device reports a higher class than its CDP-specific consumption or does not support power classification (defaults to class 0), the switch can power fewer devices because it uses the IEEE class information to track the global power budget.

By using the **power inline consumption** *wattage* interface configuration command, you can override the default power requirement specified by the IEEE classification. The difference between what is mandated by the IEEE classification and what is actually needed by the device is reclaimed into the global power budget for use by additional devices. You can then extend the switch power budget and use it more effectively.

Caution You should carefully plan your switch power budget, enable the power monitoring feature, and make certain not to oversubscribe the power supply.

Note When you manually configure the power budget, you must also consider the power loss over the cable between the switch and the powered device.

Note In interface mode, the power consumption of a device cannot exceed the power supplied to the static port.

For example, if you configure power supply to the port at 6000 mW (**power inline static6000** interface configuration command), do not configure power consumption by a device at 8000 mW on the same port (**power inline consumption8000** interface configuration command).

Budgeting Power to All PoE ports

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no cdp run**
4. **power inline consumption default** *wattage*
5. **end**
6. **show power inline consumption default**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**no cdp run** **Example:**	(Optional) Disables CDP.

	Command or Action	Purpose
	`Switch(config)# no cdp run`	
Step 4	**power inline consumption default** *wattage* **Example:** `Switch(config)# power inline consumption default 5000`	Configures the power consumption of powered devices connected to each PoE port. The range for each device is 4000 to 30000 mW (PoE+). The default is 30000 mW.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show power inline consumption default** **Example:** `Switch# show power inline consumption default`	Displays the power consumption status.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Budgeting Power to a Specific PoE Port

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no cdp run**
4. **interface** *interface-id*
5. **power inline consumption** *wattage*
6. **end**
7. **show power inline consumption**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 3	**no cdp run** **Example:** `Switch(config)# no cdp run`	(Optional) Disables CDP.
Step 4	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the physical port to be configured, and enter interface configuration mode.
Step 5	**power inline consumption** *wattage* **Example:** `Switch(config-if)# power inline consumption 5000`	Configures the power consumption of a powered device connected to a PoE port on the switch. The range for each device is 4000 to 30000 mW (PoE+). The default is 30000 mW (PoE+).

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 7	**show power inline consumption** **Example:** `Switch# show power inline consumption`	Displays the power consumption data.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Power Policing

By default, the switch monitors the real-time power consumption of connected powered devices. You can configure the switch to police the power usage. By default, policing is disabled.

Note The power consumption is displayed in units of 0.5 W. For example, if a connected device draws 3.9 W, this feature will display 4.0 W power drawn.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*

4. **power inline police** [**action**{**log** | **errdisable**}]
5. **exit**
6. Use one of the following:
    - **errdisable detect cause inline-power**
    - **errdisable recovery cause inline-power**
    - **errdisable recovery interval** *interval*
7. **exit**
8. Use one of the following:
    - **show power inline police**
    - **show errdisable recovery**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the physical port to be configured, and enter interface configuration mode.
Step 4	**power inline police** [**action**{**log** | **errdisable**}] **Example:** `Switch(config-if)# power inline police`	If the real-time power consumption exceeds the maximum power allocation on the port, configures the switch to take one of these actions: • **power inline police**—Shuts down the PoE port, turns off power to it, and puts it in the error-disabled state. **Note** You can enable error detection for the PoE error-disabled cause by using the **errdisable detect cause inline-power** global configuration command. You can also enable the timer to recover from the PoE error-disabled state by using the **errdisable recovery cause inline-power interval** *interval* global configuration command.

	Command or Action	Purpose
		• **power inline police action errdisable**—Turns off power to the port if the real-time power consumption exceeds the maximum power allocation on the port. • **power inline police action log**—Generates a syslog message while still providing power to the port. If you do not enter the **action log** keywords, the default action shuts down the port and puts the port in the error-disabled state.
Step 5	**exit** **Example:** `Switch(config-if)# exit`	Returns to global configuration mode.

Step 6	Use one of the following:
	• **errdisable detect cause inline-power**
	• **errdisable recovery cause inline-power**
	• **errdisable recovery interval** *interval*
	Example:
	`Switch(config)# errdisable detect cause inline-power`
	`Switch(config)# errdisable recovery cause inline-power`
	`Switch(config)# errdisable recovery interval 100`
		(Optional) Enables error recovery from the PoE error-disabled state, and configures the PoE recover mechanism variables.
		By default, the recovery interval is 300 seconds.
		For **interval** *interval*, specifies the time in seconds to recover from the error-disabled state. The range is 30 to 86400.

Step 7	**exit** **Example:** `Switch(config)# exit`	Returns to privileged EXEC mode.

Step 8	Use one of the following:
	• **show power inline police**
	• **show errdisable recovery**
	Example:
	`Switch# show power inline police`
	`Switch# show errdisable recovery`
		Displays the power monitoring status, and verify the error recovery settings.

Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring Power Status

Table 11: Show Commands for Power Status

Command	Purpose
show env power switch [*switch-number*]	(Optional) Displays the status of the internal power supplies for the specified switch.
show power inline [*interface-id* | **module** *switch-number*]	Displays PoE status for a switch, for an interface.
show power inline police	Displays the power policing data.

Note Use the**debug ilpower controller** privileged EXEC command to enable debugging of the platform-specific Power over Ethernet (PoE) software module on the switch in long message format. These messages include the Power Controller register reading. Use the **no** form of this command to disable debugging.

Configuration Examples for Configuring PoE

Budgeting Power: Example

When you enter one of the following commands,

- [**no**] **power inline consumption default** *wattage* global configuration command
- [**no**] **power inline consumption** *wattage*

  interface configuration command

this caution message appears:

```
%CAUTION: Interface Gi1/0/1: Misconfiguring the 'power inline  consumption/allocation'
command may cause damage to the
switch and void your warranty. Take precaution not to oversubscribe the power supply. It
is recommended to enable power
policing if the switch supports it. Refer to documentation.
```

CHAPTER 7

Configuring EEE

Restrictions for EEE

EEE has the following restrictions:

- Changing the EEE configuration resets the interface because the device has to restart Layer 1 autonegotiation.
- You might want to enable the Link Layer Discovery Protocol (LLDP) for devices that require longer wakeup times before they are able to accept data on their receive paths. Doing so enables the device to negotiate for extended system wakeup times from the transmitting link partner.

Information About EEE

EEE Overview

Energy Efficient Ethernet (EEE) is an IEEE 802.3az standard that is designed to reduce power consumption in Ethernet networks during idle periods.

Default EEE Configuration

How to Configure EEE

You can enable or disable EEE on an interface that is connected to an EEE-capable link partner.

Enabling or Disabling EEE

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **power efficient-ethernet auto**
4. **no power efficient-ethernet auto**
5. **end**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the interface to be configured, and enter interface configuration mode.
Step 3	**power efficient-ethernet auto** **Example:** `Switch(config-if)# power efficient-ethernet auto`	Enables EEE on the specified interface. When EEE is enabled, the device advertises and autonegotiates EEE to its link partner.
Step 4	**no power efficient-ethernet auto** **Example:** `Switch(config-if)# no power efficient-ethernet auto`	Disables EEE on the specified interface.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**copy running-config startup-config** **Example:**	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Switch# **copy running-config startup-config**	

Monitoring EEE

Table 12: Commands for Displaying EEE Settings

Command	Purpose
show eee capabilities interface *interface-id*	Displays EEE capabilities for the specified interface.
show eee status interface *interface-id*	Displays EEE status information for the specified interface.
show eee counters interface *interface-id*	Displays EEE counters for the specified interface.

Following are examples of the **show eee** commands

```
Switch#show eee capabilities interface gigabitEthernet0/1
Gi2/0/1
EEE(efficient-ethernet): yes (100-Tx and 1000T auto)
Link Partner : yes (100-Tx and 1000T auto)

ASIC/Interface : EEE Capable/EEE Enabled
```

```
Switch#show eee status interface gigabitEthernet0/1
Gi2/0/1 is up
EEE(efficient-ethernet): Operational
Rx LPI Status : Low Power
Tx LPI Status : Low Power
Wake Error Count : 0

ASIC EEE STATUS
Rx LPI Status : Receiving LPI
Tx LPI Status : Transmitting LPI
Link Fault Status : Link Up
Sync Status : Code group synchronization with data stream intact
```

```
Switch#show eee counters interface gigabitEthernet0/1

LP Active Tx Time (10us) : 66649648
LP Transitioning Tx : 462
LP Active Rx Time (10us) : 64911682
LP Transitioning Rx : 153
```

Examples for Cataylst Digital Building Series Switches

```
Switch#show eee capabilities interface gig0/1
Gi1/0/1
EEE(efficient-ethernet): yes (100-Tx and 1000T auto)
Link Partner : no
```

```
Switch#show eee status int gig0/1
Gi1/0/1 is up
EEE(efficient-ethernet): Disagreed
Rx LPI Status : None
```

```
Tx LPI Status : None
Wake Error Count : 0
```

Configuration Examples for Configuring EEE

This example shows how to enable EEE for an interface:

```
Switch# configure terminal
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# power efficient-ethernet auto
```

This example shows how to disable EEE for an interface:

```
Switch# configure terminal
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# no power efficient-ethernet auto
```

Additional References

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

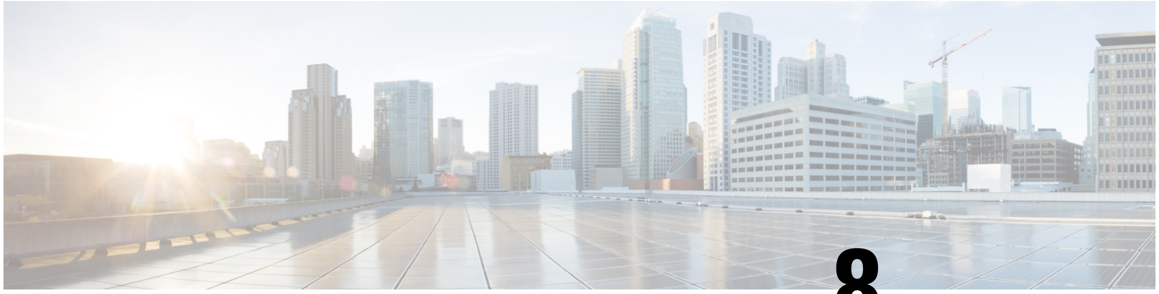
Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for Configuring EEE

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

PART II

IP Multicast Snooping



CHAPTER 8

Configuring IGMP Snooping

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

Prerequisites for Configuring IGMP Snooping

Prerequisites for IGMP Snooping

Observe these guidelines when configuring the IGMP snooping querier:

- Configure the VLAN in global configuration mode.
- Configure an IP address on the VLAN interface. When enabled, the IGMP snooping querier uses the IP address as the query source address.
- If there is no IP address configured on the VLAN interface, the IGMP snooping querier tries to use the configured global IP address for the IGMP querier. If there is no global IP address specified, the IGMP querier tries to use the VLAN switch virtual interface (SVI) IP address (if one exists). If there is no SVI IP address, the switch uses the first available IP address configured on the switch. The first IP address

available appears in the output of the **show ip interface** privileged EXEC command. The IGMP snooping querier does not generate an IGMP general query if it cannot find an available IP address on the switch.

- The IGMP snooping querier supports IGMP Versions 1 and 2.
- When administratively enabled, the IGMP snooping querier moves to the nonquerier state if it detects the presence of a multicast router in the network.
- When it is administratively enabled, the IGMP snooping querier moves to the operationally disabled state if IGMP snooping is disabled in the VLAN.
- Layer 3 multicast is not supported.
- MAC based snooping is supported in hardware.

Related Topics

Configuring the IGMP Snooping Querier , on page 98
IGMP Snooping, on page 85

Restrictions for Configuring IGMP Snooping

Restrictions for IGMP Snooping

The following are the restrictions for IGMP snooping:

- IGMP report suppression is supported only when the multicast query has IGMPv1 and IGMPv2 reports. This feature is not supported when the query includes IGMPv3 reports.
- The IGMP configurable leave time is only supported on hosts running IGMP Version 2. IGMP version 2 is the default version for the switch.

  The actual leave latency in the network is usually the configured leave time. However, the leave time might vary around the configured time, depending on real-time CPU load conditions, network delays and the amount of traffic sent through the interface.
- The IGMP throttling action restriction can be applied only to Layer 2 ports. You can use **ip igmp max-groups action replace** interface configuration command on a logical EtherChannel interface but cannot use it on ports that belong to an EtherChannel port group.

  When the maximum group limitation is set to the default (no maximum), entering the **ip igmp max-groups action** {**deny** | **replace**} command has no effect.

  If you configure the throttling action and set the maximum group limitation after an interface has added multicast entries to the forwarding table, the forwarding-table entries are either aged out or removed, depending on the throttling action.

Information About IGMP Snooping

IGMP Snooping

Layer 2 switches can use IGMP snooping to constrain the flooding of multicast traffic by dynamically configuring Layer 2 interfaces so that multicast traffic is forwarded to only those interfaces associated with IP multicast devices. As the name implies, IGMP snooping requires the LAN switch to snoop on the IGMP transmissions between the host and the router and to keep track of multicast groups and member ports. When the switch receives an IGMP report from a host for a particular multicast group, the switch adds the host port number to the forwarding table entry; when it receives an IGMP Leave Group message from a host, it removes the host port from the table entry. It also periodically deletes entries if it does not receive IGMP membership reports from the multicast clients.

Note For more information on IP multicast and IGMP, see RFC 1112 and RFC 2236.

The multicast router sends out periodic general queries to all VLANs. All hosts interested in this multicast traffic send join requests and are added to the forwarding table entry. The switch creates one entry per VLAN in the IGMP snooping IP multicast forwarding table for each group from which it receives an IGMP join request.

The switch supports IP multicast group-based bridging, instead of MAC-addressed based groups. With multicast MAC address-based groups, if an IP address being configured translates (aliases) to a previously configured MAC address or to any reserved multicast MAC addresses (in the range 224.0.0.xxx), the command fails. Because the switch uses IP multicast groups, there are no address aliasing issues.

The IP multicast groups learned through IGMP snooping are dynamic. However, you can statically configure multicast groups by using the **ip igmp snooping vlan** *vlan-id* **static** *ip_address* **interface** *interface-id* global configuration command. If you specify group membership for a multicast group address statically, your setting supersedes any automatic manipulation by IGMP snooping. Multicast group membership lists can consist of both user-defined and IGMP snooping-learned settings.

You can configure an IGMP snooping querier to support IGMP snooping in subnets without multicast interfaces because the multicast traffic does not need to be routed.

If a port spanning-tree, a port group, or a VLAN ID change occurs, the IGMP snooping-learned multicast groups from this port on the VLAN are deleted.

These sections describe IGMP snooping characteristics:

Related Topics

Configuring the IGMP Snooping Querier , on page 98
Prerequisites for IGMP Snooping, on page 83
Example: Setting the IGMP Snooping Querier Source Address, on page 111
Example: Setting the IGMP Snooping Querier Maximum Response Time, on page 111
Example: Setting the IGMP Snooping Querier Timeout, on page 111
Example: Setting the IGMP Snooping Querier Feature, on page 111

IGMP Versions

The switch supports IGMP version 1, IGMP version 2, and IGMP version 3. These versions are interoperable on the switch. For example, if IGMP snooping is enabled and the querier's version is IGMPv2, and the switch receives an IGMPv3 report from a host, then the switch can forward the IGMPv3 report to the multicast router.

An IGMPv3 switch can receive messages from and forward messages to a device running the Source Specific Multicast (SSM) feature.

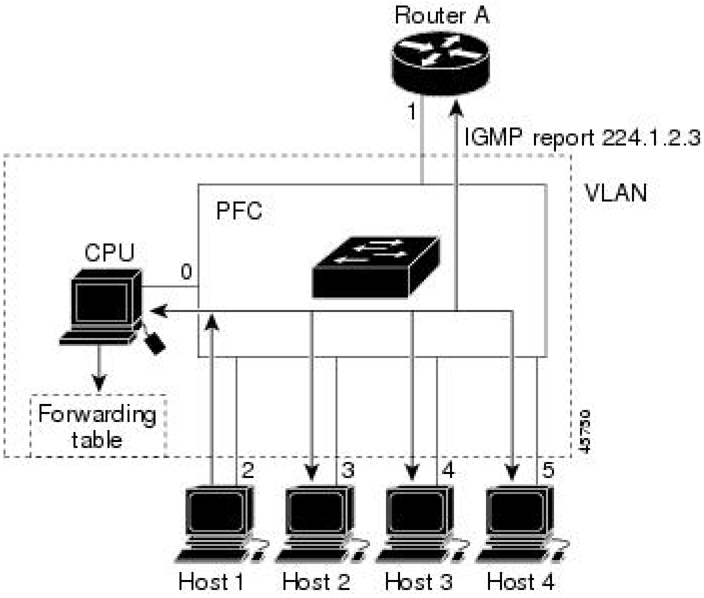
Related Topics

Restrictions for IGMP Snooping

Joining a Multicast Group

Figure 2: Initial IGMP Join Message

When a host connected to the switch wants to join an IP multicast group and it is an IGMP version 2 client, it sends an unsolicited IGMP join message, specifying the IP multicast group to join. Alternatively, when the switch receives a general query from the router, it forwards the query to all ports in the VLAN. IGMP version 1 or version 2 hosts wanting to join the multicast group respond by sending a join message to the switch. The switch CPU creates a multicast forwarding-table entry for the group if it is not already present. The CPU also adds the interface where the join message was received to the forwarding-table entry. The host associated with that interface receives multicast traffic for that multicast group.



Router A sends a general query to the switch, which forwards the query to ports 2 through 5, all of which are members of the same VLAN. Host 1 wants to join multicast group 224.1.2.3 and multicasts an IGMP membership report (IGMP join message) to the group. The switch CPU uses the information in the IGMP report to set up a forwarding-table entry that includes the port numbers connected to Host 1 and to the router.

Table 13: IGMP Snooping Forwarding Table

Destination Address	Type of Packet	Ports
224.1.2.3	IGMP	1, 2

The switch hardware can distinguish IGMP information packets from other packets for the multicast group. The information in the table tells the switching engine to send frames addressed to the 224.1.2.3 multicast IP address that are not IGMP packets to the router and to the host that has joined the group.

Figure 3: Second Host Joining a Multicast Group

If another host (for example, Host 4) sends an unsolicited IGMP join message for the same group, the CPU receives that message and adds the port number of Host 4 to the forwarding table. Because the forwarding table directs IGMP messages only to the CPU, the message is not flooded to other ports on the switch. Any known multicast traffic is forwarded to the group and not to the CPU.

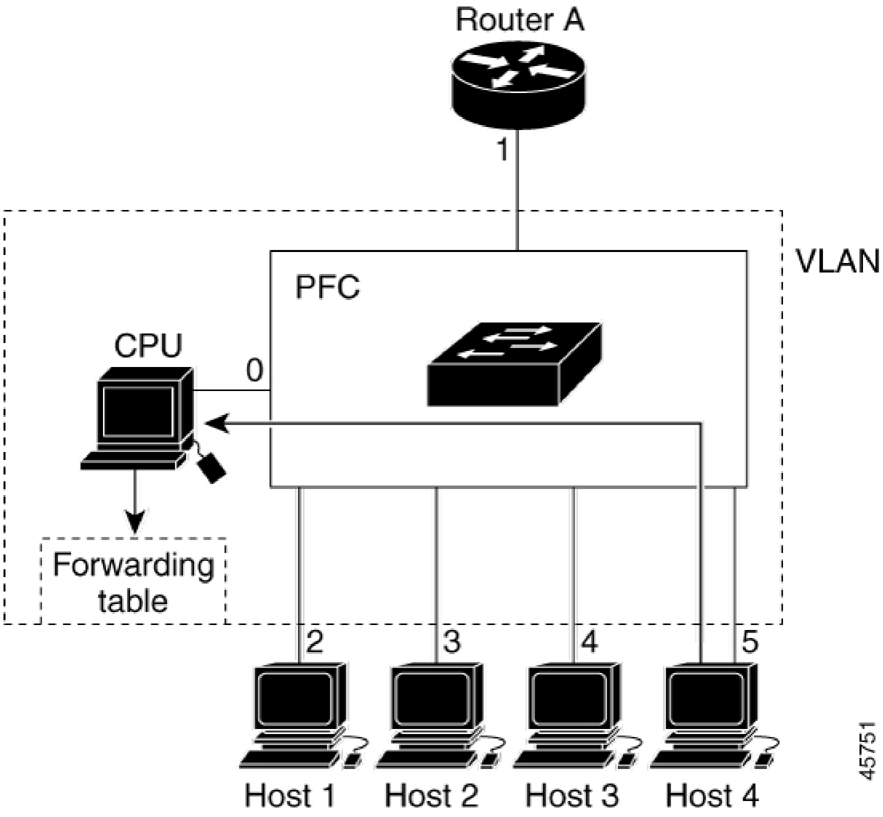


Table 14: Updated IGMP Snooping Forwarding Table

Destination Address	Type of Packet	Ports
224.1.2.3	IGMP	1, 2, 5

Related Topics

Configuring a Host Statically to Join a Group

Example: Configuring a Host Statically to Join a Group, on page 110

Leaving a Multicast Group

The router sends periodic multicast general queries, and the switch forwards these queries through all ports in the VLAN. Interested hosts respond to the queries. If at least one host in the VLAN wants to receive multicast traffic, the router continues forwarding the multicast traffic to the VLAN. The switch forwards multicast group traffic only to those hosts listed in the forwarding table for that IP multicast group maintained by IGMP snooping.

When hosts want to leave a multicast group, they can silently leave, or they can send a leave message. When the switch receives a leave message from a host, it sends a group-specific query to learn if any other devices connected to that interface are interested in traffic for the specific multicast group. The switch then updates the forwarding table for that MAC group so that only those hosts interested in receiving multicast traffic for the group are listed in the forwarding table. If the router receives no reports from a VLAN, it removes the group for the VLAN from its IGMP cache.

Immediate Leave

The switch uses IGMP snooping Immediate Leave to remove from the forwarding table an interface that sends a leave message without the switch sending group-specific queries to the interface. The VLAN interface is pruned from the multicast tree for the multicast group specified in the original leave message. Immediate Leave ensures optimal bandwidth management for all hosts on a switched network, even when multiple multicast groups are simultaneously in use.

Immediate Leave is only supported on IGMP version 2 hosts. IGMP version 2 is the default version for the switch.

Note You should use the Immediate Leave feature only on VLANs where a single host is connected to each port. If Immediate Leave is enabled on VLANs where more than one host is connected to a port, some hosts may be dropped inadvertently.

Related Topics

Enabling IGMP Immediate Leave , on page 95

Example: Enabling IGMP Immediate Leave, on page 110

IGMP Configurable-Leave Timer

You can configure the time that the switch waits after sending a group-specific query to determine if hosts are still interested in a specific multicast group. The IGMP leave response time can be configured from 100 to 32767 milliseconds.

Related Topics

Configuring the IGMP Leave Timer , on page 97

IGMP Report Suppression

Note IGMP report suppression is supported only when the multicast query has IGMPv1 and IGMPv2 reports. This feature is not supported when the query includes IGMPv3 reports.

The switch uses IGMP report suppression to forward only one IGMP report per multicast router query to multicast devices. When IGMP report suppression is enabled (the default), the switch sends the first IGMP report from all hosts for a group to all the multicast routers. The switch does not send the remaining IGMP reports for the group to the multicast routers. This feature prevents duplicate reports from being sent to the multicast devices.

If the multicast router query includes requests only for IGMPv1 and IGMPv2 reports, the switch forwards only the first IGMPv1 or IGMPv2 report from all hosts for a group to all the multicast routers.

If the multicast router query also includes requests for IGMPv3 reports, the switch forwards all IGMPv1, IGMPv2, and IGMPv3 reports for a group to the multicast devices.

If you disable IGMP report suppression, all IGMP reports are forwarded to the multicast routers.

Related Topics

Disabling IGMP Report Suppression , on page 100

Default IGMP Snooping Configuration

This table displays the default IGMP snooping configuration for the switch.

Table 15: Default IGMP Snooping Configuration

Feature	Default Setting
IGMP snooping	Enabled globally and per VLAN
Multicast routers	None configured
IGMP snooping Immediate Leave	Disabled
Static groups	None configured
TCN[1] flood query count	2
TCN query solicitation	Disabled
IGMP snooping querier	Disabled
IGMP report suppression	Enabled

[1] (1) TCN = Topology Change Notification

Related Topics

Enabling or Disabling IGMP Snooping on a Switch , on page 90

Enabling or Disabling IGMP Snooping on a VLAN Interface, on page 92

IGMP Filtering and Throttling

In some environments, for example, metropolitan or multiple-dwelling unit (MDU) installations, you might want to control the set of multicast groups to which a user on a switch port can belong. You can control the distribution of multicast services, such as IP/TV, based on some type of subscription or service plan. You might also want to limit the number of multicast groups to which a user on a switch port can belong.

With the IGMP filtering feature, you can filter multicast joins on a per-port basis by configuring IP multicast profiles and associating them with individual switch ports. An IGMP profile can contain one or more multicast groups and specifies whether access to the group is permitted or denied. If an IGMP profile denying access to a multicast group is applied to a switch port, the IGMP join report requesting the stream of IP multicast traffic is dropped, and the port is not allowed to receive IP multicast traffic from that group. If the filtering action permits access to the multicast group, the IGMP report from the port is forwarded for normal processing. You can also set the maximum number of IGMP groups that a Layer 2 interface can join.

IGMP filtering controls only group-specific query and membership reports, including join and leave reports. It does not control general IGMP queries. IGMP filtering has no relationship with the function that directs the forwarding of IP multicast traffic.

IGMP filtering applies only to the dynamic learning of IP multicast group addresses, not static configuration.

With the IGMP throttling feature, you can set the maximum number of IGMP groups that a Layer 2 interface can join. If the maximum number of IGMP groups is set, the IGMP snooping forwarding table contains the maximum number of entries, and the interface receives an IGMP join report, you can configure an interface to drop the IGMP report or to replace the randomly selected multicast entry with the received IGMP report.

Note IGMPv3 join and leave messages are not supported on switches running IGMP filtering.

Related Topics

Configuring IGMP Profiles , on page 102
Applying IGMP Profiles , on page 104
Setting the Maximum Number of IGMP Groups , on page 105
Configuring the IGMP Throttling Action , on page 107
Restrictions for IGMP Snooping

Default IGMP Filtering and Throttling Configuration

This table displays the default IGMP filtering and throttling configuration for the switch.

Table 16: Default IGMP Filtering Configuration

Feature	Default Setting
IGMP filters	None applied.
IGMP maximum number of IGMP groups	No maximum set. **Note** When the maximum number of groups is in the forwarding table, the default IGMP throttling action is to deny the IGMP report.
IGMP profiles	None defined.
IGMP profile action	Deny the range addresses.

How to Configure IGMP Snooping

Enabling or Disabling IGMP Snooping on a Switch

When IGMP snooping is globally enabled or disabled, it is also enabled or disabled in all existing VLAN interfaces. IGMP snooping is enabled on all VLANs by default, but can be enabled and disabled on a per-VLAN basis.

Global IGMP snooping overrides the VLAN IGMP snooping. If global snooping is disabled, you cannot enable VLAN snooping. If global snooping is enabled, you can enable or disable VLAN snooping.

Follow these steps to globally enable IGMP snooping on the switch:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping**
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping** **Example:** `Switch(config)# ip igmp snooping`	Globally enables IGMP snooping in all existing VLAN interfaces. **Note** To globally disable IGMP snooping on all VLAN interfaces, use the **no ip igmp snooping** global configuration command.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

Default IGMP Snooping Configuration, on page 89

Enabling or Disabling IGMP Snooping on a VLAN Interface

Follow these steps to enable IGMP snooping on a VLAN interface:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping vlan** *vlan-id*
4. **end**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping vlan** *vlan-id* **Example:** `Switch(config)# ip igmp snooping vlan 7`	Enables IGMP snooping on the VLAN interface. The VLAN ID range is 1 to 1001 and 1006 to 4094. IGMP snooping must be globally enabled before you can enable VLAN snooping. **Note** To disable IGMP snooping on a VLAN interface, use the **no ip igmp snooping vlan** *vlan-id* global configuration command for the specified VLAN number.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

Default IGMP Snooping Configuration, on page 89

Configuring a Multicast Router Port

Perform these steps to add a multicast router port (enable a static connection to a multicast router) on the switch.

Note Static connections to multicast routers are supported only on switch ports.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping vlan** *vlan-id* **mrouter interface** *interface-id*
4. **end**
5. **show ip igmp snooping mrouter** [**vlan** *vlan-id*]
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping vlan** *vlan-id* **mrouter interface** *interface-id* **Example:** `Switch(config)# ip igmp snooping vlan 5 mrouter interface gigabitethernet0/1`	Specifies the multicast router VLAN ID and the interface to the multicast router. • The VLAN ID range is 1 to 1001 and 1006 to 4094. • The interface can be a physical interface or a port channel. The port-channel range is 1 to 128. **Note** To remove a multicast router port from the VLAN, use the **no ip igmp snooping vlan** *vlan-id* **mrouter interface** *interface-id* global configuration command.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show ip igmp snooping mrouter** [**vlan** *vlan-id*] **Example:** `Switch# show ip igmp snooping mrouter vlan 5`	Verifies that IGMP snooping is enabled on the VLAN interface.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

Example: Enabling a Static Connection to a Multicast Router

Configuring a Host Statically to Join a Group

Hosts or Layer 2 ports normally join multicast groups dynamically, but you can also statically configure a host on an interface.

Follow these steps to add a Layer 2 port as a member of a multicast group:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping vlan** *vlan-id* **static** *mac_address* **interface** *interface-id*
4. **end**
5. **show ip igmp snooping groups**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping vlan** *vlan-id* **static** *mac_address* **interface** *interface-id* **Example:** `Switch(config)# ip igmp snooping vlan 105 static 0100.1212.0000 interface gigabitethernet0/1`	Statically configures a Layer 2 port as a member of a multicast group: • *vlan-id* is the multicast group VLAN ID. The range is 1 to 1001 and 1006 to 4094. • *mac-address* is the group MAC address. • *interface-id* is the member port. It can be a physical interface or a port channel (1 to 6). **Note** To remove the Layer 2 port from the multicast group, use the **no ip igmp snooping vlan** *vlan-id* **static** *mac-address* **interface** *interface-id* global configuration command.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show ip igmp snooping groups** **Example:** `Switch# show ip igmp snooping groups`	Verifies the member port and the IP address.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Enabling IGMP Immediate Leave

When you enable IGMP Immediate Leave, the switch immediately removes a port when it detects an IGMP Version 2 leave message on that port. You should use the Immediate-Leave feature only when there is a single receiver present on every port in the VLAN.

Note Immediate Leave is supported only on IGMP Version 2 hosts. IGMP Version 2 is the default version for the switch.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping vlan** *vlan-id* **immediate-leave**
4. **end**
5. **show ip igmp snooping vlan** *vlan-id*
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping vlan** *vlan-id* **immediate-leave** **Example:** `Switch(config)# ip igmp snooping vlan 21 immediate-leave`	Enables IGMP Immediate Leave on the VLAN interface. **Note** To disable IGMP Immediate Leave on a VLAN, use the **no ip igmp snooping vlan** *vlan-id* **immediate-leave** global configuration command.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show ip igmp snooping vlan** *vlan-id* **Example:** `Switch# show ip igmp snooping vlan 21`	Verifies that Immediate Leave is enabled on the VLAN interface.

	Command or Action	Purpose

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Immediate Leave , on page 88
Example: Enabling IGMP Immediate Leave, on page 110

Configuring the IGMP Leave Timer

You can configure the leave time globally or on a per-VLAN basis. Follow these steps to enable the IGMP configurable-leave timer:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping last-member-query-interval** *time*
4. **ip igmp snooping vlan** *vlan-id* **last-member-query-interval** *time*
5. **end**
6. **show ip igmp snooping**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping last-member-query-interval** *time* **Example:** `Switch(config)# ip igmp snooping`	Configures the IGMP leave timer globally. The range is 100 to 32767 milliseconds. The default leave time is 1000 milliseconds.

	Command or Action	Purpose
	`last-member-query-interval 1000`	**Note** To globally reset the IGMP leave timer to the default setting, use the **no ip igmp snooping last-member-query-interval** global configuration command.
Step 4	**ip igmp snooping vlan** *vlan-id* **last-member-query-interval** *time* **Example:** `Switch(config)# ip igmp snooping vlan 210 last-member-query-interval 1000`	(Optional) Configures the IGMP leave time on the VLAN interface. The range is 100 to 32767 milliseconds. **Note** Configuring the leave time on a VLAN overrides the globally configured timer. **Note** To remove the configured IGMP leave-time setting from the specified VLAN, use the **no ip igmp snooping vlan** *vlan-id* **last-member-query-interval** global configuration command.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show ip igmp snooping** **Example:** `Switch# show ip igmp snooping`	(Optional) Displays the configured IGMP leave time.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

IGMP Configurable-Leave Timer, on page 88

Configuring the IGMP Snooping Querier

Follow these steps to enable the IGMP snooping querier feature in a VLAN:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping querier**
4. **ip igmp snooping querier address** *ip_address*

5. **ip igmp snooping querier query-interval** *interval-count*
6. **ip igmp snooping querier tcn query** [**count** *count* | **interval** *interval*]
7. **ip igmp snooping querier timer expiry** *timeout*
8. **ip igmp snooping querier version** *version*
9. **end**
10. **show ip igmp snooping vlan** *vlan-id*
11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping querier** **Example:** `Switch(config)# ip igmp snooping querier`	Enables the IGMP snooping querier.
Step 4	**ip igmp snooping querier address** *ip_address* **Example:** `Switch(config)# ip igmp snooping querier address 172.16.24.1`	(Optional) Specifies an IP address for the IGMP snooping querier. If you do not specify an IP address, the querier tries to use the global IP address configured for the IGMP querier. **Note** The IGMP snooping querier does not generate an IGMP general query if it cannot find an IP address on the switch.
Step 5	**ip igmp snooping querier query-interval** *interval-count* **Example:** `Switch(config)# ip igmp snooping querier query-interval 30`	(Optional) Sets the interval between IGMP queriers. The range is 1 to 18000 seconds.
Step 6	**ip igmp snooping querier tcn query** [**count** *count* | **interval** *interval*] **Example:**	(Optional) Sets the time between Topology Change Notification (TCN) queries. The count range is 1 to 10. The interval range is 1 to 255 seconds.

	Command or Action	Purpose
	`Switch(config)# ip igmp snooping querier tcn query interval 20`	
Step 7	**ip igmp snooping querier timer expiry** *timeout* **Example:** `Switch(config)# ip igmp snooping querier timer expiry 180`	(Optional) Sets the length of time until the IGMP querier expires. The range is 60 to 300 seconds.
Step 8	**ip igmp snooping querier version** *version* **Example:** `Switch(config)# ip igmp snooping querier version 2`	(Optional) Selects the IGMP version number that the querier feature uses. Select 1 or 2.

Step 9	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 10	**show ip igmp snooping vlan** *vlan-id* **Example:** `Switch# show ip igmp snooping vlan 30`	(Optional) Verifies that the IGMP snooping querier is enabled on the VLAN interface. The VLAN ID range is 1 to 1001 and 1006 to 4094.
Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

IGMP Snooping, on page 85
Prerequisites for IGMP Snooping, on page 83
Example: Setting the IGMP Snooping Querier Source Address, on page 111
Example: Setting the IGMP Snooping Querier Maximum Response Time, on page 111
Example: Setting the IGMP Snooping Querier Timeout, on page 111
Example: Setting the IGMP Snooping Querier Feature, on page 111

Disabling IGMP Report Suppression

Follow these steps to disable IGMP report suppression:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no ip igmp snooping report-suppression**
4. **end**
5. **show ip igmp snooping**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**no ip igmp snooping report-suppression** **Example:** `Switch(config)# no ip igmp snooping report-suppression`	Disables IGMP report suppression. When report suppression is disabled, all IGMP reports are forwarded to the multicast routers. IGMP report suppression is enabled by default. When IGMP report supression is enabled, the switch forwards only one IGMP report per multicast router query. **Note** To re-enable IGMP report suppression, use the **ip igmp snooping report-suppression** global configuration command.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show ip igmp snooping** **Example:** `Switch# show ip igmp snooping`	Verifies that IGMP report suppression is disabled.
Step 6	**copy running-config startup-config** **Example:**	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	`Switch# copy running-config startup-config`	

Related Topics

IGMP Report Suppression, on page 88

Configuring IGMP Profiles

Follow these steps to create an IGMP profile:

This task is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp profile** *profile number*
4. **permit** | **deny**
5. **range** *ip multicast address*
6. **end**
7. **show ip igmp profile** *profile number*
8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp profile** *profile number* **Example:** `Switch(config)# ip igmp profile 3`	Assigns a number to the profile you are configuring, and enters IGMP profile configuration mode. The profile number range is 1 to 4294967295. When you are in IGMP profile configuration mode, you can create the profile by using these commands: • **deny**—Specifies that matching addresses are denied; this is the default.

	Command or Action	Purpose
		• **exit**—Exits from igmp-profile configuration mode. • **no**—Negates a command or returns to its defaults. • **permit**—Specifies that matching addresses are permitted. • **range**—Specifies a range of IP addresses for the profile. You can enter a single IP address or a range with a start and an end address. The default is for the switch to have no IGMP profiles configured. **Note** To delete a profile, use the **no ip igmp profile** *profile number* global configuration command.
Step 4	**permit | deny** **Example:** `Switch(config-igmp-profile)# permit`	(Optional) Sets the action to permit or deny access to the IP multicast address. If no action is configured, the default for the profile is to deny access.
Step 5	**range** *ip multicast address* **Example:** `Switch(config-igmp-profile)# range 229.9.9.0`	Enters the IP multicast address or range of IP multicast addresses to which access is being controlled. If entering a range, enter the low IP multicast address, a space, and the high IP multicast address. You can use the **range** command multiple times to enter multiple addresses or ranges of addresses. **Note** To delete an IP multicast address or range of IP multicast addresses, use the **no range** *ip multicast address* IGMP profile configuration command.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show ip igmp profile** *profile number* **Example:** `Switch# show ip igmp profile 3`	Verifies the profile configuration.
Step 8	**show running-config** **Example:**	Verifies your entries.

	Command or Action	Purpose
	`Switch# show running-config`	
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

IGMP Filtering and Throttling, on page 89
Restrictions for IGMP Snooping

Applying IGMP Profiles

To control access as defined in an IGMP profile, you have to apply the profile to the appropriate interfaces. You can apply IGMP profiles only to Layer 2 access ports; you cannot apply IGMP profiles to routed ports or SVIs. You cannot apply profiles to ports that belong to an EtherChannel port group. You can apply a profile to multiple interfaces, but each interface can have only one profile applied to it.

Follow these steps to apply an IGMP profile to a switch port:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **ip igmp filter** *profile number*
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/1`	Specifies the physical interface, and enters interface configuration mode. The interface must be a Layer 2 port that does not belong to an EtherChannel port group.
Step 4	**ip igmp filter** *profile number* **Example:** `Switch(config-if)# ip igmp filter 321`	Applies the specified IGMP profile to the interface. The range is 1 to 4294967295. **Note** To remove a profile from an interface, use the **no ip igmp filter** *profile number* interface configuration command.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

IGMP Filtering and Throttling, on page 89

Restrictions for IGMP Snooping

Setting the Maximum Number of IGMP Groups

Follow these steps to set the maximum number of IGMP groups that a Layer 2 interface can join:

Before you begin

This restriction can be applied to Layer 2 ports only; you cannot set a maximum number of IGMP groups on routed ports or SVIs. You also can use this command on a logical EtherChannel interface but cannot use it on ports that belong to an EtherChannel port group.

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **interface** *interface-id*
4. **ip igmp max-groups** *number*
5. **end**
6. **show running-config interface** *interface-id*
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/2`	Specifies the interface to be configured, and enters interface configuration mode. The interface can be a Layer 2 port that does not belong to an EtherChannel group or a EtherChannel interface.
Step 4	**ip igmp max-groups** *number* **Example:** `Switch(config-if)# ip igmp max-groups 20`	Sets the maximum number of IGMP groups that the interface can join. The range is 0 to 4294967294. The default is to have no maximum set. **Note** To remove the maximum group limitation and return to the default of no maximum, use the **no ip igmp max-groups** interface configuration command.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config interface** *interface-id* **Example:** `Switch# interface gigabitethernet0/1`	Verifies your entries.

	Command or Action	Purpose
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

IGMP Filtering and Throttling, on page 89
Restrictions for IGMP Snooping

Configuring the IGMP Throttling Action

After you set the maximum number of IGMP groups that a Layer 2 interface can join, you can configure an interface to replace the existing group with the new group for which the IGMP report was received.

Follow these steps to configure the throttling action when the maximum number of entries is in the forwarding table:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **ip igmp max-groups action** {**deny** | **replace**}
5. **end**
6. **show running-config interface** *interface-id*
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:**	Specifies the physical interface to be configured, and enters interface configuration mode. The interface can be a Layer 2 port that does not belong to an EtherChannel group or an

	Command or Action	Purpose
	`Switch(config)# interface gigabitethernet0/1`	EtherChannel interface. The interface cannot be a trunk port.

Step 4	**ip igmp max-groups action** {**deny** | **replace**}
	Example:
	`Switch(config-if)# ip igmp max-groups action replace`
		When an interface receives an IGMP report and the maximum number of entries is in the forwarding table, specifies the action that the interface takes:
		• **deny**—Drops the report. If you configure this throttling action, the entries that were previously in the forwarding table are not removed but are aged out. After these entries are aged out and the maximum number of entries is in the forwarding table, the switch drops the next IGMP report received on the interface.
		• **replace**—Replaces the existing group with the new group for which the IGMP report was received. If you configure this throttling action, the entries that were previously in the forwarding table are removed. When the maximum number of entries is in the forwarding table, the switch replaces a randomly selected entry with the received IGMP report.
		To prevent the switch from removing the forwarding-table entries, you can configure the IGMP throttling action before an interface adds entries to the forwarding table.
		Note To return to the default action of dropping the report, use the **no ip igmp max-groups action** interface configuration command.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config interface** *interface-id* **Example:** `Switch# show running-config interface gigabitethernet0/1`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

IGMP Filtering and Throttling, on page 89

Restrictions for IGMP Snooping

Monitoring IGMP Snooping

Monitoring IGMP Snooping Information

You can display IGMP snooping information for dynamically learned and statically configured router ports and VLAN interfaces. You can also display MAC address multicast entries for a VLAN configured for IGMP snooping.

Table 17: Commands for Displaying IGMP Snooping Information

Command	Purpose
show ip igmp snooping [**vlan** *vlan-id* [detail]]	Displays the snooping configuration information for all VLANs on the switch or for a specified VLAN. (Optional) Enter **vlan** *vlan-id* to display information for a single VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094.
show ip igmp snooping groups [**count** | **vlan** *vlan-id*]	Displays multicast table information for the switch or about a specific parameter: - **count**—Displays the total number of entries for the specified command options instead of the actual entries. - *vlan-id*—The VLAN ID range is 1 to 1001 and 1006 to 4094.
show ip igmp snooping mrouter [**vlan** *vlan-id*]	Displays information on dynamically learned and manually configured multicast router interfaces. **Note** When you enable IGMP snooping, the switch automatically learns the interface to which a multicast router is connected. These are dynamically learned interfaces. (Optional) Enter the **vlan** *vlan-id* to display information for a particular VLAN.
show ip igmp snooping querier [**vlan** *vlan-id*] **detail**	Displays information about the IP address and receiving port of the most-recently received IGMP query message in the VLAN and the configuration and operational state of the IGMP snooping querier in the VLAN.

Monitoring IGMP Filtering

You can display IGMP profile characteristics, and you can display the IGMP profile and maximum group configuration for all interfaces on the switch or for a specified interface.

Table 18: Commands for Displaying IGMP Filtering

Command	Purpose
show ip igmp profile [*profile number*]	Displays the specified IGMP profile or all the IGMP profiles defined on the switch.
show running-config [**interface** *interface-id*]	Displays the configuration of the specified interface or the configuration of all interfaces on the switch, including (if configured) the maximum number of IGMP groups to which an interface can belong and the IGMP profile applied to the interface.

Configuration Examples for IGMP Snooping

Example: Enabling a Static Connection to a Multicast Router

This example shows how to enable a static connection to a multicast router:

```
Switch configure terminal
Switch ip igmp snooping vlan 200 interface gigabitethernet0/2
Switch end
```

Example: Configuring a Host Statically to Join a Group

This example shows how to statically configure a host on a port:

```
Switch#  configure terminal
Switch#  ip igmp snooping vlan 105 static 0100.1212.0000 interface gigabitethernet0/1
Switch#  end
```

Related Topics

Configuring a Host Statically to Join a Group

Joining a Multicast Group, on page 86

Example: Enabling IGMP Immediate Leave

This example shows how to enable IGMP Immediate Leave on VLAN 130:

```
Switch# configure terminal
Switch(config)# ip igmp snooping vlan 130 immediate-leave
Switch(config)# end
```

Related Topics

Enabling IGMP Immediate Leave , on page 95
Immediate Leave , on page 88

Example: Setting the IGMP Snooping Querier Source Address

This example shows how to set the IGMP snooping querier source address to 10.0.0.64:

```
Switch# configure terminal
Switch(config)# ip igmp snooping querier 10.0.0.64
Switch(config)# end
```

Related Topics

Configuring the IGMP Snooping Querier , on page 98
IGMP Snooping, on page 85

Example: Setting the IGMP Snooping Querier Maximum Response Time

This example shows how to set the IGMP snooping querier maximum response time to 25 seconds:

```
Switch# configure terminal
Switch(config)# ip igmp snooping querier query-interval 25
Switch(config)# end
```

Related Topics

Configuring the IGMP Snooping Querier , on page 98
IGMP Snooping, on page 85

Example: Setting the IGMP Snooping Querier Timeout

This example shows how to set the IGMP snooping querier timeout to 60 seconds:

```
Switch# configure terminal
Switch(config)# ip igmp snooping querier timeout expiry 60
Switch(config)# end
```

Related Topics

Configuring the IGMP Snooping Querier , on page 98
IGMP Snooping, on page 85

Example: Setting the IGMP Snooping Querier Feature

This example shows how to set the IGMP snooping querier feature to Version 2:

```
Switch# configure terminal
Switch(config)# no ip igmp snooping querier version 2
Switch(config)# end
```

Related Topics

Configuring the IGMP Snooping Querier , on page 98
IGMP Snooping, on page 85

Example: Configuring IGMP Profiles

This example shows how to create IGMP profile 4 allowing access to the single IP multicast address and how to verify the configuration. If the action was to deny (the default), it would not appear in the **show ip igmp profile** output display.

```
Switch(config)# ip igmp profile 4
Switch(config-igmp-profile)# permit
Switch(config-igmp-profile)# range 229.9.9.0
Switch(config-igmp-profile)# end
Switch# show ip igmp profile 4
IGMP Profile 4
    permit
    range 229.9.9.0 229.9.9.0
```

Example: Applying IGMP Profile

This example shows how to apply IGMP profile 4 to a port:

```
Switch(config)# interface gigabitethernet0/2
Switch(config-if)# ip igmp filter 4
Switch(config-if)# end
```

Example: Setting the Maximum Number of IGMP Groups

This example shows how to limit to 25 the number of IGMP groups that a port can join:

```
Switch(config)# interface gigabitethernet0/2
Switch(config-if)# ip igmp max-groups 25
Switch(config-if)# end
```

Additional References

Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	

Standards and RFCs

Standard/RFC	Title
RFC 1112	*Host Extensions for IP Multicasting*
RFC 2236	*Internet Group Management Protocol, Version 2*

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

CHAPTER 9

Configuring MLD Snooping

This module contains details of configuring MLD snooping

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About Configuring IPv6 MLD Snooping

You can use Multicast Listener Discovery (MLD) snooping to enable efficient distribution of IP Version 6 (IPv6) multicast data to clients and routers in a switched network on the switch.

Understanding MLD Snooping

In IP Version 4 (IPv4), Layer 2 switches can use Internet Group Management Protocol (IGMP) snooping to limit the flooding of multicast traffic by dynamically configuring Layer 2 interfaces so that multicast traffic is forwarded to only those interfaces associated with IP multicast devices. In IPv6, MLD snooping performs a similar function. With MLD snooping, IPv6 multicast data is selectively forwarded to a list of ports that want to receive the data, instead of being flooded to all ports in a VLAN. This list is constructed by snooping IPv6 multicast control packets.

MLD is a protocol used by IPv6 multicast routers to discover the presence of multicast listeners (nodes wishing to receive IPv6 multicast packets) on the links that are directly attached to the routers and to discover which multicast packets are of interest to neighboring nodes. MLD is derived from IGMP; MLD Version 1 (MLDv1) is equivalent to IGMPv2, and MLD Version 2 (MLDv2) is equivalent to IGMPv3. MLD is a subprotocol of Internet Control Message Protocol Version 6 (ICMPv6), and MLD messages are a subset of ICMPv6 messages, identified in IPv6 packets by a preceding Next Header value of 58.

The switch supports two versions of MLD snooping:

- MLDv1 snooping detects MLDv1 control packets and sets up traffic bridging based on IPv6 destination multicast addresses.
- MLDv2 basic snooping (MBSS) uses MLDv2 control packets to set up traffic forwarding based on IPv6 destination multicast addresses.

The switch can snoop on both MLDv1 and MLDv2 protocol packets and bridge IPv6 multicast data based on destination IPv6 multicast addresses.

Note The switch does not support MLDv2 enhanced snooping, which sets up IPv6 source and destination multicast address-based forwarding.

MLD snooping can be enabled or disabled globally or per VLAN. When MLD snooping is enabled, a per-VLAN IPv6 multicast address table is constructed in software and hardware. The switch then performs IPv6 multicast-address based bridging in hardware.

MLD Messages

MLDv1 supports three types of messages:

- Listener Queries are the equivalent of IGMPv2 queries and are either General Queries or Multicast-Address-Specific Queries (MASQs).
- Multicast Listener Reports are the equivalent of IGMPv2 reports
- Multicast Listener Done messages are the equivalent of IGMPv2 leave messages.

MLDv2 supports MLDv2 queries and reports, as well as MLDv1 Report and Done messages.

Message timers and state transitions resulting from messages being sent or received are the same as those of IGMPv2 messages. MLD messages that do not have valid link-local IPv6 source addresses are ignored by MLD routers and switches.

MLD Queries

The switch sends out MLD queries, constructs an IPv6 multicast address database, and generates MLD group-specific and MLD group-and-source-specific queries in response to MLD Done messages. The switch also supports report suppression, report proxying, Immediate-Leave functionality, and static IPv6 multicast group address configuration.

When MLD snooping is disabled, all MLD queries are flooded in the ingress VLAN.

When MLD snooping is enabled, received MLD queries are flooded in the ingress VLAN, and a copy of the query is sent to the CPU for processing. From the received query, MLD snooping builds the IPv6 multicast address database. It detects multicast router ports, maintains timers, sets report response time, learns the querier IP source address for the VLAN, learns the querier port in the VLAN, and maintains multicast-address aging.

Note When the IPv6 multicast router is a Catalyst 6500 switch and you are using extended VLANs (in the range 1006 to 4094), IPv6 MLD snooping must be enabled on the extended VLAN on the Catalyst 6500 switch in order for the Catalyst 2960, 2960-S, 2960-C, 2960-X or 2960-CX switch to receive queries on the VLAN. For normal-range VLANs (1 to 1005), it is not necessary to enable IPv6 MLD snooping on the VLAN on the Catalyst 6500 switch.

When a group exists in the MLD snooping database, the switch responds to a group-specific query by sending an MLDv1 report. When the group is unknown, the group-specific query is flooded to the ingress VLAN.

When a host wants to leave a multicast group, it can send out an MLD Done message (equivalent to IGMP Leave message). When the switch receives an MLDv1 Done message, if Immediate- Leave is not enabled, the switch sends an MASQ to the port from which the message was received to determine if other devices connected to the port should remain in the multicast group.

Multicast Client Aging Robustness

You can configure port membership removal from addresses based on the number of queries. A port is removed from membership to an address only when there are no reports to the address on the port for the configured number of queries. The default number is 2.

Multicast Router Discovery

Like IGMP snooping, MLD snooping performs multicast router discovery, with these characteristics:

- Ports configured by a user never age out.
- Dynamic port learning results from MLDv1 snooping queries and IPv6 PIMv2 packets.
- If there are multiple routers on the same Layer 2 interface, MLD snooping tracks a single multicast router on the port (the router that most recently sent a router control packet).
- Dynamic multicast router port aging is based on a default timer of 5 minutes; the multicast router is deleted from the router port list if no control packet is received on the port for 5 minutes.
- IPv6 multicast router discovery only takes place when MLD snooping is enabled on the switch.
- Received IPv6 multicast router control packets are always flooded to the ingress VLAN, whether or not MLD snooping is enabled on the switch.
- After the discovery of the first IPv6 multicast router port, unknown IPv6 multicast data is forwarded only to the discovered router ports (before that time, all IPv6 multicast data is flooded to the ingress VLAN).

MLD Reports

The processing of MLDv1 join messages is essentially the same as with IGMPv2. When no IPv6 multicast routers are detected in a VLAN, reports are not processed or forwarded from the switch. When IPv6 multicast routers are detected and an MLDv1 report is received, an IPv6 multicast group address is entered in the VLAN MLD database. Then all IPv6 multicast traffic to the group within the VLAN is forwarded using this address. When MLD snooping is disabled, reports are flooded in the ingress VLAN.

When MLD snooping is enabled, MLD report suppression, called listener message suppression, is automatically enabled. With report suppression, the switch forwards the first MLDv1 report received by a group to IPv6 multicast routers; subsequent reports for the group are not sent to the routers. When MLD snooping is disabled, report suppression is disabled, and all MLDv1 reports are flooded to the ingress VLAN.

The switch also supports MLDv1 proxy reporting. When an MLDv1 MASQ is received, the switch responds with MLDv1 reports for the address on which the query arrived if the group exists in the switch on another port and if the port on which the query arrived is not the last member port for the address.

MLD Done Messages and Immediate-Leave

When the Immediate-Leave feature is enabled and a host sends an MLDv1 Done message (equivalent to an IGMP leave message), the port on which the Done message was received is immediately deleted from the group.You enable Immediate-Leave on VLANs and (as with IGMP snooping), you should only use the feature on VLANs where a single host is connected to the port. If the port was the last member of a group, the group is also deleted, and the leave information is forwarded to the detected IPv6 multicast routers.

When Immediate Leave is not enabled in a VLAN (which would be the case when there are multiple clients for a group on the same port) and a Done message is received on a port, an MASQ is generated on that port. The user can control when a port membership is removed for an existing address in terms of the number of MASQs. A port is removed from membership to an address when there are no MLDv1 reports to the address on the port for the configured number of queries.

The number of MASQs generated is configured by using the **ipv6 mld snooping last-listener-query count** global configuration command. The default number is 2.

The MASQ is sent to the IPv6 multicast address for which the Done message was sent. If there are no reports sent to the IPv6 multicast address specified in the MASQ during the switch maximum response time, the port on which the MASQ was sent is deleted from the IPv6 multicast address database. The maximum response time is the time configured by using the **ipv6 mld snooping last-listener-query-interval** global configuration command. If the deleted port is the last member of the multicast address, the multicast address is also deleted, and the switch sends the address leave information to all detected multicast routers.

Topology Change Notification Processing

When topology change notification (TCN) solicitation is enabled by using the **ipv6 mld snooping tcn query solicit** global configuration command, MLDv1 snooping sets the VLAN to flood all IPv6 multicast traffic with a configured number of MLDv1 queries before it begins sending multicast data only to selected ports. You set this value by using the **ipv6 mld snooping tcn flood query count** global configuration command. The default is to send two queries. The switch also generates MLDv1 global Done messages with valid link-local IPv6 source addresses when the switch becomes the STP root in the VLAN or when it is configured by the user. This is same as done in IGMP snooping.

How to Configure IPv6 MLD Snooping

Default MLD Snooping Configuration

Table 19: Default MLD Snooping Configuration

Feature	Default Setting
MLD snooping (Global)	Disabled.

Feature	Default Setting
MLD snooping (per VLAN)	Enabled. MLD snooping must be globally enabled for VLAN MLD snooping to take place.
IPv6 Multicast addresses	None configured.
IPv6 Multicast router ports	None configured.
MLD snooping Immediate Leave	Disabled.
MLD snooping robustness variable	Global: 2; Per VLAN: 0. **Note** The VLAN value overrides the global setting. When the VLAN value is 0, the VLAN uses the global count.
Last listener query count	Global: 2; Per VLAN: 0. **Note** The VLAN value overrides the global setting. When the VLAN value is 0, the VLAN uses the global count.
Last listener query interval	Global: 1000 (1 second); VLAN: 0. **Note** The VLAN value overrides the global setting. When the VLAN value is 0, the VLAN uses the global interval.
TCN query solicit	Disabled.
TCN query count	2.
MLD listener suppression	Enabled.

MLD Snooping Configuration Guidelines

When configuring MLD snooping, consider these guidelines:

- You can configure MLD snooping characteristics at any time, but you must globally enable MLD snooping by using the **ipv6 mld snooping** global configuration command for the configuration to take effect.
- When the IPv6 multicast router is a Catalyst 6500 switch and you are using extended VLANs (in the range 1006 to 4094), IPv6 MLD snooping must be enabled on the extended VLAN on the Catalyst 6500 switch in order for the switch to receive queries on the VLAN. For normal-range VLANs (1 to 1005), it is not necessary to enable IPv6 MLD snooping on the VLAN on the Catalyst 6500 switch.
- MLD snooping and IGMP snooping act independently of each other. You can enable both features at the same time on the switch.
- The maximum number of address entries allowed for the switch is 1000.

Enabling or Disabling MLD Snooping on the Switch

By default, IPv6 MLD snooping is globally disabled on the switch and enabled on all VLANs. When MLD snooping is globally disabled, it is also disabled on all VLANs. When you globally enable MLD snooping, the VLAN configuration overrides the global configuration. That is, MLD snooping is enabled only on VLAN interfaces in the default state (enabled).

You can enable and disable MLD snooping on a per-VLAN basis or for a range of VLANs, but if you globally disable MLD snooping, it is disabled in all VLANs. If global snooping is enabled, you can enable or disable VLAN snooping.

To globally enable MLD snooping on the switch, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 mld snooping** **Example:** `Switch(config)# ipv6 mld snooping`	Enables MLD snooping on the switch.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**copy running-config startup-config** **Example:** `Switch(config)# copy running-config startup-config`	(Optional) Save your entries in the configuration file.
Step 6	**reload** **Example:** `Switch(config)# reload`	Reload the operating system.

Enabling or Disabling MLD Snooping on a VLAN

To enable MLD snooping on a VLAN, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 mld snooping** **Example:** `Switch(config)# ipv6 mld snooping`	Enables MLD snooping on the switch.
Step 4	**ipv6 mld snooping vlan** *vlan-id* **Example:** `Switch(config)# ipv6 mld snooping vlan 1`	Enables MLD snooping on the VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094. **Note** MLD snooping must be globally enabled for VLAN snooping to be enabled.

Step 5	**end**
	Example:
	`Switch(config)# ipv6 mld snooping vlan 1`
		Returns to privileged EXEC mode.

Configuring a Static Multicast Group

Hosts or Layer 2 ports normally join multicast groups dynamically, but you can also statically configure an IPv6 multicast address and member ports for a VLAN.

To add a Layer 2 port as a member of a multicast group, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
	`Switch> enable`	
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 mld snooping vlan** *vlan-id* **static** *ipv6_multicast_address* **interface** *interface-id* **Example:** `Switch(config)# ipv6 mld snooping vlan 1 static 3333.0000.1111 interface gigabitethernet 0/1`	Configures a multicast group with a Layer 2 port as a member of a multicast group: • *vlan-id* is the multicast group VLAN ID. The VLAN ID range is 1 to 1001 and 1006 to 4094. • *ipv6_multicast_address* is the 128-bit group IPv6 address. The address must be in the form specified in RFC 2373. • *interface-id* is the member port. It can be a physical interface or a port channel (1 to 6).

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	Use one of the following:
	• **show ipv6 mld snooping address**
	• **show ipv6 mld snooping address vlan** *vlan-id*
	Example:
	`Switch# show ipv6 mld snooping address`
	or
	`Switch# show ipv6 mld snooping vlan 1`
		Verifies the static member port and the IPv6 address.

Enabling MLD Immediate Leave

To enable MLDv1 immediate leave, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
	`Switch> enable`	
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 mld snooping vlan** *vlan-id* **immediate-leave** **Example:** `Switch(config)# ipv6 mld snooping vlan 1 immediate-leave`	Enables MLD Immediate Leave on the VLAN interface.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show ipv6 mld snooping vlan** *vlan-id* **Example:** `Switch# show ipv6 mld snooping vlan 1`	Verifies that Immediate Leave is enabled on the VLAN interface.

Configuring MLD Snooping Queries

To configure MLD snooping query characteristics for the switch or for a VLAN, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 mld snooping robustness-variable** *value* **Example:** `Switch(config)# ipv6 mld snooping robustness-variable 3`	(Optional) Sets the number of queries that are sent before switch will deletes a listener (port) that does not respond to a general query. The range is 1 to 3; the default is 2.

	Command or Action	Purpose
Step 4	**ipv6 mld snooping vlan** *vlan-id* **robustness-variable** *value* **Example:** `Switch(config)# ipv6 mld snooping vlan 1 robustness-variable 3`	(Optional) Sets the robustness variable on a VLAN basis, which determines the number of general queries that MLD snooping sends before aging out a multicast address when there is no MLD report response. The range is 1 to 3; the default is 0. When set to 0, the number used is the global robustness variable value.
Step 5	**ipv6 mld snooping last-listener-query-count** *count* **Example:** `Switch(config)# ipv6 mld snooping last-listener-query-count 7`	(Optional) Sets the number of MASQs that the switch sends before aging out an MLD client. The range is 1 to 7; the default is 2. The queries are sent 1 second apart.
Step 6	**ipv6 mld snooping vlan** *vlan-id* **last-listener-query-count** *count* **Example:** `Switch(config)# ipv6 mld snooping vlan 1 last-listener-query-count 7`	(Optional) Sets the last-listener query count on a VLAN basis. This value overrides the value configured globally. The range is 1 to 7; the default is 0. When set to 0, the global count value is used. Queries are sent 1 second apart.
Step 7	**ipv6 mld snooping last-listener-query-interval** *interval* **Example:** `Switch(config)# ipv6 mld snooping last-listener-query-interval 2000`	(Optional) Sets the maximum response time that the switch waits after sending out a MASQ before deleting a port from the multicast group. The range is 100 to 32,768 thousands of a second. The default is 1000 (1 second).
Step 8	**ipv6 mld snooping vlan** *vlan-id* **last-listener-query-interval** *interval* **Example:** `Switch(config)# ipv6 mld snooping vlan 1 last-listener-query-interval 2000`	(Optional) Sets the last-listener query interval on a VLAN basis. This value overrides the value configured globally. The range is 0 to 32,768 thousands of a second. The default is 0. When set to 0, the global last-listener query interval is used.
Step 9	**ipv6 mld snooping tcn query solicit** **Example:** `Switch(config)# ipv6 mld snooping tcn query solicit`	(Optional) Enables topology change notification (TCN) solicitation, which means that VLANs flood all IPv6 multicast traffic for the configured number of queries before sending multicast data to only those ports requesting to receive it. The default is for TCN to be disabled.
Step 10	**ipv6 mld snooping tcn flood query count** *count* **Example:** `Switch(config)# ipv6 mld snooping tcn flood query count 5`	(Optional) When TCN is enabled, specifies the number of TCN queries to be sent. The range is from 1 to 10; the default is 2.
Step 11	**end**	Returns to privileged EXEC mode.
Step 12	**show ipv6 mld snooping querier** [**vlan** *vlan-id*] **Example:**	(Optional) Verifies that the MLD snooping querier information for the switch or for the VLAN.

	Command or Action	Purpose
	`Switch(config)# show ipv6 mld snooping querier vlan 1`	

Disabling MLD Listener Message Suppression

MLD snooping listener message suppression is enabled by default. When it is enabled, the switch forwards only one MLD report per multicast router query. When message suppression is disabled, multiple MLD reports could be forwarded to the multicast routers.

To disable MLD listener message suppression, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enter global configuration mode.
Step 3	**no ipv6 mld snooping listener-message-suppression** **Example:** `Switch(config)# no ipv6 mld snooping listener-message-suppression`	Disable MLD message suppression.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Return to privileged EXEC mode.

Step 5	**show ipv6 mld snooping** **Example:** `Switch# show ipv6 mld snooping`	Verify that IPv6 MLD snooping report suppression is disabled.

Displaying MLD Snooping Information

You can display MLD snooping information for dynamically learned and statically configured router ports and VLAN interfaces. You can also display IPv6 group address multicast entries for a VLAN configured for MLD snooping.

Table 20: Commands for Displaying MLD Snooping Information

Command	Purpose
show ipv6 mld snooping [**vlan** *vlan-id*]	Displays the MLD snooping configuration information for all VLANs on the switch or for a specified VLAN. (Optional) Enter **vlan** *vlan-id* to display information for a single VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094.
show ipv6 mld snooping mrouter [**vlan** *vlan-id*]	Displays information on dynamically learned and manually configured multicast router interfaces. When you enable MLD snooping, the switch automatically learns the interface to which a multicast router is connected. These are dynamically learned interfaces. (Optional) Enters **vlan** *vlan-id* to display information for a single VLAN. The VLAN ID range is 1 to 1001 and 1006 to 4094.
show ipv6 mld snooping querier [**vlan** *vlan-id*]	Displays information about the IPv6 address and incoming port for the most-recently received MLD query messages in the VLAN. (Optional) Enters **vlan** *vlan-id* to display information for a single VLAN.The VLAN ID range is 1 to 1001 and 1006 to 4094.
show ipv6 mld snooping address [**count** | **vlan** *vlan-id*]	Displays all IPv6 multicast address information or specific IPv6 multicast address information for the switch or a VLAN. • Enters **count** to show the group count on the switch or in a VLAN. • Enters **user** to display MLD snooping user-configured group information for the switch or for a VLAN.
show ipv6 mld snooping address vlan *vlan-id* [*ipv6-multicast-address*]	Displays MLD snooping for the specified VLAN and IPv6 multicast address.

Configuration Examples for Configuring MLD Snooping

Configuring a Static Multicast Group: Example

This example shows how to statically configure an IPv6 multicast group:

```
Switch# configure terminal
Switch(config)# ipv6 mld snooping vlan 2 static 3333.0000.1111 interface gigabitethernet0/1
Switch(config)# end
```

Configuring a Multicast Router Port: Example

This example shows how to add a multicast router port to VLAN 200:

```
Switch# configure terminal
Switch(config)# ipv6 mld snooping vlan 200 mrouter interface gigabitethernet

          0/2
Switch(config)# exit
```

Enabling MLD Immediate Leave: Example

This example shows how to enable MLD Immediate Leave on VLAN 130:

```
Switch# configure terminal
Switch(config)# ipv6 mld snooping vlan 130 immediate-leave
Switch(config)# exit
```

Configuring MLD Snooping Queries: Example

This example shows how to set the MLD snooping global robustness variable to 3:

```
Switch# configure terminal
Switch(config)# ipv6 mld snooping robustness-variable 3
Switch(config)# exit
```

This example shows how to set the MLD snooping last-listener query count for a VLAN to 3:

```
Switch# configure terminal
Switch(config)# ipv6 mld snooping vlan 200 last-listener-query-count 3
Switch(config)# exit
```

This example shows how to set the MLD snooping last-listener query interval (maximum response time) to 2000 (2 seconds):

```
Switch# configure terminal
Switch(config)# ipv6 mld snooping last-listener-query-interval 2000
Switch(config)# exit
```

PART III

IPv6

CHAPTER 10

Configuring IPv6 Unicast Routing

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About Configuring IPv6 Host Functions

This chapter describes how to configure IPv6 host functions on the Catalyst 2960L switch.

For information about configuring IPv6 Multicast Listener Discovery (MLD) snooping, see *Configuring MLD Snooping*.

Understanding IPv6

IPv4 users can move to IPv6 and receive services such as end-to-end security, quality of service (QoS), and globally unique addresses. The IPv6 address space reduces the need for private addresses and Network Address Translation (NAT) processing by border routers at network edges.

For information about how Cisco Systems implements IPv6, go to:

http://www.cisco.com/en/US/products/ps6553/products_ios_technology_home.html

For information about IPv6 and other features in this chapter

- See the *Cisco IOS IPv6 Configuration Library*.

- Use the Search field on Cisco.com to locate the Cisco IOS software documentation. For example, if you want information about static routes, you can enter *Implementing Static Routes for IPv6* in the search field to learn about static routes.

IPv6 Addresses

The switch supports only IPv6 unicast addresses. It does not support site-local unicast addresses, or anycast addresses.

The IPv6 128-bit addresses are represented as a series of eight 16-bit hexadecimal fields separated by colons in the format: n:n:n:n:n:n:n:n. This is an example of an IPv6 address:

2031:0000:130F:0000:0000:09C0:080F:130B

For easier implementation, leading zeros in each field are optional. This is the same address without leading zeros:

2031:0:130F:0:0:9C0:80F:130B

You can also use two colons (::) to represent successive hexadecimal fields of zeros, but you can use this short version only once in each address:

2031:0:130F::09C0:080F:130B

For more information about IPv6 address formats, address types, and the IPv6 packet header, see the http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipv6_basic/configuration/xe-3e/ip6b-xe-3e-book.html of *Cisco IOS IPv6 Configuration Library* on Cisco.com.

Supported IPv6 Unicast Routing Features

These sections describe the IPv6 protocol features supported by the switch:

128-Bit Wide Unicast Addresses

The switch supports aggregatable global unicast addresses and link-local unicast addresses. It does not support site-local unicast addresses.

- Aggregatable global unicast addresses are IPv6 addresses from the aggregatable global unicast prefix. The address structure enables strict aggregation of routing prefixes and limits the number of routing table entries in the global routing table. These addresses are used on links that are aggregated through organizations and eventually to the Internet service provider.

  These addresses are defined by a global routing prefix, a subnet ID, and an interface ID. Current global unicast address allocation uses the range of addresses that start with binary value 001 (2000::/3). Addresses with a prefix of 2000::/3(001) through E000::/3(111) must have 64-bit interface identifiers in the extended unique identifier (EUI)-64 format.

- Link local unicast addresses can be automatically configured on any interface by using the link-local prefix FE80::/10(1111 1110 10) and the interface identifier in the modified EUI format. Link-local addresses are used in the neighbor discovery protocol (NDP) and the stateless autoconfiguration process. Nodes on a local link use link-local addresses and do not require globally unique addresses to communicate. IPv6 routers do not forward packets with link-local source or destination addresses to other links.

For more information, see the section about IPv6 unicast addresses in the “Implementing IPv6 Addressing and Basic Connectivity” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

DNS for IPv6

IPv6 supports Domain Name System (DNS) record types in the DNS name-to-address and address-to-name lookup processes. The DNS AAAA resource record types support IPv6 addresses and are equivalent to an A address record in IPv4. The switch supports DNS resolution for IPv4 and IPv6.

ICMPv6

The Internet Control Message Protocol (ICMP) in IPv6 generates error messages, such as ICMP destination unreachable messages, to report errors during processing and other diagnostic functions. In IPv6, ICMP packets are also used in the neighbor discovery protocol and path MTU discovery.

Neighbor Discovery

The switch supports NDP for IPv6, a protocol running on top of ICMPv6, and static neighbor entries for IPv6 stations that do not support NDP. The IPv6 neighbor discovery process uses ICMP messages and solicited-node multicast addresses to determine the link-layer address of a neighbor on the same network (local link), to verify the reachability of the neighbor, and to keep track of neighboring routers.

The switch supports ICMPv6 redirect for routes with mask lengths less than 64 bits. ICMP redirect is not supported for host routes or for summarized routes with mask lengths greater than 64 bits.

Neighbor discovery throttling ensures that the switch CPU is not unnecessarily burdened while it is in the process of obtaining the next hop forwarding information to route an IPv6 packet. The switch drops any additional IPv6 packets whose next hop is the same neighbor that the switch is actively trying to resolve. This drop avoids further load on the CPU.

Note All IPv6 Next Hop Security are not supported in Cisco IOS Release 15.2(5)E.

IPv6 Stateless Autoconfiguration and Duplicate Address Detection

The switch uses stateless autoconfiguration to manage link, subnet, and site addressing changes, such as management of host and mobile IP addresses. A host autonomously configures its own link-local address, and booting nodes send router solicitations to request router advertisements for configuring interfaces.

For more information about autoconfiguration and duplicate address detection, see the “Implementing IPv6 Addressing and Basic Connectivity” chapter of *Cisco IOS IPv6 Configuration Library* on Cisco.com.

IPv6 Applications

The switch has IPv6 support for these applications:

- Ping, traceroute, and Telnet
- Secure Shell (SSH) over an IPv6 transport
- HTTP server access over IPv6 transport
- DNS resolver for AAAA over IPv4 transport
- Cisco Discovery Protocol (CDP) support for IPv6 addresses

For more information about managing these applications, see the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

Static Routes for IPv6

Static routes are manually configured and define an explicit route between two networking devices. Static routes are useful for smaller networks with only one path to an outside network or to provide security for certain types of traffic in a larger network.

Configuring Static Routing for IPv6 (CLI)

For configuring static routes for IPv6, see the *Configuring Static Routing for IPv6* section.

For more information about static routes, see the “Implementing Static Routes for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

RIP for IPv6

Routing Information Protocol (RIP) for IPv6 is a distance-vector protocol that uses hop count as a routing metric. It includes support for IPv6 addresses and prefixes and the all-RIP-routers multicast group address FF02::9 as the destination address for RIP update messages.

For configuring RIP for IPv6, see the *Configuring RIP for IPv6* section.

For more information about RIP for IPv6, see the “Implementing RIP for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

SNMP and Syslog Over IPv6

To support both IPv4 and IPv6, IPv6 network management requires both IPv6 and IPv4 transports. Syslog over IPv6 supports address data types for these transports.

Simple Network Management Protocol (SNMP) and syslog over IPv6 provide these features:

- Support for both IPv4 and IPv6
- IPv6 transport for SNMP and to modify the SNMP agent to support traps for an IPv6 host
- SNMP- and syslog-related MIBs to support IPv6 addressing
- Configuration of IPv6 hosts as trap receivers

For support over IPv6, SNMP modifies the existing IP transport mapping to simultaneously support IPv4 and IPv6. These SNMP actions support IPv6 transport management:

- Opens User Datagram Protocol (UDP) SNMP socket with default settings
- Provides a new transport mechanism called *SR_IPV6_TRANSPORT*
- Sends SNMP notifications over IPv6 transport
- Supports SNMP-named access lists for IPv6 transport
- Supports SNMP proxy forwarding using IPv6 transport
- Verifies SNMP Manager feature works with IPv6 transport

For information on SNMP over IPv6, including configuration procedures, see the “Managing Cisco IOS Applications over IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

For information about syslog over IPv6, including configuration procedures, see the “Implementing IPv6 Addressing and Basic Connectivity” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

HTTP(S) Over IPv6

The HTTP client sends requests to both IPv4 and IPv6 HTTP servers, which respond to requests from both IPv4 and IPv6 HTTP clients. URLs with literal IPv6 addresses must be specified in hexadecimal using 16-bit values between colons.

The accept socket call chooses an IPv4 or IPv6 address family. The accept socket is either an IPv4 or IPv6 socket. The listening socket continues to listen for both IPv4 and IPv6 signals that indicate a connection. The IPv6 listening socket is bound to an IPv6 wildcard address.

The underlying TCP/IP stack supports a dual-stack environment. HTTP relies on the TCP/IP stack and the sockets for processing network-layer interactions.

Basic network connectivity (**ping**) must exist between the client and the server hosts before HTTP connections can be made.

For more information, see the “Managing Cisco IOS Applications over IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

Default IPv6 Configuration

Table 21: Default IPv6 Configuration

Feature	Default Setting
IPv6 addresses	None configured

Configuring IPv6 Addressing and Enabling IPv6 Routing

This section describes how to assign IPv6 addresses to individual Layer 3 interfaces and to globally forward IPv6 traffic on the switch.

Before configuring IPv6 on the switch, consider the following:

- In the **ipv6 address** interface configuration command, you must enter the *ipv6-address* and *ipv6-prefix* variables with the address specified in hexadecimal using 16-bit values between colons. The *prefix-length* variable (preceded by a slash [/]) is a decimal value that shows how many of the high-order contiguous bits of the address comprise the prefix (the network portion of the address).

To forward IPv6 traffic on an interface, you must configure a global IPv6 address on that interface. Configuring an IPv6 address on an interface automatically configures a link-local address and activates IPv6 for the interface. The configured interface automatically joins these required multicast groups for that link:

- solicited-node multicast group FF02:0:0:0:0:1:ff00::/104 for each unicast address assigned to the interface (this address is used in the neighbor discovery process.)
- all-nodes link-local multicast group FF02::1
- all-routers link-local multicast group FF02::2

For more information about configuring IPv6 routing, see the “Implementing Addressing and Basic Connectivity for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

Beginning in privileged EXEC mode, follow these steps to assign an IPv6 address to a Layer 3 interface and enable IPv6 forwarding:

SUMMARY STEPS

1. **configure terminal**
2. **end**
3. **reload**
4. **configure terminal**
5. **interface** *interface-id*
6. Use one of the following:
   - **ipv6 address** *ipv6-prefix/prefix length* **eui-64**
   - **ipv6 address** *ipv6-address/prefix length*
   - **ipv6 address** *ipv6-address* **link-local**
   - **ipv6 enable**
7. **exit**
8. **end**
9. **show ipv6 interface** *interface-id*
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 2	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 3	**reload** **Example:** `Switch# reload`	Reloads the operating system.
Step 4	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode after the switch reloads.
Step 5	**interface** *interface-id* **Example:**	Enters interface configuration mode, and specifies the Layer 3 interface to configure.

	Command or Action	Purpose
	`Switch(config)# interface gigabitethernet0/1`	

Step 6	Use one of the following:
	- **ipv6 address** *ipv6-prefix/prefix length* **eui-64**
	- **ipv6 address** *ipv6-address/prefix length*
	- **ipv6 address** *ipv6-address* **link-local**
	- **ipv6 enable**
	Example:
	`Switch(config-if)# ipv6 address 2001:0DB8:c18:1::/64 eui 64`
	`Switch(config-if)# ipv6 address 2001:0DB8:c18:1::/64`
	`Switch(config-if)# ipv6 address FE80::/10 link-local`
	`Switch(config-if)# ipv6 enable`
		- Specifies a global IPv6 address with an extended unique identifier (EUI) in the low-order 64 bits of the IPv6 address. Specify only the network prefix; the last 64 bits are automatically computed from the switch MAC address. This enables IPv6 processing on the interface.
		- Manually configures an IPv6 address on the interface.
		- Specifies a link-local address on the interface to be used instead of the link-local address that is automatically configured when IPv6 is enabled on the interface. This command enables IPv6 processing on the interface.
		- Automatically configures an IPv6 link-local address on the interface, and enables the interface for IPv6 processing. The link-local address can only be used to communicate with nodes on the same link.

Step 7	**exit** **Example:** `Switch(config-if)# exit`	Returns to global configuration mode.

Step 8	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 9	**show ipv6 interface** *interface-id* **Example:** `Switch# show ipv6 interface gigabitethernet0/1`	Verifies your entries.
Step 10	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring IPv6 ICMP Rate Limiting

ICMP rate limiting is enabled by default with a default interval between error messages of 100 milliseconds and a bucket size (maximum number of tokens to be stored in a bucket) of 10.

To change the ICMP rate-limiting parameters, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 icmp error-interval** *interval* [*bucketsize*] **Example:** `Switch(config)# ipv6 icmp error-interval 50 20`	Configures the interval and bucket size for IPv6 ICMP error messages: • *interval*—The interval (in milliseconds) between tokens being added to the bucket. The range is from 0 to 2147483647 milliseconds. • *bucketsize*—(Optional) The maximum number of tokens stored in the bucket. The range is from 1 to 200.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show ipv6 interface** [*interface-id*] **Example:** `Switch# show ipv6 interface gigabitethernet0/1`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Static Routing for IPv6 (CLI)

Before configuring a static IPv6 route, you must enable routing by using the **ip routing** global configuration command, enable the forwarding of IPv6 packets by using the **ipv6 unicast-routing** global configuration command, and enable IPv6 on at least one Layer 3 interface by configuring an IPv6 address on the interface.

Note The switch supports 16 IPv6 static routes.

For more information about configuring static IPv6 routing, see the "Implementing Static Routes for IPv6" chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**ipv6 route** *ipv6-prefix/prefix length* {*ipv6-address* | *interface-id* [*ipv6-address*]} [*administrative distance*] **Example:** `Switch(config)# ipv6 route 2001:0DB8::/32 gigabitethernet0/1 130`	Configures a static IPv6 route. • *ipv6-prefix*—The IPv6 network that is the destination of the static route. It can also be a hostname when static host routes are configured. • */prefix length*—The length of the IPv6 prefix. A decimal value that shows how many of the high-order contiguous bits of the address comprise the prefix (the network portion of the address). A slash mark must precede the decimal value. • *ipv6-address*—The IPv6 address of the next hop that can be used to reach the specified network. The IPv6 address of the next hop need not be directly connected; recursion is done to find the IPv6 address of the directly connected next hop. The address must be in the form documented in RFC 2373, specified in hexadecimal using 16-bit values between colons. • *interface-id*—Specifies direct static routes from point-to-point and broadcast interfaces. With point-to-point interfaces, there is no need to specify the IPv6 address of the next hop. With broadcast interfaces, you should always specify the IPv6 address of the next hop, or ensure that the specified prefix is assigned to the link, specifying a link-local address as the next hop. You can optionally specify the IPv6 address of the next hop to which packets are sent.

	Command or Action	Purpose
		Note You must specify an *interface-id* when using a link-local address as the next hop (the link-local next hop must also be an adjacent router). • *administrative distance*—(Optional) An administrative distance. The range is 1 to 254; the default value is 1, which gives static routes precedence over any other type of route except connected routes. To configure a floating static route, use an administrative distance greater than that of the dynamic routing protocol.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 4	Use one of the following:
	• **show ipv6 static** [*ipv6-address* | *ipv6-prefix/prefix length*] [**interface** *interface-id*] [**detail**]][**recursive**] [**detail**]
	• **show ipv6 route static**
	Example:
	`Switch# show ipv6 static 2001:0DB8::/32 interface gigabitethernet0/1`
	or
	`Switch# show ipv6 route static`
		Verifies your entries by displaying the contents of the IPv6 routing table.
		• **interface** *interface-id*—(Optional) Displays only those static routes with the specified interface as an egress interface.
		• **recursive**—(Optional) Displays only recursive static routes. The **recursive** keyword is mutually exclusive with the **interface** keyword, but it can be used with or without the IPv6 prefix included in the command syntax.
		• **detail**—(Optional) Displays this additional information:
		  • For valid recursive routes, the output path set, and maximum resolution depth.
		  • For invalid routes, the reason why the route is not valid.

Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring RIP for IPv6

For more information about configuring RIP routing for IPv6, see the “Implementing RIP for IPv6” chapter in the *Cisco IOS IPv6 Configuration Library* on Cisco.com, To configure RIP routing for IPv6, perform this procedure:

Before you begin

Before configuring the switch to run IPv6 RIP, you must enable routing by using the **ip routing** global configuration command, enable the forwarding of IPv6 packets by using the **ipv6 unicast-routing** global configuration command, and enable IPv6 on any Layer 3 interfaces on which IPv6 RIP is to be enabled.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 router rip** *name* **Example:** `Switch(config)# ipv6 router rip cisco`	Configures an IPv6 RIP routing process, and enters router configuration mode for the process.
Step 4	**maximum-paths** *number-paths* **Example:** `Switch(config-router)# maximum-paths 6`	(Optional) Define the maximum number of equal-cost routes that IPv6 RIP can support. The range is from 1 to 8, and the default is 8 routes.
Step 5	**exit** **Example:** `Switch(config-router)# exit`	Returns to global configuration mode.
Step 6	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
Step 7	**ipv6 rip** *name* **enable** **Example:**	Enables the specified IPv6 RIP routing process on the interface.

	Command or Action	Purpose
	`Switch(config-if)# ipv6 rip cisco enable`	

Step 8	**ipv6 rip** *name* **default-information** {**only** | **originate**}
	Example:
	`Switch(config-if)# ipv6 rip cisco default-information only`
		(Optional) Originates the IPv6 default route (::/0) into the RIP routing process updates sent from the specified interface.
		Note To avoid routing loops after the IPv6 default route (::/0) is originated from any interface, the routing process ignores all default routes received on any interface.
		• **only**—Select to originate the default route, but suppress all other routes in the updates sent on this interface.
		• **originate**—Select to originate the default route in addition to all other routes in the updates sent on this interface.

Step 9	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 10	Use one of the following:
	• **show ipv6 rip** [*name*] [**interface** *interface-id*] [**database**] [**next-hops**]
	• **show ipv6 rip**
	Example:
	`Switch# show ipv6 rip cisco interface gigabitethernet 0/1`
	or
	`Switch# show ipv6 rip`
		• Displays information about current IPv6 RIP processes.
		• Displays the current contents of the IPv6 routing table.

Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Displaying IPv6

For complete syntax and usage information on these commands, see the Cisco IOS command reference publications.

Table 22: Command for Monitoring IPv6

Command	Purpose
show ipv6 access-list	Displays a summary of access lists.
show ipv6 cef	Displays Cisco Express Forwarding for IPv6.
show ipv6 interface *interface-id*	Displays IPv6 interface status and configuration.
show ipv6 neighbors	Displays IPv6 neighbor cache entries.
show ipv6 prefix-list	Displays a list of IPv6 prefix lists.
show ipv6 protocols	Displays a list of IPv6 routing protocols on the switch.
show ipv6 rip	Displays IPv6 RIP routing protocol status.
show ipv6 route	Displays IPv6 route table entries.
show ipv6 static	Displays IPv6 static routes.
show ipv6 traffic	Displays IPv6 traffic statistics.

Configuration Examples for IPv6 Unicast Routing

Configuring IPv6 Addressing and Enabling IPv6 Routing: Example

This example shows how to enable IPv6 with both a link-local address and a global address based on the IPv6 prefix 2001:0DB8:c18:1::/64. The EUI-64 interface ID is used in the low-order 64 bits of both addresses. Output from the **show ipv6 interface** EXEC command is included to show how the interface ID (20B:46FF:FE2F:D940) is appended to the link-local prefix FE80::/64 of the interface.

```
Switch(config)# ipv6 unicast-routing
Switch(config)# interface gigabitethernet0/11

Switch(config-if)# ipv6 address 2001:0DB8:c18:1::/64 eui 64
Switch(config-if)# end
Switch# show ipv6 interface gigabitethernet0/11
GigabitEthernet0/11 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::20B:46FF:FE2F:D940
  Global unicast address(es):
  2001:0DB8:c18:1:20B:46FF:FE2F:D940, subnet is 2001:0DB8:c18:1::/64 [EUI]
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF2F:D940
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
  Hosts use stateless autoconfig for addresses.
```

Configuring IPv6 ICMP Rate Limiting: Example

This example shows how to configure an IPv6 ICMP error message interval of 50 milliseconds and a bucket size of 20 tokens.

```
Switch(config)#ipv6 icmp error-interval 50 20
```

Configuring Static Routing for IPv6: Example

This example shows how to configure a floating static route to an interface with an administrative distance of 130:

```
Switch(config)# ipv6 route 2001:0DB8::/32 gigabitethernet 0/1 130
```

Displaying IPv6: Example

This is an example of the output from the **show ipv6 interface** privileged EXEC command:

```
Switch# show ipv6 interface
Vlan1 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::20B:46FF:FE2F:D940
  Global unicast address(es):
    3FFE:C000:0:1:20B:46FF:FE2F:D940, subnet is 3FFE:C000:0:1::/64 [EUI]
  Joined group address(es):
    FF02::1
    FF02::2
    FF02::1:FF2F:D940
  MTU is 1500 bytes
  ICMP error messages limited to one every 100 milliseconds
  ICMP redirects are enabled
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 milliseconds
  ND advertised retransmit interval is 0 milliseconds
  ND router advertisements are sent every 200 seconds
  ND router advertisements live for 1800 seconds
<output truncated>
```

CHAPTER 11

Configuring IPv6 ACL

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About Configuring IPv6 ACLs

You can filter IP version 6 (IPv6) traffic by creating IPv6 access control lists (ACLs) and applying them to interfaces similarly to the way that you create and apply IP version 4(IPv4) named ACLs.

Understanding IPv6 ACLs

A switch image supports two types of IPv6 ACLs:

- IPv6 port ACLs - Supported on inbound traffic on Layer 2 interfaces only. Applied to all IPv6 packets entering the interface.

Note If you configure unsupported IPv6 ACLs, an error message appears and the configuration does not take affect.

The switch does not support VLAN ACLs (VLAN maps) for IPv6 traffic.

You can apply both IPv4 and IPv6 ACLs to an interface.

Supported ACL Features

IPv6 ACLs on the switch have these characteristics:

- Fragmented frames (the fragments keyword as in IPv4) are supported.
- The same statistics supported in IPv4 are supported for IPv6 ACLs.
- If the switch runs out of TCAM space, packets associated with the ACL label are forwarded to the CPU, and the ACLs are applied in software.

IPv6 ACL Limitations

With IPv4, you can configure standard and extended numbered IP ACLs, named IP ACLs, and MAC ACLs. IPv6 supports only named ACLs.

The switch supports most Cisco IOS-supported IPv6 ACLs with some exceptions:

- IPv6 source and destination addresses-ACL matching is supported only on prefixes from /0 to /64 and host addresses (/128) that are in the extended universal identifier (EUI)-64 format. The switch supports only these host addresses with no loss of information:

  -aggregatable global unicast addresses

  -link local addresses
- The switch does not support matching on these keywords: **flowlabel**, **routing header**, and **undetermined-transport**.
- The switch does not support reflexive ACLs (the **reflect** keyword).
- This release supports only port ACLs for IPv6; it does not support router ACLs for IPv6 and VLAN ACLs (VLAN maps).
- The switch does not apply MAC-based ACLs on IPv6 frames.
- You cannot apply IPv6 port ACLs to Layer 2 EtherChannels.
- The switch does not support output port ACLs.
- When configuring an ACL, there is no restriction on keywords entered in the ACL, regardless of whether or not they are supported on the platform. When you apply the ACL to an interface that requires hardware forwarding (physical ports), the switch checks to determine whether or not the ACL can be supported on the interface. If not, attaching the ACL is rejected.
- If an ACL is applied to an interface and you attempt to add an access control entry (ACE) with an unsupported keyword, the switch does not allow the ACE to be added to the ACL that is currently attached to the interface.

Configuring IPv6 ACLs

To filter IPv6 traffic, you perform these steps:

SUMMARY STEPS

1. Create an IPv6 ACL, and enter IPv6 access list configuration mode.

2. Configure the IPv6 ACL to block (deny) or pass (permit) traffic.
3. Apply the IPv6 ACL to an interface.

DETAILED STEPS

	Command or Action	Purpose
Step 1	Create an IPv6 ACL, and enter IPv6 access list configuration mode.	—
Step 2	Configure the IPv6 ACL to block (deny) or pass (permit) traffic.	—
Step 3	Apply the IPv6 ACL to an interface.	—

Default IPv6 ACL Configuration

There are no IPv6 ACLs configured or applied.

Interaction with Other Features and Switches

- If a bridged frame is to be dropped due to a port ACL, the frame is not bridged.
- You can create both IPv4 and IPv6 ACLs on a switch, and you can apply both IPv4 and IPv6 ACLs to the same interface. Each ACL must have a unique name; an error message appears if you try to use a name that is already configured.

  You use different commands to create IPv4 and IPv6 ACLs and to attach IPv4 or IPv6 ACLs to the same Layer 2 interface. If you use the wrong command to attach an ACL (for example, an IPv4 command to attach an IPv6 ACL), you receive an error message.
- You cannot use MAC ACLs to filter IPv6 frames. MAC ACLs can only filter non-IP frames.
- If the hardware memory is full, for any additional configured ACLs, packets are processed to the CPU, and the ACLs are applied in software. When the hardware is full a message is printed to the console indicating the ACL has been unloaded and the packets will be processed in software.

  Note Only packets of the same type as the ACL that could not be added (ipv4, ipv6, MAC) will be processed in software.
- If the TCAM is full, for any additional configured ACLs, packets are forwarded to the CPU, and the ACLs are applied in software.

Creating IPv6 ACL

Follow these steps to create an IPv6 ACL:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ipv6access-list***access-list-name* **Example:** `ipv6 access-list access-list-name`	Define an IPv6 access list name, and enter IPv6 access-list configuration mode.

Step 4	**{deny|permit} protocol**
	Example:
	`{deny | permit} protocol`
	`{source-ipv6-prefix/prefix-length | any | host`
	`source-ipv6-address}`
	`[operator`
	`[port-number]]{destination-ipv6-prefix/prefix-length`
	` | any |host destination-ipv6-address}`
	`[operator [port-number]][dscp value]`
	`[fragments][log] [log-input] [routing][sequence`
	`value]`
	`[time-range name]`
		Enter deny or permit to specify whether to deny or permit the packet if conditions are matched. These are the conditions:
		- For protocol, enter the name or number of an Internet protocol: ahp, esp, icmp, ipv6, pcp, stcp, tcp, or udp, or an integer in the range 0 to 255 representing an IPv6 protocol number.
		- The source-ipv6-prefix/prefix-length or destination-ipv6-prefix/ prefix-length is the source or destination IPv6 network or class of networks for which to set deny or permit conditions, specified in hexadecimal and using 16-bit values between colons (see RFC 2373).
		- Enter any as an abbreviation for the IPv6 prefix ::/0.
		- For host source-ipv6-address or destination-ipv6-address, enter the source or destination IPv6 host address for which to set deny or permit conditions, specified in hexadecimal using 16-bit values between colons.
		- (Optional) For operator, specify an operand that compares the source or destination ports of the specified protocol. Operands are lt (less than), gt (greater than), eq (equal), neq (not equal), and range.
		If the operator follows the source-ipv6-prefix/prefix-length argument, it must match the source port. If the operator follows the destination-ipv6- prefix/prefix-length argument, it must match the destination port.

<table>
<tr><th></th><th>Command or Action</th><th>Purpose</th></tr>
<tr><td></td><td></td><td>• (Optional) The port-number is a decimal number from 0 to 65535 or the name of a TCP or UDP port. You can use TCP port names only when filtering TCP. You can use UDP port names only when filtering UDP.
• (Optional) Enter dscp value to match a differentiated services code point value against the traffic class value in the Traffic Class field of each IPv6 packet header. The acceptable range is from 0 to 63.
• (Optional) Enter fragments to check noninitial fragments. This keyword is visible only if the protocol is ipv6.
• (Optional) Enter log to cause an logging message to be sent to the console about the packet that matches the entry. Enter log-input to include the input interface in the log entry. Logging is supported only for router ACLs.
• (Optional) Enter routing to specify that IPv6 packets be routed.
• (Optional) Enter sequence value to specify the sequence number for the access list statement. The acceptable range is from 1 to 4294967295
• (Optional) Enter time-range name to specify the time range that applies to the deny or permit statement.</td></tr>
<tr><td><b>Step 5</b></td><td><b>{deny|permit} tcp</b>
<b>Example:</b>
<code>{deny | permit} tcp</code>
<code>{source-ipv6-prefix/prefix-length | any |</code>
<code>hostsource-ipv6-address}</code>
<code>[operator</code>
<code>[port-number]]{destination-ipv6-prefix/prefix-length</code>
<code> | any |hostdestination-ipv6-address}</code>
<code>[operator [port-number]][ack] [dscp value] [fin]</code>

<code>[log][log-input] [neq {port |protocol}] [psh]</code>
<code>[range{port | protocol}] [rst][routing] [sequence</code>
<code> value]</code>
<code>[syn] [time-range name][urg]</code></td><td>(Optional) Define a TCP access list and the access conditions.
Enter tcp for Transmission Control Protocol. The parameters are the same as those described in Step 3, with these additional optional parameters:
• ack—Acknowledgment bit set.
• fin—Finished bit set; no more data from sender.
• neq {port | protocol}—Matches only packets that are not on a given port number.
• psh—Push function bit set.
• range {port | protocol}—Matches only packets in the port number range.
• rst—Reset bit set.
• syn—Synchronize bit set.
• urg—Urgent pointer bit set.</td></tr>
</table>

<table>
<tr><th></th><th>Command or Action</th><th>Purpose</th></tr>
<tr><td>Step 6</td><td>**{deny|permit} udp**
Example:
{deny | permit} udp
{source-ipv6-prefix/prefix-length | any |
hostsource-ipv6-address}
[operator
[port-number]]{destination-ipv6-prefix/prefix-length
 | any | hostdestination-ipv6-address}
[operator [port-number]][dscp value]
[log][log-input]
[neq {port |protocol}] [range {port |protocol}]
[routing][sequence value][time-range name]</td><td>(Optional) Define a UDP access list and the access conditions.
Enter udp for the User Datagram Protocol. The UDP parameters are the same as those described for TCP, except that the operator [port]] port number or name must be a UDP port number or name.</td></tr>
<tr><td>Step 7</td><td>**{deny|permit} icmp**
Example:
{deny | permit} icmp
{source-ipv6-prefix/prefix-length | any |
hostsource-ipv6-address}
[operator [port-number]]
{destination-ipv6-prefix/prefix-length | any |
hostdestination-ipv6-address}
[operator [port-number]][icmp-type [icmp-code]
|icmp-message] [dscpvalue] [log] [log-input]
[sequence value][time-range name]</td><td>(Optional) Define an ICMP access list and the access conditions.
Enter icmp for Internet Control Message Protocol. The ICMP parameters are the same as those described for most IP protocols in Step 3a, with the addition of the ICMP message type and code parameters. These optional keywords have these meanings:
• icmp-type—Enter to filter by ICMP message type, a number from 0 to 255.
• icmp-code—Enter to filter ICMP packets that are filtered by the ICMP message code type, a number from 0 to 255.
• icmp-message—Enter to filter ICMP packets by the ICMP message type name or the ICMP message type and code name. To see a list of ICMP message type names and code names, use the ? key or see command reference for this release.</td></tr>
<tr><td>Step 8</td><td>**end**
Example:
Switch(config)# **end**</td><td>Returns to privileged EXEC mode.</td></tr>
<tr><td>Step 9</td><td>**show ipv6 access-list**
Example:
show ipv6 access-list</td><td>Verify the access list configuration.</td></tr>
<tr><td>Step 10</td><td>**show running-config**
Example:
Switch# **show running-config**</td><td>Verifies your entries.</td></tr>
</table>

	Command or Action	Purpose
Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Applying an IPv6 ACL to an Interface

This section describes how to apply IPv6 ACLs to network interfaces. You can apply an ACL to inbound traffic on Layer 2 interfaces.

Beginning in privileged EXEC mode, follow these steps to control access to an interface:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**interface** `interface_id` **Example:** `Switch# interface interface-id`	Identify a Layer 2 interface (for port ACLs) on which to apply an access list, and enter interface configuration mode.
Step 3	**ipv6 traffic-filter** *access-list-name* **Example:** `Switch# ipv6 traffic-filter access-list-name in`	Apply the access list to incoming or outgoing traffic on the interface.

Step 4	**end**
	Example:
	`Device(config)# end`
		Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Step 5	**show running-config**	Verify the access list configuration.
Step 6	**copy running-config startup-config** **Example:** `copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Displaying IPv6 ACLs

To displayIPv6 ACLs, perform this procedure:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**show access-list** **Example:** `Switch# show access-lists`	Displays all access lists configured on the switch
Step 4	**show ipv6 access-list** *acl_name* **Example:** `Switch# show ipv6 access-list [access-list-name]`	Displays all configured IPv6 access list or the access list specified by name.

Configuration Examples for IPv6 ACL

Example: Creating an IPv6 ACL

This example configures the IPv6 access list named CISCO. The first deny entry in the list denies all packets that have a destination TCP port number greater than 5000. The second deny entry denies packets that have a source UDP port number less than 5000. The second deny also logs all matches to the console. The first permit entry in the list permits all ICMP packets. The second permit entry in the list permits all other traffic. The second permit entry is necessary because an implicit deny -all condition is at the end of each IPv6 access list.

```
Switch(config)# ipv6 access-list CISCO
Switch(config-ipv6-acl)# deny tcp any any gt 5000
Switch (config-ipv6-acl)# deny ::/0 lt 5000 ::/0 log
Switch(config-ipv6-acl)# permit icmp any any
Switch(config-ipv6-acl)# permit any any
```

Example: Displaying IPv6 ACLs

This is an example of the output from the **show access-lists** privileged EXEC command. The output shows all access lists that are configured on the switch.

```
Switch #show access-lists
Extended IP access list hello
10 permit ip any any
IPv6 access list ipv6
permit ipv6 any any sequence 10
```

This is an example of the output from the show ipv6 access-lists privileged EXEC command. The output shows only IPv6 access lists configured on the switch.

```
Switch# show ipv6 access-list
IPv6 access list inbound
permit tcp any any eq bgp (8 matches) sequence 10
permit tcp any any eq telnet (15 matches) sequence 20
permit udp any any sequence 30
```

PART IV

Layer 2

CHAPTER 12

Configuring Spanning Tree Protocol

This chapter describes how to configure the Spanning Tree Protocol (STP) on port-based VLANs on the Catalyst switches. The switch can use either the per-VLAN spanning-tree plus (PVST+) protocol based on the IEEE 802.1D standard and Cisco proprietary extensions, or the rapid per-VLAN spanning-tree plus (rapid-PVST+) protocol based on the IEEE 802.1w standard. A switch stack appears as a single spanning-tree node to the rest of the network, and all stack members use the same bridge ID.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for STP

- An attempt to configure a switch as the root switch fails if the value necessary to be the root switch is less than 1.
- If your network consists of switches that support and do not support the extended system ID, it is unlikely that the switch with the extended system ID support will become the root switch. The extended system ID increases the switch priority value every time the VLAN number is greater than the priority of the connected switches running older software.
- The root switch for each spanning-tree instance should be a backbone or distribution switch. Do not configure an access switch as the spanning-tree primary root.

- The Catalyst 2960-L switch supports Spanning Tree Protocol for a maximum of 256 VLANs.

Related Topics

Configuring the Root Switch , on page 171
Bridge ID, Device Priority, and Extended System ID, on page 160
Spanning-Tree Topology and BPDUs, on page 159
Accelerated Aging to Retain Connectivity, on page 165

Information About Spanning Tree Protocol

Spanning Tree Protocol

Spanning Tree Protocol (STP) is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two stations. Multiple active paths among end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages. Switches might also learn end-station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network. Spanning-tree operation is transparent to end stations, which cannot detect whether they are connected to a single LAN segment or a switched LAN of multiple segments.

The STP uses a spanning-tree algorithm to select one switch of a redundantly connected network as the root of the spanning tree. The algorithm calculates the best loop-free path through a switched Layer 2 network by assigning a role to each port based on the role of the port in the active topology:

- Root—A forwarding port elected for the spanning-tree topology
- Designated—A forwarding port elected for every switched LAN segment
- Alternate—A blocked port providing an alternate path to the root bridge in the spanning tree
- Backup—A blocked port in a loopback configuration

The switch that has *all* of its ports as the designated role or as the backup role is the root switch. The switch that has at least *one* of its ports in the designated role is called the designated switch.

Spanning tree forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning-tree algorithm recalculates the spanning-tree topology and activates the standby path. Switches send and receive spanning-tree frames, called bridge protocol data units (BPDUs), at regular intervals. The switches do not forward these frames but use them to construct a loop-free path. BPDUs contain information about the sending switch and its ports, including switch and MAC addresses, switch priority, port priority, and path cost. Spanning tree uses this information to elect the root switch and root port for the switched network and the root port and designated port for each switched segment.

When two ports on a switch are part of a loop, the spanning-tree and path cost settings control which port is put in the forwarding state and which is put in the blocking state. The spanning-tree port priority value represents the location of a port in the network topology and how well it is located to pass traffic. The path cost value represents the media speed.

Note By default, the switch sends keepalive messages (to ensure the connection is up) only on interfaces that do not have small form-factor pluggable (SFP) modules. You can change the default for an interface by entering the [**no**] **keepalive** interface configuration command with no keywords.

Spanning-Tree Topology and BPDUs

The stable, active spanning-tree topology of a switched network is controlled by these elements:

- The unique bridge ID (switch priority and MAC address) associated with each VLAN on each switch.
- The spanning-tree path cost to the root switch.
- The port identifier (port priority and MAC address) associated with each Layer 2 interface.

When the switches in a network are powered up, each functions as the root switch. Each switch sends a configuration BPDU through all of its ports. The BPDUs communicate and compute the spanning-tree topology. Each configuration BPDU contains this information:

- The unique bridge ID of the switch that the sending switch identifies as the root switch
- The spanning-tree path cost to the root
- The bridge ID of the sending switch
- Message age
- The identifier of the sending interface
- Values for the hello, forward delay, and max-age protocol timers

When a switch receives a configuration BPDU that contains *superior* information (lower bridge ID, lower path cost, and so forth), it stores the information for that port. If this BPDU is received on the root port of the switch, the switch also forwards it with an updated message to all attached LANs for which it is the designated switch.

If a switch receives a configuration BPDU that contains *inferior* information to that currently stored for that port, it discards the BPDU. If the switch is a designated switch for the LAN from which the inferior BPDU was received, it sends that LAN a BPDU containing the up-to-date information stored for that port. In this way, inferior information is discarded, and superior information is propagated on the network.

A BPDU exchange results in these actions:

- One switch in the network is elected as the root switch (the logical center of the spanning-tree topology in a switched network). See the figure following the bullets.

  For each VLAN, the switch with the highest switch priority (the lowest numerical priority value) is elected as the root switch. If all switches are configured with the default priority (32768), the switch with the lowest MAC address in the VLAN becomes the root switch. The switch priority value occupies the most significant bits of the bridge ID, .
- A root port is selected for each switch (except the root switch). This port provides the best path (lowest cost) when the switch forwards packets to the root switch.
- The shortest distance to the root switch is calculated for each switch based on the path cost.

- A designated switch for each LAN segment is selected. The designated switch incurs the lowest path cost when forwarding packets from that LAN to the root switch. The port through which the designated switch is attached to the LAN is called the designated port.

Note If the **logging event spanning tree** command is configured on multiple interfaces and the topology changes, it may result in several logging messages and high CPU utilization. This may cause the switch to drop or delay the processing of STP BPDUs.

To prevent this behavior, remove the **logging event spanning tree** and **logging event status** commands or disable logging to the console.

All paths that are not needed to reach the root switch from anywhere in the switched network are placed in the spanning-tree blocking mode.

Related Topics

Configuring the Root Switch , on page 171

Restrictions for STP, on page 157

Bridge ID, Device Priority, and Extended System ID

The IEEE 802.1D standard requires that each switch has an unique bridge identifier (bridge ID), which controls the selection of the root switch. Because each VLAN is considered as a different *logical bridge* with PVST+ and Rapid PVST+, the same switch must have a different bridge ID for each configured VLAN. Each VLAN on the switch has a unique 8-byte bridge ID. The 2 most-significant bytes are used for the switch priority, and the remaining 6 bytes are derived from the switch MAC address.

The switch supports the IEEE 802.1t spanning-tree extensions, and some of the bits previously used for the switch priority are now used as the VLAN identifier. The result is that fewer MAC addresses are reserved for the switch, and a larger range of VLAN IDs can be supported, all while maintaining the uniqueness of the bridge ID.

The 2 bytes previously used for the switch priority are reallocated into a 4-bit priority value and a 12-bit extended system ID value equal to the VLAN ID.

Table 23: Device Priority Value and Extended System ID

Priority Value				Extended System ID (Set Equal to the VLAN ID)											
Bit 16	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

Spanning tree uses the extended system ID, the switch priority, and the allocated spanning-tree MAC address to make the bridge ID unique for each VLAN.

Support for the extended system ID affects how you manually configure the root switch, the secondary root switch, and the switch priority of a VLAN. For example, when you change the switch priority value, you change the probability that the switch will be elected as the root switch. Configuring a higher value decreases the probability; a lower value increases the probability.

If any root switch for the specified VLAN has a switch priority lower than 24576, the switch sets its own priority for the specified VLAN to 4096 less than the lowest switch priority. 4096 is the value of the least-significant bit of a 4-bit switch priority value as shown in the table.

Related Topics

Configuring the Root Switch , on page 171

Restrictions for STP, on page 157

Configuring the Root Switch , on page 204

Root Switch, on page 186

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Port Priority Versus Path Cost

If a loop occurs, spanning tree uses port priority when selecting an interface to put into the forwarding state. You can assign higher priority values (lower numerical values) to interfaces that you want selected first and lower priority values (higher numerical values) that you want selected last. If all interfaces have the same priority value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

The spanning-tree path cost default value is derived from the media speed of an interface. If a loop occurs, spanning tree uses cost when selecting an interface to put in the forwarding state. You can assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last. If all interfaces have the same cost value, spanning tree puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

Related Topics

Configuring Port Priority , on page 173

Configuring Path Cost , on page 175

Spanning-Tree Interface States

Propagation delays can occur when protocol information passes through a switched LAN. As a result, topology changes can take place at different times and at different places in a switched network. When an interface transitions directly from nonparticipation in the spanning-tree topology to the forwarding state, it can create temporary data loops. Interfaces must wait for new topology information to propagate through the switched LAN before starting to forward frames. They must allow the frame lifetime to expire for forwarded frames that have used the old topology.

Each Layer 2 interface on a switch using spanning tree exists in one of these states:

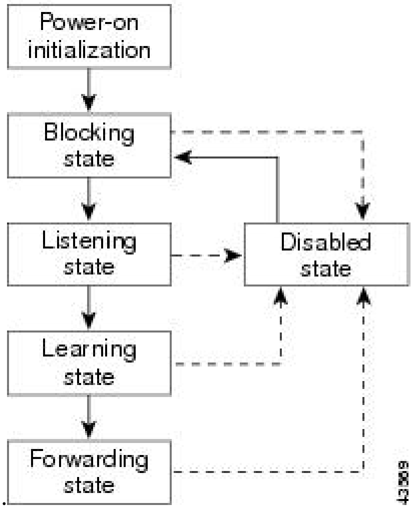
- Blocking—The interface does not participate in frame forwarding.
- Listening—The first transitional state after the blocking state when the spanning tree decides that the interface should participate in frame forwarding.
- Learning—The interface prepares to participate in frame forwarding.
- Forwarding—The interface forwards frames.
- Disabled—The interface is not participating in spanning tree because of a shutdown port, no link on the port, or no spanning-tree instance running on the port.

An interface moves through these states:

- From initialization to blocking

- From blocking to listening or to disabled
- From listening to learning or to disabled
- From learning to forwarding or to disabled
- From forwarding to disabled

Figure 4: Spanning-Tree Interface States



An interface moves through the states.

When you power up the switch, spanning tree is enabled by default, and every interface in the switch, VLAN, or network goes through the blocking state and the transitory states of listening and learning. Spanning tree stabilizes each interface at the forwarding or blocking state.

When the spanning-tree algorithm places a Layer 2 interface in the forwarding state, this process occurs:

1. The interface is in the listening state while spanning tree waits for protocol information to move the interface to the blocking state.
2. While spanning tree waits for the forward-delay timer to expire, it moves the interface to the learning state and resets the forward-delay timer.
3. In the learning state, the interface continues to block frame forwarding as the switch learns end-station location information for the forwarding database.
4. When the forward-delay timer expires, spanning tree moves the interface to the forwarding state, where both learning and frame forwarding are enabled.

Blocking State

A Layer 2 interface in the blocking state does not participate in frame forwarding. After initialization, a BPDU is sent to each switch interface. A switch initially functions as the root until it exchanges BPDUs with other switches. This exchange establishes which switch in the network is the root or root switch. If there is only one switch in the network, no exchange occurs, the forward-delay timer expires, and the interface moves to the listening state. An interface always enters the blocking state after switch initialization.

An interface in the blocking state performs these functions:

- Discards frames received on the interface

- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Receives BPDUs

Listening State

The listening state is the first state a Layer 2 interface enters after the blocking state. The interface enters this state when the spanning tree decides that the interface should participate in frame forwarding.

An interface in the listening state performs these functions:

- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Receives BPDUs

Learning State

A Layer 2 interface in the learning state prepares to participate in frame forwarding. The interface enters the learning state from the listening state.

An interface in the learning state performs these functions:

- Discards frames received on the interface
- Discards frames switched from another interface for forwarding
- Learns addresses
- Receives BPDUs

Forwarding State

A Layer 2 interface in the forwarding state forwards frames. The interface enters the forwarding state from the learning state.

An interface in the forwarding state performs these functions:

- Receives and forwards frames received on the interface
- Forwards frames switched from another interface
- Learns addresses
- Receives BPDUs

Disabled State

A Layer 2 interface in the disabled state does not participate in frame forwarding or in the spanning tree. An interface in the disabled state is nonoperational.

A disabled interface performs these functions:

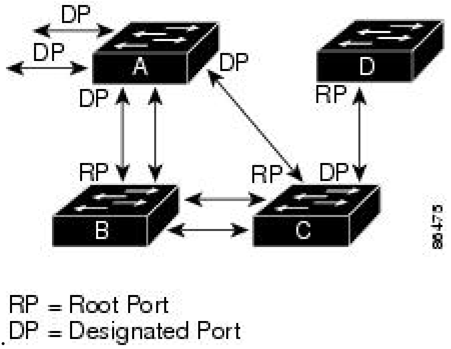
- Discards frames received on the interface

- Discards frames switched from another interface for forwarding
- Does not learn addresses
- Does not receive BPDUs

How a Switch or Port Becomes the Root Switch or Root Port

If all switches in a network are enabled with default spanning-tree settings, the switch with the lowest MAC address becomes the root switch.

Figure 5: Spanning-Tree Topology



Switch A is elected as the root switch because the switch priority of all the switches is set to the default (32768) and Switch A has the lowest MAC address. However, because of traffic patterns, number of forwarding interfaces, or link types, Switch A might not be the ideal root switch. By increasing the priority (lowering the numerical value) of the ideal switch so that it becomes the root switch, you force a spanning-tree recalculation to form a new topology with the ideal switch as the root.

When the spanning-tree topology is calculated based on default parameters, the path between source and destination end stations in a switched network might not be ideal. For instance, connecting higher-speed links to an interface that has a higher number than the root port can cause a root-port change. The goal is to make the fastest link the root port.

For example, assume that one port on Switch B is a Gigabit Ethernet link and that another port on Switch B (a 10/100 link) is the root port. Network traffic might be more efficient over the Gigabit Ethernet link. By changing the spanning-tree port priority on the Gigabit Ethernet port to a higher priority (lower numerical value) than the root port, the Gigabit Ethernet port becomes the new root port.

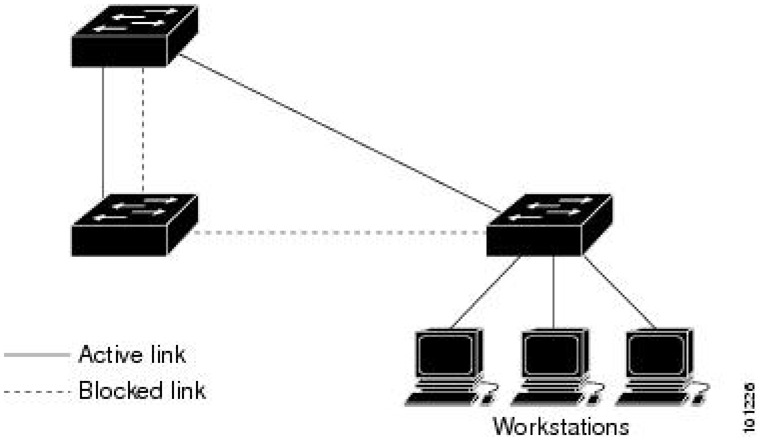
Related Topics

Configuring Port Priority , on page 173

Spanning Tree and Redundant Connectivity

Figure 6: Spanning Tree and Redundant Connectivity

You can create a redundant backbone with spanning tree by connecting two switch interfaces to another device or to two different devices. Spanning tree automatically disables one interface but enables it if the other one fails. If one link is high-speed and the other is low-speed, the low-speed link is always disabled. If the speeds are the same, the port priority and port ID are added together, and spanning tree disables the link with the highest value.



You can also create redundant links between switches by using EtherChannel groups.

Spanning-Tree Address Management

IEEE 802.1D specifies 17 multicast addresses, ranging from 0x00180C2000000 to 0x0180C2000010, to be used by different bridge protocols. These addresses are static addresses that cannot be removed.

If spanning tree is enabled, the CPU on the switch receives packets destined for 0x0180C2000000 and 0x0180C2000010. If spanning tree is disabled, the switch forwards those packets as unknown multicast addresses.

Accelerated Aging to Retain Connectivity

The default for aging dynamic addresses is 5 minutes, the default setting of the **mac address-table aging-time** global configuration command. However, a spanning-tree reconfiguration can cause many station locations to change. Because these stations could be unreachable for 5 minutes or more during a reconfiguration, the address-aging time is accelerated so that station addresses can be dropped from the address table and then relearned. The accelerated aging is the same as the forward-delay parameter value (**spanning-tree vlan** *vlan-id* **forward-time** *seconds* global configuration command) when the spanning tree reconfigures.

Because each VLAN is a separate spanning-tree instance, the switch accelerates aging on a per-VLAN basis. A spanning-tree reconfiguration on one VLAN can cause the dynamic addresses learned on that VLAN to be subject to accelerated aging. Dynamic addresses on other VLANs can be unaffected and remain subject to the aging interval entered for the switch.

Related Topics

Configuring the Root Switch , on page 171

Restrictions for STP, on page 157

Spanning-Tree Modes and Protocols

The switch supports these spanning-tree modes and protocols:

- PVST+—This spanning-tree mode is based on the IEEE 802.1D standard and Cisco proprietary extensions. The PVST+ runs on each VLAN on the switch up to the maximum supported, ensuring that each has a loop-free path through the network.

The PVST+ provides Layer 2 load-balancing for the VLAN on which it runs. You can create different logical topologies by using the VLANs on your network to ensure that all of your links are used but that no one link is oversubscribed. Each instance of PVST+ on a VLAN has a single root switch. This root switch propagates the spanning-tree information associated with that VLAN to all other switches in the network. Because each switch has the same information about the network, this process ensures that the network topology is maintained.

- Rapid PVST+—This spanning-tree mode is the same as PVST+ except that is uses a rapid convergence based on the IEEE 802.1w standard. Beginning from 15.2(4)E release, the STP default mode is Rapid PVST+ . To provide rapid convergence, the Rapid PVST+ immediately deletes dynamically learned MAC address entries on a per-port basis upon receiving a topology change. By contrast, PVST+ uses a short aging time for dynamically learned MAC address entries.

  Rapid PVST+ uses the same configuration as PVST+ (except where noted), and the switch needs only minimal extra configuration. The benefit of Rapid PVST+ is that you can migrate a large PVST+ install base to Rapid PVST+ without having to learn the complexities of the Multiple Spanning Tree Protocol (MSTP) configuration and without having to reprovision your network. In Rapid PVST+ mode, each VLAN runs its own spanning-tree instance up to the maximum supported.

- MSTP—This spanning-tree mode is based on the IEEE 802.1s standard. You can map multiple VLANs to the same spanning-tree instance, which reduces the number of spanning-tree instances required to support a large number of VLANs. The MSTP runs on top of the RSTP (based on IEEE 802.1w), which provides for rapid convergence of the spanning tree by eliminating the forward delay and by quickly transitioning root ports and designated ports to the forwarding state.

Related Topics

Changing the Spanning-Tree Mode

Supported Spanning-Tree Instances

In PVST+ or Rapid PVST+ mode, the switch supports up to 64 spanning-tree instances.

In MSTP mode, the switch supports up to 64 MST instances. The number of VLANs that can be mapped to a particular MST instance is unlimited.

Related Topics

Disabling Spanning Tree , on page 170
Default Spanning-Tree Configuration, on page 168
Default MSTP Configuration, on page 198

Spanning-Tree Interoperability and Backward Compatibility

In a mixed MSTP and PVST+ network, the common spanning-tree (CST) root must be inside the MST backbone, and a PVST+ switch cannot connect to multiple MST regions.

When a network contains switches running Rapid PVST+ and switches running PVST+, we recommend that the Rapid PVST+ switches and PVST+ switches be configured for different spanning-tree instances. In the

Rapid PVST+ spanning-tree instances, the root switch must be a Rapid PVST+ switch. In the PVST+ instances, the root switch must be a PVST+ switch. The PVST+ switches should be at the edge of the network.

Table 24: PVST+, MSTP, and Rapid-PVST+ Interoperability and Compatibility

	PVST+	MSTP	Rapid PVST+
PVST+	Yes	Yes (with restrictions)	Yes (reverts to PVST+)
MSTP	Yes (with restrictions)	Yes	Yes (reverts to PVST+)
Rapid PVST+	Yes (reverts to PVST+)	Yes (reverts to PVST+)	Yes

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202
MSTP Configuration Guidelines, on page 185
Multiple Spanning-Tree Regions, on page 186

STP and IEEE 802.1Q Trunks

The IEEE 802.1Q standard for VLAN trunks imposes some limitations on the spanning-tree strategy for a network. The standard requires only one spanning-tree instance for *all* VLANs allowed on the trunks. However, in a network of Cisco switches connected through IEEE 802.1Q trunks, the switches maintain one spanning-tree instance for *each* VLAN allowed on the trunks.

When you connect a Cisco switch to a non-Cisco device through an IEEE 802.1Q trunk, the Cisco switch uses PVST+ to provide spanning-tree interoperability. If Rapid PVST+ is enabled, the switch uses it instead of PVST+. The switch combines the spanning-tree instance of the IEEE 802.1Q VLAN of the trunk with the spanning-tree instance of the non-Cisco IEEE 802.1Q switch.

However, all PVST+ or Rapid PVST+ information is maintained by Cisco switches separated by a cloud of non-Cisco IEEE 802.1Q switches. The non-Cisco IEEE 802.1Q cloud separating the Cisco switches is treated as a single trunk link between the switches.

Rapid PVST+ is automatically enabled on IEEE 802.1Q trunks, and no user configuration is required. The external spanning-tree behavior on access ports is not affected by PVST+.

VLAN-Bridge Spanning Tree

Cisco VLAN-bridge spanning tree is used with the fallback bridging feature (bridge groups), which forwards non-IP protocols such as DECnet between two or more VLAN bridge domains or routed ports. The VLAN-bridge spanning tree allows the bridge groups to form a spanning tree on top of the individual VLAN spanning trees to prevent loops from forming if there are multiple connections among VLANs. It also prevents the individual spanning trees from the VLANs being bridged from collapsing into a single spanning tree.

To support VLAN-bridge spanning tree, some of the spanning-tree timers are increased. To use the fallback bridging feature, you must have the IP services feature set enabled on your switch.

Default Spanning-Tree Configuration

Table 25: Default Spanning-Tree Configuration

Feature	Default Setting
Enable state	Enabled on VLAN 1.
Spanning-tree mode	Rapid PVST+ (PVST+ and MSTP are disabled.)
Switch priority	32768
Spanning-tree port priority (configurable on a per-interface basis)	128
Spanning-tree port cost (configurable on a per-interface basis)	1000 Mb/s: 4 100 Mb/s: 19 10 Mb/s: 100
Spanning-tree VLAN port priority (configurable on a per-VLAN basis)	128
Spanning-tree VLAN port cost (configurable on a per-VLAN basis)	1000 Mb/s: 4 100 Mb/s: 19 10 Mb/s: 100
Spanning-tree timers	Hello time: 2 seconds Forward-delay time: 15 seconds Maximum-aging time: 20 seconds Transmit hold count: 6 BPDUs

Note Beginning in Cisco IOS Release 15.2(4)E, the default STP mode is Rapid PVST+.

Related Topics

Disabling Spanning Tree , on page 170
Supported Spanning-Tree Instances, on page 166

How to Configure Spanning-Tree Features

Changing the Spanning-Tree Mode (CLI)

The switch supports three spanning-tree modes: per-VLAN spanning tree plus (PVST+), Rapid PVST+, or multiple spanning tree protocol (MSTP). By default, the switch runs the Rapid PVST+ protocol.

If you want to enable a mode that is different from the default mode, this procedure is required.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mode** {**pvst** | **mst** | **rapid-pvst**}
4. **interface** *interface-id*
5. **spanning-tree link-type point-to-point**
6. **end**
7. **clear spanning-tree detected-protocols**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**spanning-tree mode** {**pvst** | **mst** | **rapid-pvst**}
	Example:
	`Switch(config)# spanning-tree mode pvst`
		Configures a spanning-tree mode.
		All stack members run the same version of spanning tree.
		• Select **pvst** to enable PVST+.
		• Select **mst** to enable MSTP.
		• Select **rapid-pvst** to enable rapid PVST+.

Step 4	**interface** *interface-id* **Example:** `Switch(config)# interface FastEthernet1/0/1`	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports, VLANs, and port channels. The VLAN ID range is 1 to 4094. The port-channel range is 1 to 6.
Step 5	**spanning-tree link-type point-to-point** **Example:** `Switch(config-if)# spanning-tree link-type point-to-point`	Specifies that the link type for this port is point-to-point. If you connect this port (local port) to a remote port through a point-to-point link and the local port becomes a designated port, the switch negotiates with the remote port and rapidly changes the local port to the forwarding state.
Step 6	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config-if)# end`	
Step 7	**clear spanning-tree detected-protocols** **Example:** `Switch# clear spanning-tree detected-protocols`	If any port on the switch is connected to a port on a legacy IEEE 802.1D switch, this command restarts the protocol migration process on the entire switch. This step is optional if the designated switch detects that this switch is running rapid PVST+.

Disabling Spanning Tree

Spanning tree is enabled by default on VLAN 1 and on all newly created VLANs up to the spanning-tree limit. Disable spanning tree only if you are sure there are no loops in the network topology.

Caution When spanning tree is disabled and loops are present in the topology, excessive traffic and indefinite packet duplication can drastically reduce network performance.

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no spanning-tree vlan** *vlan-id*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**no spanning-tree vlan** *vlan-id* **Example:** `Switch(config)# no spanning-tree vlan 300`	For *vlan-id*, the range is 1 to 4094.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Supported Spanning-Tree Instances, on page 166
Default Spanning-Tree Configuration, on page 168

Configuring the Root Switch

To configure a switch as the root for the specified VLAN, use the **spanning-tree vlan** *vlan-id* **root** global configuration command to modify the switch priority from the default value (32768) to a significantly lower value. When you enter this command, the software checks the switch priority of the root switches for each VLAN. Because of the extended system ID support, the switch sets its own priority for the specified VLAN to 24576 if this value will cause this switch to become the root for the specified VLAN.

Use the **diameter** keyword to specify the Layer 2 network diameter (that is, the maximum number of switch hops between any two end stations in the Layer 2 network). When you specify the network diameter, the switch automatically sets an optimal hello time, forward-delay time, and maximum-age time for a network of that diameter, which can significantly reduce the convergence time. You can use the **hello** keyword to override the automatically calculated hello time.

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-id* **root primary** [**diameter** *net-diameter*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**spanning-tree vlan** *vlan-id* **root primary** [**diameter** *net-diameter* **Example:** `Switch(config)# spanning-tree vlan 20-24 root primary diameter 4`	Configures a switch to become the root for the specified VLAN. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • (Optional) For **diameter** *net-diameter*, specify the maximum number of switches between any two end stations. The range is 2 to 7.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

What to do next

After configuring the switch as the root switch, we recommend that you avoid manually configuring the hello time, forward-delay time, and maximum-age time through the **spanning-tree vlan** *vlan-id* **hello-time**, **spanning-tree vlan** *vlan-id* **forward-time**, and the **spanning-tree vlan** *vlan-id* **max-age** global configuration commands.

Related Topics

Bridge ID, Device Priority, and Extended System ID, on page 160

Spanning-Tree Topology and BPDUs, on page 159

Accelerated Aging to Retain Connectivity, on page 165

Restrictions for STP, on page 157

Configuring a Secondary Root Device

When you configure a switch as the secondary root, the switch priority is modified from the default value (32768) to 28672. With this priority, the switch is likely to become the root switch for the specified VLAN if the primary root switch fails. This is assuming that the other network switches use the default switch priority of 32768, and therefore, are unlikely to become the root switch.

You can execute this command on more than one switch to configure multiple backup root switches. Use the same network diameter and hello-time values that you used when you configured the primary root switch with the **spanning-tree vlan** *vlan-id* **root primary** global configuration command.

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-id* **root secondary** [**diameter** *net-diameter*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-id* **root secondary** [**diameter** *net-diameter* **Example:** `Switch(config)# spanning-tree vlan 20-24 root secondary diameter 4`	Configures a switch to become the secondary root for the specified VLAN. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • (Optional) For **diameter** *net-diameter*, specify the maximum number of switches between any two end stations. The range is 2 to 7. Use the same network diameter value that you used when configuring the primary root switch.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Configuring Port Priority

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree port-priority** *priority*
5. **spanning-tree vlan** *vlan-id* **port-priority** *priority*
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports and port-channel logical interfaces (**port-channel** *port-channel-number*).
Step 4	**spanning-tree port-priority** *priority* **Example:** `Switch(config-if)# spanning-tree port-priority 0`	Configures the port priority for an interface. For *priority*, the range is 0 to 240, in increments of 16; the default is 128. Valid values are 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected. The lower the number, the higher the priority.
Step 5	**spanning-tree vlan** *vlan-id* **port-priority** *priority* **Example:** `Switch(config-if)# spanning-tree vlan 20-25 port-priority 0`	Configures the port priority for a VLAN. - For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. - For *priority*, the range is 0 to 240, in increments of 16; the default is 128. Valid values are 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected. The lower the number, the higher the priority.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Related Topics

Port Priority Versus Path Cost, on page 161

How a Switch or Port Becomes the Root Switch or Root Port, on page 164

Configuring Path Cost

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree cost** *cost*
5. **spanning-tree vlan** *vlan-id* **cost** *cost*
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports and port-channel logical interfaces (**port-channel** *port-channel-number*).
Step 4	**spanning-tree cost** *cost* **Example:** `Switch(config-if)# spanning-tree cost 250`	Configures the cost for an interface. If a loop occurs, spanning tree uses the path cost when selecting an interface to place into the forwarding state. A lower path cost represents higher-speed transmission. For *cost*, the range is 1 to 200000000; the default value is derived from the media speed of the interface.
Step 5	**spanning-tree vlan** *vlan-id* **cost** *cost* **Example:** `Switch(config-if)# spanning-tree vlan 10,12-15,20 cost 300`	Configures the cost for a VLAN. If a loop occurs, spanning tree uses the path cost when selecting an interface to place into the forwarding state. A lower path cost represents higher-speed transmission. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094.

	Command or Action	Purpose
		• For *cost*, the range is 1 to 200000000; the default value is derived from the media speed of the interface.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

The **show spanning-tree interface** *interface-id* privileged EXEC command displays information only for ports that are in a link-up operative state. Otherwise, you can use the **show running-config** privileged EXEC command to confirm the configuration.

Related Topics

Port Priority Versus Path Cost, on page 161

Configuring the Device Priority of a VLAN

You can configure the switch priority and make it more likely that a standalone switch will be chosen as the root switch.

Note Exercise care when using this command. For most situations, we recommend that you use the **spanning-tree vlan** *vlan-id* **root primary** and the **spanning-tree vlan** *vlan-id* **root secondary** global configuration commands to modify the switch priority.

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-id* **priority** *priority*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 3	**spanning-tree vlan** *vlan-id* **priority** *priority* **Example:** `Switch(config)# spanning-tree vlan 20 priority 8192`	Configures the switch priority of a VLAN. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • For *priority*, the range is 0 to 61440 in increments of 4096; the default is 32768. The lower the number, the more likely the switch will be chosen as the root switch. Valid priority values are 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440. All other values are rejected.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring the Hello Time

The hello time is the time interval between configuration messages generated and sent by the root switch.

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **spanning-tree vlan** *vlan-id* **hello-time** *seconds*
3. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**spanning-tree vlan** *vlan-id* **hello-time** *seconds* **Example:**	Configures the hello time of a VLAN. The hello time is the time interval between configuration messages generated

	Command or Action	Purpose
	`Switch(config)# spanning-tree vlan 20-24 hello-time 3`	and sent by the root switch. These messages mean that the switch is alive. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • For *seconds*, the range is 1 to 10; the default is 2.

Step 3	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring the Forwarding-Delay Time for a VLAN

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-id* **forward-time** *seconds*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-id* **forward-time** *seconds* **Example:** `Switch(config)# spanning-tree vlan 20,25 forward-time 18`	Configures the forward time of a VLAN. The forwarding delay is the number of seconds an interface waits before changing from its spanning-tree learning and listening states to the forwarding state. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated

	Command or Action	Purpose
		by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • For *seconds*, the range is 4 to 30; the default is 15.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Configuring the Maximum-Aging Time for a VLAN

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-id* **max-age** *seconds*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-id* **max-age** *seconds* **Example:** `Switch(config)# spanning-tree vlan 20 max-age 30`	Configures the maximum-aging time of a VLAN. The maximum-aging time is the number of seconds a switch waits without receiving spanning-tree configuration messages before attempting a reconfiguration. • For *vlan-id*, you can specify a single VLAN identified by VLAN ID number, a range of VLANs separated by a hyphen, or a series of VLANs separated by a comma. The range is 1 to 4094. • For *seconds*, the range is 6 to 40; the default is 20.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring the Transmit Hold-Count

You can configure the BPDU burst size by changing the transmit hold count value.

Note Changing this parameter to a higher value can have a significant impact on CPU utilization, especially in Rapid PVST+ mode. Lowering this value can slow down convergence in certain scenarios. We recommend that you maintain the default setting.

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree transmit hold-count** *value*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree transmit hold-count** *value* **Example:** `Switch(config)# spanning-tree transmit hold-count 6`	Configures the number of BPDUs that can be sent before pausing for 1 second. For *value*, the range is 1 to 20; the default is 6.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Monitoring Spanning-Tree Status

Table 26: Commands for Displaying Spanning-Tree Status

show spanning-tree active	Displays spanning-tree information on active interfaces only.
show spanning-tree detail	Displays a detailed summary of interface information.
show spanning-tree vlan *vlan-id*	Displays spanning-tree information for the specified VLAN.
show spanning-tree interface *interface-id*	Displays spanning-tree information for the specified interface.
show spanning-tree interface *interface-id* **portfast**	Displays spanning-tree portfast information for the specified interface.
show spanning-tree summary [**totals**]	Displays a summary of interface states or displays the total lines of the STP state section.

To clear spanning-tree counters, use the **clear spanning-tree** [**interface** i*nterface-id*] privileged EXEC command.

CHAPTER 13

Configuring Multiple Spanning-Tree Protocol

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for MSTP

- For two or more switches to be in the same multiple spanning tree (MST) region, they must have the same VLAN-to-instance map, the same configuration revision number, and the same name.
- For load-balancing across redundant paths in the network to work, all VLAN-to-instance mapping assignments must match; otherwise, all traffic flows on a single link.
- For load-balancing between a per-VLAN spanning tree plus (PVST+) and an MST cloud or between a rapid-PVST+ and an MST cloud to work, all MST boundary ports must be forwarding. MST boundary ports are forwarding when the root of the internal spanning tree (IST) of the MST cloud is the root of the common spanning tree (CST). If the MST cloud consists of multiple MST regions, one of the MST regions must contain the CST root, and all of the other MST regions must have a better path to the root contained within the MST cloud than a path through the PVST+ or rapid-PVST+ cloud. You might have to manually configure the switches in the clouds.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

MSTP Configuration Guidelines, on page 185

Multiple Spanning-Tree Regions, on page 186

Restrictions for MSTP

-
- PVST+, Rapid PVST+, and MSTP are supported, but only one version can be active at any time. (For example, all VLANs run PVST+, all VLANs run Rapid PVST+, or all VLANs run MSTP.)
- VLAN Trunking Protocol (VTP) propagation of the MST configuration is not supported. However, you can manually configure the MST configuration (region name, revision number, and VLAN-to-instance mapping) on each switch within the MST region by using the command-line interface (CLI) or through the Simple Network Management Protocol (SNMP) support.
- Partitioning the network into a large number of regions is not recommended. However, if this situation is unavoidable, we recommend that you partition the switched LAN into smaller LANs interconnected by routers or non-Layer 2 devices.
- A region can have one member or multiple members with the same MST configuration; each member must be capable of processing rapid spanning tree protocol (RSTP) Bridge Protocol Data Units (BPDUs). There is no limit to the number of MST regions in a network, but each region can only support up to 65 spanning-tree instances. You can assign a VLAN to only one spanning-tree instance at a time.
- After configuring a switch as the root switch, we recommend that you avoid manually configuring the hello time, forward-delay time, and maximum-age time through the **spanning-tree mst hello-time**, **spanning-tree mst forward-time**, and the **spanning-tree mst max-age** global configuration commands.

Table 27: PVST+, MSTP, and Rapid PVST+ Interoperability and Compatibility

	PVST+	MSTP	Rapid PVST+
PVST+	Yes	Yes (with restrictions)	Yes (reverts to PVST+)
MSTP	Yes (with restrictions)	Yes	Yes (reverts to PVST+)
Rapid PVST+	Yes (reverts to PVST+)	Yes (reverts to PVST+)	Yes

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

MSTP Configuration Guidelines, on page 185

Multiple Spanning-Tree Regions, on page 186

Configuring the Root Switch , on page 204

Root Switch, on page 186

Information About MSTP

MSTP Configuration

MSTP, which uses RSTP for rapid convergence, enables multiple VLANs to be grouped into and mapped to the same spanning-tree instance, reducing the number of spanning-tree instances needed to support a large number of VLANs. The MSTP provides for multiple forwarding paths for data traffic, enables load balancing, and reduces the number of spanning-tree instances required to support a large number of VLANs. It improves the fault tolerance of the network because a failure in one instance (forwarding path) does not affect other instances (forwarding paths).

Note The multiple spanning-tree (MST) implementation is based on the IEEE 802.1s standard.

The most common initial deployment of MSTP is in the backbone and distribution layers of a Layer 2 switched network. This deployment provides the highly available network required in a service-provider environment.

When the switch is in the MST mode, the RSTP, which is based on IEEE 802.1w, is automatically enabled. The RSTP provides rapid convergence of the spanning tree through explicit handshaking that eliminates the IEEE 802.1D forwarding delay and quickly transitions root ports and designated ports to the forwarding state.

Both MSTP and RSTP improve the spanning-tree operation and maintain backward compatibility with equipment that is based on the (original) IEEE 802.1D spanning tree, with existing Cisco-proprietary Multiple Instance STP (MISTP), and with existing Cisco PVST+ and rapid per-VLAN spanning-tree plus (Rapid PVST+).

MSTP Configuration Guidelines

- When you enable MST by using the **spanning-tree mode mst** global configuration command, RSTP is automatically enabled.
- For configuration guidelines about UplinkFast, BackboneFast, and cross-stack UplinkFast, see the relevant sections in the Related Topics section.
- When the switch is in MST mode, it uses the long path-cost calculation method (32 bits) to compute the path cost values. With the long path-cost calculation method, the following path cost values are supported:

Speed	Path Cost Value
10 Mb/s	2,000,000
100 Mb/s	200,000
1 Gb/s	20,000
10 Gb/s	2,000
100 Gb/s	200

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Prerequisites for MSTP, on page 183

Restrictions for MSTP, on page 184

Spanning-Tree Interoperability and Backward Compatibility, on page 166

Optional Spanning-Tree Configuration Guidelines

BackboneFast, on page 231

UplinkFast, on page 229

Root Switch

The switch maintains a spanning-tree instance for the group of VLANs mapped to it. A switch ID, consisting of the switch priority and the switch MAC address, is associated with each instance. For a group of VLANs, the switch with the lowest switch ID becomes the root switch.

When you configure a switch as the root, you modify the switch priority from the default value (32768) to a significantly lower value so that the switch becomes the root switch for the specified spanning-tree instance. When you enter this command, the switch checks the switch priorities of the root switches. Because of the extended system ID support, the switch sets its own priority for the specified instance to 24576 if this value will cause this switches to become the root for the specified spanning-tree instance.

If any root switch for the specified instance has a switch priority lower than 24576, the switch sets its own priority to 4096 less than the lowest switch priority. (4096 is the value of the least-significant bit of a 4-bit switch priority value. For more information, select "Bridge ID, Switch Priority, and Extended System ID" link in Related Topics.

If your network consists of switches that support and do not support the extended system ID, it is unlikely that the switch with the extended system ID support will become the root switch. The extended system ID increases the switch priority value every time the VLAN number is greater than the priority of the connected switches running older software.

The root switch for each spanning-tree instance should be a backbone or distribution switch. Do not configure an access switch as the spanning-tree primary root.

Use the **diameter** keyword, which is available only for MST instance 0, to specify the Layer 2 network diameter (that is, the maximum number of switch hops between any two end stations in the Layer 2 network). When you specify the network diameter, the switch automatically sets an optimal hello time, forward-delay time, and maximum-age time for a network of that diameter, which can significantly reduce the convergence time. You can use the **hello** keyword to override the automatically calculated hello time.

Related Topics

Configuring the Root Switch , on page 204

Restrictions for MSTP, on page 184

Bridge ID, Device Priority, and Extended System ID, on page 160

Multiple Spanning-Tree Regions

For switches to participate in multiple spanning-tree (MST) instances, you must consistently configure the switches with the same MST configuration information. A collection of interconnected switches that have the same MST configuration comprises an MST region.

The MST configuration controls to which MST region each switch belongs. The configuration includes the name of the region, the revision number, and the MST VLAN-to-instance assignment map. You configure the switch for a region by specifying the MST region configuration on it. You can map VLANs to an MST instance, specify the region name, and set the revision number. For instructions and an example, select the "Specifying the MST Region Configuration and Enabling MSTP" link in Related Topics.

A region can have one or multiple members with the same MST configuration. Each member must be capable of processing RSTP bridge protocol data units (BPDUs). There is no limit to the number of MST regions in a network, but each region can support up to 65 spanning-tree instances. Instances can be identified by any number in the range from 0 to 4094. You can assign a VLAN to only one spanning-tree instance at a time.

Related Topics

Illustration of MST Regions, on page 189
Specifying the MST Region Configuration and Enabling MSTP , on page 202
Prerequisites for MSTP, on page 183
Restrictions for MSTP, on page 184
Spanning-Tree Interoperability and Backward Compatibility, on page 166
Optional Spanning-Tree Configuration Guidelines
BackboneFast, on page 231
UplinkFast, on page 229

IST, CIST, and CST

Unlike PVST+ and Rapid PVST+ in which all the spanning-tree instances are independent, the MSTP establishes and maintains two types of spanning trees:

- An internal spanning tree (IST), which is the spanning tree that runs in an MST region.

  Within each MST region, the MSTP maintains multiple spanning-tree instances. Instance 0 is a special instance for a region, known as the internal spanning tree (IST). All other MST instances are numbered from 1 to 4094.

  The IST is the only spanning-tree instance that sends and receives BPDUs. All of the other spanning-tree instance information is contained in M-records, which are encapsulated within MSTP BPDUs. Because the MSTP BPDU carries information for all instances, the number of BPDUs that need to be processed to support multiple spanning-tree instances is significantly reduced.

  All MST instances within the same region share the same protocol timers, but each MST instance has its own topology parameters, such as root switch ID, root path cost, and so forth. By default, all VLANs are assigned to the IST.

  An MST instance is local to the region; for example, MST instance 1 in region A is independent of MST instance 1 in region B, even if regions A and B are interconnected.

- A common and internal spanning tree (CIST), which is a collection of the ISTs in each MST region, and the common spanning tree (CST) that interconnects the MST regions and single spanning trees.

  The spanning tree computed in a region appears as a subtree in the CST that encompasses the entire switched domain. The CIST is formed by the spanning-tree algorithm running among switches that support the IEEE 802.1w, IEEE 802.1s, and IEEE 802.1D standards. The CIST inside an MST region is the same as the CST outside a region.

Operations Within an MST Region

The IST connects all the MSTP switches in a region. When the IST converges, the root of the IST becomes the CIST regional root (called the *IST master* before the implementation of the IEEE 802.1s standard). It is the switch within the region with the lowest switch ID and path cost to the CIST root. The CIST regional root is also the CIST root if there is only one region in the network. If the CIST root is outside the region, one of the MSTP switches at the boundary of the region is selected as the CIST regional root.

When an MSTP switch initializes, it sends BPDUs claiming itself as the root of the CIST and the CIST regional root, with both of the path costs to the CIST root and to the CIST regional root set to zero. The switch also initializes all of its MST instances and claims to be the root for all of them. If the switch receives superior MST root information (lower switch ID, lower path cost, and so forth) than currently stored for the port, it relinquishes its claim as the CIST regional root.

During initialization, a region might have many subregions, each with its own CIST regional root. As switches receive superior IST information, they leave their old subregions and join the new subregion that contains the true CIST regional root. All subregions shrink except for the one that contains the true CIST regional root.

For correct operation, all switches in the MST region must agree on the same CIST regional root. Therefore, any two switches in the region only synchronize their port roles for an MST instance if they converge to a common CIST regional root.

Related Topics

Illustration of MST Regions, on page 189

Operations Between MST Regions

If there are multiple regions or legacy IEEE 802.1D switches within the network, MSTP establishes and maintains the CST, which includes all MST regions and all legacy STP switches in the network. The MST instances combine with the IST at the boundary of the region to become the CST.

The IST connects all the MSTP switches in the region and appears as a subtree in the CIST that encompasses the entire switched domain. The root of the subtree is the CIST regional root. The MST region appears as a virtual switch to adjacent STP switches and MST regions.

Only the CST instance sends and receives BPDUs, and MST instances add their spanning-tree information into the BPDUs to interact with neighboring switches and compute the final spanning-tree topology. Because of this, the spanning-tree parameters related to BPDU transmission (for example, hello time, forward time, max-age, and max-hops) are configured only on the CST instance but affect all MST instances. Parameters related to the spanning-tree topology (for example, switch priority, port VLAN cost, and port VLAN priority) can be configured on both the CST instance and the MST instance.

MSTP switches use Version 3 RSTP BPDUs or IEEE 802.1D STP BPDUs to communicate with legacy IEEE 802.1D switches. MSTP switches use MSTP BPDUs to communicate with MSTP switches.

Related Topics

Illustration of MST Regions, on page 189

IEEE 802.1s Terminology

Some MST naming conventions used in Cisco’s prestandard implementation have been changed to identify some *internal* or *regional* parameters. These parameters are significant only within an MST region, as opposed to external parameters that are relevant to the whole network. Because the CIST is the only spanning-tree instance that spans the whole network, only the CIST parameters require the external rather than the internal or regional qualifiers.

- The CIST root is the root switch for the unique instance that spans the whole network, the CIST.
- The CIST external root path cost is the cost to the CIST root. This cost is left unchanged within an MST region. Remember that an MST region looks like a single switch for the CIST. The CIST external root path cost is the root path cost calculated between these virtual switches and switches that do not belong to any region.
- The CIST regional root was called the IST master in the prestandard implementation. If the CIST root is in the region, the CIST regional root is the CIST root. Otherwise, the CIST regional root is the closest switch to the CIST root in the region. The CIST regional root acts as a root switch for the IST.
- The CIST internal root path cost is the cost to the CIST regional root in a region. This cost is only relevant to the IST, instance 0.

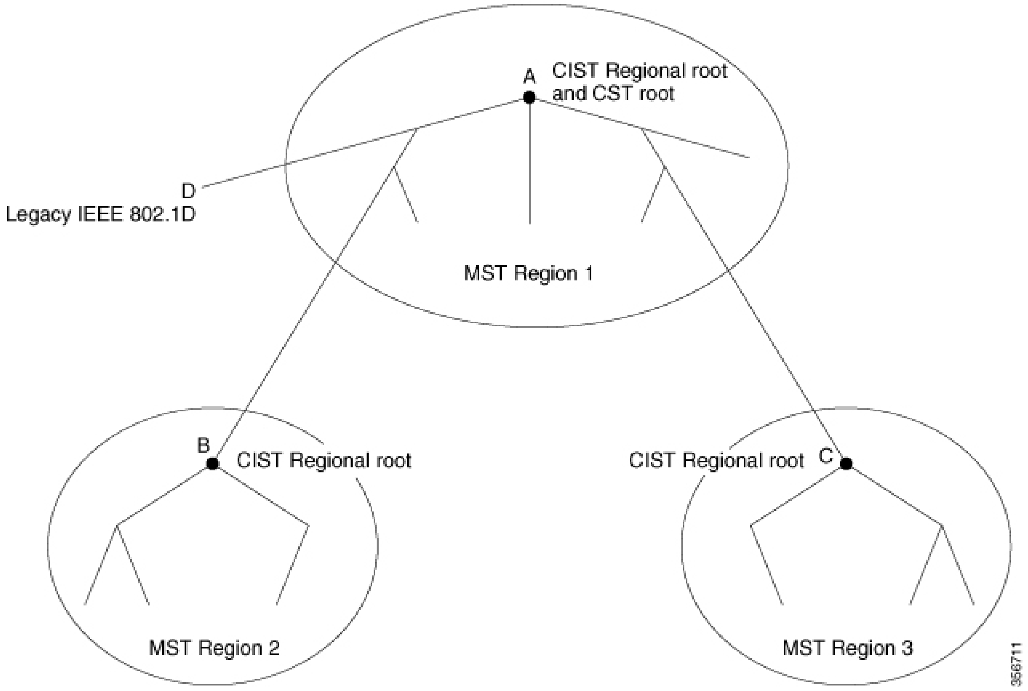
Table 28: Prestandard and Standard Terminology

IEEE Standard	Cisco Prestandard	Cisco Standard
CIST regional root	IST master	CIST regional root
CIST internal root path cost	IST master path cost	CIST internal path cost
CIST external root path cost	Root path cost	Root path cost
MSTI regional root	Instance root	Instance root
MSTI internal root path cost	Root path cost	Root path cost

Illustration of MST Regions

This figure displays three MST regions and a legacy IEEE 802.1D switch (D). The CIST regional root for region 1 (A) is also the CIST root. The CIST regional root for region 2 (B) and the CIST regional root for region 3 (C) are the roots for their respective subtrees within the CIST. The RSTP runs in all regions.

Figure 7: MST Regions, CIST Regional Root, and CST Root



Related Topics

Multiple Spanning-Tree Regions, on page 186
Operations Within an MST Region, on page 188
Operations Between MST Regions, on page 188

Hop Count

The IST and MST instances do not use the message-age and maximum-age information in the configuration BPDU to compute the spanning-tree topology. Instead, they use the path cost to the root and a hop-count mechanism similar to the IP time-to-live (TTL) mechanism.

By using the **spanning-tree mst max-hops** global configuration command, you can configure the maximum hops inside the region and apply it to the IST and all MST instances in that region. The hop count achieves the same result as the message-age information (triggers a reconfiguration). The root switch of the instance always sends a BPDU (or M-record) with a cost of 0 and the hop count set to the maximum value. When a switch receives this BPDU, it decrements the received remaining hop count by one and propagates this value as the remaining hop count in the BPDUs it generates. When the count reaches zero, the switch discards the BPDU and ages the information held for the port.

The message-age and maximum-age information in the RSTP portion of the BPDU remain the same throughout the region, and the same values are propagated by the region designated ports at the boundary.

Boundary Ports

In the Cisco prestandard implementation, a boundary port connects an MST region to a single spanning-tree region running RSTP, to a single spanning-tree region running PVST+ or rapid PVST+, or to another MST region with a different MST configuration. A boundary port also connects to a LAN, the designated switch of which is either a single spanning-tree switch or a switch with a different MST configuration.

There is no definition of a boundary port in the IEEE 802.1s standard. The IEEE 802.1Q-2002 standard identifies two kinds of messages that a port can receive:

- internal (coming from the same region)
- external (coming from another region)

When a message is internal, the CIST part is received by the CIST, and each MST instance receives its respective M-record.

When a message is external, it is received only by the CIST. If the CIST role is root or alternate, or if the external BPDU is a topology change, it could have an impact on the MST instances.

An MST region includes both switches and LANs. A segment belongs to the region of its designated port. Therefore, a port in a different region than the designated port for a segment is a boundary port. This definition allows two ports internal to a region to share a segment with a port belonging to a different region, creating the possibility of a port receiving both internal and external messages.

The primary change from the Cisco prestandard implementation is that a designated port is not defined as boundary, unless it is running in an STP-compatible mode.

Note If there is a legacy STP switch on the segment, messages are always considered external.

The other change from the Cisco prestandard implementation is that the CIST regional root switch ID field is now inserted where an RSTP or legacy IEEE 802.1Q switch has the sender switch ID. The whole region performs like a single virtual switch by sending a consistent sender switch ID to neighboring switches. In this example, switch C would receive a BPDU with the same consistent sender switch ID of root, whether or not A or B is designated for the segment.

IEEE 802.1s Implementation

The Cisco implementation of the IEEE MST standard includes features required to meet the standard, as well as some of the desirable prestandard functionality that is not yet incorporated into the published standard.

Port Role Naming Change

The boundary role is no longer in the final MST standard, but this boundary concept is maintained in Cisco's implementation. However, an MST instance port at a boundary of the region might not follow the state of the corresponding CIST port. Two boundary roles currently exist:

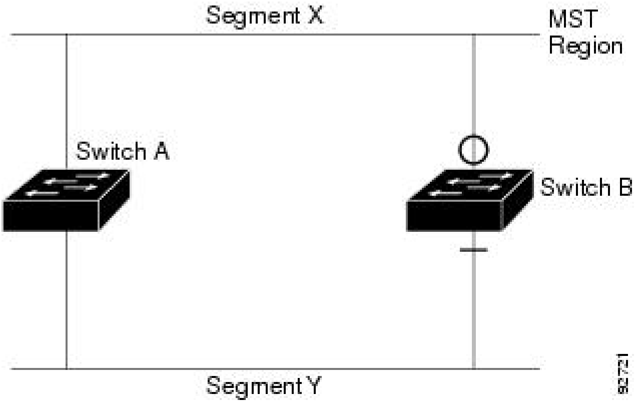
- The boundary port is the root port of the CIST regional root—When the CIST instance port is proposed and is in sync, it can send back an agreement and move to the forwarding state only after all the corresponding MSTI ports are in sync (and thus forwarding). The MSTI ports now have a special *primary* role.
- The boundary port is not the root port of the CIST regional root—The MSTI ports follow the state and role of the CIST port. The standard provides less information, and it might be difficult to understand why an MSTI port can be alternately blocking when it receives no BPDUs (MRecords). In this case, although the boundary role no longer exists, the **show** commands identify a port as boundary in the *type* column of the output.

Interoperation Between Legacy and Standard Switches

Because automatic detection of prestandard switches can fail, you can use an interface configuration command to identify prestandard ports. A region cannot be formed between a standard and a prestandard switch, but they can interoperate by using the CIST. Only the capability of load-balancing over different instances is lost in that particular case. The CLI displays different flags depending on the port configuration when a port receives prestandard BPDUs. A syslog message also appears the first time a switch receives a prestandard BPDU on a port that has not been configured for prestandard BPDU transmission.

Figure 8: Standard and Prestandard Switch Interoperation

Assume that A is a standard switch and B a prestandard switch, both configured to be in the same region. A is the root switch for the CIST, and B has a root port (BX) on segment X and an alternate port (BY) on segment Y. If segment Y flaps, and the port on BY becomes the alternate before sending out a single prestandard BPDU, AY cannot detect that a prestandard switch is connected to Y and continues to send standard BPDUs. The port BY is fixed in a boundary, and no load balancing is possible between A and B. The same problem exists on segment X, but B might transmit topology changes.



Note We recommend that you minimize the interaction between standard and prestandard MST implementations.

Detecting Unidirectional Link Failure

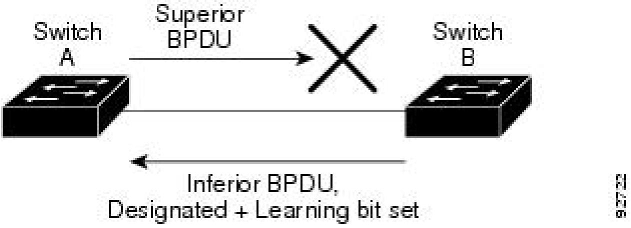
This feature is not yet present in the IEEE MST standard, but it is included in this Cisco IOS release. The software checks the consistency of the port role and state in the received BPDUs to detect unidirectional link failures that could cause bridging loops.

When a designated port detects a conflict, it keeps its role, but reverts to the discarding state because disrupting connectivity in case of inconsistency is preferable to opening a bridging loop.

Figure 9: Detecting Unidirectional Link Failure

This figure illustrates a unidirectional link failure that typically creates a bridging loop. Switch A is the root switch, and its BPDUs are lost on the link leading to switch B. RSTP and MST BPDUs include the role and state of the sending port. With this information, switch A can detect that switch B does not react to the superior

BPDUs it sends and that switch B is the designated, not root switch. As a result, switch A blocks (or keeps blocking) its port, which prevents the bridging loop.



Interoperability with IEEE 802.1D STP

A switch running MSTP supports a built-in protocol migration mechanism that enables it to interoperate with legacy IEEE 802.1D switches. If this switch receives a legacy IEEE 802.1D configuration BPDU (a BPDU with the protocol version set to 0), it sends only IEEE 802.1D BPDUs on that port. An MSTP switch also can detect that a port is at the boundary of a region when it receives a legacy BPDU, an MSTP BPDU (Version 3) associated with a different region, or an RSTP BPDU (Version 2).

However, the switch does not automatically revert to the MSTP mode if it no longer receives IEEE 802.1D BPDUs because it cannot detect whether the legacy switch has been removed from the link unless the legacy switch is the designated switch. A switch might also continue to assign a boundary role to a port when the switch to which this switch is connected has joined the region. To restart the protocol migration process (force the renegotiation with neighboring switches), use the **clear spanning-tree detected-protocols** privileged EXEC command.

If all the legacy switches on the link are RSTP switches, they can process MSTP BPDUs as if they are RSTP BPDUs. Therefore, MSTP switches send either a Version 0 configuration and TCN BPDUs or Version 3 MSTP BPDUs on a boundary port. A boundary port connects to a LAN, the designated switch of which is either a single spanning-tree switch or a switch with a different MST configuration.

RSTP Overview

The RSTP takes advantage of point-to-point wiring and provides rapid convergence of the spanning tree. Reconfiguration of the spanning tree can occur in less than 1 second (in contrast to 50 seconds with the default settings in the IEEE 802.1D spanning tree).

Port Roles and the Active Topology

The RSTP provides rapid convergence of the spanning tree by assigning port roles and by learning the active topology. The RSTP builds upon the IEEE 802.1D STP to select the switch with the highest switch priority (lowest numerical priority value) as the root switch. The RSTP then assigns one of these port roles to individual ports:

- Root port—Provides the best path (lowest cost) when the switch forwards packets to the root switch.
- Designated port—Connects to the designated switch, which incurs the lowest path cost when forwarding packets from that LAN to the root switch. The port through which the designated switch is attached to the LAN is called the designated port.
- Alternate port—Offers an alternate path toward the root switch to that provided by the current root port.

- Backup port—Acts as a backup for the path provided by a designated port toward the leaves of the spanning tree. A backup port can exist only when two ports are connected in a loopback by a point-to-point link or when a switch has two or more connections to a shared LAN segment.
- Disabled port—Has no role within the operation of the spanning tree.

A port with the root or a designated port role is included in the active topology. A port with the alternate or backup port role is excluded from the active topology.

In a stable topology with consistent port roles throughout the network, the RSTP ensures that every root port and designated port immediately transition to the forwarding state while all alternate and backup ports are always in the discarding state (equivalent to blocking in IEEE 802.1D). The port state controls the operation of the forwarding and learning processes.

Table 29: Port State Comparison

Operational Status	STP Port State (IEEE 802.1D)	RSTP Port State	Is Port Included in the Active Topology?
Enabled	Blocking	Discarding	No
Enabled	Listening	Discarding	No
Enabled	Learning	Learning	Yes
Enabled	Forwarding	Forwarding	Yes
Disabled	Disabled	Discarding	No

To be consistent with Cisco STP implementations, this guide defines the port state as *blocking* instead of *discarding*. Designated ports start in the listening state.

Rapid Convergence

The RSTP provides for rapid recovery of connectivity following the failure of a switch, a switch port, or a LAN. It provides rapid convergence for edge ports, new root ports, and ports connected through point-to-point links as follows:

- Edge ports—If you configure a port as an edge port on an RSTP switch by using the **spanning-tree portfast** interface configuration command, the edge port immediately transitions to the forwarding state. An edge port is the same as a Port Fast-enabled port, and you should enable it only on ports that connect to a single end station.
- Root ports—If the RSTP selects a new root port, it blocks the old root port and immediately transitions the new root port to the forwarding state.
- Point-to-point links—If you connect a port to another port through a point-to-point link and the local port becomes a designated port, it negotiates a rapid transition with the other port by using the proposal-agreement handshake to ensure a loop-free topology.

  Figure 10: Proposal and Agreement Handshaking for Rapid Convergence

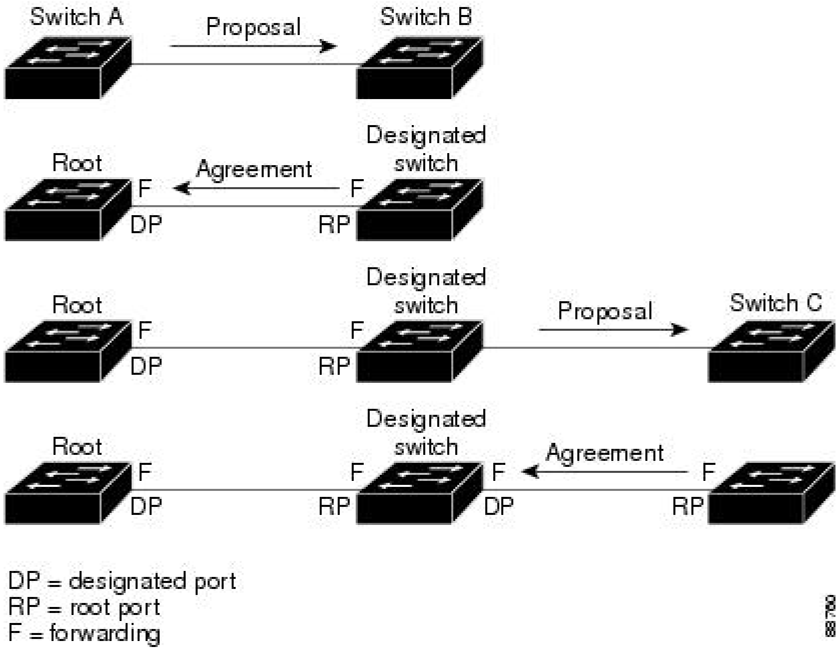
  Switch A is connected to Switch B through a point-to-point link, and all of the ports are in the blocking state. Assume that the priority of Switch A is a smaller numerical value than the priority of Switch B. Switch A sends a proposal message (a configuration BPDU with the proposal flag set) to Switch B, proposing itself as the designated switch.

After receiving the proposal message, Switch B selects as its new root port the port from which the proposal message was received, forces all nonedge ports to the blocking state, and sends an agreement message (a BPDU with the agreement flag set) through its new root port.

After receiving Switch B's agreement message, Switch A also immediately transitions its designated port to the forwarding state. No loops in the network are formed because Switch B blocked all of its nonedge ports and because there is a point-to-point link between Switches A and B.

When Switch C is connected to Switch B, a similar set of handshaking messages are exchanged. Switch C selects the port connected to Switch B as its root port, and both ends immediately transition to the forwarding state. With each iteration of this handshaking process, one more switch joins the active topology. As the network converges, this proposal-agreement handshaking progresses from the root toward the leaves of the spanning tree.

The switch learns the link type from the port duplex mode: a full-duplex port is considered to have a point-to-point connection; a half-duplex port is considered to have a shared connection. You can override the default setting that is controlled by the duplex setting by using the **spanning-tree link-type** interface configuration command.



Synchronization of Port Roles

When the switch receives a proposal message on one of its ports and that port is selected as the new root port, the RSTP forces all other ports to synchronize with the new root information.

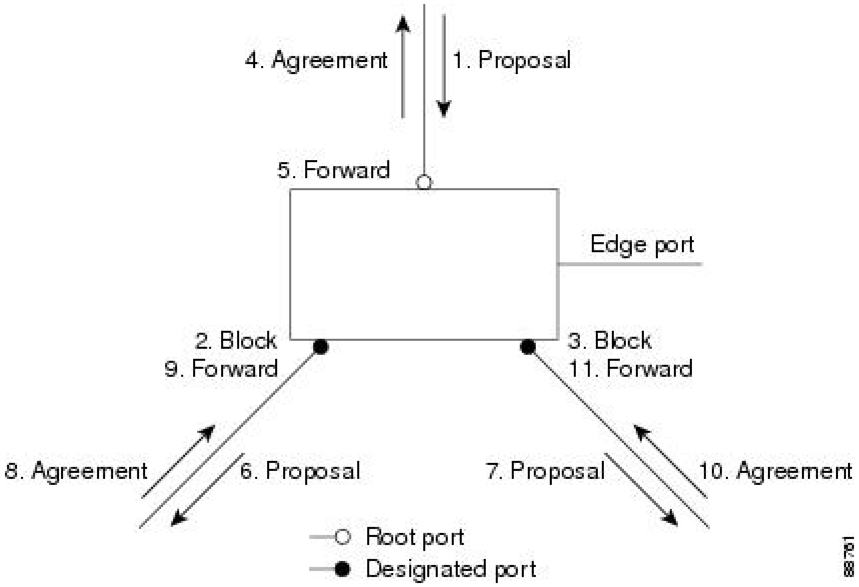
The switch is synchronized with superior root information received on the root port if all other ports are synchronized. An individual port on the switch is synchronized if

- That port is in the blocking state.
- It is an edge port (a port configured to be at the edge of the network).

If a designated port is in the forwarding state and is not configured as an edge port, it transitions to the blocking state when the RSTP forces it to synchronize with new root information. In general, when the RSTP forces a port to synchronize with root information and the port does not satisfy any of the above conditions, its port state is set to blocking.

Figure 11: Sequence of Events During Rapid Convergence

After ensuring that all of the ports are synchronized, the switch sends an agreement message to the designated switch corresponding to its root port. When the switches connected by a point-to-point link are in agreement about their port roles, the RSTP immediately transitions the port states to forwarding.



Bridge Protocol Data Unit Format and Processing

The RSTP BPDU format is the same as the IEEE 802.1D BPDU format except that the protocol version is set to 2. A new 1-byte Version 1 Length field is set to zero, which means that no version 1 protocol information is present.

Table 30: RSTP BPDU Flags

Bit	Function
0	Topology change (TC)
1	Proposal
2–3: 00 01 10 11	Port role: Unknown Alternate port Root port Designated port
4	Learning
5	Forwarding

Bit	Function
6	Agreement
7	Topology change acknowledgement (TCA)

The sending switch sets the proposal flag in the RSTP BPDU to propose itself as the designated switch on that LAN. The port role in the proposal message is always set to the designated port.

The sending switch sets the agreement flag in the RSTP BPDU to accept the previous proposal. The port role in the agreement message is always set to the root port.

The RSTP does not have a separate topology change notification (TCN) BPDU. It uses the topology change (TC) flag to show the topology changes. However, for interoperability with IEEE 802.1D switches, the RSTP switch processes and generates TCN BPDUs.

The learning and forwarding flags are set according to the state of the sending port.

Processing Superior BPDU Information

If a port receives superior root information (lower switch ID, lower path cost, and so forth) than currently stored for the port, the RSTP triggers a reconfiguration. If the port is proposed and is selected as the new root port, RSTP forces all the other ports to synchronize.

If the BPDU received is an RSTP BPDU with the proposal flag set, the switch sends an agreement message after all of the other ports are synchronized. If the BPDU is an IEEE 802.1D BPDU, the switch does not set the proposal flag and starts the forward-delay timer for the port. The new root port requires twice the forward-delay time to transition to the forwarding state.

If the superior information received on the port causes the port to become a backup or alternate port, RSTP sets the port to the blocking state but does not send the agreement message. The designated port continues sending BPDUs with the proposal flag set until the forward-delay timer expires, at which time the port transitions to the forwarding state.

Processing Inferior BPDU Information

If a designated port receives an inferior BPDU (such as a higher switch ID or a higher path cost than currently stored for the port) with a designated port role, it immediately replies with its own information.

Topology Changes

This section describes the differences between the RSTP and the IEEE 802.1D in handling spanning-tree topology changes.

- Detection—Unlike IEEE 802.1D in which *any* transition between the blocking and the forwarding state causes a topology change, *only* transitions from the blocking to the forwarding state cause a topology change with RSTP (only an increase in connectivity is considered a topology change). State changes on an edge port do not cause a topology change. When an RSTP switch detects a topology change, it deletes the learned information on all of its nonedge ports except on those from which it received the TC notification.

- Notification—Unlike IEEE 802.1D, which uses TCN BPDUs, the RSTP does not use them. However, for IEEE 802.1D interoperability, an RSTP switch processes and generates TCN BPDUs.

- Acknowledgement—When an RSTP switch receives a TCN message on a designated port from an IEEE 802.1D switch, it replies with an IEEE 802.1D configuration BPDU with the TCA bit set. However, if the TC-while timer (the same as the topology-change timer in IEEE 802.1D) is active on a root port connected to an IEEE 802.1D switch and a configuration BPDU with the TCA bit set is received, the TC-while timer is reset.

This behavior is only required to support IEEE 802.1D switches. The RSTP BPDUs never have the TCA bit set.

- Propagation—When an RSTP switch receives a TC message from another switch through a designated or root port, it propagates the change to all of its nonedge, designated ports and to the root port (excluding the port on which it is received). The switch starts the TC-while timer for all such ports and flushes the information learned on them.

- Protocol migration—For backward compatibility with IEEE 802.1D switches, RSTP selectively sends IEEE 802.1D configuration BPDUs and TCN BPDUs on a per-port basis.

  When a port is initialized, the migrate-delay timer is started (specifies the minimum time during which RSTP BPDUs are sent), and RSTP BPDUs are sent. While this timer is active, the switch processes all BPDUs received on that port and ignores the protocol type.

  If the switch receives an IEEE 802.1D BPDU after the port migration-delay timer has expired, it assumes that it is connected to an IEEE 802.1D switch and starts using only IEEE 802.1D BPDUs. However, if the RSTP switch is using IEEE 802.1D BPDUs on a port and receives an RSTP BPDU after the timer has expired, it restarts the timer and starts using RSTP BPDUs on that port.

Protocol Migration Process

A switch running MSTP supports a built-in protocol migration mechanism that enables it to interoperate with legacy IEEE 802.1D switches. If this switch receives a legacy IEEE 802.1D configuration BPDU (a BPDU with the protocol version set to 0), it sends only IEEE 802.1D BPDUs on that port. An MSTP switch also can detect that a port is at the boundary of a region when it receives a legacy BPDU, an MST BPDU (Version 3) associated with a different region, or an RST BPDU (Version 2).

However, the switch does not automatically revert to the MSTP mode if it no longer receives IEEE 802.1D BPDUs because it cannot detect whether the legacy switch has been removed from the link unless the legacy switch is the designated switch. A switch also might continue to assign a boundary role to a port when the switch to which it is connected has joined the region.

Related Topics

Restarting the Protocol Migration Process , on page 217

Default MSTP Configuration

Table 31: Default MSTP Configuration

Feature	Default Setting
Spanning-tree mode	MSTP
Switch priority (configurable on a per-CIST port basis)	32768
Spanning-tree port priority (configurable on a per-CIST port basis)	128

Feature	Default Setting
Spanning-tree port cost (configurable on a per-CIST port basis)	1000 Mb/s: 20000 100 Mb/s: 20000 10 Mb/s: 20000 1000 Mb/s: 20000 100 Mb/s: 20000 10 Mb/s: 20000
Hello time	3 seconds
Forward-delay time	20 seconds
Maximum-aging time	20 seconds
Maximum hop count	20 hops

Related Topics

Supported Spanning-Tree Instances, on page 166

Specifying the MST Region Configuration and Enabling MSTP , on page 202

About MST-to-PVST+ Interoperability (PVST+ Simulation)

The PVST+ simulation feature enables seamless interoperability between MST and Rapid PVST+. You can enable or disable this per port, or globally. PVST+ simulation is enabled by default.

However, you may want to control the connection between MST and Rapid PVST+ to protect against accidentally connecting an MST-enabled port to a Rapid PVST+-enabled port. Because Rapid PVST+ is the default STP mode, you may encounter many Rapid PVST+-enabled connections.

Disabling this feature causes the switch to stop the MST region from interacting with PVST+ regions. The MST-enabled port moves to a PVST peer inconsistent (blocking) state once it detects it is connected to a Rapid PVST+-enabled port. This port remains in the inconsistent state until the port stops receiving Shared Spanning Tree Protocol (SSTP) BPDUs, and then the port resumes the normal STP transition process.

You can for instance, disable PVST+ simulation, to prevent an incorrectly configured switch from connecting to a network where the STP mode is not MSTP (the default mode is PVST+).

Observe these guidelines when you configure MST switches (in the same region) to interact with PVST+ switches:

- Configure the root for all VLANs inside the MST region as shown in this example:

```
Switch# show spanning-tree mst interface gigabitethernet 1/1
GigabitEthernet1/1 of MST00 is root forwarding
Edge port: no             (trunk) port guard : none    (default)
Link type: point-to-point (auto)  bpdu filter: disable (default)
Boundary : boundary       (PVST)  bpdu guard : disable (default)
Bpdus sent 10, received 310

Instance Role Sts Cost  Prio.Nbr    Vlans mapped
-------- ---- --- --------- --------- -------------------------------
0        Root FWD 20000 128.1       1-2,4-2999,4000-4094
3        Boun FWD 20000 128.1       3,3000-3999
```

The ports that belong to the MST switch at the boundary simulate PVST+ and send PVST+ BPDUs for all the VLANs.

If you enable loop guard on the PVST+ switches, the ports might change to a loop-inconsistent state when the MST switches change their configuration. To correct the loop-inconsistent state, you must disable and re-enable loop guard on that PVST+ switch.

- Do not locate the root for some or all of the VLANs inside the PVST+ side of the MST switch because when the MST switch at the boundary receives PVST+ BPDUs for all or some of the VLANs on its designated ports, root guard sets the port to the blocking state.
- When you connect a PVST+ switch to two different MST regions, the topology change from the PVST+ switch does not pass beyond the first MST region. In such a case, the topology changes are propagated only in the instance to which the VLAN is mapped. The topology change stays local to the first MST region, and the Cisco Access Manager (CAM) entries in the other region are not flushed. To make the topology change visible throughout other MST regions, you can map that VLAN to IST or connect the PVST+ switch to the two regions through access links.
- When you disable the PVST+ simulation, note that the PVST+ peer inconsistency can also occur while the port is already in other states of inconsistency. For example, the root bridge for all STP instances must all be in either the MST region or the Rapid PVST+ side. If the root bridge for all STP instances are not on one side or the other, the software moves the port into a PVST + simulation-inconsistent state.

Note We recommend that you put the root bridge for all STP instances in the MST region.

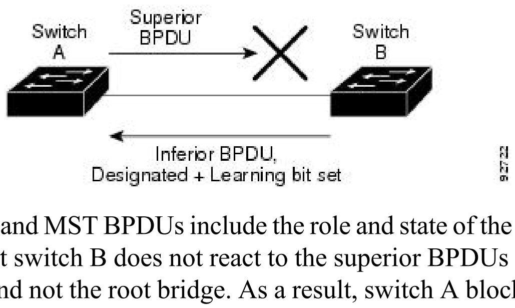
About Detecting Unidirectional Link Failure

The dispute mechanism that detects unidirectional link failures is included in the IEEE 802.1D-2004 RSTP and IEEE 802.1Q-2005 MSTP standard, and requires no user configuration.

The switch checks the consistency of the port role and state in the BPDUs it receives, to detect unidirectional link failures that could cause bridging loops. When a designated port detects a conflict, it keeps its role, but reverts to a discarding (blocking) state because disrupting connectivity in case of inconsistency is preferable to opening a bridging loop.

For example, in the figure below, Switch A is the root bridge and Switch B is the designated port. BPDUs from Switch A are lost on the link leading to switch B.

Figure 12: Detecting Unidirectional Link Failure

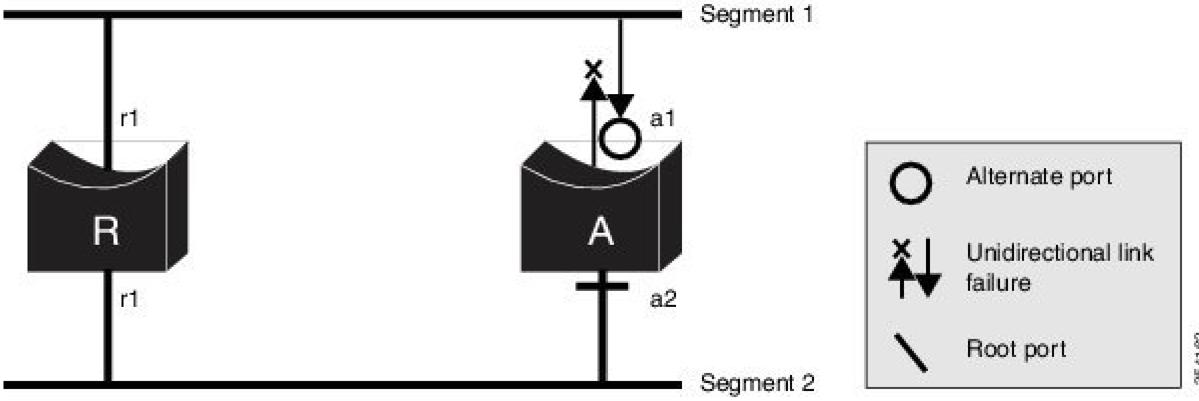


Since Rapid PVST+ (802.1w) and MST BPDUs include the role and state of the sending port, Switch A detects (from the inferior BPDU), that switch B does not react to the superior BPDUs it sends, because switch B has the role of a designated port and not the root bridge. As a result, switch A blocks (or keeps blocking) its port, thus preventing the bridging loop.

Note these guidelines and limitations relating to the dispute mechanism:

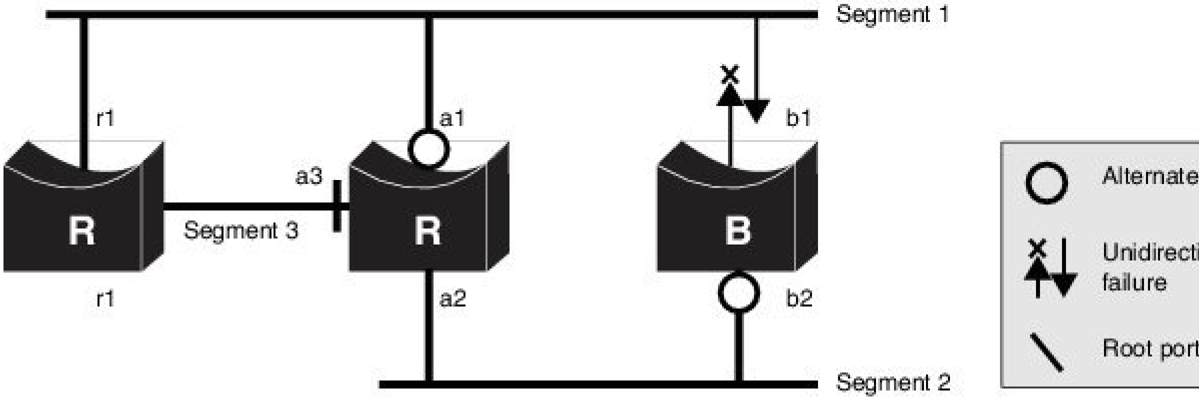
- It works only on switches running RSTP or MST (the dispute mechanism requires reading the role and state of the port initiating BPDUs).
- It may result in loss of connectivity. For example, in the figure below, Bridge A cannot transmit on the port it elected as a root port. As a result of this situation, there is loss of connectivity (r1 and r2 are designated, a1 is root and a2 is alternate. There is only a one way connectivity between A and R).

Figure 13: Loss of Connectivity



- It may cause permanent bridging loops on shared segments. For example, in the figure below, suppose that bridge R has the best priority, and that port b1 cannot receive any traffic from the shared segment 1 and sends inferior designated information on segment 1. Both r1 and a1 can detect this inconsistency. However, with the current dispute mechanism, only r1 will revert to discarding while the root port a1 opens a permanent loop. However, this problem does not occur in Layer 2 switched networks that are connected by point-to-point links.

Figure 14: Bridging Loops on Shared Segments



How to Configure MSTP Features

Specifying the MST Region Configuration and Enabling MSTP

For two or more switches to be in the same MST region, they must have the same VLAN-to-instance mapping, the same configuration revision number, and the same name.

A region can have one member or multiple members with the same MST configuration; each member must be capable of processing RSTP BPDUs. There is no limit to the number of MST regions in a network, but each region can only support up to 65 spanning-tree instances. You can assign a VLAN to only one spanning-tree instance at a time.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mst configuration**
4. **instance** *instance-id* **vlan** *vlan-range*
5. **name** *name*
6. **revision** *version*
7. **show pending**
8. **exit**
9. **spanning-tree mode mst**
10. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree mst configuration** **Example:** `Switch(config)# spanning-tree mst configuration`	Enters MST configuration mode.
Step 4	**instance** *instance-id* **vlan** *vlan-range*	Maps VLANs to an MST instance.

	Command or Action	Purpose
	Example: `Switch(config-mst)# instance 1 vlan 10-20`	- For *instance-id*, the range is 0 to 4094. - For **vlan** *vlan-range*, the range is 1 to 4094. When you map VLANs to an MST instance, the mapping is incremental, and the VLANs specified in the command are added to or removed from the VLANs that were previously mapped. To specify a VLAN range, use a hyphen; for example, **instance 1 vlan 1-63** maps VLANs 1 through 63 to MST instance 1. To specify a VLAN series, use a comma; for example, **instance 1 vlan 10, 20, 30** maps VLANs 10, 20, and 30 to MST instance 1.
Step 5	**name** *name* **Example:** `Switch(config-mst)# name region1`	Specifies the configuration name. The *name* string has a maximum length of 32 characters and is case sensitive.
Step 6	**revision** *version* **Example:** `Switch(config-mst)# revision 1`	Specifies the configuration revision number. The range is 0 to 65535.
Step 7	**show pending** **Example:** `Switch(config-mst)# show pending`	Verifies your configuration by displaying the pending configuration.
Step 8	**exit** **Example:** `Switch(config-mst)# exit`	Applies all changes, and returns to global configuration mode.
Step 9	**spanning-tree mode mst** **Example:** `Switch(config)# spanning-tree mode mst`	Enables MSTP. RSTP is also enabled. Changing spanning-tree modes can disrupt traffic because all spanning-tree instances are stopped for the previous mode and restarted in the new mode. You cannot run both MSTP and PVST+ or both MSTP and Rapid PVST+ at the same time.

Step 10	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

MSTP Configuration Guidelines, on page 185
Multiple Spanning-Tree Regions, on page 186
Prerequisites for MSTP, on page 183
Restrictions for MSTP, on page 184
Spanning-Tree Interoperability and Backward Compatibility, on page 166
Optional Spanning-Tree Configuration Guidelines
BackboneFast, on page 231
UplinkFast, on page 229
Default MSTP Configuration, on page 198
Configuring the Root Switch , on page 204
Bridge ID, Device Priority, and Extended System ID, on page 160
Configuring a Secondary Root Switch , on page 205
Configuring Port Priority , on page 206
Configuring Path Cost , on page 208
Configuring the Switch Priority , on page 209
Configuring the Hello Time , on page 211
Configuring the Forwarding-Delay Time , on page 212
Configuring the Maximum-Aging Time , on page 213
Configuring the Maximum-Hop Count , on page 214
Specifying the Link Type to Ensure Rapid Transitions , on page 215
Designating the Neighbor Type , on page 216
Restarting the Protocol Migration Process , on page 217

Configuring the Root Switch

This procedure is optional.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

You must also know the specified MST instance ID. Step 2 in the example uses 0 as the instance ID because that was the instance ID set up by the instructions listed under Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mst** *instance-id* **root primary**
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Switch> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree mst** *instance-id* **root primary** **Example:** `Switch(config)# spanning-tree mst 0 root primary`	Configures a switch as the root switch. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Root Switch, on page 186
Specifying the MST Region Configuration and Enabling MSTP , on page 202
Restrictions for MSTP, on page 184
Bridge ID, Device Priority, and Extended System ID, on page 160
Configuring a Secondary Root Switch , on page 205

Configuring a Secondary Root Switch

When you configure a switch with the extended system ID support as the secondary root, the switch priority is modified from the default value (32768) to 28672. The switch is then likely to become the root switch for the specified instance if the primary root switch fails. This is assuming that the other network switches use the default switch priority of 32768 and therefore are unlikely to become the root switch.

You can execute this command on more than one switch to configure multiple backup root switches. Use the same network diameter and hello-time values that you used when you configured the primary root switch with the **spanning-tree mst** *instance-id* **root primary** global configuration command.

This procedure is optional.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

You must also know the specified MST instance ID. This example uses 0 as the instance ID because that was the instance ID set up by the instructions listed under Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mst** *instance-id* **root secondary**
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree mst** *instance-id* **root secondary** **Example:** `Switch(config)# spanning-tree mst 0 root secondary`	Configures a switch as the secondary root switch. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202
Configuring the Root Switch , on page 204

Configuring Port Priority

If a loop occurs, the MSTP uses the port priority when selecting an interface to put into the forwarding state. You can assign higher priority values (lower numerical values) to interfaces that you want selected first and lower priority values (higher numerical values) that you want selected last. If all interfaces have the same priority value, the MSTP puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

This procedure is optional.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

You must also know the specified MST instance ID and the interface used. This example uses 0 as the instance ID and GigabitEthernet0/1 as the interface because that was the instance ID and interface set up by the instructions listed under Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree mst** *instance-id* **port-priority** *priority*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies an interface to configure, and enters interface configuration mode.
Step 4	**spanning-tree mst** *instance-id* **port-priority** *priority* **Example:** `Switch(config-if)# spanning-tree mst 0 port-priority 64`	Configures port priority. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094. • For *priority*, the range is 0 to 240 in increments of 16. The default is 128. The lower the number, the higher the priority.

	Command or Action	Purpose
		The priority values are 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240. All other values are rejected.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

The **show spanning-tree mst interface** *interface-id* privileged EXEC command displays information only if the port is in a link-up operative state. Otherwise, you can use the **show running-config interface** privileged EXEC command to confirm the configuration.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Configuring Path Cost , on page 208

Configuring Path Cost

The MSTP path cost default value is derived from the media speed of an interface. If a loop occurs, the MSTP uses cost when selecting an interface to put in the forwarding state. You can assign lower cost values to interfaces that you want selected first and higher cost values that you want selected last. If all interfaces have the same cost value, the MSTP puts the interface with the lowest interface number in the forwarding state and blocks the other interfaces.

This procedure is optional.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

You must also know the specified MST instance ID and the interface used. This example uses 0 as the instance ID and GigabitEthernet0/1 as the interface because that was the instance ID and interface set up by the instructions listed under Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree mst** *instance-id* **cost** *cost*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Switch> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports and port-channel logical interfaces. The port-channel range is 1 to 48.
Step 4	**spanning-tree mst** *instance-id* **cost** *cost* **Example:** `Switch(config-if)# spanning-tree mst 0 cost 17031970`	Configures the cost. If a loop occurs, the MSTP uses the path cost when selecting an interface to place into the forwarding state. A lower path cost represents higher-speed transmission. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094. • For *cost*, the range is 1 to 200000000; the default value is derived from the media speed of the interface.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

The **show spanning-tree mst interface** *interface-id* privileged EXEC command displays information only for ports that are in a link-up operative state. Otherwise, you can use the **show running-config** privileged EXEC command to confirm the configuration.

Related Topics

Configuring Port Priority , on page 206
Specifying the MST Region Configuration and Enabling MSTP , on page 202

Configuring the Switch Priority

Changing the priority of a switch makes it more likely to be chosen as the root switch whether it is a standalone switch.

Note Exercise care when using this command. For normal network configurations, we recommend that you use the **spanning-tree mst** *instance-id* **root primary** and the **spanning-tree mst** *instance-id* **root secondary** global configuration commands to specify a switch as the root or secondary root switch. You should modify the switch priority only in circumstances where these commands do not work.

This procedure is optional.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

You must also know the specified MST instance ID used. This example uses 0 as the instance ID because that was the instance ID set up by the instructions listed under Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mst** *instance-id* **priority** *priority*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree mst** *instance-id* **priority** *priority* **Example:** `Switch(config)# spanning-tree mst 0 priority 40960`	Configures the switch priority. • For *instance-id*, you can specify a single instance, a range of instances separated by a hyphen, or a series of instances separated by a comma. The range is 0 to 4094. • For *priority*, the range is 0 to 61440 in increments of 4096; the default is 32768. The lower the number, the more likely the switch will be chosen as the root switch.

	Command or Action	Purpose
		Priority values are 0, 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440. These are the only acceptable values.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Configuring the Hello Time

The hello time is the time interval between configuration messages generated and sent by the root switch.

This procedure is optional.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mst hello-time** *seconds*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**spanning-tree mst hello-time** *seconds* **Example:** `Switch(config)# spanning-tree mst hello-time 4`	Configures the hello time for all MST instances. The hello time is the time interval between configuration messages generated and sent by the root switch. These messages indicate that the switch is alive. For *seconds*, the range is 1 to 10; the default is 3.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Configuring the Forwarding-Delay Time

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mst forward-time** *seconds*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree mst forward-time** *seconds* **Example:**	Configures the forward time for all MST instances. The forwarding delay is the number of seconds a port waits

	Command or Action	Purpose
	`Switch(config)# spanning-tree mst forward-time 25`	before changing from its spanning-tree learning and listening states to the forwarding state. For *seconds*, the range is 4 to 30; the default is 20.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Configuring the Maximum-Aging Time

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mst max-age** *seconds*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree mst max-age** *seconds* **Example:** `Switch(config)# spanning-tree mst max-age 40`	Configures the maximum-aging time for all MST instances. The maximum-aging time is the number of seconds a switch waits without receiving spanning-tree configuration messages before attempting a reconfiguration.

	Command or Action	Purpose
		For *seconds*, the range is 6 to 40; the default is 20.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Configuring the Maximum-Hop Count

This procedure is optional.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mst max-hops** *hop-count*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree mst max-hops** *hop-count* **Example:** `Switch(config)# spanning-tree mst max-hops 25`	Specifies the number of hops in a region before the BPDU is discarded, and the information held for a port is aged. For *hop-count*, the range is 1 to 255; the default is 20.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Specifying the Link Type to Ensure Rapid Transitions

If you connect a port to another port through a point-to-point link and the local port becomes a designated port, the RSTP negotiates a rapid transition with the other port by using the proposal-agreement handshake to ensure a loop-free topology.

By default, the link type is controlled from the duplex mode of the interface: a full-duplex port is considered to have a point-to-point connection; a half-duplex port is considered to have a shared connection. If you have a half-duplex link physically connected point-to-point to a single port on a remote switch running MSTP, you can override the default setting of the link type and enable rapid transitions to the forwarding state.

This procedure is optional.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

You must also know the specified MST instance ID and the interface used. This example uses 0 as the instance ID and GigabitEthernet0/1 as the interface because that was the instance ID and interface set up by the instructions listed under Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree link-type point-to-point**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports, VLANs, and port-channel logical interfaces. The VLAN ID range is 1 to 4094. The port-channel range is 1 to 48.
Step 4	**spanning-tree link-type point-to-point** **Example:** `Switch(config-if)# spanning-tree link-type point-to-point`	Specifies that the link type of a port is point-to-point.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Designating the Neighbor Type

A topology could contain both prestandard and IEEE 802.1s standard compliant devices. By default, ports can automatically detect prestandard devices, but they can still receive both standard and prestandard BPDUs. When there is a mismatch between a device and its neighbor, only the CIST runs on the interface.

You can choose to set a port to send only prestandard BPDUs. The prestandard flag appears in all the **show** commands, even if the port is in STP compatibility mode.

This procedure is optional.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree mst pre-standard**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies an interface to configure, and enters interface configuration mode. Valid interfaces include physical ports.
Step 4	**spanning-tree mst pre-standard** **Example:** `Switch(config-if)# spanning-tree mst pre-standard`	Specifies that the port can send only prestandard BPDUs.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202

Restarting the Protocol Migration Process

This procedure restarts the protocol migration process and forces renegotiation with neighboring switches. It reverts the switch to MST mode. It is needed when the switch no longer receives IEEE 802.1D BPDUs after it has been receiving them.

Follow these steps to restart the protocol migration process (force the renegotiation with neighboring switches) on the switch.

Before you begin

A multiple spanning tree (MST) must be specified and enabled on the switch. For instructions, see Related Topics.

If you want to use the interface version of the command, you must also know the MST interface used. This example uses GigabitEthernet0/1 as the interface because that was the interface set up by the instructions listed under Related Topics.

SUMMARY STEPS

1. **enable**
2. Enter one of the following commands:
   - **clear spanning-tree detected-protocols**
   - **clear spanning-tree detected-protocols interface** *interface-id*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

Step 2	Enter one of the following commands:
	• **clear spanning-tree detected-protocols**
	• **clear spanning-tree detected-protocols interface** *interface-id*
	Example:
	`Switch# clear spanning-tree detected-protocols`
	or
	`Switch# clear spanning-tree detected-protocols interface gigabitethernet 0/1`
		The switch reverts to the MSTP mode, and the protocol migration process restarts.

What to do next

This procedure may need to be repeated if the switch receives more legacy IEEE 802.1D configuration BPDUs (BPDUs with the protocol version set to 0).

Related Topics

Specifying the MST Region Configuration and Enabling MSTP , on page 202
Protocol Migration Process, on page 198

Configuring PVST+ Simulation

PVST+ simulation is enabled by default. This means that all ports automatically interoperate with a connected device that is running in Rapid PVST+ mode. If you disabled the feature and want to re-configure it, refer to the following tasks.

To enable PVST+ simulation globally, perform this task:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree mst simulate pvst global**

4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree mst simulate pvst global** **Example:** `Switch(config)# spanning-tree mst simulate pvst global`	Enables PVST+ simulation globally. To prevent the switch from automatically interoperating with a connecting switch that is running Rapid PVST+, enter the **no** version of the command.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Enabling PVST+ Simulation on a Port

To enable PVST+ simulation on a port, perform this task:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree mst simulate pvst**
5. **end**
6. **show spanning-tree summary**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
	`Switch> enable`	
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gi`	Selects a port to configure.
Step 4	**spanning-tree mst simulate pvst** **Example:** `Switch(config-if)# spanning-tree mst simulate pvst`	Enables PVST+ simulation on the specified interface. To prevent a specified interface from automatically interoperating with a connecting switch that is not running MST, enter the **spanning-tree mst simulate pvst disable** command.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show spanning-tree summary** **Example:** `Switch# show spanning-tree summary`	Verifies the configuration.

Examples

Examples: PVST+ Simulation

This example shows how to prevent the switch from automatically interoperating with a connecting switch that is running Rapid PVST+:

```
Switch# configure terminal
Switch(config)# no spanning-tree mst simulate pvst global
```

This example shows how to prevent a port from automatically interoperating with a connecting device that is running Rapid PVST+:

```
Switch(config)# interface0/1
Switch(config-if)# spanning-tree mst simulate pvst disable
```

The following sample output shows the system message you receive when a SSTP BPDU is received on a port and PVST+ simulation is disabled:

```
Message
SPANTREE_PVST_PEER_BLOCK: PVST BPDU detected on port %s [port number].

Severity
Critical

Explanation
A PVST+ peer was detected on the specified interface on the switch. PVST+
 simulation feature is disabled, as a result of which the interface was
moved to the spanning tree
Blocking state.

Action
Identify the PVST+ switch from the network which might be configured
incorrectly.
```

The following sample output shows the system message you receive when peer inconsistency on the interface is cleared:

```
Message
SPANTREE_PVST_PEER_UNBLOCK: Unblocking port %s [port number].

Severity
Critical

Explanation
The interface specified in the error message has been restored to normal
 spanning tree state.

Action
None.
```

This example shows the spanning tree status when port **0/1** has been configured to disable PVST+ simulation and is currently in the peer type inconsistent state:

```
Switch# show spanning-tree
VLAN0010
  Spanning tree enabled protocol mstp
  Root ID Priority  32778
          Address   0002.172c.f400
          This bridge is the root
          Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
  Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)
            Address  0002.172c.f400
          Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
          Aging Time 300
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- -------------------------
Gi0/1           Desg BKN*4         128.270 P2p *PVST_Peer_Inc
```

This example shows the spanning tree summary when PVST+ simulation is enabled in the MSTP mode:

```
Switch# show spanning-tree summary
Switch is in mst mode (IEEE Standard)
Root bridge for: MST0
EtherChannel misconfig guard is enabled
Extended system ID is enabled
Portfast Default is disabled
PortFast BPDU Guard Default is disabled
Portfast BPDU Filter Default is disabled
Loopguard Default is disabled
UplinkFast is disabled
BackboneFast is disabled
Pathcost method used is long
PVST Simulation Default is enabled
Name                   Blocking Listening Learning Forwarding STP Active
---------------------- -------- --------- -------- ---------- ----------
MST0                         2          0        0          0          2
---------------------- -------- --------- -------- ---------- ----------
1 mst                        2          0        0          0          2
```

This example shows the spanning tree summary when PVST+ simulation is disabled in any STP mode:

```
Switch# show spanning-tree summary
Switch is in mst mode (IEEE Standard)
Root bridge for: MST0
EtherChannel misconfig guard is enabled
Extended system ID is enabled
Portfast Default is disabled
PortFast BPDU Guard Default is disabled
Portfast BPDU Filter Default is disabled
Loopguard Default is disabled
UplinkFast is disabled
BackboneFast is disabled
Pathcost method used is long
PVST Simulation Default is disabled
Name                   Blocking Listening Learning Forwarding STP Active
---------------------- -------- --------- -------- ---------- ----------
MST0                          2         0        0          0          2
---------------------- -------- --------- -------- ---------- ----------
1 mst                         2         0        0          0          2
```

This example shows the spanning tree summary when the switch is not in MSTP mode, that is, the switch is in PVST or Rapid-PVST mode. The output string displays the current STP mode:

```
Switch# show spanning-tree summary
Switch is in rapid-pvst mode
Root bridge for: VLAN0001, VLAN2001-VLAN2002
EtherChannel misconfig guard is enabled
Extended system ID is enabled
Portfast Default is disabled
PortFast BPDU Guard Default is disabled
Portfast BPDU Filter Default is disabled
```

```
Loopguard Default is disabled
UplinkFast is disabled
BackboneFast is disabled
Pathcost method used is short
PVST Simulation Default is enabled but inactive in rapid-pvst mode
Name                   Blocking Listening Learning Forwarding STP Active
---------------------- -------- --------- -------- ---------- ----------
VLAN0001                      2         0        0          0          2
VLAN2001                      2         0        0          0          2
VLAN2002                      2         0        0          0          2
---------------------- -------- --------- -------- ---------- ----------
3 vlans                       6         0        0          0          6
```

This example shows the interface details when PVST+ simulation is globally enabled, or the default configuration:

```
Switch# show spanning-tree interface0/1 detail
Port 269 (GigabitEthernet0/1) of VLAN0002 is forwarding
   Port path cost 4, Port priority 128, Port Identifier 128.297.
   Designated root has priority 32769, address 0013.5f20.01c0
   Designated bridge has priority 32769, address 0013.5f20.01c0
   Designated port id is 128.297, designated path cost 0
   Timers: message age 0, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   Link type is point-to-point by default
   PVST Simulation is enabled by default
   BPDU: sent 132, received 1
```

This example shows the interface details when PVST+ simulation is globally disabled:

```
Switch# show spanning-tree interface0/1 detail
Port 269 (GigabitEthernet0/1) of VLAN0002 is forwarding
   Port path cost 4, Port priority 128, Port Identifier 128.297.
   Designated root has priority 32769, address 0013.5f20.01c0
   Designated bridge has priority 32769, address 0013.5f20.01c0
   Designated port id is 128.297, designated path cost 0
   Timers: message age 0, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   Link type is point-to-point by default
   PVST Simulation is disabled by default
   BPDU: sent 132, received 1
```

This example shows the interface details when PVST+ simulation is explicitly enabled on the port:

```
Switch# show spanning-tree interface0/1 detail
Port 269 (GigabitEthernet0/1) of VLAN0002 is forwarding
   Port path cost 4, Port priority 128, Port Identifier 128.297.
   Designated root has priority 32769, address 0013.5f20.01c0
   Designated bridge has priority 32769, address 0013.5f20.01c0
   Designated port id is 128.297, designated path cost 0
   Timers: message age 0, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   Link type is point-to-point by default
   PVST Simulation is enabled
   BPDU: sent 132, received 1
```

This example shows the interface details when the PVST+ simulation feature is disabled and a PVST Peer inconsistency has been detected on the port:

```
Switch# show spanning-tree interface0/1 detail
```

```
Port 269 (GigabitEthernet0/1) of VLAN0002 is broken (PVST Peer Inconsistent)
   Port path cost 4, Port priority 128, Port Identifier 128.297.
   Designated root has priority 32769, address 0013.5f20.01c0
   Designated bridge has priority 32769, address 0013.5f20.01c0
   Designated port id is 128.297, designated path cost 0
   Timers: message age 0, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   Link type is point-to-point by default
   PVST Simulation is disabled
   BPDU: sent 132, received 1
```

Examples: Detecting Unidirectional Link Failure

This example shows the spanning tree status when port **0/1 detail** has been configured to disable PVST+ simulation and the port is currently in the peer type inconsistent state:

```
Switch# show spanning-tree
VLAN0010
  Spanning tree enabled protocol rstp
  Root ID    Priority 32778
             Address  0002.172c.f400
             This bridge is the root
             Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
  Bridge ID  Priority 32778 (priority 32768 sys-id-ext 10)
             Address  0002.172c.f400
             Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
             Aging Time 300

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- -------------------------
Gi0/1            Desg BKN 4         128.270  P2p Dispute
```

This example shows the interface details when a dispute condition is detected:

```
Switch# show spanning-tree interface0/1 detail
Port 269 (GigabitEthernet0/1) of VLAN0002 is designated blocking (dispute)
   Port path cost 4, Port priority 128, Port Identifier 128.297.
   Designated root has priority 32769, address 0013.5f20.01c0
   Designated bridge has priority 32769, address 0013.5f20.01c0
   Designated port id is 128.297, designated path cost 0
   Timers: message age 0, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   Link type is point-to-point by default
   BPDU: sent 132, received 1
```

Monitoring MST Configuration and Status

Table 32: Commands for Displaying MST Status

show spanning-tree mst configuration	Displays the MST region configuration.
show spanning-tree mst configuration digest	Displays the MD5 digest included in the current MSTCI.

show spanning-tree mst	Displays MST information for the all instances. **Note** This command displays information for ports in a link-up operative state.
show spanning-tree mst *instance-id*	Displays MST information for the specified instance. **Note** This command displays information only if the port is in a link-up operative state.
show spanning-tree mst interface *interface-id*	Displays MST information for the specified interface.

Feature Information for MSTP

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 14

Configuring Optional Spanning-Tree Features

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restriction for Optional Spanning-Tree Features

- PortFast minimizes the time that interfaces must wait for spanning tree to converge, so it is effective only when used on interfaces connected to end stations. If you enable PortFast on an interface connecting to another switch, you risk creating a spanning-tree loop.

Related Topics

Enabling PortFast , on page 238

PortFast, on page 228

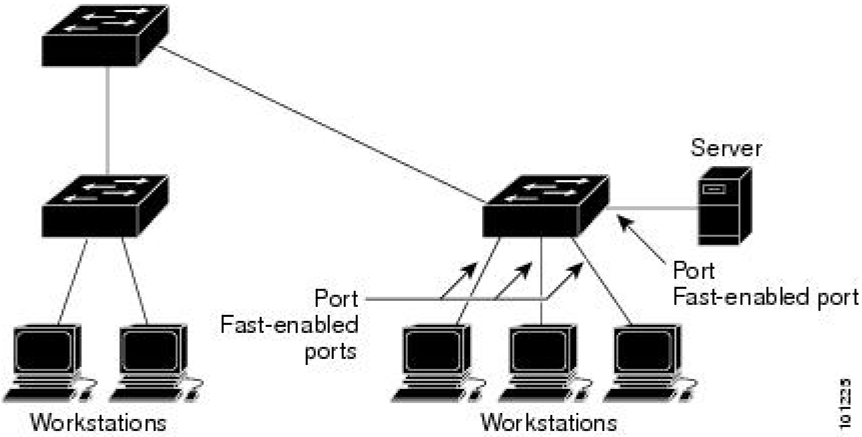
Information About Optional Spanning-Tree Features

PortFast

PortFast immediately brings an interface configured as an access or trunk port to the forwarding state from a blocking state, bypassing the listening and learning states.

Figure 15: PortFast-Enabled Interfaces

You can use PortFast on interfaces connected to a single workstation or server to allow those devices to immediately connect to the network, rather than waiting for the spanning tree to converge.



Interfaces connected to a single workstation or server should not receive bridge protocol data units (BPDUs). An interface with PortFast enabled goes through the normal cycle of spanning-tree status changes when the switch is restarted.

You can enable this feature by enabling it on either the interface or on all nontrunking ports.

Related Topics

Enabling PortFast , on page 238

Restriction for Optional Spanning-Tree Features, on page 227

BPDU Guard

The Bridge Protocol Data Unit (BPDU) guard feature can be globally enabled on the switch or can be enabled per port, but the feature operates with some differences.

When you enable BPDU guard at the global level on PortFast edge-enabled ports, spanning tree shuts down ports that are in a PortFast edge-operational state if any BPDU is received on them. In a valid configuration, PortFast edge-enabled ports do not receive BPDUs. Receiving a BPDU on a Port Fast edge-enabled port means an invalid configuration, such as the connection of an unauthorized device, and the BPDU guard feature puts the port in the error-disabled state. When this happens, the switch shuts down the entire port on which the violation occurred.

When you enable BPDU guard at the interface level on any port without also enabling the PortFast edge feature, and the port receives a BPDU, it is put in the error-disabled state.

The BPDU guard feature provides a secure response to invalid configurations because you must manually put the interface back in service. Use the BPDU guard feature in a service-provider network to prevent an access port from participating in the spanning tree.

Related Topics

Enabling BPDU Guard , on page 240

BPDU Filtering

The BPDU filtering feature can be globally enabled on the switch or can be enabled per interface, but the feature operates with some differences.

Enabling BPDU filtering on PortFast edge-enabled interfaces at the global level keeps those interfaces that are in a PortFast edge-operational state from sending or receiving BPDUs. The interfaces still send a few BPDUs at link-up before the switch begins to filter outbound BPDUs. You should globally enable BPDU filtering on a switch so that hosts connected to these interfaces do not receive BPDUs. If a BPDU is received on a PortFast edge-enabled interface, the interface loses its PortFast edge-operational status, and BPDU filtering is disabled.

Enabling BPDU filtering on an interface without also enabling the PortFast edge feature keeps the interface from sending or receiving BPDUs.

Caution Enabling BPDU filtering on an interface is the same as disabling spanning tree on it and can result in spanning-tree loops.

You can enable the BPDU filtering feature for the entire switch or for an interface.

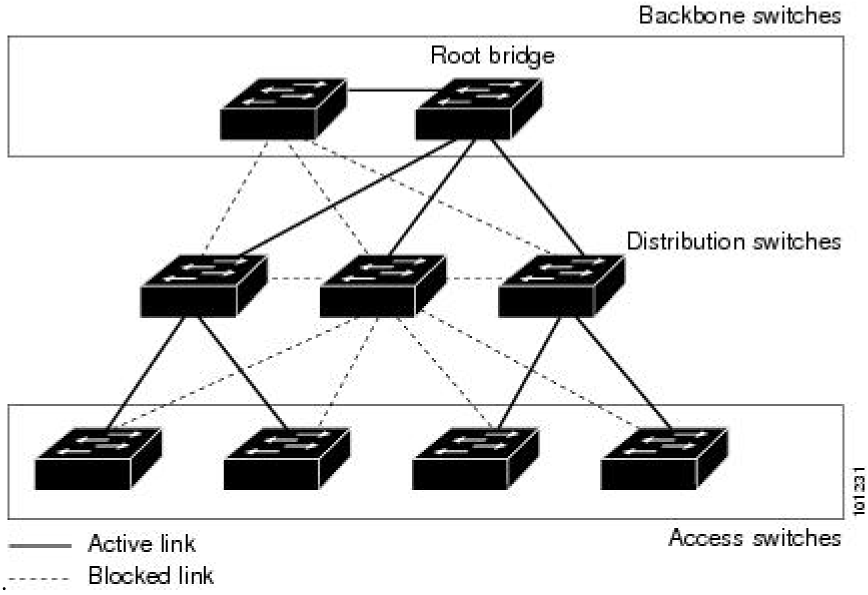
Related Topics

Enabling BPDU Filtering , on page 241

UplinkFast

Figure 16: Switches in a Hierarchical Network

Switches in hierarchical networks can be grouped into backbone switches, distribution switches, and access switches. This complex network has distribution switches and access switches that each have at least one redundant link that spanning tree blocks to prevent loops.



If a switch loses connectivity, it begins using the alternate paths as soon as the spanning tree selects a new root port. You can accelerate the choice of a new root port when a link or switch fails or when the spanning tree reconfigures itself by enabling UplinkFast. The root port transitions to the forwarding state immediately without going through the listening and learning states, as it would with the normal spanning-tree procedures.

When the spanning tree reconfigures the new root port, other interfaces flood the network with multicast packets, one for each address that was learned on the interface. You can limit these bursts of multicast traffic by reducing the max-update-rate parameter (the default for this parameter is 150 packets per second). However, if you enter zero, station-learning frames are not generated, so the spanning-tree topology converges more slowly after a loss of connectivity.

Note UplinkFast is most useful in wiring-closet switches at the access or edge of the network. It is not appropriate for backbone devices. This feature might not be useful for other types of applications.

UplinkFast provides fast convergence after a direct link failure and achieves load-balancing between redundant Layer 2 links using uplink groups. An uplink group is a set of Layer 2 interfaces (per VLAN), only one of which is forwarding at any given time. Specifically, an uplink group consists of the root port (which is forwarding) and a set of blocked ports, except for self-looping ports. The uplink group provides an alternate path in case the currently forwarding link fails.

Figure 17: UplinkFast Example Before Direct Link Failure

This topology has no link failures. Switch A, the root switch, is connected directly to Switch B over link L1 and to Switch C over link L2. The Layer 2 interface on Switch C that is connected directly to Switch B is in a blocking state.

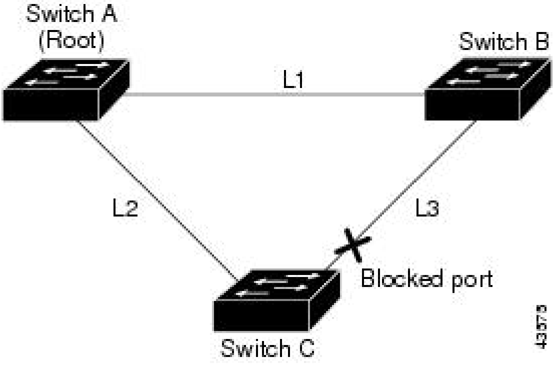
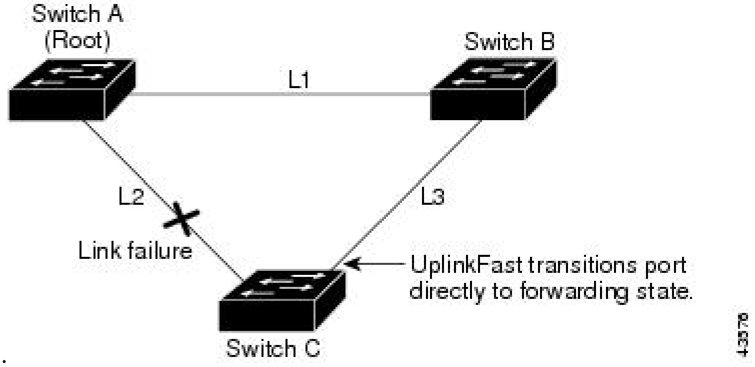


Figure 18: UplinkFast Example After Direct Link Failure

If Switch C detects a link failure on the currently active link L2 on the root port (a direct link failure), UplinkFast unblocks the blocked interface on Switch C and transitions it to the forwarding state without going through the listening and learning states. This change takes approximately 1 to 5 seconds.



Related Topics

- Specifying the MST Region Configuration and Enabling MSTP , on page 202
- MSTP Configuration Guidelines, on page 185
- Multiple Spanning-Tree Regions, on page 186
- Enabling UplinkFast for Use with Redundant Links , on page 242
- Events That Cause Fast Convergence

BackboneFast

BackboneFast detects indirect failures in the core of the backbone. BackboneFast is a complementary technology to the UplinkFast feature, which responds to failures on links directly connected to access switches. BackboneFast optimizes the maximum-age timer, which controls the amount of time the switch stores protocol information received on an interface. When a switch receives an inferior BPDU from the designated port of another switch, the BPDU is a signal that the other switch might have lost its path to the root, and BackboneFast tries to find an alternate path to the root.

BackboneFast starts when a root port or blocked interface on a switch receives inferior BPDUs from its designated switch. An inferior BPDU identifies a switch that declares itself as both the root bridge and the designated switch. When a switch receives an inferior BPDU, it means that a link to which the switch is not directly connected (an indirect link) has failed (that is, the designated switch has lost its connection to the root switch). Under spanning-tree rules, the switch ignores inferior BPDUs for the maximum aging time (default is 20 seconds).

The switch tries to find if it has an alternate path to the root switch. If the inferior BPDU arrives on a blocked interface, the root port and other blocked interfaces on the switch become alternate paths to the root switch. (Self-looped ports are not considered alternate paths to the root switch.) If the inferior BPDU arrives on the root port, all blocked interfaces become alternate paths to the root switch. If the inferior BPDU arrives on the root port and there are no blocked interfaces, the switch assumes that it has lost connectivity to the root switch, causes the maximum aging time on the root port to expire, and becomes the root switch according to normal spanning-tree rules.

If the switch discovers that it still has an alternate path to the root, it expires the maximum aging time on the interface that received the inferior BPDU. If all the alternate paths to the root switch indicate that the switch has lost connectivity to the root switch, the switch expires the maximum aging time on the interface that received the RLQ reply. If one or more alternate paths can still connect to the root switch, the switch makes all interfaces on which it received an inferior BPDU its designated ports and moves them from the blocking state (if they were in the blocking state), through the listening and learning states, and into the forwarding state.

Figure 19: BackboneFast Example Before Indirect Link Failure

This is an example topology with no link failures. Switch A, the root switch, connects directly to Switch B over link L1 and to Switch C over link L2. The Layer 2 interface on Switch C that connects directly to Switch B is in the blocking state.

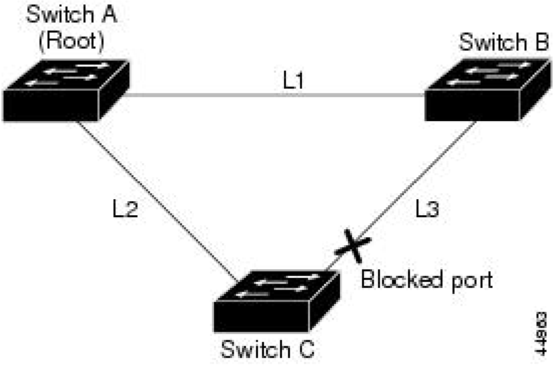


Figure 20: BackboneFast Example After Indirect Link Failure

If link L1 fails, Switch C cannot detect this failure because it is not connected directly to link L1. However, because Switch B is directly connected to the root switch over L1, it detects the failure, elects itself the root, and begins sending BPDUs to Switch C, identifying itself as the root. When Switch C receives the inferior BPDUs from Switch B, Switch C assumes that an indirect failure has occurred. At that point, BackboneFast allows the blocked interface on Switch C to move immediately to the listening state without waiting for the maximum aging time for the interface to expire. BackboneFast then transitions the Layer 2 interface on Switch C to the forwarding state, providing a path from Switch B to Switch A. The root-switch election takes approximately 30 seconds, twice the Forward Delay time if the default Forward Delay time of 15 seconds is set. BackboneFast reconfigures the topology to account for the failure of link L1.

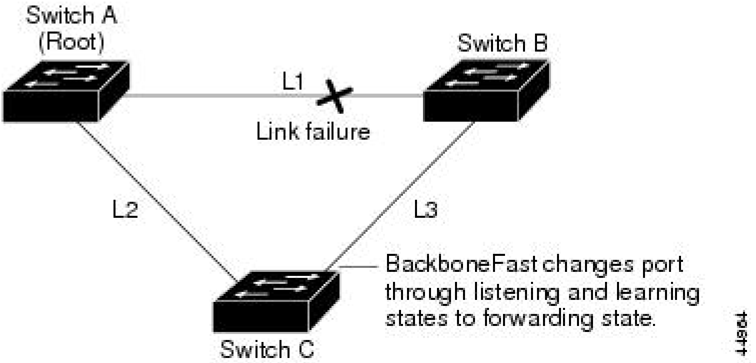
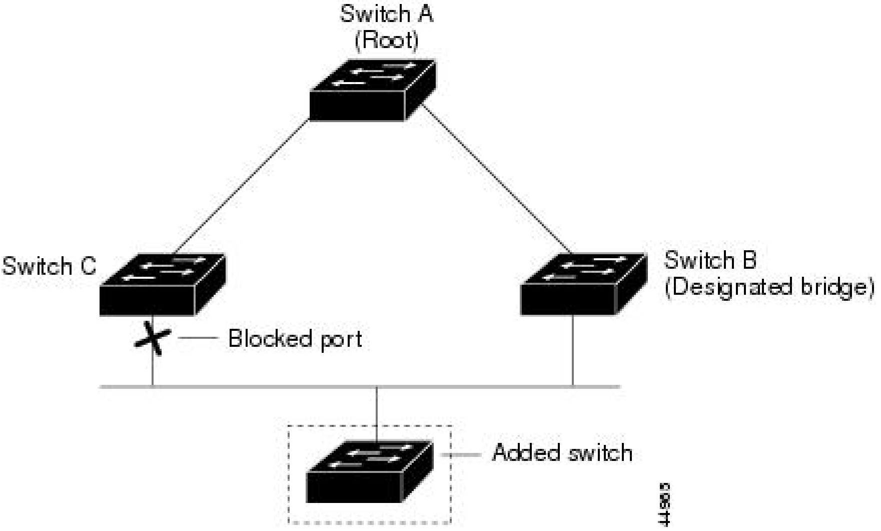

Switch A
(Root)
Switch B
L1
Link failure
L2
L3
BackboneFast changes port
through listening and learning
states to forwarding state.
Switch C
44964

Figure 21: Adding a Switch in a Shared-Medium Topology

If a new switch is introduced into a shared-medium topology, BackboneFast is not activated because the inferior BPDUs did not come from the recognized designated switch (Switch B). The new switch begins sending inferior BPDUs that indicate it is the root switch. However, the other switches ignore these inferior BPDUs, and the new switch learns that Switch B is the designated switch to Switch A, the root switch.



Related Topics

- Specifying the MST Region Configuration and Enabling MSTP , on page 202
- MSTP Configuration Guidelines, on page 185
- Multiple Spanning-Tree Regions, on page 186
- Enabling BackboneFast , on page 245

EtherChannel Guard

You can use EtherChannel guard to detect an EtherChannel misconfiguration between the switch and a connected device. A misconfiguration can occur if the switch interfaces are configured in an EtherChannel, but the interfaces on the other device are not. A misconfiguration can also occur if the channel parameters are not the same at both ends of the EtherChannel.

If the switch detects a misconfiguration on the other device, EtherChannel guard places the switch interfaces in the error-disabled state, and displays an error message.

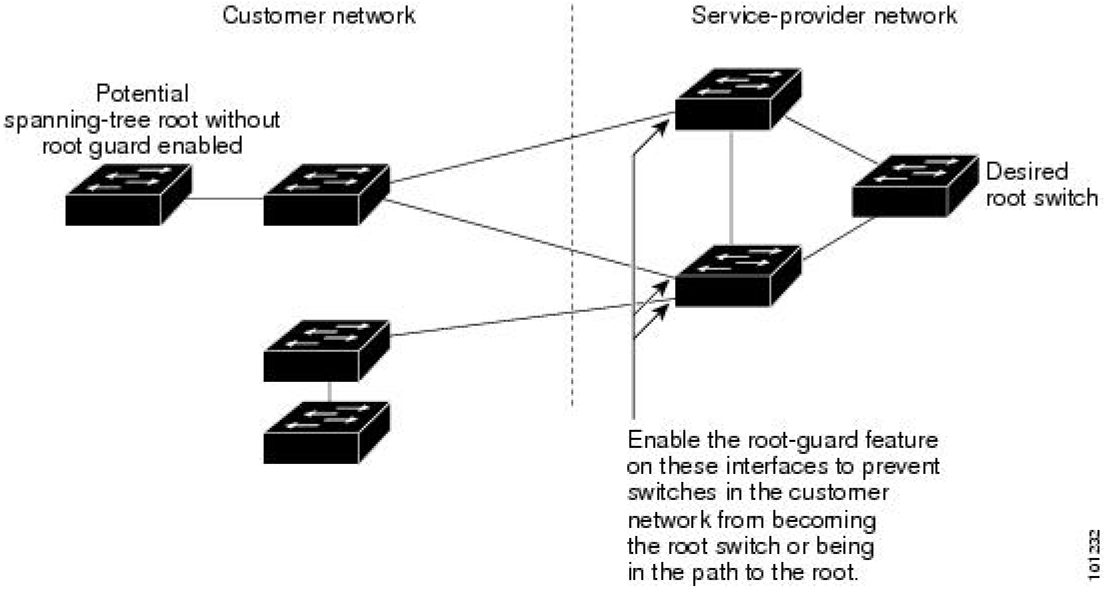
Related Topics

Enabling EtherChannel Guard , on page 246

Root Guard

Figure 22: Root Guard in a Service-Provider Network

The Layer 2 network of a service provider (SP) can include many connections to switches that are not owned by the SP. In such a topology, the spanning tree can reconfigure itself and select a customer switch as the root switch. You can avoid this situation by enabling root guard on SP switch interfaces that connect to switches in your customer's network. If spanning-tree calculations cause an interface in the customer network to be selected as the root port, root guard then places the interface in the root-inconsistent (blocked) state to prevent the customer's switch from becoming the root switch or being in the path to the root.


Customer network
Service-provider network
Potential spanning-tree root without root guard enabled
Desired root switch
Enable the root-guard feature on these interfaces to prevent switches in the customer network from becoming the root switch or being in the path to the root.
101232

If a switch outside the SP network becomes the root switch, the interface is blocked (root-inconsistent state), and spanning tree selects a new root switch. The customer's switch does not become the root switch and is not in the path to the root.

If the switch is operating in multiple spanning-tree (MST) mode, root guard forces the interface to be a designated port. If a boundary port is blocked in an internal spanning-tree (IST) instance because of root guard, the interface also is blocked in all MST instances. A boundary port is an interface that connects to a LAN, the designated switch of which is either an IEEE 802.1D switch or a switch with a different MST region configuration.

Root guard enabled on an interface applies to all the VLANs to which the interface belongs. VLANs can be grouped and mapped to an MST instance.

Caution Misuse of the root guard feature can cause a loss of connectivity.

Related Topics

Enabling Root Guard , on page 247

Loop Guard

You can use loop guard to prevent alternate or root ports from becoming designated ports because of a failure that leads to a unidirectional link. This feature is most effective when it is enabled on the entire switched network. Loop guard prevents alternate and root ports from becoming designated ports, and spanning tree does not send BPDUs on root or alternate ports.

When the switch is operating in PVST+ or rapid-PVST+ mode, loop guard prevents alternate and root ports from becoming designated ports, and spanning tree does not send BPDUs on root or alternate ports.

When the switch is operating in MST mode, BPDUs are not sent on nonboundary ports only if the interface is blocked by loop guard in all MST instances. On a boundary port, loop guard blocks the interface in all MST instances.

Related Topics

Enabling Loop Guard , on page 248

STP PortFast Port Types

You can configure a spanning tree port as an edge port, a network port, or a normal port. A port can be in only one of these states at a given time. The default spanning tree port type is normal. You can configure the port type either globally or per interface.

Depending on the type of device to which the interface is connected, you can configure a spanning tree port as one of these port types:

- A PortFast edge port—is connected to a Layer 2 host. This can be either an access port or an edge trunk port (**portfast edge trunk**). This type of port interface immediately transitions to the forwarding state, bypassing the listening and learning states. Use PortFast edge on Layer 2 access ports connected to a single workstation or server to allow those devices to connect to the network immediately, rather than waiting for spanning tree to converge.

  Even if the interface receives a bridge protocol data unit (BPDU), spanning tree does not place the port into the blocking state. Spanning tree sets the port's operating state to *non-port fast* even if the configured state remains *port fast edge* and starts participating in the topology change.

  Note If you configure a port connected to a Layer 2 switch or bridge as an edge port, you might create a bridging loop.

- A PortFast network port—is connected only to a Layer 2 switch or bridge. Bridge Assurance is enabled only on PortFast network ports. For more information, refer to *Bridge Assurance*.

  Note If you configure a port that is connected to a Layer 2 host as a spanning tree network port, the port will automatically move into the blocking state.

- A PortFast normal port—is the default type of spanning tree port.

Note Beginning with Cisco IOS Release 15.2(4)E, or IOS XE 3.8.0E, if you enter the **spanning-tree portfast** [trunk] command in the global or interface configuration mode, the system automatically saves it as **spanning-tree portfast edge** [trunk].

Related Topics

Enabling PortFast Port Types, on page 249

Bridge Assurance

You can use Bridge Assurance to help prevent looping conditions that are caused by unidirectional links (one-way traffic on a link or port), or a malfunction in a neighboring switch. Here a malfunction refers to a switch that is not able to run STP any more, while still forwarding traffic (a brain dead switch).

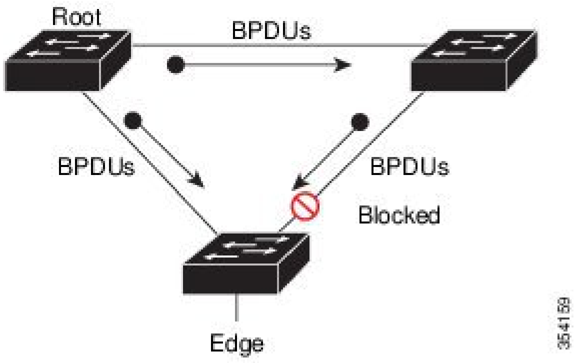
BPDUs are sent out on all operational network ports, including alternate and backup ports, for each hello time period. Bridge Assurance monitors the receipt of BPDUs on point-to-point links on all network ports. When a port does not receive BPDUs within the alloted hello time period, the port is put into a blocked state (the same as a port inconsistent state, which stops forwarding of frames). When the port resumes receipt of BPDUs, the port resumes normal spanning tree operations.

Note Only Rapid PVST+ and MST spanning tree protocols support Bridge Assurance. PVST+ does not support Bridge Assurance.

The following example shows how Bridge Assurance protects your network from bridging loops.

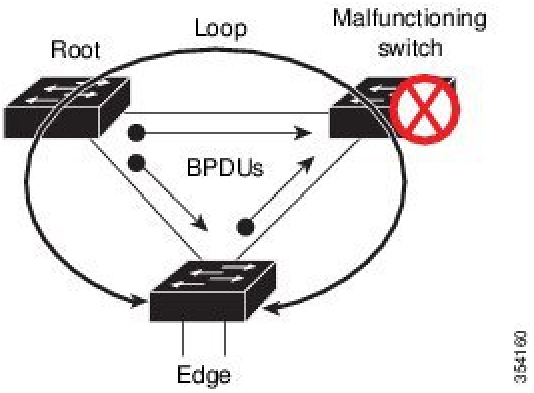
The following figure shows a network with normal STP topology.

Figure 23: Network with Normal STP Topology



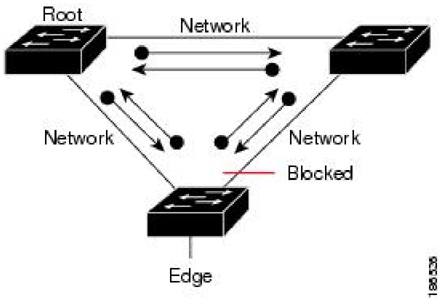
The following figure demonstrates a potential network problem when the device fails (brain dead) and Bridge Assurance is not enabled on the network.

Figure 24: Network Loop Due to a Malfunctioning Switch



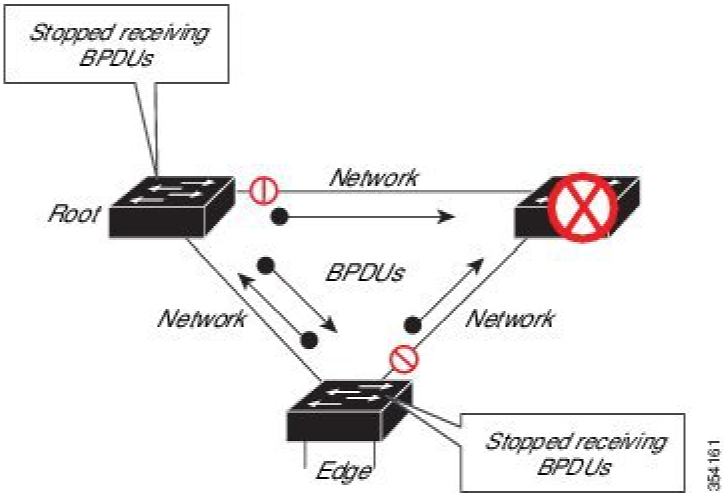
The following figure shows the network with Bridge Assurance enabled, and the STP topology progressing normally with bidirectional BDPUs issuing from every STP network port.

Figure 25: Network with STP Topology Running Bridge Assurance



The following figure shows how the potential network problem shown in figure *Network Loop Due to a Malfunctioning Switch* does not occur when you have Bridge Assurance enabled on your network.

Figure 26: Network Problem Averted with Bridge Assurance Enabled



The system generates syslog messages when a port is block and unblocked. The following sample output shows the log that is generated for each of these states:

BRIDGE_ASSURANCE_BLOCK

```
Sep 17 09:48:16.249 PDT: %SPANTREE-2-BRIDGE_ASSURANCE_BLOCK: Bridge Assurance blocking port
 GigabitEthernet0/1 on VLAN0001.
```

BRIDGE_ASSURANCE_UNBLOCK

```
Sep 17 09:48:58.426 PDT: %SPANTREE-2-BRIDGE_ASSURANCE_UNBLOCK: Bridge Assurance unblocking
 port GigabitEthernet0/1 on VLAN0001.
```

Follow these guidelines when enabling Bridge Assurance:

- It can only be enabled or disabled globally.
- It applies to all operational network ports, including alternate and backup ports.
- Only Rapid PVST+ and MST spanning tree protocols support Bridge Assurance. PVST+ does not support Bridge Assurance.
- For Bridge Assurance to work properly, it must be supported and configured on both ends of a point-to-point link. If the device on one side of the link has Bridge Assurance enabled and the device on the other side does not, the connecting port is blocked and in a Bridge Assurance inconsistent state. We recommend that you enable Bridge Assurance throughout your network.
- To enable Bridge Assurance on a port, BPDU filtering and BPDU Guard must be disabled.
- You can enable Bridge Assurance in conjunction with Loop Guard.
- You can enable Bridge Assurance in conjunction with Root Guard. The latter is designed to provide a way to enforce the root bridge placement in the network.

Related Topics

Enabling Bridge Assurance, on page 253

How to Configure Optional Spanning-Tree Features

Enabling PortFast

An interface with the PortFast feature enabled is moved directly to the spanning-tree forwarding state without waiting for the standard forward-time delay.

If you enable the voice VLAN feature, the PortFast feature is automatically enabled. When you disable voice VLAN, the PortFast feature is not automatically disabled.

You can enable this feature if your switch is running PVST+, Rapid PVST+, or MSTP.

Caution Use PortFast only when connecting a single end station to an access or trunk port. Enabling this feature on an interface connected to a switch or hub could prevent spanning tree from detecting and disabling loops in your network, which could cause broadcast storms and address-learning problems.

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree portfast** {**disable** | **edge** | **network**}
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies an interface to configure, and enters interface configuration mode.

Step 4	**spanning-tree portfast** {**disable** | **edge** | **network**}
	Example:
	`Switch(config-if)# spanning-tree portfast edge`
		Enables PortFast on an access port connected to a single workstation or server.
		Enter the following keywords for additional options:
		• Enter **disable** to disable portfast for the interface.
		• Enter **edge** to enable portfast edge for the interface.
		• Enter **network** to enable portfast network for the interface.
		By default, PortFast is disabled on all interfaces.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

What to do next

You can use the **spanning-tree portfast default** global configuration command to globally enable the PortFast feature on all nontrunking ports.

Related Topics

PortFast, on page 228
Restriction for Optional Spanning-Tree Features, on page 227

Enabling BPDU Guard

You can enable the BPDU guard feature if your switch is running PVST+, Rapid PVST+, or MSTP.

⚠ **Caution** Configure PortFast edge only on ports that connect to end stations; otherwise, an accidental topology loop could cause a data packet loop and disrupt switch and network operation.

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree portfast edge**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the interface connected to an end station, and enters interface configuration mode.
Step 4	**spanning-tree portfast edge** **Example:**	Enables the PortFast edge feature.

	Command or Action	Purpose
	`Switch(config-if)# spanning-tree portfast edge`	

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

What to do next

To prevent the port from shutting down, you can use the **errdisable detect cause bpduguard shutdown vlan** global configuration command to shut down just the offending VLAN on the port where the violation occurred.

You also can use the **spanning-tree bpduguard enable** interface configuration command to enable BPDU guard on any port without also enabling the PortFast edge feature. When the port receives a BPDU, it is put it in the error-disabled state.

Related Topics

BPDU Guard, on page 228

Enabling BPDU Filtering

You can also use the **spanning-tree bpdufilter enable** interface configuration command to enable BPDU filtering on any interface without also enabling the PortFast edge feature. This command prevents the interface from sending or receiving BPDUs.

Caution Enabling BPDU filtering on an interface is the same as disabling spanning tree on it and can result in spanning-tree loops.

You can enable the BPDU filtering feature if your switch is running PVST+, Rapid PVST+, or MSTP.

Caution Configure PortFast edge only on interfaces that connect to end stations; otherwise, an accidental topology loop could cause a data packet loop and disrupt switch and network operation.

This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree portfast edge bpdufilter default**
4. **interface** *interface-id*
5. **spanning-tree portfast edge**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree portfast edge bpdufilter default** **Example:** `Switch(config)# spanning-tree portfast edge bpdufilter default`	Globally enables BPDU filtering. By default, BPDU filtering is disabled.
Step 4	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the interface connected to an end station, and enters interface configuration mode.
Step 5	**spanning-tree portfast edge** **Example:** `Switch(config-if)# spanning-tree portfast edge`	Enables the PortFast edge feature on the specified interface.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Related Topics

BPDU Filtering, on page 229

Enabling UplinkFast for Use with Redundant Links

Note When you enable UplinkFast, it affects all VLANs on the switch. You cannot configure UplinkFast on an individual VLAN.

You can configure the UplinkFast feature for Rapid PVST+ or for the MSTP, but the feature remains disabled (inactive) until you change the spanning-tree mode to PVST+.

This procedure is optional. Follow these steps to enable UplinkFast and CSUF.

Before you begin

UplinkFast cannot be enabled on VLANs that have been configured with a switch priority. To enable UplinkFast on a VLAN with switch priority configured, first restore the switch priority on the VLAN to the default value using the **no spanning-tree vlan** *vlan-id* **priority** global configuration command.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree uplinkfast** [**max-update-rate** *pkts-per-second*]
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree uplinkfast** [**max-update-rate** *pkts-per-second*] **Example:** `Switch(config)# spanning-tree uplinkfast max-update-rate 200`	Enables UplinkFast. (Optional) For *pkts-per-second*, the range is 0 to 32000 packets per second; the default is 150. If you set the rate to 0, station-learning frames are not generated, and the spanning-tree topology converges more slowly after a loss of connectivity. When you enter this command, CSUF also is enabled on all nonstack port interfaces.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

When UplinkFast is enabled, the switch priority of all VLANs is set to 49152. If you change the path cost to a value less than 3000 and you enable UplinkFast or UplinkFast is already enabled, the path cost of all interfaces and VLAN trunks is increased by 3000 (if you change the path cost to 3000 or above, the path cost is not altered). The changes to the switch priority and the path cost reduce the chance that a switch will become the root switch.

When UplinkFast is disabled, the switch priorities of all VLANs and path costs of all interfaces are set to default values if you did not modify them from their defaults.

When you enable the UplinkFast feature using these instructions, CSUF is automatically globally enabled on nonstack port interfaces.

Related Topics

UplinkFast, on page 229
Cross-Stack UplinkFast
How Cross-Stack UplinkFast Works
Events That Cause Fast Convergence

Disabling UplinkFast

This procedure is optional.

Follow these steps to disable UplinkFast and Cross-Stack UplinkFast (CSUF).

Before you begin

UplinkFast must be enabled.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no spanning-tree uplinkfast**
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**no spanning-tree uplinkfast** **Example:** `Switch(config)# no spanning-tree uplinkfast`	Disables UplinkFast and CSUF on the switch and all of its VLANs.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

When UplinkFast is disabled, the switch priorities of all VLANs and path costs of all interfaces are set to default values if you did not modify them from their defaults.

When you disable the UplinkFast feature using these instructions, CSUF is automatically globally disabled on nonstack port interfaces.

Enabling BackboneFast

You can enable BackboneFast to detect indirect link failures and to start the spanning-tree reconfiguration sooner.

You can configure the BackboneFast feature for Rapid PVST+ or for the MSTP, but the feature remains disabled (inactive) until you change the spanning-tree mode to PVST+.

This procedure is optional. Follow these steps to enable BackboneFast on the switch.

Before you begin

If you use BackboneFast, you must enable it on all switches in the network. BackboneFast is not supported on Token Ring VLANs. This feature is supported for use with third-party switches.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree backbonefast**
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**spanning-tree backbonefast** **Example:** `Switch(config)# spanning-tree backbonefast`	Enables BackboneFast.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

BackboneFast, on page 231

Enabling EtherChannel Guard

You can enable EtherChannel guard to detect an EtherChannel misconfiguration if your switch is running PVST+, Rapid PVST+, or MSTP.

This procedure is optional.

Follow these steps to enable EtherChannel Guard on the switch.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree etherchannel guard misconfig**
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree etherchannel guard misconfig** **Example:**	Enables EtherChannel guard.

	Command or Action	Purpose
	`Switch(config)# spanning-tree etherchannel guard misconfig`	

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

What to do next

You can use the **show interfaces status err-disabled** privileged EXEC command to show which switch ports are disabled because of an EtherChannel misconfiguration. On the remote device, you can enter the **show etherchannel summary** privileged EXEC command to verify the EtherChannel configuration.

After the configuration is corrected, enter the **shutdown** and **no shutdown** interface configuration commands on the port-channel interfaces that were misconfigured.

Related Topics

EtherChannel Guard, on page 233

Enabling Root Guard

Root guard enabled on an interface applies to all the VLANs to which the interface belongs. Do not enable the root guard on interfaces to be used by the UplinkFast feature. With UplinkFast, the backup interfaces (in the blocked state) replace the root port in the case of a failure. However, if root guard is also enabled, all the backup interfaces used by the UplinkFast feature are placed in the root-inconsistent state (blocked) and are prevented from reaching the forwarding state.

Note You cannot enable both root guard and loop guard at the same time.

You can enable this feature if your switch is running PVST+, Rapid PVST+, or MSTP.

This procedure is optional.

Follow these steps to enable root guard on the switch.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **spanning-tree guard root**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies an interface to configure, and enters interface configuration mode.
Step 4	**spanning-tree guard root** **Example:** `Switch(config-if)# spanning-tree guard root`	Enables root guard on the interface. By default, root guard is disabled on all interfaces.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Related Topics

Root Guard, on page 234

Enabling Loop Guard

You can use loop guard to prevent alternate or root ports from becoming designated ports because of a failure that leads to a unidirectional link. This feature is most effective when it is configured on the entire switched network. Loop guard operates only on interfaces that are considered point-to-point by the spanning tree.

Note You cannot enable both loop guard and root guard at the same time.

You can enable this feature if your switch is running PVST+, Rapid PVST+, or MSTP.

This procedure is optional. Follow these steps to enable loop guard on the switch.

SUMMARY STEPS

1. Enter one of the following commands:

- **show spanning-tree active**
- **show spanning-tree mst**

2. **configure terminal**
3. **spanning-tree loopguard default**
4. **end**

DETAILED STEPS

	Command or Action	Purpose

Step 1	Enter one of the following commands:
	• **show spanning-tree active**
	• **show spanning-tree mst**
	Example:
	`Switch# show spanning-tree active`
	or
	`Switch# show spanning-tree mst`
		Verifies which interfaces are alternate or root ports.

Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree loopguard default** **Example:** `Switch(config)# spanning-tree loopguard default`	Enables loop guard. By default, loop guard is disabled.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Loop Guard, on page 235

Enabling PortFast Port Types

This section describes the different steps to enable Portfast Port types.

Related Topics

STP PortFast Port Types, on page 235

Configuring the Default Port State Globally

To configure the default PortFast state, perform this task:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree portfast** [**edge** | **network** | **normal**] **default**
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree portfast** [**edge** | **network** | **normal**] **default** **Example:** `Switch(config)# spanning-tree portfast default`	Configures the default state for all interfaces on the switch. You have these options: • (Optional) **edge**—Configures all interfaces as edge ports. This assumes all ports are connected to hosts/servers. • (Optional) **network**—Configures all interfaces as spanning tree network ports. This assumes all ports are connected to switches and bridges. Bridge Assurance is enabled on all network ports by default. • (Optional) **normal**—Configures all interfaces normal spanning tree ports. These ports can be connected to any type of device. • **default**—The default port type is normal.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Configuring PortFast Edge on a Specified Interface

Interfaces configured as edge ports immediately transition to the forwarding state, without passing through the blocking or learning states, on linkup.

Note Because the purpose of this type of port is to minimize the time that access ports must wait for spanning tree to converge, it is most effective when used on access ports. If you enable PortFast edge on a port connecting to another switch, you risk creating a spanning tree loop.

To configure an edge port on a specified interface, perform this task:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id* | **port-channel** *port_channel_number*
4. **spanning-tree portfast edge** [**trunk**]
5. end
6. **show running interface** *interface-id* | **port-channel** *port_channel_number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* | **port-channel** *port_channel_number* **Example:** `Switch(config)# interface gigabitethernet 0/1 | port-channel port_channel_number`	Specifies an interface to configure.
Step 4	**spanning-tree portfast edge** [**trunk**] **Example:** `Switch(config-if)# spanning-tree portfast trunk`	Enables edge behavior on a Layer 2 access port connected to an end workstation or server. • (Optional) **trunk**—Enables edge behavior on a trunk port. Use this keyword if the link is a trunk. Use this command only on ports that are connected to end host devices that terminate VLANs and from which the port should never receive STP BPDUs. Such end host

	Command or Action	Purpose
		devices include workstations, servers, and ports on routers that are not configured to support bridging. • Use the **no** version of the command to disable PortFast edge.

Step 5	end
	Example:
	`Switch(config-if)# end`
		Exits configuration mode.

Step 6	**show running interface** *interface-id* | **port-channel** *port_channel_number* **Example:** `Switch# show running interface gigabitethernet 0/1| port-channel port_channel_number`	Verifies the configuration.

Configuring a PortFast Network Port on a Specified Interface

Ports that are connected to Layer 2 switches and bridges can be configured as network ports.

Note Bridge Assurance is enabled only on PortFast network ports. For more information, refer to *Bridge Assurance*.

To configure a port as a network port, perform this task.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id* | **port-channel** *port_channel_number*
4. **spanning-tree portfast network**
5. end
6. **show running interface** *interface-id* | **port-channel** *port_channel_number*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**interface** *interface-id* | **port-channel** *port_channel_number*
	Example:
	`Switch(config)# interface gigabitethernet 0/1|`
	`port-channel port_channel_number`
		Specifies an interface to configure.

Step 4	**spanning-tree portfast network** **Example:** `Switch(config-if)# spanning-tree portfast network`	Enables edge behavior on a Layer 2 access port connected to an end workstation or server. • Configures the port as a network port. If you have enabled Bridge Assurance globally, it automatically runs on a spanning tree network port. • Use the **no** version of the command to disable PortFast.

Step 5	end
	Example:
	`Switch(config-if)# end`
		Exits configuration mode.

Step 6	**show running interface** *interface-id* | **port-channel** *port_channel_number*
	Example:
	`Switch# show running interface gigabitethernet 0/1`
	` | port-channel port_channel_number`
		Verifies the configuration.

Enabling Bridge Assurance

To configure the Bridge Assurance, perform the steps given below:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree bridge assurance**
4. **end**
5. **show spanning-tree summary**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree bridge assurance** **Example:** `Switch(config)# spanning-tree bridge assurance`	Enables Bridge Assurance on all network ports on the switch. Bridge Assurance is enabled by default. Use the **no** version of the command to disable the feature. Disabling Bridge Assurance causes all configured network ports to behave as normal spanning tree ports.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show spanning-tree summary** **Example:** `Switch# show spanning-tree summary`	Displays spanning tree information and shows if Bridge Assurance is enabled.

Related Topics

Bridge Assurance, on page 236

Examples

Examples: Configuring PortFast Edge on a Specified Interface

This example shows how to enable edge behavior on GigabitEthernet interface 0/1:

```
Switch# configure terminal
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# spanning-tree portfast edge
Switch(config-if)# end
Switch#
```

This example shows how to verify the configuration:

```
Switch# show running-config interface gigabitethernet0/1
Building configuration...
Current configuration:
!
interface GigabitEthernet0/1
no ip address
switchport
switchport access vlan 200
switchport mode access
spanning-tree portfast edge
end
```

This example shows how you can display that port GigabitEthernet 0/1 is currently in the edge state:

```
Switch# show spanning-tree vlan 200
VLAN0200
Spanning tree enabled protocol rstp
Root ID Priority 2
Address 001b.2a68.5fc0
Cost 3
Port 125 (GigabitEthernet5/9)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Bridge ID Priority 2 (priority 0 sys-id-ext 2)
Address 7010.5c9c.5200
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 0 sec
Interface Role Sts Cost Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi0/1 Desg FWD 4 128.1 P2p Edge
```

Examples: Configuring a PortFast Network Port on a Specified Interface

This example shows how to configure GigabitEthernet interface 0/1 as a network port:

```
Switch# configure terminal
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# spanning-tree portfast network
Switch(config-if)# end
Switch#
```

This example shows how to verify the configuration:

```
Switch# show running-config interface gigabitethernet0/1
Building configuration...
Current configuration:
!
interface GigabitEthernet0/1
no ip address
switchport
switchport access vlan 200
switchport mode access
spanning-tree portfast network
end
```

This example shows the output for show spanning-tree vlan

```
Switch# show spanning-tree vlan
Sep 17 09:51:36.370 PDT: %SYS-5-CONFIG_I: Configured from console by console2

VLAN0002
  Spanning tree enabled protocol rstp
  Root ID    Priority    2
             Address     7010.5c9c.5200
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    2      (priority 0 sys-id-ext 2)
             Address     7010.5c9c.5200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time  0   sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/1             Desg FWD 4         128.1    P2p Edge
Po4                 Desg FWD 3         128.480  P2p Network
Gi4/0/1             Desg FWD 4         128.169  P2p Edge
Gi4/0/47            Desg FWD 4         128.215  P2p Network

Switch#
```

Example: Configuring Bridge Assurance

This output shows port GigabitEthernet **0/1** has been configured as a network port and it is currently in the Bridge Assurance inconsistent state.

Note The output shows the port type as network and *BA_Inc, indicating that the port is in an inconsistent state.

```
Switch# show spanning-tree
VLAN0010
Spanning tree enabled protocol rstp
Root ID Priority 32778
Address 0002.172c.f400
This bridge is the root
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)
Address 0002.172c.f400
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300
Interface Role Sts   Cost    Prio.   Nbr    Type
---------------- ---- --- --------- -------- --------------------------------
Gi0/1    Desg BKN*4 128.270 Network, P2p *BA_Inc
```

The example shows the output for show spanning-tree summary.

```
Switch#sh spanning-tree summary
Switch is in rapid-pvst mode
Root bridge for: VLAN0001-VLAN0002, VLAN0128
EtherChannel misconfig guard            is enabled
Extended system ID                      is enabled
Portfast Default                        is network
Portfast Edge BPDU Guard Default        is disabled
Portfast Edge BPDU Filter Default       is disabled
Loopguard Default                       is enabled
PVST Simulation Default                 is enabled but inactive in rapid-pvst mode
Bridge Assurance                        is enabled
UplinkFast                              is disabled
BackboneFast                            is disabled
Configured Pathcost method used is short
```

```
Name                   Blocking Listening Learning Forwarding STP Active
---------------------- -------- --------- -------- ---------- ----------
VLAN0001                      0         0        0          5          5
VLAN0002                      0         0        0          4          4
VLAN0128                      0         0        0          4          4
---------------------- -------- --------- -------- ---------- ----------
3 vlans                       0         0        0         13         13

Switch#
```

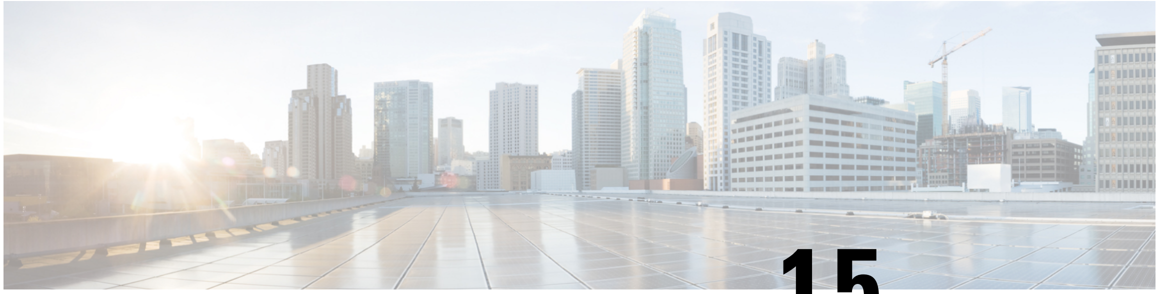
Monitoring the Spanning-Tree Status

Table 33: Commands for Monitoring the Spanning-Tree Status

Command	Purpose
show spanning-tree active	Displays spanning-tree information on active interfaces only.
show spanning-tree detail	Displays a detailed summary of interface information.
show spanning-tree interface *interface-id*	Displays spanning-tree information for the specified interface.
show spanning-tree mst interface *interface-id*	Displays MST information for the specified interface.
show spanning-tree summary [**totals**]	Displays a summary of interface states or displays the total lines of the spanning-tree state section.
show spanning-tree mst interface *interface-id* **portfast edge**	Displays spanning-tree portfast information for the specified interface.

Feature Information for Optional Spanning-Tree Features

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.



CHAPTER 15

Configuring Resilient Ethernet Protocol

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

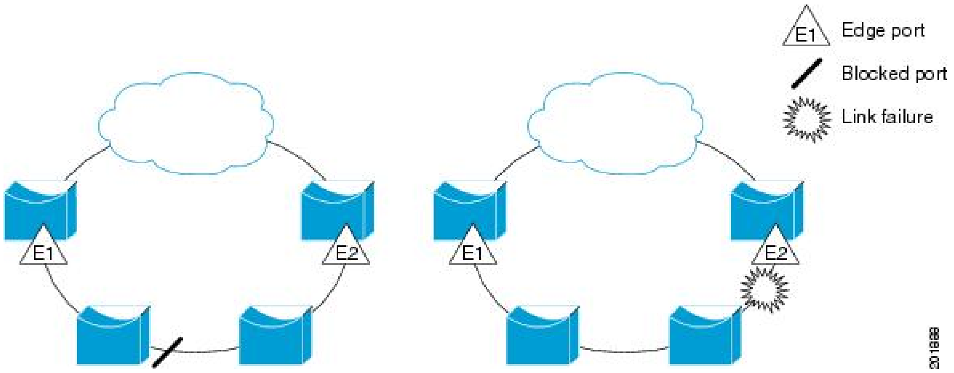
Overview of Resilient Ethernet Protocol

Resilient Ethernet Protocol (REP) is a Cisco-proprietary protocol that provides an alternative to Spanning Tree Protocol (STP) to control network loops, handle link failures, and improve convergence time. REP controls a group of ports connected in a segment, ensures that the segment does not create any bridging loops, and responds to link failures within the segment. REP provides a basis for constructing more complex networks and supports VLAN load balancing.

A REP segment is a chain of ports connected to each other and configured with a segment ID. Each segment consists of standard (nonedge) segment ports and two user-configured edge ports. A device can have no more than two ports that belong to the same segment, and each segment port can have only one external neighbor. A segment can go through a shared medium, but on any link, only two ports can belong to the same segment. REP is supported only on Trunk Ethernet Flow Point (EFP) interfaces.

The following figure shows an example of a segment consisting of six ports spread across four switches. Ports E1 and E2 are configured as edge ports. When all the ports are operational (as in the segment on the left), a single port is blocked, as shown by the diagonal line. When there is a failure in the network, the blocked port returns to the forwarding state to minimize network disruption.

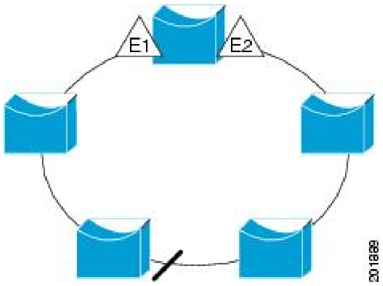
Figure 27: REP Open Segment



The segment shown in the figure above is an open segment; there is no connectivity between the two edge ports. The REP segment cannot cause a bridging loop, and you can safely connect the segment edges to any network. All the hosts connected to devices inside the segment have two possible connections to the rest of the network through the edge ports, but only one connection is accessible at any time. If a failure occurs on any segment or on any port on a REP segment, REP unblocks all the ports to ensure that connectivity is available through the other gateway.

The segment shown in the following figure is a ring segment, with both the edge ports located on the same device. With this configuration, you can create a redundant connection between any two devices in the segment.

Figure 28: REP Ring Segment



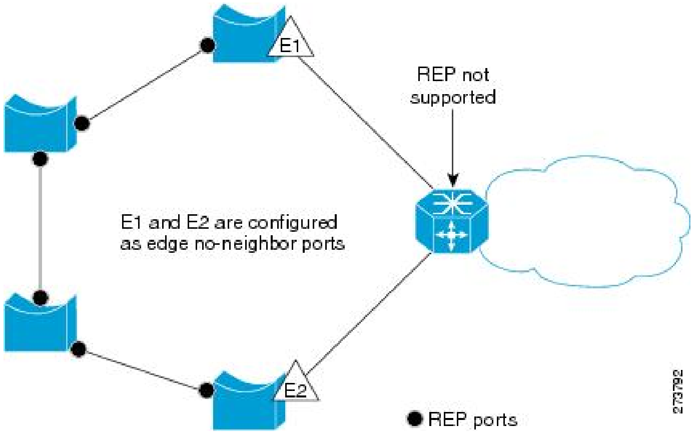
REP segments have the following characteristics:

- If all the ports in a segment are operational, one port (referred to as the *alternate* port) is in the blocked state for each VLAN. If VLAN load balancing is configured, two ports in the segment control the blocked state of VLANs.
- If one or more ports in a segment is not operational, and cause a link failure, all the ports forward traffic on all the VLANs to ensure connectivity.
- In case of a link failure, alternate ports are unblocked as quickly as possible. When the failed link is up, a logically blocked port per VLAN is selected with minimal disruption to the network.

You can construct almost any type of network based on REP segments. REP also supports VLAN load balancing, which is controlled by the primary edge port (any port in the segment).

In access ring-topologies, the neighboring switch might not support REP as shown in the following figure. In this scenario, you can configure the non-REP-facing ports (E1 and E2) as edge no-neighbor ports. These ports inherit all the properties of edge ports, and you can configure them the same as any edge port, including configuring them to send STP or REP topology change notices to the aggregation switch. In this scenario, the STP topology change notice (TCN) that is sent is a multiple spanning-tree (MST) STP message.

Figure 29: Edge No-Neighbor Ports



REP has these limitations:

- You must configure each segment port; an incorrect configuration might cause forwarding loops in the networks.
- REP can manage only a single failed port within the segment; multiple port failures within the REP segment cause loss of network connectivity.
- You should configure REP only in networks with redundancy. Configuring REP in a network without redundancy causes loss of connectivity.

Link Integrity

REP does not use an end-to-end polling function between edge ports to verify link integrity. It implements local link failure detection. The REP Link Status Layer (LSL) detects its REP-aware neighbor and establishes connectivity within the segment. All the VLANs are blocked on an interface until the neighbor is detected. After the neighbor is identified, REP determines which neighbor port should become the alternate port and which ports should forward traffic.

Each port in a segment has a unique port ID. The port ID format is similar to that used by the spanning tree algorithm: a port number (unique on the bridge) associated to a MAC address (unique in the network). When a segment port is coming up, its LSL starts sending packets that include the segment ID and the port ID. The port is declared as operational after it performs a three-way handshake with a neighbor in the same segment.

A segment port does not become operational if:

- No neighbor has the same segment ID.
- More than one neighbor has the same segment ID.
- A neighbor does not acknowledge a local port as a peer.

Each port creates an adjacency with its immediate neighbor. After the neighbor adjacencies are created, the ports negotiate with each other to determine the blocked port for the segment, which will function as the alternate port. All the other ports become unblocked. By default, REP packets are sent to a bridge protocol data unit-class MAC address. The packets can also be sent to a Cisco multicast address, which is used only to send blocked port advertisement (BPA) messages when there is a failure in the segment. The packets are dropped by the devices not running REP.

Fast Convergence

REP runs on a physical link basis and not on a per-VLAN basis. Only one hello message is required for all the VLANs, and this reduces the load on the protocol. We recommend that you create VLANs consistently on all the switches in a given segment and configure the same allowed VLANs on the REP trunk ports. To avoid the delay introduced by relaying messages in software, REP also allows some packets to be flooded to a regular multicast address. These messages operate at the hardware flood layer (HFL) and are flooded to the entire network, not just the REP segment. Switches that do not belong to the segment treat them as data traffic. You can control flooding of these messages by configuring an administrative VLAN for the entire domain or for a particular segment.

VLAN Load Balancing

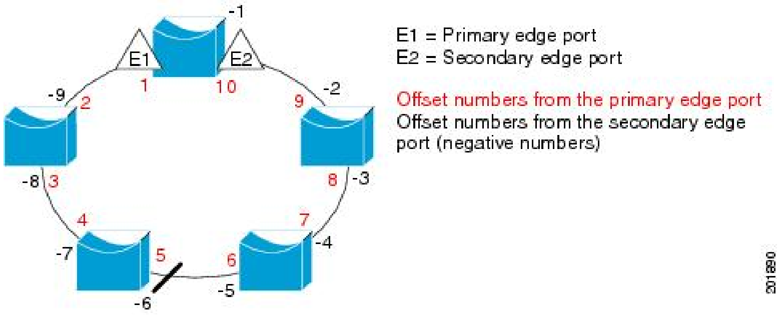
One edge port in the REP segment acts as the primary edge port; and another as the secondary edge port. It is the primary edge port that always participates in VLAN load balancing in the segment. REP VLAN balancing is achieved by blocking some VLANs at a configured alternate port and all the other VLANs at the primary edge port. When you configure VLAN load balancing, you can specify the alternate port in one of three ways:

- By entering the port ID of the interface. To identify the port ID of a port in the segment, enter the **show interface rep detail** interface configuration command for the port.
- By entering the **preferred** keyword to select the port that you previously configured as the preferred alternate port with the **rep segment** *segment-id* **preferred** interface configuration command.
- By entering the neighbor offset number of a port in the segment, which identifies the downstream neighbor port of an edge port. The neighbor offset number range is –256 to +256; a value of 0 is invalid. The primary edge port has an offset number of 1; positive numbers above 1 identify downstream neighbors of the primary edge port. Negative numbers indicate the secondary edge port (offset number -1) and its downstream neighbors.

Note Configure offset numbers on the primary edge port by identifying a port’s downstream position from the primary (or secondary) edge port. Never enter an offset value of 1 because that is the offset number of the primary edge port.

The following figure shows neighbor offset numbers for a segment, where E1 is the primary edge port and E2 is the secondary edge port. The numbers inside the ring are numbers offset from the primary edge port; the numbers outside of the ring show the offset numbers from the secondary edge port. Note that you can identify all the ports (except the primary edge port) by either a positive offset number (downstream position from the primary edge port) or a negative offset number (downstream position from the secondary edge port). If E2 became the primary edge port, its offset number would then be 1 and E1 would be -1.

Figure 30: Neighbor Offset Numbers in a Segment


-1
E1
E2
1
10
-9
2
-2
9
-8
3
8
-3
4
7
-7
5
6
-4
-6
-5
E1 = Primary edge port
E2 = Secondary edge port
Offset numbers from the primary edge port
Offset numbers from the secondary edge port (negative numbers)
201890

When the REP segment is complete, all the VLANs are blocked. When you configure VLAN load balancing, you must also configure triggers in one of two ways:

- Manually trigger VLAN load balancing at any time by entering the **rep preempt segment** *segment-id* privileged EXEC command on the switch that has the primary edge port.
- Configure a preempt delay time by entering the **rep preempt delay** *seconds* interface configuration command. After a link failure and recovery, VLAN load balancing begins after the configured preemption time period elapses. Note that the delay timer restarts if another port fails before the time has elapsed.

Note When VLAN load balancing is configured, it does not start working until triggered by either manual intervention or a link failure and recovery.

When VLAN load balancing is triggered, the primary edge port sends out a message to alert all the interfaces in the segment about the preemption. When the secondary port receives the message, the message is sent to the network to notify the alternate port to block the set of VLANs specified in the message and to notify the primary edge port to block the remaining VLANs.

You can also configure a particular port in the segment to block all the VLANs. Only the primary edge port initiates VLAN load balancing, which is not possible if the segment is not terminated by an edge port on each end. The primary edge port determines the local VLAN load-balancing configuration.

Reconfigure the primary edge port to reconfigure load balancing. When you change the load-balancing configuration, the primary edge port waits for the **rep preempt segment** command or for the configured preempt delay period after a port failure and recovery, before executing the new configuration. If you change an edge port to a regular segment port, the existing VLAN load-balancing status does not change. Configuring a new edge port might cause a new topology configuration.

Spanning Tree Interaction

REP does not interact with the STP or the Flex Link feature, but can coexist with both. A port that belongs to a segment is removed from spanning tree control, and STP BPDUs are not accepted or sent from segment ports. Therefore, STP cannot run on a segment.

To migrate from an STP ring configuration to an REP segment configuration, begin by configuring a single port in the ring as part of the segment and continue by configuring contiguous ports to minimize the number of segments. Since each segment always contains a blocked port, multiple segments means multiple blocked ports and a potential loss of connectivity. After the segment is configured in both directions up to the location of the edge ports, configure the edge ports.

REP Ports

REP segments consist of Failed, Open, or Alternate ports:

- A port configured as a regular segment port starts as a failed port.
- After the neighbor adjacencies are determined, the port transitions to alternate port state, blocking all the VLANs on the interface. Blocked-port negotiations occur, and when the segment settles, one blocked port remains in the alternate role and all the other ports become open ports.
- When a failure occurs in a link, all the ports move to the Failed state. When the Alternate port receives the failure notification, it changes to the Open state, forwarding all the VLANs.

A regular segment port converted to an edge port, or an edge port converted to a regular segment port, does not always result in a topology change. If you convert an edge port into a regular segment port, VLAN load balancing is not implemented unless it has been configured. For VLAN load balancing, you must configure two edge ports in the segment.

A segment port that is reconfigured as a spanning tree port restarts according to the spanning tree configuration. By default, this is a designated blocking port. If PortFast is configured or if STP is disabled, the port goes into the forwarding state.

How to Configure Resilient Ethernet Protocol

A segment is a collection of ports connected to one another in a chain and configured with a segment ID. To configure REP segments, configure the REP administrative VLAN (or use the default VLAN 1) and then add the ports to the segment, using interface configuration mode. You should configure two edge ports in a segment, with one of them being the primary edge port and the other the secondary edge port by default. A segment should have only one primary edge port. If you configure two ports in a segment as primary edge ports, for example, ports on different switches, the REP selects one of them to serve as the segment's primary edge port. If required, you can configure the location to which segment topology change notices (STCNs) and VLAN load balancing are to be sent.

Default REP Configuration

REP is disabled on all the interfaces. When enabled, the interface is a regular segment port unless it is configured as an edge port.

When REP is enabled, the task of sending segment topology change notices (STCNs) is disabled, all the VLANs are blocked, and the administrative VLAN is VLAN 1.

When VLAN load balancing is enabled, the default is manual preemption with the delay timer disabled. If VLAN load balancing is not configured, the default after manual preemption is to block all the VLANs in the primary edge port.

REP Configuration Guidelines

Follow these guidelines when configuring REP:

- We recommend that you begin by configuring one port and then configure contiguous ports to minimize the number of segments and the number of blocked ports.
- If more than two ports in a segment fail when no external neighbors are configured, one port goes into a forwarding state for the data path to help maintain connectivity during configuration. In the **show rep interface** command output, the Port Role for this port is displayed as **Fail Logical Open**; the Port Role for the other failed port is displayed as **Fail No Ext Neighbor**. When the external neighbors for the failed ports are configured, the ports go through the alternate port transitions and eventually go to an open state, or remain as the alternate port, based on the alternate port selection mechanism.
- REP ports must be Layer 2 IEEE 802.1Q or Trunk ports.
- We recommend that you configure all the trunk ports in a segment with the same set of allowed VLANs.
- Be careful when configuring REP through a Telnet connection because REP blocks all the VLANs until another REP interface sends a message to unblock it. You might lose connectivity to the router if you enable REP in a Telnet session that accesses the router through the same interface.
- You cannot run REP and STP or REP and Flex Links on the same segment or interface.
- If you connect an STP network to an REP segment, be sure that the connection is at the segment edge. An STP connection that is not at the edge might cause a bridging loop because STP does not run on REP segments. All the STP BPDUs are dropped at REP interfaces.
- You must configure all the trunk ports in a segment with the same set of allowed VLANs. If this is not done, misconfiguration occurs.
- If REP is enabled on two ports on a switch, both the ports must be either regular segment ports or edge ports. REP ports follow these rules:
  - There is no limit to the number of REP ports on a switch. However, only two ports on a switch can belong to the same REP segment.
  - If only one port on a switch is configured in a segment, the port should be an edge port.
  - If two ports on a switch belong to the same segment, they must both be edge ports, regular segment ports, or one regular port and one edge no-neighbor port. An edge port and regular segment port on a switch cannot belong to the same segment.
  - If two ports on a switch belong to the same segment, and one is configured as an edge port and one as a regular segment port (a misconfiguration), the edge port is treated as a regular segment port.
- REP interfaces come up in a blocked state and remain in a blocked state until they are safe to be unblocked. You must, therefore, be aware of the status of REP interfaces to avoid sudden connection losses.
- REP sends all the LSL PDUs in the untagged frames to the native VLAN. The BPA message sent to a Cisco multicast address is sent to the administration VLAN, which is VLAN 1 by default.
- You can configure the duration for which a REP interface remains up without receiving a hello from a neighbor. Use the **rep lsl-age-timer** value interface configuration command to set the time from 120 ms to 10000 ms. The LSL hello timer is then set to the age-timer value divided by 3. In normal operation, three LSL hellos are sent before the age timer on the peer switch expires and checks for hello messages.
  - EtherChannel port channel interfaces do not support LSL age-timer values less than 1000 ms. If you try to configure a value less than 1000 ms on a port channel, you receive an error message and the command is rejected.

- REP ports cannot be configured as one of the following port types:
    - Switched Port Analyzer (SPAN) destination port
    - Tunnel port
    - Access port
- REP is supported on EtherChannels, but not on an individual port that belongs to an EtherChannel.
- There can be a maximum of 64 REP segments per switch.

Configuring REP Administrative VLAN

To avoid the delay created by link-failure messages, and VLAN-blocking notifications during load balancing, REP floods packets to a regular multicast address at the hardware flood layer (HFL). These messages are flooded to the whole network, and not just the REP segment. You can control the flooding of these messages by configuring an administrative VLAN.

Follow these guidelines when configuring the REP administrative VLAN:

- If you do not configure an administrative VLAN, the default is VLAN 1.
- You can configure one admin VLAN on the switch for all segments.
- The administrative VLAN cannot be the RSPAN VLAN.

To configure the REP administrative VLAN, follow these steps, beginning in privileged EXEC mode:

SUMMARY STEPS

1. **configure terminal**
2. **rep admin vlan** *vlan-id*
3. **end**
4. **show interface** [*interface-id*] **rep detail**
5. **copy running-config startup config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**rep admin vlan** *vlan-id* **Example:** `Switch(config)# rep admin vlan 2`	Specifies the administrative VLAN. The range is from 2 to 4094. To set the admin VLAN to 1, which is the default, enter the **no rep admin vlan** global configuration command.

	Command or Action	Purpose

Step 3	**end**
	Example:
	`Switch(config)# end`
		Exits global configuration mode and returns to privileged EXEC mode.

Step 4	**show interface** [*interface-id*] **rep detail** **Example:** `Switch# show interface gigabitethernet1/1 rep detail`	(Optional) Verifies the configuration on a REP interface.
Step 5	**copy running-config startup config** **Example:** `Switch# copy running-config startup config`	(Optional) Saves your entries in the switch startup configuration file.

Configuring a REP Interface

To configure REP, enable REP on each segment interface and identify the segment ID. This task is mandatory, and must be done before other REP configurations. You must also configure a primary and secondary edge port on each segment. All the other steps are optional.

Follow these steps to enable and configure REP on an interface:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport mode trunk**
5. **rep segment** *segment-id* [**edge** [**no-neighbor**] [**primary**]] [**preferred**]
6. **rep stcn** {**interface** *interface id* | **segment** *id-list* | **stp**}
7. **rep block port** {**id** *port-id* | *neighbor-offset* | **preferred**} **vlan** {*vlan-list* | **all**}
8. **rep preempt delay** *seconds*
9. **rep lsl-age-timer** *value*
10. **end**
11. **show interface** [*interface-id*] **rep** [**detail**]
12. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch# interface gigabitethernet1/1`	Specifies the interface, and enters interface configuration mode. The interface can be a physical Layer 2 interface or a port channel (logical interface).
Step 4	**switchport mode trunk** **Example:** `Switch# switchport mode trunk`	Configures the interface as a Layer 2 trunk port.
Step 5	**rep segment** *segment-id* [**edge** [**no-neighbor**] [**primary**]] [**preferred**] **Example:** `Switch# rep segment 1 edge no-neighbor primary`	Enables REP on the interface and identifies a segment number. The segment ID range is from 1 to 1024. **Note** You must configure two edge ports, including one primary edge port, for each segment. These optional keywords are available: • (Optional) **edge**—Configures the port as an edge port. Each segment has only two edge ports. Entering the keyword **edge** without the keyword **primary** configures the port as the secondary edge port. • (Optional) **primary**—Configures the port as the primary edge port, the port on which you can configure VLAN load balancing. • (Optional) **no-neighbor**—Configures a port with no external REP neighbors as an edge port. The port inherits all the properties of an edge port, and you can configure the properties the same way you would for an edge port. **Note** Although each segment can have only one primary edge port, if you configure edge ports on two different switches and enter the keyword **primary** on both the switches, the configuration is valid. However, REP selects only one of these ports as the segment primary edge port. You can identify the primary edge port for a segment by entering the **show rep topology** privileged EXEC command. • (Optional) **preferred**—Indicates that the port is the preferred alternate port or the preferred port for VLAN load balancing.

	Command or Action	Purpose
		Note Configuring a port as preferred does not guarantee that it becomes the alternate port; it merely gives the port a slight edge over equal contenders. The alternate port is usually a previously failed port.

Step 6	**rep stcn** {**interface** *interface id* | **segment** *id-list* | **stp**}
	Example:
	`Switch# rep stcn segment 25-50`
		(Optional) Configures the edge port to send segment topology change notices (STCNs).
		• **interface** *interface-id*—Designates a physical interface or port channel to receive STCNs.
		• **segment** *id-list*—Identifies one or more segments to receive STCNs. The range is from 1 to 1024.
		• **stp**—Sends STCNs to STP networks.
		Note Spanning Tree (MST) mode is required on edge no-neighbor nodes when **rep stcn stp** command is configured for sending STCNs to STP networks.

Step 7	**rep block port** {**id** *port-id* | *neighbor-offset* | **preferred**} **vlan** {*vlan-list* | **all**}
	Example:
	`Switch# rep block port id 0009001818D68700 vlan 1-100`
		(Optional) Configures VLAN load balancing on the primary edge port, identifies the REP alternate port in one of three ways (**id** *port-id*, *neighbor_offset*, **preferred**), and configures the VLANs to be blocked on the alternate port.
		• **id** *port-id*—Identifies the alternate port by port ID. The port ID is automatically generated for each port in the segment. You can view interface port IDs by entering the **show interface** *type number* **rep** [**detail**] privileged EXEC command.
		• *neighbor_offset*—Number to identify the alternate port as a downstream neighbor from an edge port. The range is from -256 to 256, with negative numbers indicating the downstream neighbor from the secondary edge port. A value of **0** is invalid. Enter **-1** to identify the secondary edge port as the alternate port.
		Note Because you enter the **rep block port** command at the primary edge port (offset number 1), you cannot enter an offset value of 1 to identify an alternate port.
		• **preferred**—Selects the regular segment port previously identified as the preferred alternate port for VLAN load balancing.
		• **vlan** *vlan-list*—Blocks one VLAN or a range of VLANs.

	Command or Action	Purpose
		- **vlan all**—Blocks all the VLANs. **Note** Enter this command only on the REP primary edge port.
Step 8	**rep preempt delay** *seconds* **Example:** `Switch# rep preempt delay 100`	(Optional) Configures a preempt time delay. - Use this command if you want VLAN load balancing to be automatically triggered after a link failure and recovery. - The time delay range is between15 to 300 seconds. The default is manual preemption with no time delay. **Note** Enter this command only on the REP primary edge port.
Step 9	**rep lsl-age-timer** *value* **Example:** `Switch# rep lsl-age-timer 2000`	(Optional) Configures a time (in milliseconds) for which the REP interface remains up without receiving a hello from a neighbor. The range is from 120 to 10000 ms in 40-ms increments. The default is 5000 ms (5 seconds). **Note** - EtherChannel port channel interfaces do not support LSL age-timer values that are less than 1000 ms. - Both the ports on the link should have the same LSL age configured in order to avoid link flaps.

Step 10	**end**
	Example:
	`Switch(config)# end`
		Exits global configuration mode and returns to privileged EXEC mode.

Step 11	**show interface** [*interface-id*] **rep** [**detail**] **Example:** `Switch(config)# show interface gigabitethernet1/1 rep detail`	(Optional) Displays the REP interface configuration.
Step 12	**copy running-config startup-config** **Example:** `Switch(config)# copy running-config startup-config`	(Optional) Saves your entries in the router startup configuration file.

Setting Manual Preemption for VLAN Load Balancing

If you do not enter the **rep preempt delay** *seconds* interface configuration command on the primary edge port to configure a preemption time delay, the default is to manually trigger VLAN load balancing on the segment. Be sure that all the other segment configurations have been completed before manually preempting VLAN load balancing. When you enter the **rep preempt delay segment** *segment-id* command, a confirmation message is displayed before the command is executed because preemption might cause network disruption.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **rep preempt segment** *segment-id*
4. **show rep topology segment** *segment-id*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**rep preempt segment** *segment-id*
	Example:
	`Switch# rep preempt segment 100`
	`The command will cause a momentary traffic`
	`disruption.`
	`Do you still want to continue? [confirm]`
		Manually triggers VLAN load balancing on the segment.
		You need to confirm the command before it is executed.

Step 4	**show rep topology segment** *segment-id* **Example:** `Switch# show rep topology segment 100`	(Optional) Displays REP topology information.

Step 5	**end**
	Example:
	`Switch# end`
		Exits privileged EXEC mode.

Configuring SNMP Traps for REP

You can configure a router to send REP-specific traps to notify the Simple Network Management Protocol (SNMP) server of link-operational status changes and port role changes.

SUMMARY STEPS

1. **configure terminal**
2. **snmp mib rep trap-rate** *value*
3. **end**
4. **show running-config**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**snmp mib rep trap-rate** *value* **Example:** `Switch(config)# snmp mib rep trap-rate 500`	Enables the switch to send REP traps, and sets the number of traps sent per second. • Enter the number of traps sent per second. The range is from 0 to 1000. The default is 0 (no limit is imposed; a trap is sent at every occurrence).

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 4	**show running-config** **Example:** `Switch# show running-config`	(Optional) Displays the running configuration, which can be used to verify the REP trap configuration.
Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the switch startup configuration file.

Monitoring Resilient Ethernet Protocol Configuration

You can display the rep interface and rep topology details using the commands in this topic.

- **show interface** [*interface-id*] **rep** [**detail**]

Displays REP configuration and status for an interface or for all the interfaces.

- (Optional) **detail**—Displays interface-specific REP information.

Example:

```
Device# show interfaces TenGigabitEthernet4/1 rep detail

TenGigabitEthernet4/1 REP enabled
Segment-id: 3 (Primary Edge)
PortID: 03010015FA66FF80
Preferred flag: No
Operational Link Status: TWO_WAY
Current Key: 02040015FA66FF804050
Port Role: Open
Blocked VLAN: <empty>
Admin-vlan: 1
Preempt Delay Timer: disabled
Configured Load-balancing Block Port: none
Configured Load-balancing Block VLAN: none
STCN Propagate to: none
LSL PDU rx: 999, tx: 652
HFL PDU rx: 0, tx: 0
BPA TLV rx: 500, tx: 4
BPA (STCN, LSL) TLV rx: 0, tx: 0
BPA (STCN, HFL) TLV rx: 0, tx: 0
EPA-ELECTION TLV rx: 6, tx: 5
EPA-COMMAND TLV rx: 0, tx: 0
EPA-INFO TLV rx: 135, tx: 136
```

- **show rep topology** [**segment** *segment-id*] [**archive**] [**detail**]

Displays REP topology information for a segment or for all the segments, including the primary and secondary edge ports in the segment.

- (Optional) **archive**—Displays the last stable topology.

Note An archive topology is not retained when the switch reloads.

- (Optional) **detail**—Displays detailed archived information.

Example:

```
Device# show rep topology

REP Segment 1
BridgeName       PortName   Edge Role
---------------- ---------- ---- ----
10.64.106.63     Te5/4      Pri  Open
10.64.106.228    Te3/4           Open
10.64.106.228    Te3/3           Open
10.64.106.67     Te4/3           Open
10.64.106.67     Te4/4           Alt
10.64.106.63     Te4/4      Sec  Open

REP Segment 3
BridgeName       PortName   Edge Role
---------------- ---------- ---- ----
10.64.106.63     Gi50/1     Pri  Open
```

```
SVT_3400_2       Gi0/3           Open
SVT_3400_2       Gi0/4           Open
10.64.106.68     Gi40/2          Open
10.64.106.68     Gi40/1          Open
10.64.106.63     Gi50/2     Sec  Alt
```

Configuration Examples for Resilient Ethernet Protocol

This section provides the following configuration examples:

Example: Configuring the REP Administrative VLAN

This example shows how to configure the administrative VLAN as VLAN 100, and verify the configuration by entering the **show interface rep detail** command on one of the REP interfaces:

```
Switch# configure terminal
Switch(config)# rep admin vlan 100
Switch(config)# end
Switch# show interface gigabitethernet1/1 rep detail

GigabitEthernet1/1 REP enabled
Segment-id: 2 (Edge)
PortID: 00010019E7144680
Preferred flag: No
Operational Link Status: TWO_WAY
Current Key: 0002001121A2D5800E4D
Port Role: Open
Blocked Vlan: <empty>
Admin-vlan: 100
Preempt Delay Timer: disabled
LSL Ageout Timer: 5000 ms
Configured Load-balancing Block Port: none
Configured Load-balancing Block VLAN: none
STCN Propagate to: none
LSL PDU rx: 3322, tx: 1722
HFL PDU rx: 32, tx: 5
BPA TLV rx: 16849, tx: 508
BPA (STCN, LSL) TLV rx: 0, tx: 0
BPA (STCN, HFL) TLV rx: 0, tx: 0
EPA-ELECTION TLV rx: 118, tx: 118
EPA-COMMAND TLV rx: 0, tx: 0
EPA-INFO TLV rx: 4214, tx: 4190
```

The following example shows how to create an administrative VLAN per segment. Here, VLAN 2 is configured as the administrative VLAN only for REP segment 2. All the remaining segments that are not configured have VLAN 1 as the administrative VLAN by default.

```
Switch# configure terminal
Switch(config)# rep admin vlan 2 segment 2
Switch(config)# end
```

Example: Configuring a REP Interface

This example shows how to configure an interface as the primary edge port for segment 1, to send STCNs to segments 2 through 5, and to configure the alternate port as the port with port ID 0009001818D68700 to block all the VLANs after a preemption delay of 60 seconds after a segment port failure and recovery. The interface is configured to remain up for 6000 ms without receiving a hello from a neighbor.

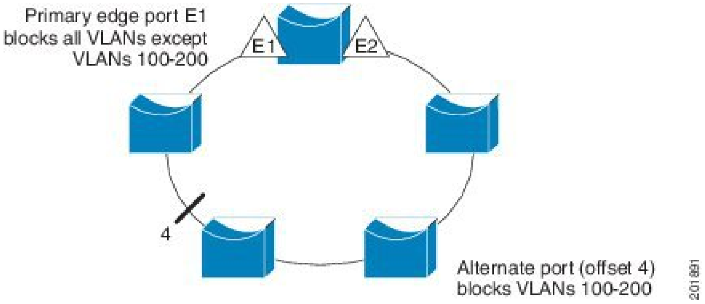
```
Switch# configure terminal
Switch (conf)# interface gigabitethernet1/1
Switch (conf-if)# rep segment 1 edge primary
Switch (conf-if)# rep stcn segment 2-5
Switch (conf-if)# rep block port 0009001818D68700 vlan all
Switch (conf-if)# rep preempt delay 60
Switch (conf-if)# rep lsl-age-timer 6000
Switch (conf-if)# end
```

This example shows how to configure the same configuration when the interface has no external REP neighbor:

```
Switch# configure terminal
Switch (conf)# interface gigabitethernet1/1
Switch (conf-if)# rep segment 1 edge no-neighbor primary
Switch (conf-if)# rep stcn segment 2-5
Switch (conf-if)# rep block port 0009001818D68700 vlan all
Switch (conf-if)# rep preempt delay 60
Switch (conf-if)# rep lsl-age-timer 6000
Switch (conf-if)# end
```

This example shows how to configure the VLAN blocking configuration shown in the Figure 5. The alternate port is the neighbor with neighbor offset number 4. After manual preemption, VLANs 100 to 200 are blocked at this port, and all the other VLANs are blocked at the primary edge port E1 (Gigabit Ethernet port 1/1).

Figure 31: Example of VLAN Blocking



```
Switch# configure terminal
Switch (conf)# interface gigabitethernet1/1
Switch (conf-if)# rep segment 1 edge primary
Switch (conf-if)# rep block port 4 vlan 100-200
Switch (conf-if)# end
```

Additional References for REP

Related Documents

Related Topic	Document Title
REP commands	

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use the Cisco MIB Locator found at: http://www.cisco.com/go/mibs.

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for Resilient Ethernet Protocol

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use the Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 34: Feature Information for Resilient Ethernet Protocol

Feature Name	Release	Feature Information
Resilient Ethernet Protocol	Cisco IOS Release 15.2(6)E1	This feature was introduced. In Cisco IOS Release 15.2(6)E1, this feature is supported on Cisco Catalyst 2960-L Series Switches, Cisco Catalyst 2960-X Series Switches, and Cisco Digital Building.

CHAPTER 16

Configuring EtherChannels

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for EtherChannels

- All ports in an EtherChannel must be assigned to the same VLAN or they must be configured as trunk ports.
- When the ports in an EtherChannel are configured as trunk ports, all the ports must be configured with the same mode (either Inter-Switch Link [ISL] or IEEE 802.1Q).

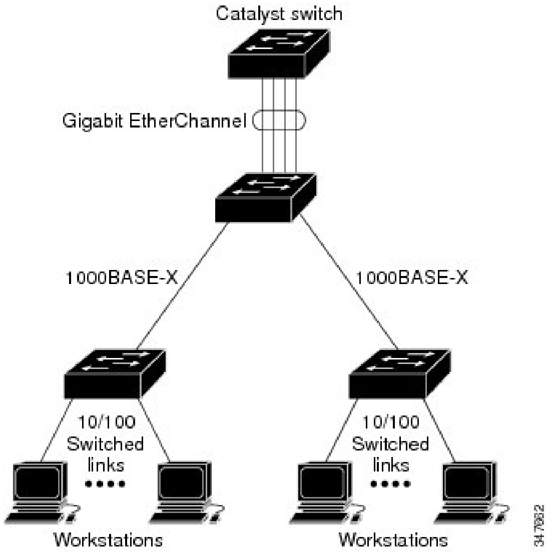
Information About EtherChannels

EtherChannel Overview

EtherChannel provides fault-tolerant high-speed links between switches, routers, and servers. You can use the EtherChannel to increase the bandwidth between the wiring closets and the data center, and you can deploy it anywhere in the network where bottlenecks are likely to occur. EtherChannel provides automatic recovery for the loss of a link by redistributing the load across the remaining links. If a link fails, EtherChannel redirects traffic from the failed link to the remaining links in the channel without intervention.

An EtherChannel consists of individual Ethernet links bundled into a single logical link.

Figure 32: Typical EtherChannel Configuration



The EtherChannel provides full-duplex bandwidth up to 8 Gb/s (Gigabit EtherChannel) or 40 Gb/s (10-Gigabit EtherChannel) between your switch and another switch or host. Note: Bandwidth upto 40 Gb/s (10-Gigabit EtherChannel) is supported with Cisco IOS Release 15.2(6)E and later releases.

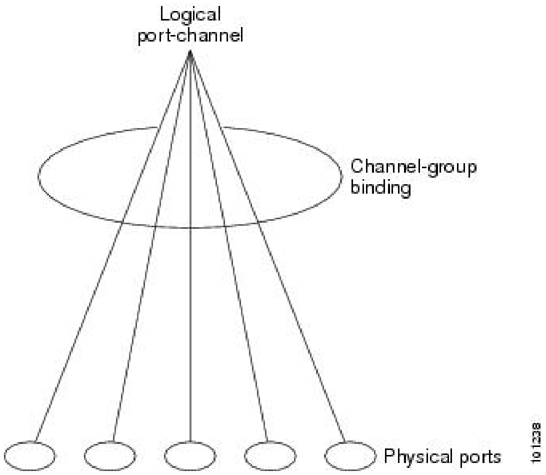
Each EtherChannel can consist of up to eight compatibly configured Ethernet ports.

Channel Groups and Port-Channel Interfaces

An EtherChannel comprises a channel group and a port-channel interface. The channel group binds physical ports to the port-channel interface. Configuration changes applied to the port-channel interface apply to all the physical ports bound together in the channel group.

Figure 33: Relationship of Physical Ports, Channel Group and Port-Channel Interface

The **channel-group** command binds the physical port and the port-channel interface together. Each EtherChannel has a port-channel logical interface numbered from 1 to 6. This port-channel interface number corresponds to the one specified with the **channel-group** interface configuration command.



- With Layer 2 ports, use the **channel-group** interface configuration command to dynamically create the port-channel interface.

  You also can use the **interface port-channel** *port-channel-number* global configuration command to manually create the port-channel interface, but then you must use the **channel-group** *channel-group-number* command to bind the logical interface to a physical port. The *channel-group-number* can be the same as the *port-channel-number,* or you can use a new number. If you use a new number, the **channel-group** command dynamically creates a new port channel.

Related Topics

Creating Port-Channel Logical Interfaces
EtherChannel Configuration Guidelines, on page 284
Default EtherChannel Configuration
Layer 2 EtherChannel Configuration Guidelines, on page 285
Configuring the Physical Interfaces

Port Aggregation Protocol

The Port Aggregation Protocol (PAgP) is a Cisco-proprietary protocol that can be run only on Cisco switches and on those switches licensed by vendors to support PAgP. PAgP facilitates the automatic creation of EtherChannels by exchanging PAgP packets between Ethernet ports.

By using PAgP, the switch learns the identity of partners capable of supporting PAgP and the capabilities of each port. It then dynamically groups similarly configured ports (on a single switch) into a single logical link (channel or aggregate port). Similarly configured ports are grouped based on hardware, administrative, and port parameter constraints. For example, PAgP groups the ports with the same speed, duplex mode, native VLAN, VLAN range, and trunking status and type. After grouping the links into an EtherChannel, PAgP adds the group to the spanning tree as a single switch port.

PAgP Modes

PAgP modes specify whether a port can send PAgP packets, which start PAgP negotiations, or only respond to PAgP packets received.

Table 35: EtherChannel PAgP Modes

Mode	Description
auto	Places a port into a passive negotiating state, in which the port responds to PAgP packets it receives but does not start PAgP packet negotiation. This setting minimizes the transmission of PAgP packets.
desirable	Places a port into an active negotiating state, in which the port starts negotiations with other ports by sending PAgP packets.

Switch ports exchange PAgP packets only with partner ports configured in the **auto** or **desirable** modes. Ports configured in the **on** mode do not exchange PAgP packets.

Both the **auto** and **desirable** modes enable ports to negotiate with partner ports to form an EtherChannel based on criteria such as port speed. and for Layer 2 EtherChannels, based on trunk state and VLAN numbers.

Ports can form an EtherChannel when they are in different PAgP modes as long as the modes are compatible. For example:

- A port in the **desirable** mode can form an EtherChannel with another port that is in the **desirable** or **auto** mode.
- A port in the **auto** mode can form an EtherChannel with another port in the **desirable** mode.

A port in the **auto** mode cannot form an EtherChannel with another port that is also in the **auto** mode because neither port starts PAgP negotiation.

Related Topics

Configuring Layer 2 EtherChannels , on page 287
EtherChannel Configuration Guidelines, on page 284
Default EtherChannel Configuration
Layer 2 EtherChannel Configuration Guidelines, on page 285
Creating Port-Channel Logical Interfaces
Configuring the Physical Interfaces

Silent Mode

If your switch is connected to a partner that is PAgP-capable, you can configure the switch port for nonsilent operation by using the **non-silent** keyword. If you do not specify **non-silent** with the **auto** or **desirable** mode, silent mode is assumed.

Use the silent mode when the switch is connected to a device that is not PAgP-capable and seldom, if ever, sends packets. An example of a silent partner is a file server or a packet analyzer that is not generating traffic. In this case, running PAgP on a physical port connected to a silent partner prevents that switch port from ever becoming operational. However, the silent setting allows PAgP to operate, to attach the port to a channel group, and to use the port for transmission.

Related Topics

Configuring Layer 2 EtherChannels , on page 287

EtherChannel Configuration Guidelines, on page 284
Default EtherChannel Configuration
Layer 2 EtherChannel Configuration Guidelines, on page 285
Creating Port-Channel Logical Interfaces
Configuring the Physical Interfaces

PAgP Learn Method and Priority

Network devices are classified as PAgP physical learners or aggregate-port learners. A device is a physical learner if it learns addresses by physical ports and directs transmissions based on that knowledge. A device is an aggregate-port learner if it learns addresses by aggregate (logical) ports. The learn method must be configured the same at both ends of the link.

When a device and its partner are both aggregate-port learners, they learn the address on the logical port-channel. The device sends packets to the source by using any of the ports in the EtherChannel. With aggregate-port learning, it is not important on which physical port the packet arrives.

PAgP cannot automatically detect when the partner device is a physical learner and when the local device is an aggregate-port learner. Therefore, you must manually set the learning method on the local device to learn addresses by physical ports. You also must set the load-distribution method to source-based distribution, so that any given source MAC address is always sent on the same physical port.

You also can configure a single port within the group for all transmissions and use other ports for hot-standby. The unused ports in the group can be swapped into operation in just a few seconds if the selected single port loses hardware-signal detection. You can configure which port is always selected for packet transmission by changing its priority with the **pagp port-priority** interface configuration command. The higher the priority, the more likely that the port will be selected.

Note The switch supports address learning only on aggregate ports even though the **physical-port** keyword is provided in the CLI. The **pagp learn-method** command and the **pagp port-priority** command have no effect on the switch hardware, but they are required for PAgP interoperability with devices that only support address learning by physical ports, such as the Catalyst 1900 switch.

Related Topics

Configuring the PAgP Learn Method and Priority , on page 289
EtherChannel Configuration Guidelines, on page 284
Default EtherChannel Configuration
Monitoring EtherChannel, PAgP, and LACP Status, on page 299
Layer 2 EtherChannel Configuration Guidelines, on page 285

PAgP Interaction with Other Features

The Dynamic Trunking Protocol (DTP) and the Cisco Discovery Protocol (CDP) send and receive packets over the physical ports in the EtherChannel. Trunk ports send and receive PAgP protocol data units (PDUs) on the lowest numbered VLAN.

In Layer 2 EtherChannels, the first port in the channel that comes up provides its MAC address to the EtherChannel. If this port is removed from the bundle, one of the remaining ports in the bundle provides its MAC address to the EtherChannel.

PAgP sends and receives PAgP PDUs only from ports that are up and have PAgP enabled for the auto or desirable mode.

Link Aggregation Control Protocol

The LACP is defined in IEEE 802.3ad and enables Cisco switches to manage Ethernet channels between switches that conform to the IEEE 802.3ad protocol. LACP facilitates the automatic creation of EtherChannels by exchanging LACP packets between Ethernet ports.

By using LACP, the switch learns the identity of partners capable of supporting LACP and the capabilities of each port. It then dynamically groups similarly configured ports into a single logical link (channel or aggregate port). Similarly configured ports are grouped based on hardware, administrative, and port parameter constraints. For example, LACP groups the ports with the same speed, duplex mode, native VLAN, VLAN range, and trunking status and type. After grouping the links into an EtherChannel, LACP adds the group to the spanning tree as a single switch port.

The independent mode behavior of ports in a port channel is changed. With CSCtn96950, by default, standalone mode is enabled. When no response is received from an LACP peer, ports in the port channel are moved to suspended state.

LACP Modes

LACP modes specify whether a port can send LACP packets or only receive LACP packets.

Table 36: EtherChannel LACP Modes

Mode	Description
active	Places a port into an active negotiating state in which the port starts negotiations with other ports by sending LACP packets.
passive	Places a port into a passive negotiating state in which the port responds to LACP packets that it receives, but does not start LACP packet negotiation. This setting minimizes the transmission of LACP packets.

Both the **active** and **passive LACP** modes enable ports to negotiate with partner ports to an EtherChannel based on criteria such as port speed, and for Layer 2 EtherChannels, based on trunk state and VLAN numbers.

Ports can form an EtherChannel when they are in different LACP modes as long as the modes are compatible. For example:

- A port in the **active** mode can form an EtherChannel with another port that is in the **active** or **passive** mode.
- A port in the **passive** mode cannot form an EtherChannel with another port that is also in the **passive** mode because neither port starts LACP negotiation.

Related Topics

Configuring Layer 2 EtherChannels , on page 287
EtherChannel Configuration Guidelines, on page 284
Default EtherChannel Configuration
Layer 2 EtherChannel Configuration Guidelines, on page 285

LACP Interaction with Other Features

The DTP and the CDP send and receive packets over the physical ports in the EtherChannel. Trunk ports send and receive LACP PDUs on the lowest numbered VLAN.

In Layer 2 EtherChannels, the first port in the channel that comes up provides its MAC address to the EtherChannel. If this port is removed from the bundle, one of the remaining ports in the bundle provides its MAC address to the EtherChannel.

LACP sends and receives LACP PDUs only from ports that are up and have LACP enabled for the active or passive mode.

EtherChannel On Mode

EtherChannel **on** mode can be used to manually configure an EtherChannel. The **on** mode forces a port to join an EtherChannel without negotiations. The **on** mode can be useful if the remote device does not support PAgP or LACP. In the **on** mode, a usable EtherChannel exists only when the switches at both ends of the link are configured in the **on** mode.

Ports that are configured in the **on** mode in the same channel group must have compatible port characteristics, such as speed and duplex. Ports that are not compatible are suspended, even though they are configured in the **on** mode.

Caution You should use care when using the **on** mode. This is a manual configuration, and ports on both ends of the EtherChannel must have the same configuration. If the group is misconfigured, packet loss or spanning-tree loops can occur.

Default EtherChannel Configuration

The default EtherChannel configuration is described in this table.

Table 37: Default EtherChannel Configuration

Feature	Default Setting
Channel groups	None assigned.
Port-channel logical interface	None defined.
PAgP mode	No default.
PAgP learn method	Aggregate-port learning on all ports.
PAgP priority	128 on all ports.
LACP mode	No default.
LACP learn method	Aggregate-port learning on all ports.
LACP port priority	32768 on all ports.

Feature	Default Setting
LACP system priority	32768.
LACP system ID	LACP system priority and the switch MAC address.

EtherChannel Configuration Guidelines

If improperly configured, some EtherChannel ports are automatically disabled to avoid network loops and other problems. Follow these guidelines to avoid configuration problems:

- Configure a PAgP EtherChannel with up to eight Ethernet ports of the same type.
- Configure a LACP EtherChannel with up to 16 Ethernet ports of the same type. Up to eight ports can be active, and up to eight ports can be in standby mode.
- Configure all ports in an EtherChannel to operate at the same speeds and duplex modes.
- Enable all ports in an EtherChannel. A port in an EtherChannel that is disabled by using the **shutdown** interface configuration command is treated as a link failure, and its traffic is transferred to one of the remaining ports in the EtherChannel.
- When a group is first created, all ports follow the parameters set for the first port to be added to the group. If you change the configuration of one of these parameters, you must also make the changes to all ports in the group:
    - Allowed-VLAN list
    - Spanning-tree path cost for each VLAN
    - Spanning-tree port priority for each VLAN
    - Spanning-tree Port Fast setting
- Do not configure a port to be a member of more than one EtherChannel group.
- Do not configure an EtherChannel in both the PAgP and LACP modes. EtherChannel groups running PAgP and LACP can coexist on the same switch. Individual EtherChannel groups can run either PAgP or LACP, but they cannot interoperate.
- Do not configure a secure port as part of an EtherChannel or the reverse.
- Do not configure a port that is an active or a not-yet-active member of an EtherChannel as an IEEE 802.1x port. If you try to enable IEEE 802.1x on an EtherChannel port, an error message appears, and IEEE 802.1x is not enabled.
- If EtherChannels are configured on switch interfaces, remove the EtherChannel configuration from the interfaces before globally enabling IEEE 802.1x on a switch by using the **dot1x system-auth-control** global configuration command.
- Do not enable link-state tracking on individual interfaces that will be part of a downstream Etherchannel interface.

Related Topics

Configuring Layer 2 EtherChannels , on page 287

EtherChannel Overview
EtherChannel Modes
EtherChannel on Switches
EtherChannel Link Failover
LACP Modes, on page 282
PAgP Modes , on page 280
Silent Mode, on page 280
Creating Port-Channel Logical Interfaces
Channel Groups and Port-Channel Interfaces, on page 278
Configuring the Physical Interfaces
Configuring EtherChannel Load-Balancing
Load-Balancing and Forwarding Methods
MAC Address Forwarding
IP Address Forwarding
Load-Balancing Advantages
Configuring the PAgP Learn Method and Priority , on page 289
PAgP Learn Method and Priority, on page 281
Configuring the LACP System Priority , on page 291
Configuring the LACP Port Priority , on page 292

Layer 2 EtherChannel Configuration Guidelines

When configuring Layer 2 EtherChannels, follow these guidelines:

- Assign all ports in the EtherChannel to the same VLAN, or configure them as trunks. Ports with different native VLANs cannot form an EtherChannel.
- An EtherChannel supports the same allowed range of VLANs on all the ports in a trunking Layer 2 EtherChannel. If the allowed range of VLANs is not the same, the ports do not form an EtherChannel even when PAgP is set to the **auto** or **desirable** mode.
- Ports with different spanning-tree path costs can form an EtherChannel if they are otherwise compatibly configured. Setting different spanning-tree path costs does not, by itself, make ports incompatible for the formation of an EtherChannel.

Related Topics

Configuring Layer 2 EtherChannels , on page 287
EtherChannel Overview
EtherChannel Modes
EtherChannel on Switches
EtherChannel Link Failover
LACP Modes, on page 282
PAgP Modes , on page 280
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Creating Port-Channel Logical Interfaces
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Configuring EtherChannel Load-Balancing

Load-Balancing and Forwarding Methods
MAC Address Forwarding
IP Address Forwarding
Load-Balancing Advantages
Configuring the PAgP Learn Method and Priority , on page 289
PAgP Learn Method and Priority, on page 281
Configuring the LACP System Priority , on page 291
Configuring the LACP Port Priority , on page 292

Auto-LAG

The auto-LAG feature provides the ability to auto create EtherChannels on ports connected to a switch. By default, auto-LAG is disabled globally and is enabled on all port interfaces. The auto-LAG applies to a switch only when it is enabled globally.

On enabling auto-LAG globally, the following scenarios are possible:

- All port interfaces participate in creation of auto EtherChannels provided the partner port interfaces have EtherChannel configured on them. For more information, see the *"The supported auto-LAG configurations between the actor and partner devices"* table below.
- Ports that are already part of manual EtherChannels cannot participate in creation of auto EtherChannels.
- When auto-LAG is disabled on a port interface that is already a part of an auto created EtherChannel, the port interface will unbundle from the auto EtherChannel.

The following table shows the supported auto-LAG configurations between the actor and partner devices:

Table 38: The supported auto-LAG configurations between the actor and partner devices

Actor/Partner	Active	Passive	Auto
Active	Yes	Yes	Yes
Passive	Yes	No	Yes
Auto	Yes	Yes	Yes

On disabling auto-LAG globally, all auto created Etherchannels become manual EtherChannels.

You cannot add any configurations in an existing auto created EtherChannel. To add, you should first convert it into a manual EtherChannel by executing the **port-channel**<*channel-number*>**persistent**.

Note Auto-LAG uses the LACP protocol to create auto EtherChannel. Only one EtherChannel can be automatically created with the unique partner devices.

Related Topics

Configuring Auto-LAG Globally, on page 296
Configuring Auto LAG: Examples, on page 301
Configuring Auto-LAG on a Port Interface, on page 297

Configuring Persistence with Auto-LAG, on page 298
Auto-LAG Configuration Guidelines, on page 287

Auto-LAG Configuration Guidelines

Follow these guidelines when configuring the auto-LAG feature.

- When auto-LAG is enabled globally and on the port interface , and if you do not want the port interface to become a member of the auto EtherChannel, disable the auto-LAG on the port interface.
- A port interface will not bundle to an auto EtherChannel when it is already a member of a manual EtherChannel. To allow it to bundle with the auto EtherChannel, first unbundle the manual EtherChannel on the port interface.
- When auto-LAG is enabled and auto EtherChannel is created, you can create multiple EtherChannels manually with the same partner device. But by default, the port tries to create auto EtherChannel with the partner device.
- The auto-LAG is supported only on Layer 2 EtherChannel. It is not supported on Layer 3 interface and Layer 3 EtherChannel.

Related Topics

Configuring Auto-LAG Globally, on page 296
Configuring Auto LAG: Examples, on page 301
Configuring Auto-LAG on a Port Interface, on page 297
Configuring Persistence with Auto-LAG, on page 298
Auto-LAG, on page 286

How to Configure EtherChannels

After you configure an EtherChannel, configuration changes applied to the port-channel interface apply to all the physical ports assigned to the port-channel interface, and configuration changes applied to the physical port affect only the port where you apply the configuration.

Configuring Layer 2 EtherChannels

You configure Layer 2 EtherChannels by assigning ports to a channel group with the **channel-group** interface configuration command. This command automatically creates the port-channel logical interface.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **switchport mode** {**access** | **trunk**}
4. **switchport access vlan** *vlan-id*
5. **channel-group** *channel-group-number* **mode** {**auto** [**non-silent**] | **desirable** [**non-silent**] | **on** } | { **active** | **passive**}
6. **end**

DETAILED STEPS

<table>
<tr><th></th><th>Command or Action</th><th>Purpose</th></tr>
<tr><td>Step 1</td><td>**configure terminal**
Example:
`Switch# configure terminal`</td><td>Enters global configuration mode.</td></tr>
<tr><td>Step 2</td><td>**interface** *interface-id*
Example:
`Switch(config)# interface gigabitethernet0/1`</td><td>Specifies a physical port, and enters interface configuration mode.
Valid interfaces are physical ports.
For a PAgP EtherChannel, you can configure up to eight ports of the same type and speed for the same group.
For a LACP EtherChannel, you can configure up to 16 Ethernet ports of the same type. Up to eight ports can be active, and up to eight ports can be in standby mode.</td></tr>
<tr><td>Step 3</td><td>**switchport mode** {**access** | **trunk**}
Example:
`Switch(config-if)# switchport mode access`</td><td>Assigns all ports as static-access ports in the same VLAN, or configure them as trunks.
If you configure the port as a static-access port, assign it to only one VLAN. The range is 1 to 4094.</td></tr>
<tr><td>Step 4</td><td>**switchport access vlan** *vlan-id*
Example:
`Switch(config-if)# switchport access vlan 22`</td><td>(Optional) If you configure the port as a static-access port, assign it to only one VLAN. The range is 1 to 4094.</td></tr>
<tr><td>Step 5</td><td>**channel-group** *channel-group-number* **mode** {**auto** [**non-silent**] | **desirable** [**non-silent**] | **on** } | { **active** | **passive**}
Example:
`Switch(config-if)# channel-group 5 mode auto`</td><td>Assigns the port to a channel group, and specifies the PAgP or the LACP mode.
For *channel-group-number*, the range is 1 to 6.
For **mode**, select one of these keywords:
• **auto** –Enables PAgP only if a PAgP device is detected. It places the port into a passive negotiating state, in which the port responds to PAgP packets it receives but does not start PAgP packet negotiation..
• **desirable** –Unconditionally enables PAgP. It places the port into an active negotiating state, in which the port starts negotiations with other ports by sending PAgP packets. .
• **on** –Forces the port to channel without PAgP or LACP. In the **on** mode, an EtherChannel exists only when a port group in the **on** mode is connected to another port group in the **on** mode.</td></tr>
</table>

	Command or Action	Purpose
		• **non-silent** –(Optional) If your switch is connected to a partner that is PAgP-capable, configures the switch port for nonsilent operation when the port is in the **auto** or **desirable** mode. If you do not specify **non-silent**, silent is assumed. The silent setting is for connections to file servers or packet analyzers. This setting allows PAgP to operate, to attach the port to a channel group, and to use the port for transmission. • **active**—Enables LACP only if a LACP device is detected. It places the port into an active negotiating state in which the port starts negotiations with other ports by sending LACP packets. • **passive** –Enables LACP on the port and places it into a passive negotiating state in which the port responds to LACP packets that it receives, but does not start LACP packet negotiation.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Related Topics

EtherChannel Overview
EtherChannel Modes
EtherChannel on Switches
EtherChannel Link Failover
LACP Modes, on page 282
PAgP Modes , on page 280
Silent Mode, on page 280
EtherChannel Configuration Guidelines, on page 284
Default EtherChannel Configuration
Layer 2 EtherChannel Configuration Guidelines, on page 285

Configuring the PAgP Learn Method and Priority

This task is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **pagp learn-method physical-port**
4. **pagp port-priority** *priority*

5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the port for transmission, and enters interface configuration mode.
Step 3	**pagp learn-method physical-port** **Example:** `Switch(config-if)# pagp learn-method physical port`	Selects the PAgP learning method. By default, **aggregation-port learning** is selected, which means the switch sends packets to the source by using any of the ports in the EtherChannel. With aggregate-port learning, it is not important on which physical port the packet arrives. Selects **physical-port** to connect with another switch that `is` a physical learner. The learning method must be configured the same at both ends of the link.
Step 4	**pagp port-priority** *priority* **Example:** `Switch(config-if)# pagp port-priority 200`	Assigns a priority so that the selected port is chosen for packet transmission. For *priority*, the range is 0 to 255. The default is 128. The higher the priority, the more likely that the port will be used for PAgP transmission.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Related Topics

PAgP Learn Method and Priority, on page 281
EtherChannel Configuration Guidelines, on page 284
Default EtherChannel Configuration
Monitoring EtherChannel, PAgP, and LACP Status, on page 299
Layer 2 EtherChannel Configuration Guidelines, on page 285

Configuring LACP Hot-Standby Ports

When enabled, LACP tries to configure the maximum number of LACP-compatible ports in a channel, up to a maximum of 16 ports. Only eight LACP links can be active at one time. The software places any additional links in a hot-standby mode. If one of the active links becomes inactive, a link that is in the hot-standby mode becomes active in its place.

If you configure more than eight links for an EtherChannel group, the software automatically decides which of the hot-standby ports to make active based on the LACP priority. To every link between systems that operate LACP, the software assigns a unique priority made up of these elements (in priority order):

- LACP system priority
- System ID (the switch MAC address)
- LACP port priority
- Port number

In priority comparisons, numerically lower values have higher priority. The priority decides which ports should be put in standby mode when there is a hardware limitation that prevents all compatible ports from aggregating.

Determining which ports are active and which are hot standby is a two-step procedure. First the system with a numerically lower system priority and system ID is placed in charge of the decision. Next, that system decides which ports are active and which are hot standby, based on its values for port priority and port number. The port priority and port number values for the other system are not used.

You can change the default values of the LACP system priority and the LACP port priority to affect how the software selects active and standby links.

Configuring the LACP System Priority

You can configure the system priority for all the EtherChannels that are enabled for LACP by using the **lacp system-priority** global configuration command. You cannot configure a system priority for each LACP-configured channel. By changing this value from the default, you can affect how the software selects active and standby links.

You can use the **show etherchannel summary** privileged EXEC command to see which ports are in the hot-standby mode (denoted with an H port-state flag).

Follow these steps to configure the LACP system priority. This procedure is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **lacp system-priority** *priority*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Switch> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**lacp system-priority** *priority* **Example:** `Switch(config)# lacp system-priority 32000`	Configures the LACP system priority. The range is 1 to 65535. The default is 32768. The lower the value, the higher the system priority.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

EtherChannel Configuration Guidelines, on page 284

Default EtherChannel Configuration

Layer 2 EtherChannel Configuration Guidelines, on page 285

Monitoring EtherChannel, PAgP, and LACP Status, on page 299

Configuring the LACP Port Priority

By default, all ports use the same port priority. If the local system has a lower value for the system priority and the system ID than the remote system, you can affect which of the hot-standby links become active first by changing the port priority of LACP EtherChannel ports to a lower value than the default. The hot-standby ports that have lower port numbers become active in the channel first. You can use the **show etherchannel summary** privileged EXEC command to see which ports are in the hot-standby mode (denoted with an H port-state flag).

Note If LACP is not able to aggregate all the ports that are compatible (for example, the remote system might have more restrictive hardware limitations), all the ports that cannot be actively included in the EtherChannel are put in the hot-standby state and are used only if one of the channeled ports fails.

Follow these steps to configure the LACP port priority. This procedure is optional.

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **interface** *interface-id*
4. **lacp port-priority** *priority*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the port to be configured, and enters interface configuration mode.
Step 4	**lacp port-priority** *priority* **Example:** `Switch(config-if)# lacp port-priority 32000`	Configures the LACP port priority. The range is 1 to 65535. The default is 32768. The lower the value, the more likely that the port will be used for LACP transmission.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Related Topics

EtherChannel Configuration Guidelines, on page 284
Default EtherChannel Configuration
Layer 2 EtherChannel Configuration Guidelines, on page 285
Monitoring EtherChannel, PAgP, and LACP Status, on page 299

Configuring the LACP Port Channel Min-Links Feature

You can specify the minimum number of active ports that must be in the link-up state and bundled in an EtherChannel for the port channel interface to transition to the link-up state. Using EtherChannel min-links, you can prevent low-bandwidth LACP EtherChannels from becoming active. Port channel min-links also cause LACP EtherChannels to become inactive if they have too few active member ports to supply the requiredminimum bandwidth.

To configure the minimum number of links that are required for a port channel. Perform the following tasks.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface port-channel** *channel-number*
4. **port-channel min-links** *min-links-number*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface port-channel** *channel-number* **Example:** `Switch(config)# interface port-channel 2`	Enters interface configuration mode for a port-channel. For *channel-number*, the range is 1 to 6.
Step 4	**port-channel min-links** *min-links-number* **Example:** `Switch(config-if)# port-channel min-links 3`	Specifies the minimum number of member ports that must be in the link-up state and bundled in the EtherChannel for the port channel interface to transition to the link-up state. For *min-links-number* , the range is 2 to 8.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Related Topics

Configuring LACP Port Channel Min-Links: Examples, on page 302

Configuring LACP Fast Rate Timer

You can change the LACP timer rate to modify the duration of the LACP timeout. Use the **lacp rate** command to set the rate at which LACP control packets are received by an LACP-supported interface. You can change the timeout rate from the default rate (30 seconds) to the fast rate (1 second). This command is supported only on LACP-enabled interfaces.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**fastethernet** | **gigabitethernet** | **tengigabitethernet**} *slot/port*
4. **lacp rate** {**normal** | **fast**}
5. **end**
6. **show lacp internal**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**fastethernet** | **gigabitethernet** | **tengigabitethernet**} *slot/port* **Example:** `Switch(config)# interface gigabitEthernet 2/1`	Configures an interface and enters interface configuration mode.

Step 4	**lacp rate** {**normal** | **fast**}
	Example:
	`Switch(config-if)# lacp rate fast`
		Configures the rate at which LACP control packets are received by an LACP-supported interface.
		• To reset the timeout rate to its default, use the **no lacp rate** command.

Step 5	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	

Step 6	**show lacp internal**
	Example:
	`Switch# show lacp internal`
	`Switch# show lacp counters`
		Verifies your configuration.

Related Topics

Example: Configuring LACP Fast Rate Timer, on page 302

Configuring Auto-LAG Globally

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. [**no**] **port-channel auto**
4. **end**
5. **show etherchannel auto**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	[**no**] **port-channel auto** **Example:** `Switch(config)# port-channel auto`	Enables the auto-LAG feature on a switch globally. Use the no form of this command to disable the auto-LAG feature on the switch globally. **Note** By default, the auto-LAG feature is enabled on the port.
Step 4	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 5	**show etherchannel auto** **Example:** `Switch# show etherchannel auto`	Displays that EtherChannel is created automatically.

Related Topics

Auto-LAG, on page 286
Auto-LAG Configuration Guidelines, on page 287
Configuring Auto LAG: Examples, on page 301
Configuring Auto-LAG on a Port Interface, on page 297
Configuring Persistence with Auto-LAG, on page 298

Configuring Auto-LAG on a Port Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. [**no**] **channel-group auto**
5. **end**
6. **show etherchannel auto**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port interface to be enabled for auto-LAG, and enters interface configuration mode.

	Command or Action	Purpose
Step 4	[no] **channel-group auto** **Example:** `Switch(config-if)# channel-group auto`	(Optional) Enables auto-LAG feature on individual port interface. Use the no form of this command to disable the auto-LAG feature on individual port interface. **Note** By default, the auto-LAG feature is enabled on the port.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**show etherchannel auto** **Example:** `Switch# show etherchannel auto`	Displays that EtherChannel is created automatically.

What to do next

Related Topics

Configuring Auto-LAG Globally, on page 296
Auto-LAG, on page 286
Auto-LAG Configuration Guidelines, on page 287
Configuring Persistence with Auto-LAG, on page 298
Configuring Auto LAG: Examples, on page 301

Configuring Persistence with Auto-LAG

You use the persistence command to convert the auto created EtherChannel into a manual one and allow you to add configuration on the existing EtherChannel.

SUMMARY STEPS

1. **enable**
2. **port-channel** *channel-number* **persistent**
3. **show etherchannel summary**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**port-channel** *channel-number* **persistent** **Example:**	Converts the auto created EtherChannel into a manual one and allows you to add configuration on the EtherChannel.

	Command or Action	Purpose
	`Switch# port-channel 1 persistent`	
Step 3	**show etherchannel summary** **Example:** `Switch# show etherchannel summary`	Displays the EtherChannel information.

Related Topics

Configuring Auto-LAG Globally, on page 296
Auto-LAG, on page 286
Auto-LAG Configuration Guidelines, on page 287
Configuring Auto-LAG on a Port Interface, on page 297
Configuring Auto LAG: Examples, on page 301

Monitoring EtherChannel, PAgP, and LACP Status

You can display EtherChannel, PAgP, and LACP status using the commands listed in this table.

Table 39: Commands for Monitoring EtherChannel, PAgP, and LACP Status

Command	Description
clear lacp { *channel-group-number* **counters** | **counters** }	Clears LACP channel-group information and traffic counters.
clear pagp { *channel-group-number* **counters** | **counters** }	Clears PAgP channel-group information and traffic counters.
show etherchannel [*channel-group-number* { **detail** | **load-balance** | **port** | **port-channel** | **protocol** | **summary** }] [**detail** | **load-balance** | **port** | **port-channel** | **protocol** | **auto** | **summary**]	Displays EtherChannel information in a brief, detailed, and one-line summary form. Also displays the load-balance or frame-distribution scheme, port, port-channel, protocol, and Auto-LAG information.
show pagp [*channel-group-number*] { **counters** | **internal** | **neighbor** }	Displays PAgP information such as traffic information, the internal PAgP configuration, and neighbor information.
show pagp [*channel-group-number*] **dual-active**	Displays the dual-active detection status.
show lacp [*channel-group-number*] { **counters** | **internal** | **neighbor** | **sys-id**}	Displays LACP information such as traffic information, the internal LACP configuration, and neighbor information.
show running-config	Verifies your configuration entries.
show etherchannel load-balance	Displays the load balance or frame distribution scheme among ports in the port channel.

Related Topics

Configuring the PAgP Learn Method and Priority , on page 289
PAgP Learn Method and Priority, on page 281
Configuring the LACP System Priority , on page 291
Configuring the LACP Port Priority , on page 292

Configuration Examples for Configuring EtherChannels

Configuring Layer 2 EtherChannels: Examples

This example shows how to configure an EtherChannel on a single switch. It assigns two ports as static-access ports in VLAN 10 to channel 5 with the PAgP mode **desirable**:

```
Switch# configure terminal
Switch(config)# interface range gigabitethernet0/1 -2
Switch(config-if-range)# switchport mode access
Switch(config-if-range)# switchport access vlan 10
Switch(config-if-range)# channel-group 5 mode desirable non-silent
Switch(config-if-range)# end
```

This example shows how to configure an EtherChannel on a single switch. It assigns two ports as static-access ports in VLAN 10 to channel 5 with the LACP mode **active** **:**

```
Switch# configure terminal
Switch(config)# interface range gigabitethernet0/1 -2
Switch(config-if-range)# switchport mode access
Switch(config-if-range)# switchport access vlan 10
Switch(config-if-range)# channel-group 5 mode active
Switch(config-if-range)# end
```

PoE or LACP negotiation errors may occur if you configure two ports from switch to the access point (AP). This scenario can be avoided if the port channel configuration is on the switch side. For more details, see the following example:

```
interface Port-channel1
  switchport access vlan 20
 switchport mode access
  switchport nonegotiate
  no port-channel standalone-disable   <--this one
  spanning-tree portfast
```

Note If the port reports LACP errors on port flap, you should include the following command as well: **no errdisable detect cause pagp-flap**

Configuring Auto LAG: Examples

This example shows how to configure Auto-LAG on a switch

```
switch> enable
switch# configure terminal
switch (config)# port-channel auto
switch (config-if)# end
switch#  show etherchannel auto
```

The following example shows the summary of EtherChannel that was created automatically.

```
switch# show etherchannel auto
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator
        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port
        A - formed by Auto LAG

Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1      Po1(SUA)        LACP      Gi1/0/45(P) Gi2/0/21(P) Gi3/0/21(P)
```

The following example shows the summary of auto EtherChannel after executing the **port-channel** 1 **persistent** command.

```
switch# port-channel 1 persistent

switch# show etherchannel summary
Switch# show etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator
        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port
        A - formed by Auto LAG

Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1      Po1(SU)         LACP      Gi1/0/45(P) Gi2/0/21(P) Gi3/0/21(P)
```

Related Topics

Configuring Auto-LAG Globally, on page 296

Auto-LAG, on page 286

Auto-LAG Configuration Guidelines, on page 287

Configuring Persistence with Auto-LAG, on page 298

Configuring Auto-LAG on a Port Interface, on page 297

Configuring LACP Port Channel Min-Links: Examples

This example shows how to configure LACP port-channel min-links:

```
switch > enable
switch# configure terminal
switch(config)# interface port-channel 5
switch(config-if)# port-channel min-links 3
switch#  show etherchannel 25 summary
switch# end
```

When the minimum links requirement is not met in standalone switches, the port-channel is flagged and assigned SM/SN or RM/RN state.

```
 switch# show etherchannel 5 summary

Flags: D - down P - bundled in port-channel
I - stand-alone s - suspended
H - Hot-standby (LACP only)
R - Layer3 S - Layer2
U - in use N- not in use, no aggregration
f - failed to allocate aggregator
M - not in use, no aggregation due to minimum links not met
m- not in use, port not aggregated due to minimum links not met
u - unsuitable for bundling
w - waiting to be aggregated
d - default port
Number of channel-groups in use: 6
Number of aggregators: 6

 Group   Port-channel   Protocol    Ports
------+-------------+-----------+-----------------------------------------------
 6       Po25(RM)        LACP        Gi1/3/1(D) Gi1/3/2(D) Gi2/2/25(D) Gi2/2/26(W)
```

Related Topics

Configuring the LACP Port Channel Min-Links Feature , on page 294

Example: Configuring LACP Fast Rate Timer

This example shows you how to configure the LACP rate:

```
switch> enable
switch# configure terminal
switch(config)# interface gigabitEthernet 2/1
switch(config-if)# lacp rate fast
switch(config-if)# exit
switch(config)# end
switch# show lacp internal
switch# show lacp counters
```

The following is sample output from the **show lacp internal** command:

```
switch# show lacp internal
Flags: S - Device is requesting Slow LACPDUs
F - Device is requesting Fast LACPDUs
A - Device is in Active mode P - Device is in Passive mode
Channel group 6
LACP port Admin Oper Port Port
Port Flags State Priority Key Key Number State
Te1/49 FA bndl 32768 0x19 0x19 0x32 0x3F
```

```
Te1/50 FA bndl 32768 0x19 0x19 0x33 0x3F
Te1/51 FA bndl 32768 0x19 0x19 0x34 0x3F
Te1/52 FA bndl 32768 0x19 0x19 0x35 0x3F
```

The following is sample output from the **show lacp counters** command:

```
switch# show lacp counters

LACPDUs Marker Marker Response LACPDUs
Port Sent Recv Sent Recv Sent Recv Pkts Err
---------------------------------------------------------------------
Channel group: 6
Te1/1/27 2 2 0 0 0 0 0
Te2/1/25 2 2 0 0 0 0 0
```

Related Topics

Configuring LACP Fast Rate Timer, on page 295

Additional References for EtherChannels

Related Documents

Related Topic	Document Title
Layer 2 command reference	

Standards and RFCs

Standard/RFC	Title
None	—

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for EtherChannels

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.
Cisco IOS 15.2(3)E2, Cisco IOS XE 3.7.2E	Auto-LAG feature was introduced.

CHAPTER 17

Configuring Link-State Tracking

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for Configuring Link-State Tracking

- You can configure only two link-state groups per switch.
- An interface cannot be a member of more than one link-state group.
- An interface that is defined as an upstream interface in a link-state group cannot also be defined as a downstream interface in the link-state group.
- Do not enable link-state tracking on individual interfaces that will part of a downstream EtherChannel interface.
- Add the upstream interfaces to the link state group before adding the downstream interfaces. Otherwise, the downstream interface is put in error-disabled state.

- When a downstream interface is configured as a SPAN destination port, it is placed in error-disabled state when all upstream interfaces in its group are down. When an upstream interface is configured as a SPAN destination port, it is considered as a link-down event on the interface.

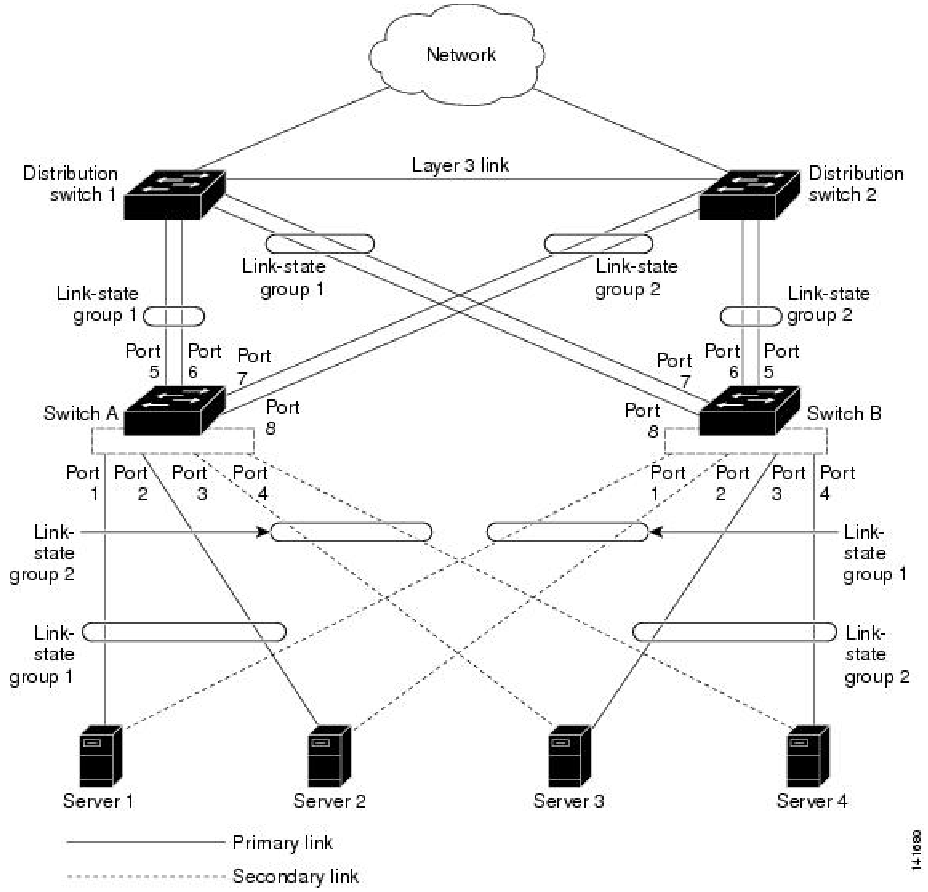
Understanding Link-State Tracking

Link-state tracking, also known as trunk failover, binds the link state of multiple interfaces. Link-state tracking can be with server NIC adapter teaming to provide redundancy in the network. When the server NIC adapters are configured in a primary or secondary relationship, and the link is lost on the primary interface, network connectivity is transparently changed to the secondary interface.

Note An interface can be an aggregation of ports (an EtherChannel) or a single physical port in either access or trunk mode .

The configuration in this figure ensures that the network traffic flow is balanced.

Figure 34: Typical Link-State Tracking Configuration



- For links to switches and other network devices

  - Server 1 and server 2 use switch A for primary links and switch B for secondary links.
  - Server 3 and server 4 use switch B for primary links and switch A for secondary links.

- Link-state group 1 on switch A
  - Switch A provides primary links to server 1 and server 2 through link-state group 1. Port 1 is connected to server 1, and port 2 is connected to server 2. Port 1 and port 2 are the downstream interfaces in link-state group 1.
  - Port 5 and port 6 are connected to distribution switch 1 through link-state group 1. Port 5 and port 6 are the upstream interfaces in link-state group 1.
- Link-state group 2 on switch A
  - Switch A provides secondary links to server 3 and server 4 through link-state group 2. Port 3 is connected to server 3, and port 4 is connected to server 4. Port 3 and port 4 are the downstream interfaces in link-state group 2.
  - Port 7 and port 8 are connected to distribution switch 2 through link-state group 2. Port 7 and port 8 are the upstream interfaces in link-state group 2.
- Link-state group 2 on switch B
  - Switch B provides primary links to server 3 and server 4 through link-state group 2. Port 3 is connected to server 3, and port 4 is connected to server 4. Port 3 and port 4 are the downstream interfaces in link-state group 2.
  - Port 5 and port 6 are connected to distribution switch 2 through link-state group 2. Port 5 and port 6 are the upstream interfaces in link-state group 2.
- Link-state group 1 on switch B
  - Switch B provides secondary links to server 1 and server 2 through link-state group 1. Port 1 is connected to server 1, and port 2 is connected to server 2. Port 1 and port 2 are the downstream interfaces in link-state group 1.
  - Port 7 and port 8 are connected to distribution switch 1 through link-state group 1. Port 7 and port 8 are the upstream interfaces in link-state group 1.

In a link-state group, the upstream ports can become unavailable or lose connectivity because the distribution switch or router fails, the cables are disconnected, or the link is lost. These are the interactions between the downstream and upstream interfaces when link-state tracking is enabled:

- If any of the upstream interfaces are in the link-up state, the downstream interfaces can change to or remain in the link-up state.
- If all of the upstream interfaces become unavailable, link-state tracking automatically puts the downstream interfaces in the error-disabled state. Connectivity to and from the servers is automatically changed from the primary server interface to the secondary server interface. For example, in the previous figure, if the upstream link for port 6 is lost, the link states of downstream ports 1 and 2 do not change. However, if the link for upstream port 5 is also lost, the link state of the downstream ports changes to the link-down state. Connectivity to server 1 and server 2 is then changed from link-state group1 to link-state group 2. The downstream ports 3 and 4 do not change state because they are in link-group 2.

- If the link-state group is configured, link-state tracking is disabled, and the upstream interfaces lose connectivity, the link states of the downstream interfaces remain unchanged. The server does not recognize that upstream connectivity has been lost and does not failover to the secondary interface.

You can recover a downstream interface link-down condition by removing the failed downstream port from the link-state group. To recover multiple downstream interfaces, disable the link-state group.

How to Configure Link-State Tracking

To enable link-state tracking, create a link-state group and specify the interfaces that are assigned to the group. This task is optional.

SUMMARY STEPS

1. **configure terminal**
2. **link state track** *number*
3. **interface** *interface-id*
4. **link state group** [*number*]{**upstream** | **downstream**}
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**link state track** *number* **Example:** `Switch(config)# link state track 2`	Creates a link-state group and enables link-state tracking. The group number can be 1 or 2; the default is 1.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/1`	Specifies a physical interface or range of interfaces to configure, and enters interface configuration mode. Valid interfaces include switch ports in access or trunk mode (IEEE 802.1q) or routed ports. **Note** Do not enable link-state tracking on individual interfaces that will be part of an Etherchannel interface.
Step 4	**link state group** [*number*]{**upstream**	**downstream**} **Example:**	Specifies a link-state group and configures the interface as either an upstream or downstream interface in the group.

	Command or Action	Purpose
	`Switch(config-if)# link state group 2 upstream`	

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Monitoring Link-State Tracking

You can display link-state tracking status using the command in this table.

Table 40: Commands for Monitoring Link-State Tracking Status

Command	Description
show link state group [*number*] [**detail**]	Displays the link-state group information.

Configuring Link-State Tracking: Example

This example shows how to create the link-state group 1 and configure the interfaces in the link-state group.

```
Switch# configure terminal
Switch(config)# link state track 1
Switch(config-if)# interface range gigabitethernet0/21-22
Switch(config-if)# link state group 1 upstream
Switch(config-if)# interface gigabitethernet0/1
Switch(config-if)# link state group 1 downstream
Switch(config-if)# interface gigabitethernet0/3
Switch(config-if)# link state group 1 downstream
Switch(config-if)# interface gigabitethernet0/5
Switch(config-if)# link state group 1 downstream
Switch(config-if)# end
```

Feature Information for Link-State Tracking

Release	Modification
Cisco IOS 15.2(6)E1	This feature was introduced.

CHAPTER 18

Configuring UniDirectional Link Detection

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for Configuring UDLD

The following are restrictions for configuring UniDirectional Link Detection (UDLD):

- A UDLD-capable port cannot detect a unidirectional link if it is connected to a UDLD-incapable port of another switch.
- When configuring the mode (normal or aggressive), make sure that the same mode is configured on both sides of the link.

Caution Loop guard works only on point-to-point links. We recommend that each end of the link has a directly connected device that is running STP.

Information About UDLD

UniDirectional Link Detection (UDLD) is a Layer 2 protocol that enables devices connected through fiber-optic or twisted-pair Ethernet cables to monitor the physical configuration of the cables and detect when a unidirectional link exists. All connected devices must support UDLD for the protocol to successfully identify and disable unidirectional links. When UDLD detects a unidirectional link, it disables the affected port and alerts you. Unidirectional links can cause a variety of problems, including spanning-tree topology loops.

Modes of Operation

UDLD two modes of operation: normal (the default) and aggressive. In normal mode, UDLD can detect unidirectional links due to misconnected ports on fiber-optic connections. In aggressive mode, UDLD can also detect unidirectional links due to one-way traffic on fiber-optic and twisted-pair links and to misconnected ports on fiber-optic links.

In normal and aggressive modes, UDLD works with the Layer 1 mechanisms to learn the physical status of a link. At Layer 1, autonegotiation takes care of physical signaling and fault detection. UDLD performs tasks that autonegotiation cannot perform, such as detecting the identities of neighbors and shutting down misconnected ports. When you enable both autonegotiation and UDLD, the Layer 1 and Layer 2 detections work together to prevent physical and logical unidirectional connections and the malfunctioning of other protocols.

A unidirectional link occurs whenever traffic sent by a local device is received by its neighbor but traffic from the neighbor is not received by the local device.

Normal Mode

In normal mode, UDLD detects a unidirectional link when fiber strands in a fiber-optic port are misconnected and the Layer 1 mechanisms do not detect this misconnection. If the ports are connected correctly but the traffic is one way, UDLD does not detect the unidirectional link because the Layer 1 mechanism, which is supposed to detect this condition, does not do so. In this case, the logical link is considered undetermined, and UDLD does not disable the port.

When UDLD is in normal mode, if one of the fiber strands in a pair is disconnected, as long as autonegotiation is active, the link does not stay up because the Layer 1 mechanisms detects a physical problem with the link. In this case, UDLD does not take any action and the logical link is considered undetermined.

Aggressive Mode

In aggressive mode, UDLD detects a unidirectional link by using the previous detection methods. UDLD in aggressive mode can also detect a unidirectional link on a point-to-point link on which no failure between the two devices is allowed. It can also detect a unidirectional link when one of these problems exists:

- On fiber-optic or twisted-pair links, one of the ports cannot send or receive traffic.
- On fiber-optic or twisted-pair links, one of the ports is down while the other is up.
- One of the fiber strands in the cable is disconnected.

In these cases, UDLD disables the affected port.

In a point-to-point link, UDLD hello packets can be considered as a heart beat whose presence guarantees the health of the link. Conversely, the loss of the heart beat means that the link must be shut down if it is not possible to reestablish a bidirectional link.

If both fiber strands in a cable are working normally from a Layer 1 perspective, UDLD in aggressive mode detects whether those fiber strands are connected correctly and whether traffic is flowing bidirectionally between the correct neighbors. This check cannot be performed by autonegotiation because autonegotiation operates at Layer 1.

Methods to Detect Unidirectional Links

UDLD operates by using two methods:

- Neighbor database maintenance
- Event-driven detection and echoing

Neighbor Database Maintenance

UDLD learns about other UDLD-capable neighbors by periodically sending a hello packet (also called an advertisement or probe) on every active port to keep each device informed about its neighbors.

When the switch receives a hello message, it caches the information until the age time (hold time or time-to-live) expires. If the switch receives a new hello message before an older cache entry ages, the switch replaces the older entry with the new one.

Whenever a port is disabled and UDLD is running, whenever UDLD is disabled on a port, or whenever the switch is reset, UDLD clears all existing cache entries for the ports affected by the configuration change. UDLD sends at least one message to inform the neighbors to flush the part of their caches affected by the status change. The message is intended to keep the caches synchronized.

Event-Driven Detection and Echoing

UDLD relies on echoing as its detection operation. Whenever a UDLD device learns about a new neighbor or receives a resynchronization request from an out-of-sync neighbor, it restarts the detection window on its side of the connection and sends echo messages in reply. Because this behavior is the same on all UDLD neighbors, the sender of the echoes expects to receive an echo in reply.

If the detection window ends and no valid reply message is received, the link might shut down, depending on the UDLD mode. When UDLD is in normal mode, the link might be considered undetermined and might not be shut down. When UDLD is in aggressive mode, the link is considered unidirectional, and the port is disabled.

UDLD Reset Options

If an interface becomes disabled by UDLD, you can use one of the following options to reset UDLD:

- The **udld reset** interface configuration command.
- The **shutdown** interface configuration command followed by the **no shutdown** interface configuration command restarts the disabled port.
- The **no udld** {**aggressive** | **enable**} global configuration command followed by the **udld** {**aggressive** | **enable**} global configuration command reenables the disabled ports.

- The **no udld port** interface configuration command followed by the **udld port** [**aggressive**] interface configuration command reenables the disabled fiber-optic port.
- The **errdisable recovery cause udld** global configuration command enables the timer to automatically recover from the UDLD error-disabled state, and the **errdisable recovery interval** *interval* global configuration command specifies the time to recover from the UDLD error-disabled state.

Default UDLD Configuration

Table 41: Default UDLD Configuration

Feature	Default Setting
UDLD global enable state	Globally disabled
UDLD per-port enable state for fiber-optic media	Disabled on all Ethernet fiber-optic ports
UDLD per-port enable state for twisted-pair (copper) media	Disabled on all Ethernet 10/100 and 1000BASE-TX ports
UDLD aggressive mode	Disabled

How to Configure UDLD

Enabling UDLD Globally

Follow these steps to enable UDLD in the aggressive or normal mode and to set the configurable message timer on all fiber-optic ports on the switch.

SUMMARY STEPS

1. **configure terminal**
2. **udld** {**aggressive** | **enable** | **message time** *message-timer-interval*}
3. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**udld** {**aggressive** | **enable** | **message time** *message-timer-interval*} **Example:**	Specifies the UDLD mode of operation: • **aggressive**—Enables UDLD in aggressive mode on all fiber-optic ports.

	Command or Action	Purpose
	`Switch(config)# udld enable message time 10`	• **enable**—Enables UDLD in normal mode on all fiber-optic ports on the switch. UDLD is disabled by default. An individual interface configuration overrides the setting of the **udld enable** global configuration command. • **message time** *message-timer-interval*—Configures the period of time between UDLD probe messages on ports that are in the advertisement phase and are detected to be bidirectional. The range is from 1 to 90 seconds; the default value is 15. **Note** This command affects fiber-optic ports only. Use the **udld** interface configuration command to enable UDLD on other port types. Use the **no** form of this command, to disable UDLD.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Enabling UDLD on an Interface

Follow these steps either to enable UDLD in the aggressive or normal mode or to disable UDLD on a port.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **udld port** [**aggressive**]
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be enabled for UDLD, and enters interface configuration mode.
Step 3	**udld port** [**aggressive**] **Example:** `Switch(config-if)# udld port aggressive`	UDLD is disabled by default. • **udld port**—Enables UDLD in normal mode on the specified port. • **udld port aggressive**—(Optional) Enables UDLD in aggressive mode on the specified port. **Note** Use the **no udld port** interface configuration command to disable UDLD on a specified fiber-optic port.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Monitoring and Maintaining UDLD

Command	Purpose
show udld [*interface-id* | **neighbors**]	Displays the UDLD status for the specified port or for all ports.

Additional References for UDLD

Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	

Standards and RFCs

Standard/RFC	Title
None	—

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for UDLD

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

PART V

Network Management

CHAPTER 19

Configuring Cisco IOS Configuration Engine

Prerequisites for Configuring the Configuration Engine

- Obtain the name of the configuration engine instance to which you are connecting.
- Because the CNS uses both the event bus and the configuration server to provide configurations to devices, you must define both ConfigID and Device ID for each configured switch.
- All switches configured with the **cns config partial** global configuration command must access the event bus. The DeviceID, as originated on the switch, must match the DeviceID of the corresponding switch definition in the Cisco Configuration Engine. You must know the hostname of the event bus to which you are connecting.

Restrictions for Configuring the Configuration Engine

- Within the scope of a single instance of the configuration server, no two configured switches can share the same value for ConfigID.
- Within the scope of a single instance of the event bus, no two configured switches can share the same value for DeviceID.

Information About Configuring the Configuration Engine

Cisco Configuration Engine Software

The Cisco Configuration Engine is network management utility software that acts as a configuration service for automating the deployment and management of network devices and services. Each Cisco Configuration Engine manages a group of Cisco devices (switches and routers) and the services that they deliver, storing their configurations and delivering them as needed. The Cisco Configuration Engine automates initial configurations and configuration updates by generating device-specific configuration changes, sending them to the device, executing the configuration change, and logging the results.

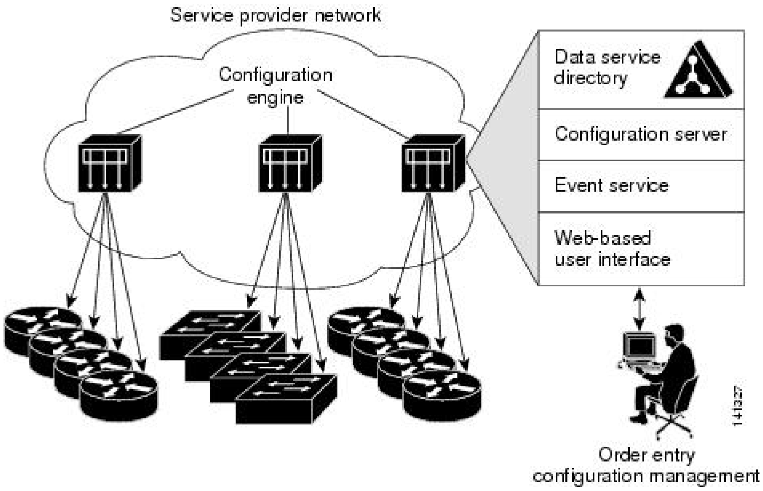
The Cisco Configuration Engine supports standalone and server modes and has these Cisco Networking Services (CNS) components:

- Configuration service:
    - Web server
    - File manager
    - Namespace mapping server
- Event service (event gateway)
- Data service directory (data models and schema)

Note Support for Cisco Configuration Engine will be deprecated in future releases. Use the configuration described in Cisco Plug and Play Feature Guide .

In standalone mode, the Cisco Configuration Engine supports an embedded directory service. In this mode, no external directory or other data store is required. In server mode, the Cisco Configuration Engine supports the use of a user-defined external directory.

Figure 35: Cisco Configuration Engine Architectural Overview



Configuration Service

The Configuration Service is the core component of the Cisco Configuration Engine. It consists of a Configuration Server that works with Cisco IOS CNS agents on the switch. The Configuration Service delivers device and service configurations to the switch for initial configuration and mass reconfiguration by logical groups. Switches receive their initial configuration from the Configuration Service when they start up on the network for the first time.

The Configuration Service uses the CNS Event Service to send and receive configuration change events and to send success and failure notifications.

The Configuration Server is a web server that uses configuration templates and the device-specific configuration information stored in the embedded (standalone mode) or remote (server mode) directory.

Configuration templates are text files containing static configuration information in the form of CLI commands. In the templates, variables are specified by using Lightweight Directory Access Protocol (LDAP) URLs that reference the device-specific configuration information stored in a directory.

The Cisco IOS agent can perform a syntax check on received configuration files and publish events to show the success or failure of the syntax check. The configuration agent can either apply configurations immediately or delay the application until receipt of a synchronization event from the configuration server.

Event Service

The Cisco Configuration Engine uses the Event Service for receipt and generation of configuration events. The Event Service consists of an event agent and an event gateway. The event agent is on the switch and facilitates the communication between the switch and the event gateway on the Cisco Configuration Engine.

The Event Service is a highly capable publish-and-subscribe communication method. The Event Service uses subject-based addressing to send messages to their destinations. Subject-based addressing conventions define a simple, uniform namespace for messages and their destinations.

NameSpace Mapper

The Cisco Configuration Engine includes the NameSpace Mapper (NSM) that provides a lookup service for managing logical groups of devices based on application, device or group ID, and event.

Cisco IOS devices recognize only event subject-names that match those configured in Cisco IOS software; for example, cisco.cns.config.load. You can use the namespace mapping service to designate events by using any desired naming convention. When you have populated your data store with your subject names, NSM changes your event subject-name strings to those known by Cisco IOS.

For a subscriber, when given a unique device ID and event, the namespace mapping service returns a set of events to which to subscribe. Similarly, for a publisher, when given a unique group ID, device ID, and event, the mapping service returns a set of events on which to publish.

Cisco Networking Services IDs and Device Hostnames

The Cisco Configuration Engine assumes that a unique identifier is associated with each configured switch. This unique identifier can take on multiple synonyms, where each synonym is unique within a particular namespace. The event service uses namespace content for subject-based addressing of messages.

The Cisco Configuration Engine intersects two namespaces, one for the event bus and the other for the configuration server. Within the scope of the configuration server namespace, the term *ConfigID* is the unique identifier for a device. Within the scope of the event bus namespace, the term *DeviceID* is the CNS unique identifier for a device.

ConfigID

Each configured switch has a unique ConfigID, which serves as the key into the Cisco Configuration Engine directory for the corresponding set of switch CLI attributes. The ConfigID defined on the switch must match the ConfigID for the corresponding switch definition on the Cisco Configuration Engine.

The ConfigID is fixed at startup time and cannot be changed until the device restarts, even if the switch hostname is reconfigured.

DeviceID

Each configured switch participating on the event bus has a unique DeviceID, which is analogous to the switch source address so that the switch can be targeted as a specific destination on the bus.

The origin of the DeviceID is defined by the Cisco IOS hostname of the switch. However, the DeviceID variable and its usage reside within the event gateway adjacent to the switch.

The logical Cisco IOS termination point on the event bus is embedded in the event gateway, which in turn functions as a proxy on behalf of the switch. The event gateway represents the switch and its corresponding DeviceID to the event bus.

The switch declares its hostname to the event gateway immediately after the successful connection to the event gateway. The event gateway couples the DeviceID value to the Cisco IOS hostname each time this connection is established. The event gateway retains this DeviceID value for the duration of its connection to the switch.

Hostname and DeviceID

The DeviceID is fixed at the time of the connection to the event gateway and does not change even when the switch hostname is reconfigured.

When changing the switch hostname on the switch, the only way to refresh the DeviceID is to break the connection between the switch and the event gateway. For instructions on refreshing DeviceIDs, see "Related Topics."

When the connection is reestablished, the switch sends its modified hostname to the event gateway. The event gateway redefines the DeviceID to the new value.

Caution When using the Cisco Configuration Engine user interface, you must first set the DeviceID field to the hostname value that the switch acquires *after*, not *before*, and you must reinitialize the configuration for your Cisco IOS CNS agent. Otherwise, subsequent partial configuration command operations may malfunction.

Hostname, DeviceID, and ConfigID

In standalone mode, when a hostname value is set for a switch, the configuration server uses the hostname as the DeviceID when an event is sent on hostname. If the hostname has not been set, the event is sent on the cn=<*value*> of the device.

In server mode, the hostname is not used. In this mode, the unique DeviceID attribute is always used for sending an event on the bus. If this attribute is not set, you cannot update the switch.

These and other associated attributes (tag value pairs) are set when you run **Setup** on the Cisco Configuration Engine.

Automated CNS Configuration

To enable automated CNS configuration of the switch, you must first complete the prerequisites listed in this topic. When you complete them, power on the switch. At the **setup** prompt, do nothing; the switch begins the initial configuration. When the full configuration file is loaded on your switch, you do not need to do anything else.

For more information on what happens during initial configuration, see "Related Topics."

Table 42: Prerequisites for Enabling Automatic Configuration

Device	Required Configuration
Access switch	Factory default (no configuration file)
Distribution switch	• IP helper address • Enable DHCP relay agent[2] • IP routing (if used as default gateway)

Device	Required Configuration
DHCP server	• IP address assignment • TFTP server IP address • Path to bootstrap configuration file on the TFTP server • Default gateway IP address
TFTP server	• A bootstrap configuration file that includes the CNS configuration commands that enable the switch to communicate with the Configuration Engine • The switch configured to use either the switch MAC address or the serial number (instead of the default hostname) to generate the ConfigID and EventID • The CNS event agent configured to push the configuration file to the switch
CNS Configuration Engine	One or more templates for each type of device, with the ConfigID of the device mapped to the template.

[2] A DHCP Relay is needed only when the DHCP Server is on a different subnet from the client.

How to Configure the Configuration Engine

Enabling the CNS Event Agent

Note You must enable the CNS event agent on the switch before you enable the CNS configuration agent.

Follow these steps to enable the CNS event agent on the switch.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **cns event** {*hostname* | *ip-address*} [*port-number*] [[**keepalive** *seconds retry-count*] [**failover-time** *seconds*] [**reconnect-time** *time*] | **backup**]
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**cns event** {*hostname* | *ip-address*} [*port-number*] [[**keepalive** *seconds retry-count*] [**failover-time** *seconds*] [**reconnect-time** *time*] | **backup**] **Example:** `Switch(config)# cns event 10.180.1.27 keepalive 120 10`	Enables the event agent, and enters the gateway parameters. • For {*hostname* | *ip-address*}, enter either the hostname or the IP address of the event gateway. • (Optional) For *port number*, enter the port number for the event gateway. The default port number is 11011. • (Optional) For **keepalive** *seconds*, enter how often the switch sends keepalive messages. For *retry-count*, enter the number of unanswered keepalive messages that the switch sends before the connection is terminated. The default for each is 0. • (Optional) For **failover-time** *seconds*, enter how long the switch waits for the primary gateway route after the route to the backup gateway is established. • (Optional) For **reconnect-time** *time*, enter the maximum time interval that the switch waits before trying to reconnect to the event gateway. • (Optional) Enter **backup** to show that this is the backup gateway. (If omitted, this is the primary gateway.) **Note** Though visible in the command-line help string, the **encrypt** and the **clock-timeout** *time* keywords are not supported.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

To verify information about the event agent, use the **show cns event connections** command in privileged EXEC mode.

To disable the CNS event agent, use the **no cns event** { *ip-address* | *hostname* } global configuration command.

Refreshing DeviceIDs

Follow these steps to refresh a DeviceID when changing the hostname on the switch.

SUMMARY STEPS

1. **enable**
2. **show cns config connections**
3. Make sure that the CNS event agent is properly connected to the event gateway.
4. **show cns event connections**
5. Record from the output of Step 4 the information for the currently connected connection listed below. You will be using the IP address and port number in subsequent steps of these instructions.
6. **configure terminal**
7. **no cns event** *ip-address port-number*
8. **cns event** *ip-address port-number*
9. **end**
10. Make sure that you have reestablished the connection between the switch and the event connection by examining the output from **show cns event connections**.
11. **show running-config**
12. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
	`Switch> enable`	
Step 2	**show cns config connections** **Example:** `Switch# show cns config connections`	Displays whether the CNS event agent is connecting to the gateway, connected, or active, and the gateway used by the event agent, its IP address and port number.
Step 3	Make sure that the CNS event agent is properly connected to the event gateway.	Examine the output of **show cns config connections** for the following: • Connection is active. • Connection is using the currently configured switch hostname. The DeviceID will be refreshed to correspond to the new hostname configuration using these instructions.
Step 4	**show cns event connections** **Example:** `Switch# show cns event connections`	Displays the event connection information for your switch.
Step 5	Record from the output of Step 4 the information for the currently connected connection listed below. You will be using the IP address and port number in subsequent steps of these instructions.	
Step 6	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 7	**no cns event** *ip-address port-number* **Example:** `Switch(config)# no cns event 172.28.129.22 2012`	Specifies the IP address and port number that you recorded in Step 5 in this command. This command breaks the connection between the switch and the event gateway. It is necessary to first break, then reestablish, this connection to refresh the DeviceID.
Step 8	**cns event** *ip-address port-number* **Example:** `Switch(config)# cns event 172.28.129.22 2012`	Specifies the IP address and port number that you recorded in Step 5 in this command. This command reestablishes the connection between the switch and the event gateway.

Step 9	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 10	Make sure that you have reestablished the connection between the switch and the event connection by examining the output from **show cns event connections**.	
Step 11	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 12	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring CNS Configurations

Table 43: CNS show Commands

Command	Purpose
show cns config connections `Switch# show cns config connections`	Displays the status of the CNS Cisco IOS CNS agent connections.
show cns config outstanding `Switch# show cns config outstanding`	Displays information about incremental (partial) CNS configurations that have started but are not yet completed.
show cns config stats `Switch# show cns config stats`	Displays statistics about the Cisco IOS CNS agent.
show cns event connections `Switch# show cns event connections`	Displays the status of the CNS event agent connections.
show cns event gateway `Switch# show cns event gateway`	Displays the event gateway information for your switch.
show cns event stats `Switch# show cns event stats`	Displays statistics about the CNS event agent.

Command	Purpose
show cns event subject `Switch# show cns event subject`	Displays a list of event agent subjects that are subscribed to by applications.

Additional References

Related Documents

Related Topic	Document Title
Configuration Engine Setup	*Cisco Configuration Engine Installation and Setup Guide, 1.5 for Linux* https://www.cisco.com/en/US/docs/net_mgmt/configuration_engine/1.5/installation_linux/guide/setup_1.html

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

Standards and RFCs

Standard/RFC	Title
None	-

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for the Configuration Engine

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 20

Configuring the Cisco Discovery Protocol

Cisco Discovery Protocol is a Layer 2, media-independent, and network-independent protocol that runs on Cisco devices and enables networking applications to learn about directly connected devices nearby. This protocol facilitates the management of Cisco devices by discovering these devices, determining how they are configured, and allowing systems using different network-layer protocols to learn about each other.

This module describes Cisco Discovery Protocol Version 2 and how it functions with SNMP.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About CDP

Cisco Discovery Protocol Overview

Cisco Discovery Protocol is a device discovery protocol that runs over Layer 2 (the data-link layer) on all Cisco-manufactured devices (routers, bridges, access servers, controllers, and switches) and allows network management applications to discover Cisco devices that are neighbors of already known devices. With Cisco Discovery Protocol, network management applications can learn the device type and the SNMP agent address of neighboring devices running lower-layer, transparent protocols. This feature enables applications to send SNMP queries to neighboring devices.

Cisco Discovery Protocol runs on all media that support Subnetwork Access Protocol (SNAP). Because Cisco Discovery Protocol runs over the data-link layer only, two systems that support different network-layer protocols can learn about each other.

Each Cisco Discovery Protocol-configured device sends periodic messages to a multicast address, advertising at least one address at which it can receive SNMP messages. The advertisements also contain time-to-live, or holdtime information, which is the length of time a receiving device holds Cisco Discovery Protocol information before discarding it. Each device also listens to the messages sent by other devices to learn about neighboring devices.

On the switch, Cisco Discovery Protocol enables Network Assistant to display a graphical view of the network. The switch uses Cisco Discovery Protocol to find cluster candidates and maintain information about cluster members and other devices up to three cluster-enabled devices away from the command switch by default.

- Cisco Discovery Protocol identifies connected endpoints that communicate directly with the switch.
- To prevent duplicate reports of neighboring devices, only one wired switch reports the location information.
- The wired switch and the endpoints both send and receive location information.

Related Topics

Configuring Cisco Discovery Protocol Characteristics, on page 334
Monitoring and Maintaining Cisco Discovery Protocol, on page 342

Default Cisco Discovery Protocol Configuration

This table shows the default Cisco Discovery Protocol configuration.

Feature	Default Setting
Cisco Discovery Protocol global state	Enabled
Cisco Discovery Protocol interface state	Enabled
Cisco Discovery Protocol timer (packet update frequency)	60 seconds
Cisco Discovery Protocol holdtime (before discarding)	180 seconds
Cisco Discovery Protocol Version-2 advertisements	Enabled

Related Topics

Enabling Cisco Discovery Protocol, on page 338
Disabling Cisco Discovery Protocol , on page 336
Enabling Cisco Discovery Protocol on an Interface, on page 341
Disabling Cisco Discovery Protocol on an Interface, on page 339

How to Configure CDP

Configuring Cisco Discovery Protocol Characteristics

You can configure these Cisco Discovery Protocol characteristics:

- Frequency of Cisco Discovery Protocol updates
- Amount of time to hold the information before discarding it
- Whether or not to send Version 2 advertisements

Note Steps 3 through 5 are all optional and can be performed in any order.

Follow these steps to configure the Cisco Discovery Protocol characteristics.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **cdp timer** *seconds*
4. **cdp holdtime** *seconds*
5. **cdp advertise-v2**
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**cdp timer** *seconds* **Example:** `Switch(config)# cdp timer 20`	(Optional) Sets the transmission frequency of Cisco Discovery Protocol updates in seconds. The range is 5 to 254; the default is 60 seconds.
Step 4	**cdp holdtime** *seconds* **Example:** `Switch(config)# cdp holdtime 60`	(Optional) Specifies the amount of time a receiving device should hold the information sent by your device before discarding it. The range is 10 to 255 seconds; the default is 180 seconds.

	Command or Action	Purpose
Step 5	**cdp advertise-v2** **Example:** `Switch(config)# cdp advertise-v2`	(Optional) Configures Cisco Discovery Protocol to send Version 2 advertisements. This is the default state.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

Use the **no** form of the Cisco Discovery Protocol commands to return to the default settings.

Related Topics

Cisco Discovery Protocol Overview, on page 333
Monitoring and Maintaining Cisco Discovery Protocol, on page 342

Disabling Cisco Discovery Protocol

Cisco Discovery Protocol is enabled by default.

Note Switch clusters and other Cisco devices (such as Cisco IP Phones) regularly exchange Cisco Discovery Protocol messages. Disabling Cisco Discovery Protocol can interrupt cluster discovery and device connectivity.

Follow these steps to disable the Cisco Discovery Protocol device discovery capability.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no cdp run**
4. **end**

5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**no cdp run** **Example:** `Switch(config)# no cdp run`	Disables Cisco Discovery Protocol.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

You must reenable Cisco Discovery Protocol to use it.

Related Topics

Enabling Cisco Discovery Protocol, on page 338
Default Cisco Discovery Protocol Configuration, on page 334

Enabling Cisco Discovery Protocol

Cisco Discovery Protocol is enabled by default.

> **Note** Switch clusters and other Cisco devices (such as Cisco IP Phones) regularly exchange Cisco Discovery Protocol messages. Disabling Cisco Discovery Protocol can interrupt cluster discovery and device connectivity.

Follow these steps to enable Cisco Discovery Protocol when it has been disabled.

Before you begin

Cisco Discovery Protocol must be disabled, or it cannot be enabled.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **cdp run**
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**cdp run** **Example:** `Switch(config)# cdp run`	Enables Cisco Discovery Protocol if it has been disabled.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

Use the **show run all** command to show that Cisco Discovery Protocol has been enabled. If you enter only **show run**, the enabling of Cisco Discovery Protocol may not be displayed.

Related Topics

Default Cisco Discovery Protocol Configuration, on page 334

Disabling Cisco Discovery Protocol , on page 336

Disabling Cisco Discovery Protocol on an Interface

Cisco Discovery Protocol is enabled by default on all supported interfaces to send and to receive Cisco Discovery Protocol information.

Note Switch clusters and other Cisco devices (such as Cisco IP Phones) regularly exchange Cisco Discovery Protocol messages. Disabling Cisco Discovery Protocol can interrupt cluster discovery and device connectivity.

Note Cisco Discovery Protocol bypass is not supported and may cause a port go into err-disabled state.

Follow these steps to disable Cisco Discovery Protocol on a port.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **no cdp enable**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the interface on which you are disabling Cisco Discovery Protocol, and enters interface configuration mode.
Step 4	**no cdp enable** **Example:** `Switch(config-if)# no cdp enable`	Disables Cisco Discovery Protocol on the interface specified in Step 3.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

Enabling Cisco Discovery Protocol on an Interface, on page 341

Default Cisco Discovery Protocol Configuration, on page 334

Enabling Cisco Discovery Protocol on an Interface

Cisco Discovery Protocol is enabled by default on all supported interfaces to send and to receive Cisco Discovery Protocol information.

Note Switch clusters and other Cisco devices (such as Cisco IP Phones) regularly exchange Cisco Discovery Protocol messages. Disabling Cisco Discovery Protocol can interrupt cluster discovery and device connectivity.

Note Cisco Discovery Protocol bypass is not supported and may cause a port go into err-disabled state.

Follow these steps to enable Cisco Discovery Protocol on a port on which it has been disabled.

Before you begin

Cisco Discovery Protocol must be disabled on the port that you are trying to Cisco Discovery Protocol enable on, or it cannot be enabled.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **cdp enable**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/1`	Specifies the interface on which you are enabling Cisco Discovery Protocol, and enters interface configuration mode.

	Command or Action	Purpose
Step 4	**cdp enable** **Example:** `Switch(config-if)# cdp enable`	Enables Cisco Discovery Protocol on a disabled interface.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

Default Cisco Discovery Protocol Configuration, on page 334
Disabling Cisco Discovery Protocol on an Interface, on page 339

Monitoring and Maintaining Cisco Discovery Protocol

Table 44: Commands for Displaying Cisco Discovery Protocol Information

Command	Description
clear cdp counters	Resets the traffic counters to zero.
clear cdp table	Deletes the Cisco Discovery Protocol table of information about neighbors.
show cdp	Displays global information, such as frequency of transmissions and the holdtime for packets being sent.

Command	Description
show cdp entry *entry-name* [**version**] [**protocol**]	Displays information about a specific neighbor. You can enter an asterisk (*) to display all Cisco Discovery Protocol neighbors, or you can enter the name of the neighbor about which you want information. You can also limit the display to information about the protocols enabled on the specified neighbor or information about the version of software running on the device.
show cdp interface [*interface-id*]	Displays information about interfaces where Cisco Discovery Protocol is enabled. You can limit the display to the interface about which you want information.
show cdp neighbors [*interface-id*] [*detail*]	Displays information about neighbors, including device type, interface type and number, holdtime settings, capabilities, platform, and port ID. You can limit the display to neighbors of a specific interface or expand the display to provide more detailed information.
show cdp traffic	Displays Cisco Discovery Protocol counters, including the number of packets sent and received and checksum errors.

Related Topics

Configuring Cisco Discovery Protocol Characteristics, on page 334
Cisco Discovery Protocol Overview, on page 333

Additional References

Related Documents

Related Topic	Document Title
System Management Commands	

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

Standards and RFCs

Standard/RFC	Title
None	-

MIBs

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for Cisco Discovery Protocol

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 21

Configuring Simple Network Management Protocol

Prerequisites for SNMP

Supported SNMP Versions

This software release supports the following SNMP versions:

- SNMPv1—The Simple Network Management Protocol, a Full Internet Standard, defined in RFC 1157.
- SNMPv2C replaces the Party-based Administrative and Security Framework of SNMPv2Classic with the community-string-based Administrative Framework of SNMPv2C while retaining the bulk retrieval and improved error handling of SNMPv2Classic. It has these features:
  - SNMPv2—Version 2 of the Simple Network Management Protocol, a Draft Internet Standard, defined in RFCs 1902 through 1907.
  - SNMPv2C—The community-string-based Administrative Framework for SNMPv2, an Experimental Internet Protocol defined in RFC 1901.
- SNMPv3—Version 3 of the SNMP is an interoperable standards-based protocol defined in RFCs 2273 to 2275. SNMPv3 provides secure access to devices by authenticating and encrypting packets over the network and includes these security features:
  - Message integrity—Ensures that a packet was not tampered with in transit.
  - Authentication—Determines that the message is from a valid source.

- Encryption—Mixes the contents of a package to prevent it from being read by an unauthorized source.

Note To select encryption, enter the **priv** keyword.

Both SNMPv1 and SNMPv2C use a community-based form of security. The community of managers able to access the agent's MIB is defined by an IP address access control list and password.

SNMPv2C includes a bulk retrieval function and more detailed error message reporting to management stations. The bulk retrieval function retrieves tables and large quantities of information, minimizing the number of round-trips required. The SNMPv2C improved error-handling includes expanded error codes that distinguish different kinds of error conditions; these conditions are reported through a single error code in SNMPv1. Error return codes in SNMPv2C report the error type.

SNMPv3 provides for both security models and security levels. A security model is an authentication strategy set up for a user and the group within which the user resides. A security level is the permitted level of security within a security model. A combination of the security level and the security model determine which security method is used when handling an SNMP packet. Available security models are SNMPv1, SNMPv2C, and SNMPv3.

The following table identifies characteristics and compares different combinations of security models and levels:

Table 45: SNMP Security Models and Levels

Model	Level	Authentication	Encryption	Result
SNMPv1	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
SNMPv2C	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
SNMPv3	noAuthNoPriv	Username	No	Uses a username match for authentication.
SNMPv3	authNoPriv	Message Digest 5 (MD5) or Secure Hash Algorithm (SHA)	No	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms.

Model	Level	Authentication	Encryption	Result
SNMPv3	authPriv	MD5 or SHA	Data Encryption Standard (DES) or Advanced Encryption Standard (AES)	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms. Allows specifying the User-based Security Model (USM) with these encryption algorithms: • DES 56-bit encryption in addition to authentication based on the CBC-DES (DES-56) standard. • 3DES 168-bit encryption • AES 128-bit, 192-bit, or 256-bit encryption

You must configure the SNMP agent to use the SNMP version supported by the management station. Because an agent can communicate with multiple managers, you can configure the software to support communications using SNMPv1, SNMPv2C, or SNMPv3.

Restrictions for SNMP

Version Restrictions

- SNMPv1 does not support informs.

Information About SNMP

SNMP Overview

SNMP is an application-layer protocol that provides a message format for communication between managers and agents. The SNMP system consists of an SNMP manager, an SNMP agent, and a management information base (MIB). The SNMP manager can be part of a network management system (NMS) such as Cisco Prime Infrastructure. The agent and MIB reside on the switch. To configure SNMP on the switch, you define the relationship between the manager and the agent.

The SNMP agent contains MIB variables whose values the SNMP manager can request or change. A manager can get a value from an agent or store a value into the agent. The agent gathers data from the MIB, the repository for information about device parameters and network data. The agent can also respond to a manager's requests to get or set data.

An agent can send unsolicited traps to the manager. Traps are messages alerting the SNMP manager to a condition on the network. Traps can mean improper user authentication, restarts, link status (up or down), MAC address tracking, closing of a TCP connection, loss of connection to a neighbor, or other significant events.

SNMP Manager Functions

The SNMP manager uses information in the MIB to perform the operations described in the following table:

Table 46: SNMP Operations

Operation	Description
get-request	Retrieves a value from a specific variable.
get-next-request	Retrieves a value from a variable within a table.[3]
get-bulk-request[4]	Retrieves large blocks of data, such as multiple rows in a table, that would otherwise require the transmission of many small blocks of data.
get-response	Replies to a get-request, get-next-request, and set-request sent by an NMS.
set-request	Stores a value in a specific variable.
trap	An unsolicited message sent by an SNMP agent to an SNMP manager when some event has occurred.

[3] With this operation, an SNMP manager does not need to know the exact variable name. A sequential search is performed to find the needed variable from within a table.

[4] The get-bulk command only works with SNMPv2 or later.

SNMP Agent Functions

The SNMP agent responds to SNMP manager requests as follows:

- Get a MIB variable—The SNMP agent begins this function in response to a request from the NMS. The agent retrieves the value of the requested MIB variable and responds to the NMS with that value.
- Set a MIB variable—The SNMP agent begins this function in response to a message from the NMS. The SNMP agent changes the value of the MIB variable to the value requested by the NMS.

The SNMP agent also sends unsolicited trap messages to notify an NMS that a significant event has occurred on the agent. Examples of trap conditions include, but are not limited to, when a port or module goes up or down, when spanning-tree topology changes occur, and when authentication failures occur.

SNMP Community Strings

SNMP community strings authenticate access to MIB objects and function as embedded passwords. In order for the NMS to access the switch, the community string definitions on the NMS must match at least one of the three community string definitions on the switch.

A community string can have one of the following attributes:

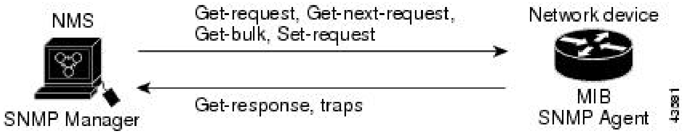
- Read-only (RO)—Gives all objects in the MIB except the community strings read access to authorized management stations, but does not allow write access.
- Read-write (RW)—Gives all objects in the MIB read and write access to authorized management stations, but does not allow access to the community strings.
- When a cluster is created, the command switch manages the exchange of messages among member switches and the SNMP application. The Network Assistant software appends the member switch number (@esN, where N is the switch number) to the first configured RW and RO community strings on the command switch and propagates them to the member switches.

SNMP MIB Variables Access

An example of an NMS is the Cisco Prime Infrastructure network management software. Cisco Prime Infrastructure software uses the switch MIB variables to set device variables and to poll devices on the network for specific information. The results of a poll can be displayed as a graph and analyzed to troubleshoot internetworking problems, increase network performance, verify the configuration of devices, monitor traffic loads, and more.

As shown in the figure, the SNMP agent gathers data from the MIB. The agent can send traps, or notification of certain events, to the SNMP manager, which receives and processes the traps. Traps alert the SNMP manager to a condition on the network such as improper user authentication, restarts, link status (up or down), MAC address tracking, and so forth. The SNMP agent also responds to MIB-related queries sent by the SNMP manager in *get-request*, *get-next-request*, and *set-request* format.

Figure 36: SNMP Network



SNMP Notifications

SNMP allows the switch to send notifications to SNMP managers when particular events occur. SNMP notifications can be sent as traps or inform requests. In command syntax, unless there is an option in the command to select either traps or informs, the keyword traps refers to either traps or informs, or both. Use the **snmp-server host** command to specify whether to send SNMP notifications as traps or informs.

Note SNMPv1 does not support informs.

Traps are unreliable because the receiver does not send an acknowledgment when it receives a trap, and the sender cannot determine if the trap was received. When an SNMP manager receives an inform request, it acknowledges the message with an SNMP response protocol data unit (PDU). If the sender does not receive a response, the inform request can be sent again. Because they can be resent, informs are more likely than traps to reach their intended destination.

The characteristics that make informs more reliable than traps also consume more resources in the switch and in the network. Unlike a trap, which is discarded as soon as it is sent, an inform request is held in memory until a response is received or the request times out. Traps are sent only once, but an inform might be resent or retried several times. The retries increase traffic and contribute to a higher overhead on the network. Therefore, traps and informs require a trade-off between reliability and resources. If it is important that the SNMP manager receive every notification, use inform requests. If traffic on the network or memory in the switch is a concern and notification is not required, use traps.

SNMP ifIndex MIB Object Values

In an NMS, the IF-MIB generates and assigns an interface index (ifIndex) object value that is a unique number greater than zero to identify a physical or a logical interface. When the switch reboots or the switch software is upgraded, the switch uses this same value for the interface. For example, if the switch assigns a port 2 an ifIndex value of 10003, this value is the same after the switch reboots.

The switch uses one of the values in the following table to assign an ifIndex value to an interface:

Table 47: ifIndex Values

Interface Type	ifIndex Range
SVI[5]	1–4999
EtherChannel	5001–5048
Tunnel	5078–5142
Physical (such as Gigabit Ethernet or SFP[6]-module interfaces) based on type and port numbers	10000–14500
Null	14501
Loopback and Tunnel	24567+

[5] SVI = switch virtual interface
[6] SFP = small form-factor pluggable

Default SNMP Configuration

Feature	Default Setting
SNMP agent	Disabled[7].
SNMP trap receiver	None configured.
SNMP traps	None enabled except the trap for TCP connections (tty).
SNMP version	If no version keyword is present, the default is Version 1.

Feature	Default Setting
SNMPv3 authentication	If no keyword is entered, the default is the **noauth** (noAuthNoPriv) security level.
SNMP notification type	If no type is specified, all notifications are sent.

[7] This is the default when the switch starts and the startup configuration does not have any **snmp-server** global configuration commands.

SNMP Configuration Guidelines

If the switch starts and the switch startup configuration has at least one **snmp-server** global configuration command, the SNMP agent is enabled.

An SNMP *group* is a table that maps SNMP users to SNMP views. An SNMP *user* is a member of an SNMP group. An SNMP *host* is the recipient of an SNMP trap operation. An SNMP *engine ID* is a name for the local or remote SNMP engine.

When configuring SNMP, follow these guidelines:

- When configuring an SNMP group, do not specify a notify view. The **snmp-server host** global configuration command auto-generates a notify view for the user and then adds it to the group associated with that user. Modifying the group's notify view affects all users associated with that group.
- To configure a remote user, specify the IP address or port number for the remote SNMP agent of the device where the user resides.
- Before you configure remote users for a particular agent, configure the SNMP engine ID, using the **snmp-server engineID** global configuration command with the **remote** option. The remote agent's SNMP engine ID and user password are used to compute the authentication and privacy digests. If you do not configure the remote engine ID first, the configuration command fails.
- When configuring SNMP informs, you need to configure the SNMP engine ID for the remote agent in the SNMP database before you can send proxy requests or informs to it.
- If a local user is not associated with a remote host, the switch does not send informs for the **auth** (authNoPriv) and the **priv** (authPriv) authentication levels.
- Changing the value of the SNMP engine ID has significant results. A user's password (entered on the command line) is converted to an MD5 or SHA security digest based on the password and the local engine ID. The command-line password is then destroyed, as required by RFC 2274. Because of this deletion, if the value of the engine ID changes, the security digests of SNMPv3 users become invalid, and you need to reconfigure SNMP users by using the **snmp-server user** *username* global configuration command. Similar restrictions require the reconfiguration of community strings when the engine ID changes.

How to Configure SNMP

Disabling the SNMP Agent

The **no snmp-server** global configuration command disables all running versions (Version 1, Version 2C, and Version 3) of the SNMP agent on the device. You reenable all versions of the SNMP agent by the first **snmp-server** global configuration command that you enter. There is no Cisco IOS command specifically designated for enabling SNMP.

Follow these steps to disable the SNMP agent.

Before you begin

The SNMP Agent must be enabled before it can be disabled. The SNMP agent is enabled by the first **snmp-server** global configuration command entered on the device.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no snmp-server**
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**no snmp-server** **Example:** `Switch(config)# no snmp-server`	Disables the SNMP agent operation.
Step 4	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Community Strings

You use the SNMP community string to define the relationship between the SNMP manager and the agent. The community string acts like a password to permit access to the agent on the switch. Optionally, you can specify one or more of these characteristics associated with the string:

- An access list of IP addresses of the SNMP managers that are permitted to use the community string to gain access to the agent
- A MIB view, which defines the subset of all MIB objects accessible to the given community
- Read and write or read-only permission for the MIB objects accessible to the community

Follow these steps to configure a community string on the switch.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server community** *string* [**view** *view-name*] [**ro** | **rw**] [*access-list-number*]
4. **access-list** *access-list-number* {**deny** | **permit**} *source* [*source-wildcard*]
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**snmp-server community** *string* [**view** *view-name*] [**ro** | **rw**] [*access-list-number*] **Example:** `Switch(config)# snmp-server community comaccess ro 4`	Configures the community string. **Note** The @ symbol is used for delimiting the context information. Avoid using the @ symbol as part of the SNMP community string when configuring this command. • For *string*, specify a string that acts like a password and permits access to the SNMP protocol. You can configure one or more community strings of any length. • (Optional) For **view**, specify the view record accessible to the community. • (Optional) Specify either read-only (**ro**) if you want authorized management stations to retrieve MIB objects, or specify read-write (**rw**) if you want authorized management stations to retrieve and modify MIB objects. By default, the community string permits read-only access to all objects. • (Optional) For *access-list-number*, enter an IP standard access list numbered from 1 to 99 and 1300 to 1999.
Step 4	**access-list** *access-list-number* {**deny** | **permit**} *source* [*source-wildcard*] **Example:** `Switch(config)# access-list 4 deny any`	(Optional) If you specified an IP standard access list number in Step 3, then create the list, repeating the command as many times as necessary. • For *access-list-number*, enter the access list number specified in Step 3. • The **deny** keyword denies access if the conditions are matched. The **permit** keyword permits access if the conditions are matched. • For *source*, enter the IP address of the SNMP managers that are permitted to use the community string to gain access to the agent. • (Optional) For *source-wildcard*, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore. Recall that the access list is always terminated by an implicit deny statement for everything.

	Command or Action	Purpose

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

To disable access for an SNMP community, set the community string for that community to the null string (do not enter a value for the community string).

To remove a specific community string, use the **no snmp-server** community string global configuration command.

You can specify an identification name (engine ID) for the local or remote SNMP server engine on the switch. You can configure an SNMP server group that maps SNMP users to SNMP views, and you can add new users to the SNMP group.

Configuring SNMP Groups and Users

You can specify an identification name (engine ID) for the local or remote SNMP server engine on the switch. You can configure an SNMP server group that maps SNMP users to SNMP views, and you can add new users to the SNMP group.

Follow these steps to configure SNMP groups and users on the switch.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server engineID** {**local** *engineid-string* | **remote** *ip-address* [**udp-port** *port-number*] *engineid-string*}
4. **snmp-server group** *group-name* {**v1** | **v2c** | **v3** {**auth** | **noauth** | **priv**}} [**read** *readview*] [**write** *writeview*] [**notify** *notifyview*] [**access** *access-list*]
5. **snmp-server user** *username group-name* {**remote** *host* [**udp-port** *port*]} {**v1** [**access** *access-list*] | **v2c** [**access** *access-list*] | **v3** [**encrypted**] [**access** *access-list*] [**auth** {**md5** | **sha**} *auth-password*] } [*priv* {**des** | **3des** | **aes** {**128** | **192** | **256**}} *priv-password*]

6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**snmp-server engineID** {**local** *engineid-string* | **remote** *ip-address* [**udp-port** *port-number*] *engineid-string*}
	Example:
	`Switch(config)# snmp-server engineID local 1234`
		Configures a name for either the local or remote copy of SNMP.
		• The *engineid-string* is a 24-character ID string with the name of the copy of SNMP. You need not specify the entire 24-character engine ID if it has trailing zeros. Specify only the portion of the engine ID up to the point where only zeros remain in the value. The Step Example configures an engine ID of 123400000000000000000000.
		• If you select **remote**, specify the *ip-address* of the device that contains the remote copy of SNMP and the optional User Datagram Protocol (UDP) port on the remote device. The default is 162.

Step 4	**snmp-server group** *group-name* {**v1** | **v2c** | **v3** {**auth** | **noauth** | **priv**}} [**read** *readview*] [**write** *writeview*] [**notify** *notifyview*] [**access** *access-list*] **Example:** `Switch(config)# snmp-server group public v2c access lmnop`	Configures a new SNMP group on the remote device. For *group-name*, specify the name of the group. Specify one of the following security models: • **v1** is the least secure of the possible security models. • **v2c** is the second least secure model. It allows transmission of informs and integers twice the normal width. • **v3**, the most secure, requires you to select one of the following authentication levels: **auth**—Enables the Message Digest 5 (MD5) and the Secure Hash Algorithm (SHA) packet authentication.

	Command or Action	Purpose
		noauth—Enables the noAuthNoPriv security level. This is the default if no keyword is specified. **priv**—Enables Data Encryption Standard (DES) packet encryption (also called privacy). (Optional) Enter **read** *readview* with a string (not to exceed 64 characters) that is the name of the view in which you can only view the contents of the agent. (Optional) Enter **write** *writeview* with a string (not to exceed 64 characters) that is the name of the view in which you enter data and configure the contents of the agent. (Optional) Enter **notify** *notifyview* with a string (not to exceed 64 characters) that is the name of the view in which you specify a notify, inform, or trap. (Optional) Enter **access** *access-list* with a string (not to exceed 64 characters) that is the name of the access list.
Step 5	**snmp-server user** *username group-name* {**remote** *host* [**udp-port** *port*] } {**v1** [**access** *access-list*] | **v2c** [**access** *access-list*] | **v3** [**encrypted**] [**access** *access-list*] [**auth** {**md5** | **sha**} *auth-password*] } [*priv* {**des** | **3des** | **aes** {**128** | **192** | **256**} } *priv-password*] **Example:** `Switch(config)#  snmp-server user Pat public v2c`	Adds a new user for an SNMP group. The *username* is the name of the user on the host that connects to the agent. The *group-name* is the name of the group to which the user is associated. Enter **remote** to specify a remote SNMP entity to which the user belongs and the hostname or IP address of that entity with the optional UDP port number. The default is 162. Enter the SNMP version number (**v1**, **v2c**, or **v3**). If you enter **v3**, you have these additional options: • **encrypted** specifies that the password appears in encrypted format. This keyword is available only when the **v3** keyword is specified. • **auth** is an authentication level setting session that can be either the HMAC-MD5-96 (**md5**) or the HMAC-SHA-96 (**sha**) authentication level and requires a password string *auth-password* (not to exceed 64 characters). If you enter **v3** you can also configure a private (**priv**) encryption algorithm and password string *priv-password* using the following keywords (not to exceed 64 characters): • **priv** specifies the User-based Security Model (USM). • **des** specifies the use of the 56-bit DES algorithm. • **3des** specifies the use of the 168-bit DES algorithm.

	Command or Action	Purpose
		• **aes** specifies the use of the DES algorithm. You must select either 128-bit, 192-bit, or 256-bit encryption. (Optional) Enter **access** *access-list* with a string (not to exceed 64 characters) that is the name of the access list.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring SNMP Notifications

A trap manager is a management station that receives and processes traps. Traps are system alerts that the switch generates when certain events occur. By default, no trap manager is defined, and no traps are sent. Switches running this Cisco IOS release can have an unlimited number of trap managers.

Note Many commands use the word **traps** in the command syntax. Unless there is an option in the command to select either traps or informs, the keyword **traps** refers to traps, informs, or both. Use the **snmp-server host** global configuration command to specify whether to send SNMP notifications as traps or informs.

You can use the **snmp-server host** global configuration command for a specific host to receive the notification types listed in the following table. You can enable any or all of these traps and configure a trap manager to receive them.

Table 48: Device Notification Types

Notification Type Keyword	Description
bridge	Generates STP bridge MIB traps.
cluster	Generates a trap when the cluster configuration changes.
config	Generates a trap for SNMP configuration changes.
copy-config	Generates a trap for SNMP copy configuration changes.

Notification Type Keyword	Description
cpu threshold	Allow CPU-related traps.
entity	Generates a trap for SNMP entity changes.
envmon	Generates environmental monitor traps. You can enable any or all of these environmental traps: fan, shutdown, status, supply, temperature.
errdisable	Generates a trap for a port VLAN errdisabled. You can also set a maximum trap rate per minute. The range is from 0 to 10000; the default is 0, which means there is no rate limit.
flash	Generates SNMP FLASH notifications. In a switch stack, you can optionally enable notification for flash insertion or removal, which would cause a trap to be issued whenever a switch in the stack is removed or inserted (physical removal, power cycle, or reload).
fru-ctrl	Generates entity field-replaceable unit (FRU) control traps. In the switch stack, this trap refers to the insertion or removal of a switch in the stack.
hsrp	Generates a trap for Hot Standby Router Protocol (HSRP) changes.
ipmulticast	Generates a trap for IP multicast routing changes.
ipsla	Generates a trap for the SNMP IP Service Level Agreements (SLAs).
mac-notification	Generates a trap for MAC address notifications.
msdp	Generates a trap for Multicast Source Discovery Protocol (MSDP) changes.
ospf	Generates a trap for Open Shortest Path First (OSPF) changes. You can enable any or all of these traps: Cisco specific, errors, link-state advertisement, rate limit, retransmit, and state changes.
pim	Generates a trap for Protocol-Independent Multicast (PIM) changes. You can enable any or all of these traps: invalid PIM messages, neighbor changes, and rendezvous point (RP)-mapping changes.
port-security	Generates SNMP port security traps. You can also set a maximum trap rate per second. The range is from 0 to 1000; the default is 0, which means that there is no rate limit. **Note** When you configure a trap by using the notification type **port-security**, configure the port security trap first, and then configure the port security trap rate: 1. **snmp-server enable traps port-security** 2. **snmp-server enable traps port-security trap-rate** *rate*
snmp	Generates a trap for SNMP-type notifications for authentication, cold start, warm start, link up or link down.

Notification Type Keyword	Description
storm-control	Generates a trap for SNMP storm-control. You can also set a maximum trap rate per minute. The range is from 0 to 1000; the default is 0 (no limit is imposed; a trap is sent at every occurrence).
stpx	Generates SNMP STP Extended MIB traps.
syslog	Generates SNMP syslog traps.
tty	Generates a trap for TCP connections. This trap is enabled by default.
vlan-membership	Generates a trap for SNMP VLAN membership changes.
vlancreate	Generates SNMP VLAN created traps.
vlandelete	Generates SNMP VLAN deleted traps.
vtp	Generates a trap for VLAN Trunking Protocol (VTP) changes.

Follow these steps to configure the switch to send traps or informs to a host.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server engineID remote** *ip-address engineid-string*
4. **snmp-server user** *username group-name* {**remote** *host* [**udp-port** *port*] } {**v1** [**access** *access-list*] | **v2c** [**access** *access-list*] | **v3** [**encrypted**] [**access** *access-list*] [**auth** {**md5** | **sha**} *auth-password*] }
5. **snmp-server group** *group-name* {**v1** | **v2c** | **v3** {**auth** | **noauth** | **priv**} } [**read** *readview*] [**write** *writeview*] [**notify** *notifyview*] [**access** *access-list*]
6. **snmp-server host** *host-addr* [**informs** | **traps**] [**version** {**1** | **2c** | **3** {**auth** | **noauth** | **priv**} }] *community-string* [*notification-type*]
7. **snmp-server enable traps** *notification-types*
8. **snmp-server trap-source** *interface-id*
9. **snmp-server queue-length** *length*
10. **snmp-server trap-timeout** *seconds*
11. **end**
12. **show running-config**
13. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**snmp-server engineID remote** *ip-address engineid-string* **Example:** `Switch(config)# snmp-server engineID remote 192.180.1.27 00000063000100a1c0b4011b`	Specifies the engine ID for the remote host.

Step 4	**snmp-server user** *username group-name* {**remote** *host* [**udp-port** *port*] } {**v1** [**access** *access-list*] | **v2c** [**access** *access-list*] | **v3** [**encrypted**] [**access** *access-list*] [**auth** {**md5** | **sha**} *auth-password*] }
	Example:
	`Switch(config)#  snmp-server user Pat public v2c`
		Configures an SNMP user to be associated with the remote host created in Step 3.
		Note You cannot configure a remote user for an address without first configuring the engine ID for the remote host. Otherwise, you receive an error message, and the command is not executed.

Step 5	**snmp-server group** *group-name* {**v1** | **v2c** | **v3** {**auth** | **noauth** | **priv**}} [**read** *readview*] [**write** *writeview*] [**notify** *notifyview*] [**access** *access-list*] **Example:** `Switch(config)# snmp-server group public v2c access lmnop`	Configures an SNMP group.
Step 6	**snmp-server host** *host-addr* [**informs** | **traps**] [**version** {**1** | **2c** | **3** {**auth** | **noauth** | **priv**} }] *community-string* [*notification-type*] **Example:** `Switch(config)# snmp-server host 203.0.113.1 comaccess snmp`	Specifies the recipient of an SNMP trap operation. For *host-addr*, specify the name or Internet address of the host (the targeted recipient). (Optional) Specify **traps** (the default) to send SNMP traps to the host. (Optional) Specify **informs** to send SNMP informs to the host. (Optional) Specify the SNMP **version** (**1**, **2c**, or **3**). SNMPv1 does not support informs. (Optional) For Version 3, select authentication level **auth**, **noauth**, or **priv**. **Note** The **priv** keyword is available only when the cryptographic software image is installed. For *community-string*, when **version 1** or **version 2c** is specified, enter the password-like community string sent with the notification operation. When **version 3** is specified, enter the SNMPv3 username.

	Command or Action	Purpose
		The @ symbol is used for delimiting the context information. Avoid using the @ symbol as part of the SNMP community string when configuring this command. (Optional) For *notification-type*, use the keywords listed in the table above. If no type is specified, all notifications are sent.
Step 7	**snmp-server enable traps** *notification-types* **Example:** `Switch(config)# snmp-server enable traps snmp`	Enables the switch to send traps or informs and specifies the type of notifications to be sent. For a list of notification types, see the table above, or enter **snmp-server enable traps ?** To enable multiple types of traps, you must enter a separate **snmp-server enable traps** command for each trap type. **Note** When you configure a trap by using the notification type **port-security**, configure the port security trap first, and then configure the port security trap rate: **a. snmp-server enable traps port-security** **b. snmp-server enable traps port-security trap-rate** *rate*
Step 8	**snmp-server trap-source** *interface-id* **Example:** `Switch(config)# snmp-server trap-source gigabitethernet 0/1`	(Optional) Specifies the source interface, which provides the IP address for the trap message. This command also sets the source IP address for informs.
Step 9	**snmp-server queue-length** *length* **Example:** `Switch(config)# snmp-server queue-length 20`	(Optional) Establishes the message queue length for each trap host. The range is 1 to 5000; the default is 10.
Step 10	**snmp-server trap-timeout** *seconds* **Example:** `Switch(config)# snmp-server trap-timeout 60`	(Optional) Defines how often to resend trap messages. The range is 1 to 1000; the default is 30 seconds.

Step 11	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 12	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.

	Command or Action	Purpose
Step 13	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

The **snmp-server host** command specifies which hosts receive the notifications. The **snmp-server enable traps** command globally enables the method for the specified notification (for traps and informs). To enable a host to receive an inform, you must configure an **snmp-server host informs** command for the host and globally enable informs by using the **snmp-server enable traps** command.

To remove the specified host from receiving traps, use the **no snmp-server host** *host* global configuration command. The **no snmp-server host** command with no keywords disables traps, but not informs, to the host. To disable informs, use the **no snmp-server host informs** global configuration command. To disable a specific trap type, use the **no snmp-server enable traps** *notification-types* global configuration command.

Setting the Agent Contact and Location Information

Follow these steps to set the system contact and location of the SNMP agent so that these descriptions can be accessed through the configuration file.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server contact** *text*
4. **snmp-server location** *text*
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**snmp-server contact** *text* **Example:** `Switch(config)# snmp-server contact Dial System Operator at beeper 21555`	Sets the system contact string.
Step 4	**snmp-server location** *text* **Example:** `Switch(config)# snmp-server location Building 3/Room 222`	Sets the system location string.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Limiting TFTP Servers Used Through SNMP

Follow these steps to limit the TFTP servers used for saving and loading configuration files through SNMP to the servers specified in an access list.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server tftp-server-list** *access-list-number*
4. **access-list** *access-list-number* {**deny** | **permit**} *source* [*source-wildcard*]
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**snmp-server tftp-server-list** *access-list-number* **Example:** `Switch(config)# snmp-server tftp-server-list 44`	Limits the TFTP servers used for configuration file copies through SNMP to the servers in the access list. For *access-list-number*, enter an IP standard access list numbered from 1 to 99 and 1300 to 1999.
Step 4	**access-list** *access-list-number* {**deny** | **permit**} *source* [*source-wildcard*] **Example:** `Switch(config)# access-list 44 permit 10.1.1.2`	Creates a standard access list, repeating the command as many times as necessary. For *access-list-number*, enter the access list number specified in Step 3. The **deny** keyword denies access if the conditions are matched. The **permit** keyword permits access if the conditions are matched. For *source*, enter the IP address of the TFTP servers that can access the switch. (Optional) For *source-wildcard*, enter the wildcard bits, in dotted decimal notation, to be applied to the source. Place ones in the bit positions that you want to ignore. The access list is always terminated by an implicit deny statement for everything.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.

	Command or Action	Purpose
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring SNMP Status

To display SNMP input and output statistics, including the number of illegal community string entries, errors, and requested variables, use the **show snmp** privileged EXEC command. You also can use the other privileged EXEC commands listed in the table to display SNMP information.

Table 49: Commands for Displaying SNMP Information

Command	Purpose
show snmp	Displays SNMP statistics.
	Displays information on the local SNMP engine and all remote engines that have been configured on the device.
show snmp group	Displays information on each SNMP group on the network.
show snmp pending	Displays information on pending SNMP requests.
show snmp sessions	Displays information on the current SNMP sessions.
show snmp user	Displays information on each SNMP user name in the SNMP users table. **Note** You must use this command to display SNMPv3 configuration information for **auth** | **noauth** | **priv** mode. This information is not displayed in the **show running-config** output.

SNMP Examples

This example shows how to enable all versions of SNMP. The configuration permits any SNMP manager to access all objects with read-only permissions using the community string *public*. This configuration does not cause the switch to send any traps.

```
Switch(config)# snmp-server community public
```

This example shows how to permit any SNMP manager to access all objects with read-only permission using the community string *public*. The switch also sends VTP traps to the hosts 192.180.1.111 and 192.180.1.33

using SNMPv1 and to the host 192.180.1.27 using SNMPv2C. The community string *public* is sent with the traps.

```
Switch(config)# snmp-server community public
Switch(config)# snmp-server enable traps vtp
Switch(config)# snmp-server host 192.180.1.27 version 2c public
Switch(config)# snmp-server host 192.180.1.111 version 1 public
Switch(config)# snmp-server host 192.180.1.33 public
```

This example shows how to allow read-only access for all objects to members of access list 4 that use the *comaccess* community string. No other SNMP managers have access to any objects. SNMP Authentication Failure traps are sent by SNMPv2C to the host *cisco.com* using the community string *public*.

```
Switch(config)# snmp-server community comaccess ro 4
Switch(config)# snmp-server enable traps snmp authentication
Switch(config)# snmp-server host cisco.com version 2c public
```

This example shows how to send Entity MIB traps to the host *cisco.com*. The community string is restricted. The first line enables the switch to send Entity MIB traps in addition to any traps previously enabled. The second line specifies the destination of these traps and overwrites any previous **snmp-server** host commands for the host *cisco.com*.

```
Switch(config)# snmp-server enable traps entity
Switch(config)# snmp-server host cisco.com restricted entity
```

This example shows how to enable the switch to send all traps to the host *myhost.cisco.com* using the community string *public*:

```
Switch(config)# snmp-server enable traps
Switch(config)# snmp-server host myhost.cisco.com public
```

This example shows how to associate a user with a remote host and to send **auth** (authNoPriv) authentication-level informs when the user enters global configuration mode:

```
Switch(config)# snmp-server engineID remote 192.180.1.27 00000063000100a1c0b4011b
Switch(config)# snmp-server group authgroup v3 auth
Switch(config)# snmp-server user authuser authgroup remote 192.180.1.27 v3 auth md5 mypassword
Switch(config)# snmp-server user authuser authgroup v3 auth md5 mypassword
Switch(config)# snmp-server host 192.180.1.27 informs version 3 auth authuser config
Switch(config)# snmp-server enable traps
Switch(config)# snmp-server inform retries 0
```

Additional References

Related Documents

Related Topic	Document Title
SNMP Commands	

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

Standards and RFCs

Standard/RFC	Title
None	-

MIBs

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for Simple Network Management Protocol

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 22

Configuring SPAN

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Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for SPAN

SPAN

The restrictions for SPAN are as follows:

- For SPAN sources, you can monitor traffic for a single port or a series or range of ports for each session.
- The destination port cannot be a source port; a source port cannot be a destination port.
- You cannot have two SPAN sessions using the same destination port.
- You cannot have two SPAN sessions using the same source port.

- When you configure a switch port as a SPAN destination port, it is no longer a normal switch port; only monitored traffic passes through the SPAN destination port.
- Entering SPAN configuration commands does not remove previously configured SPAN parameters. You must enter the **no monitor session** *session_number* global configuration command to delete configured SPAN parameters.
- You can configure a disabled port to be a source or destination port, but the SPAN function does not start until the destination port and at least one source port are enabled.

Traffic monitoring in a SPAN session has the following restrictions:

- The switch supports up to four local SPAN sessions.
- SPAN sessions do not interfere with the normal operation of the switch. However, an oversubscribed SPAN destination, for example, a 10-Mb/s port monitoring a 100-Mb/s port, can result in dropped or lost packets.
- When SPAN is enabled, each packet being monitored is sent twice, once as normal traffic and once as a monitored packet. Monitoring a large number of ports could potentially generate large amounts of network traffic.
- You can configure SPAN sessions on disabled ports; however, a SPAN session does not become active unless you enable the destination port and at least one source port for that session.

Information About SPAN

SPAN

You can analyze network traffic passing through ports by using SPAN to send a copy of the traffic to another port on the switch or on another switch that has been connected to a network analyzer or other monitoring or security device. SPAN copies (or mirrors) traffic received or sent (or both) on source ports to a destination port for analysis. SPAN does not affect the switching of network traffic on the source ports. You must dedicate the destination port for SPAN use. Except for traffic that is required for the SPAN session, destination ports do not receive or forward traffic.

Only traffic that enters or leaves source ports can be monitored by using SPAN.

You can use the SPAN destination port to inject traffic from a network security device. For example, if you connect a Cisco Intrusion Detection System (IDS) sensor appliance to a destination port, the IDS device can send TCP reset packets to close down the TCP session of a suspected attacker.

Default SPAN Configuration

Table 50: Default SPAN Configuration

Feature	Default Setting
SPAN state	Disabled.
Source port traffic to monitor	Both received and sent traffic (**both**).

Feature	Default Setting
Encapsulation type (destination port)	Native form (untagged packets).
Ingress forwarding (destination port)	Disabled.

Configuration Guidelines

SPAN Configuration Guidelines

- To remove a source or destination port from the SPAN session, use the **no monitor session** *session_number* **source interface** *interface-id* global configuration command or the **no monitor session** *session_number* **destination interface** *interface-id* global configuration command. For destination interfaces, the **encapsulation** options are ignored with the **no** form of the command.

How to Configure SPAN

Creating a Local SPAN Session

Follow these steps to create a SPAN session and specify the source (monitored) ports or VLANs and the destination (monitoring) ports.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no monitor session** *session_number*
4. **monitor session** *session_number* **source** {**interface** *interface-id*} [**,** | **-**] [**both** | **rx** | **tx**]
5. **monitor session** *session_number* **destination** {**interface** *interface-id* [**,** | **-**] }
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 3	**no monitor session** *session_number* **Example:** `Switch(config)# no monitor session 1`	Removes existing SPAN configuration for the specified session. The range is 1 to 4.
Step 4	**monitor session** *session_number* **source** {**interface** *interface-id*} [**,** | **-**] [**both** | **rx** | **tx**] **Example:** `Switch(config)# monitor session 1 source interface gigabitethernet0/1`	Specifies the SPAN session and the source port (monitored port). • For *session_number*, the range is 1 to 4. • For *interface-id*, specify the source port to monitor. Valid interfaces include physical interfaces and port-channel logical interfaces (**port-channel** *port-channel-number*). Valid port-channel numbers are 1 to 6. • (Optional) [**,** | **-**] Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen. • (Optional) **both** | **rx** | **tx**—Specifies the direction of traffic to monitor. If you do not specify a traffic direction, the source interface sends both sent and received traffic. • **both**—Monitors both received and sent traffic. • **rx**—Monitors received traffic. • **tx**—Monitors sent traffic. **Note** You can use the **monitor session** *session_number* **source** command multiple times to configure multiple source ports.

Step 5	**monitor session** *session_number* **destination** {**interface** *interface-id* [**,** | **-**] }
	Example:
	`Switch(config)# monitor session 1 destination interface gigabitethernet0/2`
		Specifies the SPAN session and the destination port (monitoring port). The port LED changes to amber when the configuration changes take effect. The LED returns to its original state(green) only after removing the SPAN destination configuration.
		Note For local SPAN, you must use the same session number for the source and destination interfaces.
		• For *session_number*, specify the session number entered in step 4.

	Command or Action	Purpose
		• For *interface-id*, specify the destination port. The destination interface must be a physical port; it cannot be an EtherChannel, and it cannot be a VLAN. • (Optional) [**,** | **-**] Specifies a series or range of interfaces. Enter a space before and after the comma; enter a space before and after the hyphen. **Note** You can use **monitor session** *session_number* **destination** command multiple times to configure multiple destination ports.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Creating a Local SPAN Session and Configuring Incoming Traffic

Follow these steps to create a SPAN session, to specify the source ports or VLANs and the destination ports, and to enable incoming traffic on the destination port for a network security device (such as a Cisco IDS Sensor Appliance).

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no monitor session** *session_number*
4. **monitor session** *session_number* **source** {**interface** *interface-id*} [**,** | **-**] [**both** | **rx** | **tx**]
5. **monitor session** *session_number* **destination** {**interface** *interface-id* [**encapsulation replicate ingress** {**vlan** *vlan-id*} | **ingress** {**vlan** *vlan-id*}]}
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**no monitor session** *session_number* **Example:** `Switch(config)# no monitor session 1`	Removes existing SPAN configuration for the specified session. The range is 1 to 4.
Step 4	**monitor session** *session_number* **source** {**interface** *interface-id*} [**,** | **-**] [**both** | **rx** | **tx**] **Example:** `Switch(config)# monitor session 2 source gigabitethernet0/1 rx`	Specifies the SPAN session and the source port (monitored port).

Step 5	**monitor session** *session_number* **destination** {**interface** *interface-id* [**encapsulation replicate ingress** {**vlan** *vlan-id*} | **ingress** {**vlan** *vlan-id*}]}
	Example:
	`Switch(config)# monitor session 2 destination interface gigabitethernet0/2 ingress vlan 6`
		Specifies the SPAN session, the destination port, the packet encapsulation, and the ingress VLAN and encapsulation.
		• For *session_number*, specify the session number entered in Step 4.
		• For *interface-id*, specify the destination port. The destination interface must be a physical port; it cannot be an EtherChannel, and it cannot be a VLAN.
		•
		• (Optional) **encapsulation replicate**—Specifies that the destination interface replicates the source interface encapsulation method. If not selected, the default is to send packets in native form (untagged).
		• **ingress**—Enables forwarding of incoming traffic on the destination port and to specify the encapsulation type.

Step 6	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring SPAN Operations

The following table describes the command used to display SPAN operations configuration and results to monitor operations:

Table 51: Monitoring SPAN Operations

Command	Purpose
show monitor session	Displays the current SPAN configuration. Enter the **all** keyword to show configuration for all SPAN sessions, the **local** keyword to show configurations for local sessions only, and the **range** keyword to show configurations for a range of SPAN sessions.

SPAN Configuration Examples

Example: Configuring Local SPAN

This example shows how to set up SPAN session 1 for monitoring source port traffic to a destination port. First, any existing SPAN configuration for session 1 is deleted, and then bidirectional traffic is mirrored from source Gigabit Ethernet port 1 to destination Gigabit Ethernet port 2, retaining the encapsulation method.

```
Switch> enable
Switch# configure terminal
Switch(config)# no monitor session 1
Switch(config)# monitor session 1 source interface gigabitethernet0/1
Switch(config)# monitor session 1 destination interface gigabitethernet0/2
```

```
encapsulation replicate
Switch(config)# end
```

This example shows how to remove port 1 as a SPAN source for SPAN session 1:

```
Switch> enable
Switch# configure terminal
Switch(config)# no monitor session 1 source interface gigabitethernet0/1
Switch(config)# end
```

This example shows how to disable received traffic monitoring on port 1, which was configured for bidirectional monitoring:

```
Switch> enable
Switch# configure terminal
Switch(config)# no monitor session 1 source interface gigabitethernet0/1 rx
```

The monitoring of traffic received on port 1 is disabled, but traffic sent from this port continues to be monitored.

This example shows how to remove any existing configuration on SPAN session 2, configure SPAN session 2 to monitor received traffic on all ports belonging to VLANs 1 through 3, and send it to destination Gigabit Ethernet port 2. The configuration is then modified to also monitor all traffic on all ports belonging to VLAN 10.

```
Switch> enable
Switch# configure terminal
Switch(config)# no monitor session 2
Switch(config)# monitor session 2 destination interface gigabitethernet0/2
Switch(config)# end
```

This example shows how to remove any existing configuration on SPAN session 2, configure SPAN session 2 to monitor received traffic on Gigabit Ethernet source port 1, and send it to destination Gigabit Ethernet port 2 with the same egress encapsulation type as the source port, and to enable ingress forwarding with VLAN 6 as the default ingress VLAN:

```
Switch> enable
Switch# configure terminal
Switch(config)# no monitor session 2
Switch(config)# monitor session 2 source gigabitethernet0/1 rx
Switch(config)# monitor session 2 destination interface gigabitethernet0/2 encapsulation
replicate ingress vlan 6
Switch(config)# end
```

Additional References

Related Documents

Related Topic	Document Title
System Commands	

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

Standards and RFCs

Standard/RFC	Title
None	-

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for SPAN

Release	Modification
Cisco IOS Release 15.2(5)ECisco IOS 15.2(5)E	Switch Port Analyzer (SPAN): Allows monitoring of switch traffic on a port or VLAN using a sniffer/analyzer or RMON probe. This feature was introduced.

Release	Modification
Cisco IOS Release 15.2(5)ECisco IOS 15.2(5)E	SPAN destination port support on EtherChannels: Provides the ability to configure a SPAN destination port on an EtherChannel. This feature was introduced.
Cisco IOS Release 15.2(5)ECisco IOS 15.2(5)E	Switch Port Analyzer (SPAN) - distributed egress SPAN: Provides distributed egress SPAN functionality onto line cards in conjunction with ingress SPAN already been distributed to line cards. By distributing egress SPAN functionalities onto line cards, the performance of the system is improved. This feature was introduced.
Cisco IOS Release 15.2(6)E2	Support for 4 SPAN sessions was introduced.

PART VI

QoS

CHAPTER 23

Configuring QoS

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for QoS

Before configuring standard QoS, you must have a thorough understanding of these items:

- The types of applications used and the traffic patterns on your network.
- Traffic characteristics and needs of your network. For example, is the traffic on your network bursty? Do you need to reserve bandwidth for voice and video streams?
- Bandwidth requirements and speed of the network.
- Location of congestion points in the network.

QoS ACL Guidelines

Follow these guidelines when configuring QoS with access control lists (ACLs):

- It is not possible to match IP fragments against configured IP extended ACLs to enforce QoS. IP fragments are sent as best-effort. IP fragments are denoted by fields in the IP header.
- Only one ACL per class map and only one **match** class-map configuration command per class map are supported. The ACL can have multiple ACEs, which match fields against the contents of the packet.

Policing Guidelines

- Only one policer is applied to a packet on an ingress port. Only the average rate and committed burst parameters are configurable.
- On a port configured for QoS, all traffic received through the port is classified, policed, and marked according to the policy map attached to the port. On a trunk port configured for QoS, traffic in all VLANs received through the port is classified, policed, and marked according to the policy map attached to the port.
- If you have EtherChannel ports configured on your switch, you must configure QoS classification, policing, mapping, and queueing on the individual physical ports that comprise the EtherChannel. You must decide whether the QoS configuration should match on all ports in the EtherChannel.
- If you need to modify a policy map of an existing QoS policy, first remove the policy map from all interfaces, and then modify or copy the policy map. After you finish the modification, apply the modified policy map to the interfaces. If you do not first remove the policy map from all interfaces, high CPU usage can occur, which, in turn, can cause the console to pause for a very long time.

General QoS Guidelines

These are the general QoS guidelines:

- You configure QoS only on physical ports; there is no support for it at the VLAN level and EtherChannel ports.
- Control traffic (such as spanning-tree bridge protocol data units [BPDUs] and routing update packets) received by the switch are subject to all ingress QoS processing.
- You are likely to lose data when you change queue settings; therefore, try to make changes when traffic is at a minimum.

Restrictions for QoS

The following are the restrictions for QoS:

- Ingress queueing and aggregate policy are not supported.
- Only 32 class-maps are supported per ASIC.
- Ternary content-addressable memory (TCAM) sharing of policy-map (policer/marking) across ports is not supported. Because of this, the number of interfaces on which auto-QoS/QoS policy-map can be applied is limited.

- The same TCAM region must be used for both security Access control lists (ACLs) and ACLs used via policy map.
- Policy-maps with the **match ip dscp** command matches both IPv4 and IPv6 addresses, which limits the scale number to 16 class-maps. One TCAM entry is created for IPv4 and one TCAM entry for IPv6.
- Per ASIC, 8 TCP port comparators and 8 UDP port comparators are supported, and each gt (greater than)/lt (less than)/neq (not equal) operator uses 1 port comparator, and each range operator uses 2 port comparators. A policy-map with this combination affects the TCAM scale and number of interfaces to which the policy-map can be attached.
- The following restrictions apply to IPv4 ACL network interfaces:
  - When controlling access to an interface, you can use a named or numbered ACL.
  - If you apply an ACL to a Layer 3 interface, and routing is not enabled on the switch, the ACL only filters packets that are intended for the CPU, such as SNMP, Telnet, or web traffic.
  - You do not have to enable routing to apply ACLs on Layer 2 interfaces.
- Deny ACLs are not supported on QoS policy-maps.
- Policed action transmit is not supported; only exceed action drop is supported.
- You can configure QoS only on physical ports. VLAN-based QoS is not supported. You configure the QoS settings, such as classification, queueing, and scheduling, and apply the policy map to a port. When configuring QoS on a physical port, you apply a nonhierarchical policy map to a port.

Information About QoS

QoS Implementation

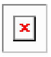
Typically, networks operate on a best-effort delivery basis, which means that all traffic has equal priority and an equal chance of being delivered in a timely manner. When congestion occurs, all traffic has an equal chance of being dropped.

When you configure the QoS feature, you can select specific network traffic, prioritize it according to its relative importance, and use congestion-management and congestion-avoidance techniques to provide preferential treatment. Implementing QoS in your network makes network performance more predictable and bandwidth utilization more effective.

The QoS implementation is based on the Differentiated Services (Diff-Serv) architecture, a standard from the Internet Engineering Task Force (IETF). This architecture specifies that each packet is classified upon entry into the network.

Figure 37: QoS Classification Layers in Frames and Packets

The special bits in the Layer 2 frame or a Layer 3 packet are shown in the following figure:



Layer 2 Frame Prioritization Bits

Layer 2 Inter-Switch Link (ISL) frame headers have a 1-byte User field that carries an IEEE 802.1p class of service (CoS) value in the three least-significant bits. On ports configured as Layer 2 ISL trunks, all traffic is in ISL frames.

Layer 2 802.1Q frame headers have a 2-byte Tag Control Information field that carries the CoS value in the three most-significant bits, which are called the User Priority bits. On ports configured as Layer 2 802.1Q trunks, all traffic is in 802.1Q frames except for traffic in the native VLAN.

Other frame types cannot carry Layer 2 CoS values.

Layer 2 CoS values range from 0 for low priority to 7 for high priority.

Layer 3 Packet Prioritization Bits

Layer 3 IP packets can carry ranging from 0 to 63.

End-to-End QoS Solution Using Classification

All switches and routers that access the Internet rely on the class information to provide the same forwarding treatment to packets with the same class information and different treatment to packets with different class information. The class information in the packet can be assigned by end hosts or by switches or routers along the way, based on a configured policy, detailed examination of the packet, or both. Detailed examination of the packet is expected to occur closer to the edge of the network, so that the core switches and routers are not overloaded with this task.

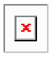
Switches and routers along the path can use the class information to limit the amount of resources allocated per traffic class. The behavior of an individual device when handling traffic in the Diff-Serv architecture is called per-hop behavior. If all devices along a path provide a consistent per-hop behavior, you can construct an end-to-end QoS solution.

Implementing QoS in your network can be a simple task or complex task and depends on the QoS features offered by your internetworking devices, the traffic types and patterns in your network, and the granularity of control that you need over incoming and outgoing traffic.

QoS Basic Model

To implement QoS, the switch must distinguish packets or flows from one another (classify), assign a label to indicate the given quality of service as the packets move through the switch, make the packets comply with the configured resource usage limits (police and mark), and provide different treatment (queue and schedule) in all situations where resource contention exists. The switch also needs to ensure that traffic sent from it meets a specific traffic profile (shape).

Figure 38: QoS Basic Wired Model



Actions at Ingress Port

Actions at the ingress port include classifying traffic, policing, and marking:

- Classifying a distinct path for a packet by associating it with a QoS label. The switch maps the CoS or DSCP in the packet to a QoS label to distinguish one kind of traffic from another. The QoS label that is generated identifies all future QoS actions to be performed on this packet.
- Policing determines whether a packet is in or out of profile by comparing the rate of the incoming traffic to the configured policer. The policer limits the bandwidth consumed by a flow of traffic. The result is passed to the marker.
- Marking evaluates the policer and configuration information for the action to be taken when a packet is out of profile and determines what to do with the packet (pass through a packet without modification, marking down the QoS label in the packet, or dropping the packet).

Note Queueing and scheduling are only supported at egress and not at ingress on the switch.

Actions at Egress Port

Actions at the egress port include queueing and scheduling:

- Queueing evaluates the QoS packet label and the corresponding CoS value before selecting which of the four egress queues to use. Because congestion can occur when multiple ingress ports simultaneously send data to an egress port, WTD differentiates traffic classes and subjects the packets to different thresholds based on the QoS label. If the threshold is exceeded, the packet is dropped.
- Scheduling services the four egress queues based on their configured SRR shared or shaped weights. One of the queues (queue 1) can be the priority queue, which is serviced until empty before the other queues are serviced.

Classification Overview

Classification is the process of distinguishing one kind of traffic from another by examining the fields in the packet. Classification is enabled only if QoS is globally enabled on the switch. By default, QoS is globally disabled, so no classification occurs.

During classification, the switch performs a lookup and assigns a QoS label to the packet. The QoS label identifies all QoS actions to be performed on the packet and from which queue the packet is sent.

The QoS label is based on the DSCP or the CoS value in the packet and decides the queuing and scheduling actions to perform on the packet. The label is mapped according to the trust setting and the packet type as shown in the Classification Flowchart.

You specify which fields in the frame or packet that you want to use to classify incoming traffic.

Non-IP Traffic Classification

The following table describes the non-IP traffic classification options for your QoS configuration.

Table 52: Non- IP Traffic Classifications

Non-IP Traffic Classification	Description
Trust the CoS value	Trust the CoS value in the incoming frame (configure the port to trust CoS), and then use the configurable CoS-to-DSCP map to generate a DSCP value for the packet. Layer 2 ISL frame headers carry the CoS value in the 3 least-significant bits of the 1-byte User field. Layer 2 802.1Q frame headers carry the CoS value in the 3 most-significant bits of the Tag Control Information field. CoS values range from 0 for low priority to 7 for high priority.
Trust the DSCP value	Trust the DSCP value in the incoming frame. These configurations are meaningless for non-IP traffic. If you configure a port with either of these options and non-IP traffic is received, the switch assigns a CoS value and generates an internal DSCP value from the CoS-to-DSCP map. The switch uses the internal DSCP value to generate a CoS value representing the priority of the traffic.
Perform classification based on configured Layer 2 MAC ACL	Perform the classification based on a configured Layer 2 MAC access control list (ACL), which can examine the MAC source address, the MAC destination address, and other fields. If no ACL is configured, the packet is assigned 0 as the DSCP and CoS values, which means best-effort traffic. Otherwise, the policy-map action specifies a DSCP or CoS value to assign to the incoming frame.

After classification, the packet is sent to the policing and marking stages.

IP Traffic Classification

The following table describes the IP traffic classification options for your QoS configuration.

Table 53: IP Traffic Classifications

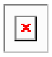
IP Traffic Classification	Description
Trust the DSCP value	Trust the DSCP value in the incoming packet (configure the port to trust DSCP), and assign the same DSCP value to the packet. The IETF defines the 6 most-significant bits of the 1-byte ToS field as the DSCP. The priority represented by a particular DSCP value is configurable. DSCP values range from 0 to 63. You can also classify IP traffic based on IPv6 DSCP. For ports that are on the boundary between two QoS administrative domains, you can modify the DSCP to another value by using the configurable DSCP-to-DSCP-mutation map.

IP Traffic Classification	Description
Trust the CoS value	Trust the CoS value (if present) in the incoming packet, and generate a DSCP value for the packet by using the CoS-to-DSCP map. If the CoS value is not present, use the default port CoS value.
IP standard or an extended ACL	Perform the classification based on a configured IP standard or an extended ACL, which examines various fields in the IP header. If no ACL is configured, the packet is assigned 0 as the DSCP and CoS values, which means best-effort traffic. Otherwise, the policy-map action specifies a DSCP or CoS value to assign to the incoming frame.
Override configured CoS	Override the configured CoS of incoming packets, and apply the default port CoS value to them. For IPv6 packets, the DSCP value is rewritten by using the CoS-to-DSCP map and by using the default CoS of the port. You can do this for both IPv4 and IPv6 traffic.

After classification, the packet is sent to the policing and marking stages.

Classification Flowchart

Figure 39: Classification Flowchart



Access Control Lists

You can use IP standard, IP extended, or Layer 2 MAC ACLs to define a group of packets with the same characteristics (class). You can also classify IP traffic based on IPv6 ACLs.

In the QoS context, the permit and deny actions in the access control entries (ACEs) have different meanings from security ACLs:

- If a match with a permit action is encountered (first-match principle), the specified QoS-related action is taken.
- If a match with a deny action is encountered, the ACL being processed is skipped, and the next ACL is processed.

Note Deny action is supported in Cisco IOS Release 3.7.4E and later releases.

- If no match with a permit action is encountered and all the ACEs have been examined, no QoS processing occurs on the packet, and the switch offers best-effort service to the packet.
- If multiple ACLs are configured on a port, the lookup stops after the packet matches the first ACL with a permit action, and QoS processing begins.

Note When creating an access list, note that by default the end of the access list contains an implicit deny statement for everything if it did not find a match before reaching the end.

After a traffic class has been defined with the ACL, you can attach a policy to it. A policy might contain multiple classes with actions specified for each one of them. A policy might include commands to classify the class as a particular aggregate (for example, assign a DSCP) or rate-limit the class. This policy is then attached to a particular port on which it becomes effective.

You implement IP ACLs to classify IP traffic by using the **access-list** global configuration command; you implement Layer 2 MAC ACLs to classify non-IP traffic by using the **mac access-list extended** global configuration command.

Classification Based on Class Maps and Policy Maps

A class map is a mechanism that you use to name a specific traffic flow (or class) and to isolate it from all other traffic. The class map defines the criteria used to match against a specific traffic flow to further classify it. The criteria can include matching the access group defined by the ACL or matching a specific list of DSCP values. If you have more than one type of traffic that you want to classify, you can create another class map and use a different name. After a packet is matched against the class-map criteria, you further classify it through the use of a policy map.

A policy map specifies which traffic class to act on. Actions can include trusting the CoS or DSCP values in the traffic class; setting a specific DSCP value in the traffic class; or specifying the traffic bandwidth limitations and the action to take when the traffic is out of profile. Before a policy map can be effective, you must attach it to a port.

You create a class map by using the **class-map** global configuration command or the **class** policy-map configuration command. You should use the **class-map** command when the map is shared among many ports. When you enter the **class-map** command, the switch enters the class-map configuration mode. In this mode, you define the match criterion for the traffic by using the **match** class-map configuration command.

You can configure a default class by using the **class class-default** policy-map configuration command. Unclassified traffic (traffic specified in the other traffic classes configured on the policy-map) is treated as default traffic.

You create and name a policy map by using the **policy-map** global configuration command. When you enter this command, the switch enters the policy-map configuration mode. In this mode, you specify the actions to take on a specific traffic class by using the **class** or **set** policy-map configuration and policy-map class configuration commands.

The policy map can contain the **police** policy-map class configuration commands, which define the policer, the bandwidth limitations of the traffic, and the action to take if the limits are exceeded.

To enable the policy map, you attach it to a port by using the **service-policy** interface configuration command.

Policing and Marking Overview

After a packet is classified and has a DSCP-based or CoS-based QoS label assigned to it, the policing and marking process can begin.

Policing involves creating a policer that specifies the bandwidth limits for the traffic. Packets that exceed the limits are *out of profile* or *nonconforming*. Each policer decides on a packet-by-packet basis whether the packet is in or out of profile and specifies the actions on the packet. These actions, carried out by the marker, include passing through the packet without modification, dropping the packet, or modifying (marking down) the assigned DSCP of the packet and allowing the packet to pass through. The configurable policed-DSCP map provides the packet with a new DSCP-based QoS label. Marked-down packets use the same queues as the original QoS label to prevent packets in a flow from getting out of order.

Note All traffic, regardless of whether it is bridged or routed, is subjected to a policer, if one is configured. As a result, bridged packets might be dropped or might have their DSCP or CoS fields modified when they are policed and marked.

You can configure policing on a physical port. After you configure the policy map and policing actions, attach the policy to a port by using the **service-policy** interface configuration command.

Physical Port Policing

In policy maps on physical ports, you can create individual policers. QoS applies the bandwidth limits specified in the policer separately to each matched traffic class. You configure this type of policer within a policy map by using the **police** policy-map class configuration command.

Policing uses a token-bucket algorithm. As each frame is received by the switch, a token is added to the bucket. The bucket has a hole in it and leaks at a rate that you specify as the average traffic rate in bits per second. Each time a token is added to the bucket, the switch verifies that there is enough room in the bucket. If there is not enough room, the packet is marked as nonconforming, and the specified policer action is taken (dropped or marked down).

How quickly the bucket fills is a function of the bucket depth (burst-byte), the rate at which the tokens are removed (rate-bps), and the duration of the burst above the average rate. The size of the bucket imposes an upper limit on the burst length and limits the number of frames that can be transmitted back-to-back. If the burst is short, the bucket does not overflow, and no action is taken against the traffic flow. However, if a burst is long and at a higher rate, the bucket overflows, and the policing actions are taken against the frames in that burst.

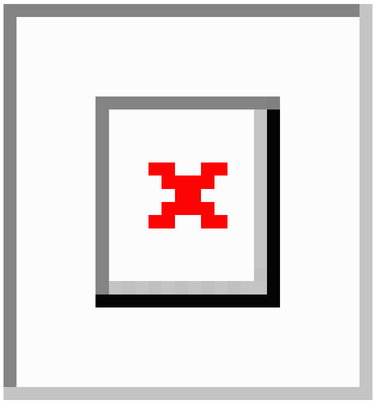
You configure the bucket depth (the maximum burst that is tolerated before the bucket overflows) by using the burst-byte option of the **police** policy-map class configuration command. You configure how fast (the average rate) that the tokens are removed from the bucket by using the *rate-bps* option of the **police** policy-map class configuration command.

Figure 40: Policing and Marking Flowchart on Physical Ports

Queueing and Scheduling Overview

The switch has queues at specific points to help prevent congestion.

Figure 41: Egress Queue Location on Switch



Note The switch supports 4 egress queues by default and there is an option to enable a total of 8 egress queues. The 8 egress queue configuration is only supported on a standalone switch.

The Catalyst 2960-L switches support Scheduled Round Robin (SRR). They do not support Weighted Round Robin (WRR). Currently, you can configure SRR with **wrr** commands instead of **srr** commands. From Cisco IOS Release 15.2(5)E2 and later, the **wrr** commands will be replaced with the **srr** commands on the switch.

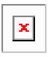
Weighted Tail Drop

Egress queues use an enhanced version of the tail-drop congestion-avoidance mechanism called weighted tail drop (WTD). WTD is implemented on queues to manage the queue lengths and to provide drop precedences for different traffic classifications.

As a frame is enqueued to a particular queue, WTD uses the frame's assigned QoS label to subject it to different thresholds. If the threshold is exceeded for that QoS label (the space available in the destination queue is less than the size of the frame), the switch drops the frame.

Each queue has three threshold values. The QoS label determines which of the three threshold values is subjected to the frame. Of the three thresholds, two are configurable (explicit) and one is not (implicit).

Figure 42: WTD and Queue Operation

The following figure shows an example of WTD operating on a queue whose size is 1000 frames. Three drop percentages are configured: 40 percent (400 frames), 60 percent (600 frames), and 100 percent (1000 frames). These percentages indicate that up to 400 frames can be queued at the 40-percent threshold, up to 600 frames at the 60-percent threshold, and up to 1000 frames at the 100-percent threshold.

In the example, CoS values 6 and 7 have a greater importance than the other CoS values, and they are assigned to the 100-percent drop threshold (queue-full state). CoS values 4 and 5 are assigned to the 60-percent threshold, and CoS values 0 to 3 are assigned to the 40-percent threshold.

Suppose the queue is already filled with 600 frames, and a new frame arrives. It contains CoS values 4 and 5 and is subjected to the 60-percent threshold. If this frame is added to the queue, the threshold will be exceeded, so the switch drops it.

SRR Shaping and Sharing

You can configure SRR on egress queues for sharing or for shaping.

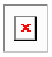
In shaped mode, the egress queues are guaranteed a percentage of the bandwidth, and they are rate-limited to that amount. Shaped traffic does not use more than the allocated bandwidth even if the link is idle. Shaping provides a more even flow of traffic over time and reduces the peaks and valleys of bursty traffic. With shaping, the absolute value of each weight is used to compute the bandwidth available for the queues.

In shared mode, the queues share the bandwidth among them according to the configured weights. The bandwidth is guaranteed at this level but not limited to it. For example, if a queue is empty and no longer requires a share of the link, the remaining queues can expand into the unused bandwidth and share it among them. With sharing, the ratio of the weights controls the frequency of dequeuing; the absolute values are meaningless. Shaping and sharing is configured per interface. Each interface can be uniquely configured.

Queueing and Scheduling on Egress Queues

The following figure shows queueing and scheduling flowcharts for egress ports on the switch.

Figure 43: Queueing and Scheduling Flowchart for Egress Ports on the Switch



Note If the expedite queue is enabled, SRR services it until it is empty before servicing the other three queues.

Egress Expedite Queue

Each port supports four egress queues, one of which (queue 1) can be the egress expedite queue. These queues are assigned to a queue-set. All traffic exiting the switch flows through one of these four queues and is subjected to a threshold based on the QoS label assigned to the packet.

Note If the expedite queue is enabled, SRR services it until it is empty before servicing the other three queues.

Queues and WTD Thresholds

You can assign each packet that flows through the switch to a queue and to a threshold.

Specifically, you map DSCP or CoS values to an egress queue and map DSCP or CoS values to a threshold ID. You use the **mls qos srr-queue output dscp-map queue** *queue-id* {*dscp1...dscp8* | **threshold** *threshold-id dscp1...dscp8*} or the **mls qos srr-queue output cos-map queue** *queue-id* {*cos1...cos8* | **threshold** *threshold-id cos1...cos8*} global configuration command. You can display the DSCP output queue threshold map and the CoS output queue threshold map by using the **show mls qos maps** privileged EXEC command.

The queues use WTD to support distinct drop percentages for different traffic classes. Each queue has three drop thresholds: two configurable (*explicit*) WTD thresholds and one nonconfigurable (*implicit*) threshold preset to the queue-full state. You assign the two WTD threshold percentages for threshold ID 1 and ID 2. The drop threshold for threshold ID 3 is preset to the queue-full state, and you cannot modify it.

Shaped or Shared Mode

You assign shared or shaped weights to the port by using the **srr-queue bandwidth share** *weight1 weight2 weight3 weight4* or the **srr-queue bandwidth shape** *weight1 weight2 weight3 weight4* interface configuration command.

The buffer allocation together with the SRR weight ratios control how much data can be buffered and sent before packets are dropped. The weight ratio is the ratio of the frequency in which the SRR scheduler sends packets from each queue.

All four queues participate in the SRR unless the expedite queue is enabled, in which case the first bandwidth weight is ignored and is not used in the ratio calculation. The expedite queue is a priority queue, and it is serviced until empty before the other queues are serviced. You enable the expedite queue by using the **priority-queue out** interface configuration command.

You can combine the commands described in this section to prioritize traffic by placing packets with particular CoSs into certain queues, by allocating a large queue size or by servicing the queue more frequently, and by adjusting queue thresholds so that packets with lower priorities are dropped.

Note The egress queue default settings are suitable for most situations. You should change them only when you have a thorough understanding of the egress queues and if these settings do not meet your QoS solution.

Packet Modification

A packet is classified, policed, and queued to provide QoS. The following packet modifications can occur during the process to provide QoS:

- For IP and non-IP packets, classification involves assigning a QoS label to a packet based on the DSCP or CoS of the received packet. However, the packet is not modified at this stage; only an indication of the assigned DSCP or CoS value is carried along.
- During policing, IP and non-IP packets can have another DSCP assigned to them (if they are out of profile and the policer specifies a markdown DSCP). Once again, the DSCP in the packet is not modified, but an indication of the marked-down value is carried along. For IP packets, the packet modification occurs at a later stage; for non-IP packets the DSCP is converted to CoS and used for queueing and scheduling decisions.
- Depending on the QoS label assigned to a frame and the mutation chosen, the DSCP and CoS values of the frame are rewritten. If you do not configure a table map and if you configure the port to trust the DSCP of the incoming frame, the DSCP value in the frame is not changed, but the CoS is rewritten according to the DSCP-to-CoS map. If you configure the port to trust the CoS of the incoming frame and it is an IP packet, the CoS value in the frame is not changed, but the DSCP might be changed according to the CoS-to-DSCP map.

  The input mutation causes the DSCP to be rewritten depending on the new value of DSCP chosen. The set action in a policy map also causes the DSCP to be rewritten.

Standard QoS Default Configuration

QoS is disabled by default.

When QoS is disabled, there is no concept of trusted or untrusted ports because the packets are not modified. The CoS or DSCP values in the packet are not changed.

Traffic is switched in pass-through mode. The packets are switched without any rewrites and classified as best effort without any policing.

When QoS is enabled using the **mls qos** global configuration command and all other QoS settings are at their defaults, traffic is classified as best effort (the DSCP and CoS value is set to 0) without any policing. No policy maps are configured. The default port trust state on all ports is untrusted.

Default Egress Queue Configuration

The following tables describe the default egress queue configurations.

The following table shows the default egress queue configuration for each queue-set when QoS is enabled. All ports are mapped to queue-set 1. The port bandwidth limit is set to 100 percent and rate unlimited. Note that for the SRR shaped weights (absolute) feature, a shaped weight of zero indicates that the queue is operating in shared mode. Note that for the SRR shared weights feature, one quarter of the bandwidth is allocated to each queue.

Table 54: Default Egress Queue Configuration

Feature	Queue 1	Queue 2	Queue 3	Queue 4
Buffer allocation	25 percent	25 percent	25 percent	25 percent
WTD drop threshold 1	80 percent	80 percent	80 percent	80 percent
WTD drop threshold 2	80 percent	80 percent	80 percent	80 percent
Reserved threshold	1000 percent	1000 percent	1000 percent	1000 percent
Maximum threshold	400 percent	400 percent	400 percent	400 percent
SRR shaped weights (absolute)	25	0	0	0
SRR shared weights	25	25	25	25

The following table shows the default CoS output queue threshold map when QoS is enabled.

Table 55: Default CoS Output Queue Threshold Map

CoS Value	Queue ID–Threshold ID
0, 1	2–1
2, 3	3–1
4	4–1
5	1–1
6, 7	4–1

Default Mapping Table Configuration

The default DSCP-to-DSCP-mutation map is a null map, which maps an incoming DSCP value to the same DSCP value.

The default policed-DSCP map is a null map, which maps an incoming DSCP value to the same DSCP value (no markdown).

How to Configure QoS

Enabling QoS Globally

By default, QoS is disabled on the switch.

The following procedure to enable QoS globally is required.

SUMMARY STEPS

1. **configure terminal**
2. **mls qos**
3. **end**
4. **show mls qos**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**mls qos** **Example:** `Switch(config)# mls qos`	Enables QoS globally. QoS operates with the default settings described in the related topic sections below. **Note** To disable QoS, use the **no mls qos** global configuration command.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 4	**show mls qos** **Example:**	Verifies the QoS configuration.

	Command or Action	Purpose
	`Switch# show mls qos`	
Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Classification Using Port Trust States

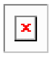
These sections describe how to classify incoming traffic by using port trust states.

Note Depending on your network configuration, you must perform one or more of these tasks in this module or one or more of the tasks in the Configuring a QoS Policy.

Configuring the Trust State on Ports Within the QoS Domain

Packets entering a QoS domain are classified at the edge of the QoS domain. When the packets are classified at the edge, the switch port within the QoS domain can be configured to one of the trusted states because there is no need to classify the packets at every switch within the QoS domain.

Figure 44: Port Trusted States on Ports Within the QoS Domain



SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **mls qos trust** [**cos** | **dscp**]
4. **end**
5. **show mls qos interface**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be trusted, and enters interface configuration mode. Valid interfaces are physical ports.
Step 3	**mls qos trust** [**cos** | **dscp**] **Example:** `Switch(config-if)# mls qos trust cos`	Configures the port trust state. By default, the port is not trusted. If no keyword is specified, the default is **dscp**. The keywords have these meanings: • **cos**—Classifies an ingress packet by using the packet CoS value. For an untagged packet, the port default CoS value is used. The default port CoS value is 0. • **dscp**—Classifies an ingress packet by using the packet DSCP value. For a non-IP packet, the packet CoS value is used if the packet is tagged; for an untagged packet, the default port CoS is used. Internally, the switch maps the CoS value to a DSCP value by using the CoS-to-DSCP map. To return a port to its untrusted state, use the **no mls qos trust** interface configuration command.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 5	**show mls qos interface** **Example:** `Switch# show mls qos interface`	Verifies your entries.

Step 6	**copy running-config startup-config**
	Example:
	`Switch# copy running-config`
	`startup-config`
		(Optional) Saves your entries in the configuration file.

Configuring the CoS Value for an Interface

QoS assigns the CoS value specified with the **mls qos cos** interface configuration command to untagged frames received on trusted and untrusted ports.

Beginning in privileged EXEC mode, follow these steps to define the default CoS value of a port or to assign the default CoS to all incoming packets on the port.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **mls qos cos** {*default-cos* | **override**}
4. **end**
5. **show mls qos interface**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/2`	Specifies the port to be configured, and enters interface configuration mode. Valid interfaces include physical ports.

Step 3	**mls qos cos** {*default-cos* | **override**}
	Example:
	`Switch(config-if)# mls qos cos override`
		Configures the default CoS value for the port.
		• For *default-cos,* specify a default CoS value to be assigned to a port. If the packet is untagged, the default CoS value becomes the packet CoS value. The CoS range is 0 to 7. The default is 0.
		• Use the **override** keyword to override the previously configured trust state of the incoming packet and to apply the default port CoS value to the port on all incoming packets. By default, CoS override is disabled.
		Use the **override** keyword when all incoming packets on specified ports deserve higher or lower priority than packets entering from other ports. Even if a port was previously set to trust DSCP or CoS, this command overrides the previously configured trust state, and all the incoming CoS values are assigned the default CoS value configured with this command. If an incoming packet is tagged, the CoS value of the packet is modified with the default CoS of the port at the ingress port.

	Command or Action	Purpose
		Note To return to the default setting, use the **no mls qos cos** {*default-cos* | **override**} interface configuration command.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 5	**show mls qos interface** **Example:** `Switch# show mls qos interface`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a Trusted Boundary to Ensure Port Security

In a typical network, you connect a Cisco IP Phone to a switch port and cascade devices that generate data packets from the back of the telephone. The Cisco IP Phone guarantees the voice quality through a shared data link by marking the CoS level of the voice packets as high priority (CoS = 5) and by marking the data packets as low priority (CoS = 0). Traffic sent from the telephone to the switch is typically marked with a tag that uses the 802.1Q header. The header contains the VLAN information and the class of service (CoS) 3-bit field, which is the priority of the packet.

For most Cisco IP Phone configurations, the traffic sent from the telephone to the switch should be trusted to ensure that voice traffic is properly prioritized over other types of traffic in the network. By using the **mls qos trust cos** interface configuration command, you configure the switch port to which the telephone is connected to trust the CoS labels of all traffic received on that port. Use the **mls qos trust dscp** interface configuration command to configure a routed port to which the telephone is connected to trust the DSCP labels of all traffic received on that port.

With the trusted setting, you also can use the trusted boundary feature to prevent misuse of a high-priority queue if a user bypasses the telephone and connects the PC directly to the switch. Without trusted boundary, the CoS labels generated by the PC are trusted by the switch (because of the trusted CoS setting). By contrast, trusted boundary uses CDP to detect the presence of a Cisco IP Phone (such as the Cisco IP Phone 7910, 7935, 7940, and 7960) on a switch port. If the telephone is not detected, the trusted boundary feature disables the trusted setting on the switch port and prevents misuse of a high-priority queue. Note that the trusted boundary feature is not effective if the PC and Cisco IP Phone are connected to a hub that is connected to the switch.

SUMMARY STEPS

1. **configure terminal**
2. **cdp run**
3. **interface** *interface-id*
4. **cdp enable**
5. Use one of the following:
   - **mls qos trust cos**
   - **mls qos trust dscp**
6. **mls qos trust device cisco-phone**
7. **end**
8. **show mls qos interface**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**cdp run** **Example:** `Switch(config)# cdp run`	Enables CDP globally. By default, CDP is enabled.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/1`	Specifies the port connected to the Cisco IP Phone, and enters interface configuration mode. Valid interfaces include physical ports.
Step 4	**cdp enable** **Example:** `Switch(config-if)# cdp enable`	Enables CDP on the port. By default, CDP is enabled.
Step 5	Use one of the following: • **mls qos trust cos** • **mls qos trust dscp** **Example:**	Configures the switch port to trust the CoS value in traffic received from the Cisco IP Phone. or Configures the routed port to trust the DSCP value in traffic received from the Cisco IP Phone.

	Command or Action	Purpose
	`Switch(config-if)# mls qos trust cos`	By default, the port is not trusted.
Step 6	**mls qos trust device cisco-phone** **Example:** `Switch(config-if)# mls qos trust device cisco-phone`	Specifies that the Cisco IP Phone is a trusted device. You cannot enable both trusted boundary and auto-QoS (**auto qos voip** interface configuration command) at the same time; they are mutually exclusive. **Note** To disable the trusted boundary feature, use the **no mls qos trust device** interface configuration command.

Step 7	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 8	**show mls qos interface** **Example:** `Switch# show mls qos interface`	Verifies your entries.
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Enabling DSCP Transparency Mode

The switch supports the DSCP transparency feature. It affects only the DSCP field of a packet at egress. By default, DSCP transparency is disabled. The switch modifies the DSCP field in an incoming packet, and the DSCP field in the outgoing packet is based on the quality of service (QoS) configuration, including the port trust setting, policing, and marking.

If DSCP transparency is enabled by using the **no mls qos rewrite ip dscp** command, the switch does not modify the DSCP field in the incoming packet, and the DSCP field in the outgoing packet is the same as that in the incoming packet.

Regardless of the DSCP transparency configuration, the switch modifies the internal DSCP value of the packet, which the switch uses to generate a class of service (CoS) value that represents the priority of the traffic. The switch also uses the internal DSCP value to select an egress queue and threshold.

SUMMARY STEPS

1. **configure terminal**
2. **mls qos**

3. **no mls qos rewrite ip dscp**
4. **end**
5. **show mls qos interface** [*interface-id*]
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**mls qos** **Example:** `Switch(config)# mls qos`	Enables QoS globally.
Step 3	**no mls qos rewrite ip dscp** **Example:** `Switch(config)# no mls qos rewrite ip dscp`	Enables DSCP transparency. The switch is configured to not modify the DSCP field of the IP packet.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show mls qos interface** [*interface-id*] **Example:** `Switch# show mls qos interface gigabitethernet0/1`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

DSCP Transparency Mode

To configure the switch to modify the DSCP value based on the trust setting or on an ACL by disabling DSCP transparency, use the **mls qos rewrite ip dscp** global configuration command.

If you disable QoS by using the **no mls qos** global configuration command, the CoS and DSCP values are not changed (the default QoS setting).

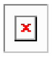
If you enter the **no mls qos rewrite ip dscp** global configuration command to enable DSCP transparency and then enter the **mls qos trust** [**cos** | **dscp**] interface configuration command, DSCP transparency is still enabled.

Note For Catalyst 2960-L switches, DSCP transparency is disabled by default.

Configuring the DSCP Trust State on a Port Bordering Another QoS Domain

If you are administering two separate QoS domains between which you want to implement QoS features for IP traffic, you can configure the switch ports bordering the domains to a DSCP-trusted state. The receiving port accepts the DSCP-trusted value and avoids the classification stage of QoS. If the two domains use different DSCP values, you can configure the DSCP-to-DSCP-mutation map to translate a set of DSCP values to match the definition in the other domain.

Figure 45: DSCP-Trusted State on a Port Bordering Another QoS Domain



Beginning in privileged EXEC mode, follow these steps to configure the DSCP-trusted state on a port and modify the DSCP-to-DSCP-mutation map. To ensure a consistent mapping strategy across both QoS domains, you must perform this procedure on the ports in both domains.

SUMMARY STEPS

1. **configure terminal**
2. **mls qos map dscp-mutation** *in-dscp* **to** *out-dscp*
3. **interface** *interface-id*
4. **mls qos trust dscp**
5. **end**
6. **show mls qos maps dscp-mutation**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.

Step 2	**mls qos map dscp-mutation** *in-dscp* **to** *out-dscp*
	Example:
	`Switch(config)# mls qos map`
	`dscp-mutation`
		Modifies the DSCP-to-DSCP-mutation map.
		The default DSCP-to-DSCP-mutation map is a null map, which maps an incoming DSCP value to the same DSCP value.

	Command or Action	Purpose
	`10 11 12 13 to 30`	• For *in-dscp*, enter up to eight DSCP values separated by spaces. Then enter the **to** keyword. • For *out-dscp*, enter a single DSCP value. The DSCP range is 0 to 63.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/2`	Specifies the port to be trusted, and enter interface configuration mode. Valid interfaces include physical ports.
Step 4	**mls qos trust dscp** **Example:** `Switch(config-if)# mls qos trust dscp`	Configures the ingress port as a DSCP-trusted port. By default, the port is not trusted. **Note** To return a port to its non-trusted state, use the **no mls qos trust** interface configuration command.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**show mls qos maps dscp-mutation** **Example:** `Switch# show mls qos maps dscp-mutation`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy-running-config startup-config`	(Optional) Saves your entries in the configuration file. **Note** To return a port to its non-trusted state, use the **no mls qos trust interface** configuration command. To return to the default DSCP-to-DSCP-mutation map values, use the **no mls qos map dscp-mutation** *dscp-mutation-name* global configuration command.

Configuring a QoS Policy

Configuring a QoS policy typically requires the following tasks:

- Classifying traffic into classes

- Configuring policies applied to those traffic classes
- Attaching policies to ports

These sections describe how to classify, police, and mark traffic. Depending on your network configuration, you must perform one or more of the modules in this section.

Classifying Traffic by Using ACLs

You can classify IP traffic by using IPv4 standard ACLS, IPv4 extended ACLs, or IPv6 ACLs.

You can classify non-IP traffic by using Layer 2 MAC ACLs.

Creating an IP Standard ACL for IPv4 Traffic

Before you begin

Before you perform this task, determine which access lists you will be using for your QoS configuration.

SUMMARY STEPS

1. **configure terminal**
2. **access-list** *access-list-number* {**permit**} *source* [*source-wildcard*]
3. **end**
4. **show access-lists**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**access-list** *access-list-number* {**permit**} *source* [*source-wildcard*] **Example:** `Switch(config)# access-list 1 permit 192.2.255.0 10.1.1.255`	Creates an IP standard ACL, repeating the command as many times as necessary. • For *access-list-number*, enter the access list number. The range is 1 to 99 and 1300 to 1999. • Use the **permit** keyword to permit a certain type of traffic if the conditions are matched. • For *source*, enter the network or host from which the packet is being sent. You can use the **any** keyword as an abbreviation for 0.0.0.0 255.255.255.255. • (Optional) For *source-wildcard*, enter the wildcard bits in dotted decimal notation to be applied to the source. Place ones in the bit positions that you want to ignore.

	Command or Action	Purpose
		When you create an access list, remember that by default the end of the access list contains an implicit deny statement for everything if it did not find a match before reaching the end. **Note** To delete an access list, use the **no access-list** *access-list-number* global configuration command.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 4	**show access-lists** **Example:** `Switch# show access-lists`	Verifies your entries.
Step 5	**copy running-config startup-config** **Example:** `Switch# copy-running-config startup-config`	(Optional) Saves your entries in the configuration file.

Creating an IP Extended ACL for IPv4 Traffic

Before you begin

Before you perform this task, determine which access lists you will be using for your QoS configuration.

SUMMARY STEPS

1. **configure terminal**
2. **access-list** *access-list-number* **permit** *protocol source source-wildcard destination destination-wildcard*
3. **end**
4. **show access-lists**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 2	**access-list** *access-list-number* **permit** *protocol source source-wildcard destination destination-wildcard* **Example:** `Switch(config)# access-list 100 permit ip any any dscp 32`	Creates an IP extended ACL, repeating the command as many times as necessary. • For *access-list-number*, enter the access list number. The range is 100 to 199 and 2000 to 2699. • Use the **permit** keyword to permit a certain type of traffic if the conditions are matched. • For *protocol*, enter the name or number of an IP protocol. Use the question mark (?) to see a list of available protocol keywords. • For *source*, enter the network or host from which the packet is being sent. You specify this by using dotted decimal notation, by using the **any** keyword as an abbreviation for *source* 0.0.0.0 *source-wildcard* 255.255.255.255, or by using the **host** keyword for *source* 0.0.0.0. • For *source-wildcard*, enter the wildcard bits by placing ones in the bit positions that you want to ignore. You specify the wildcard by using dotted decimal notation, by using the **any** keyword as an abbreviation for *source* 0.0.0.0 *source-wildcard* 255.255.255.255, or by using the **host** keyword for *source* 0.0.0.0. • For *destination*, enter the network or host to which the packet is being sent. You have the same options for specifying the *destination and destination-wildcard* as those described by *source* and *source-wildcard*. When creating an access list, remember that, by default, the end of the access list contains an implicit deny statement for everything if it did not find a match before reaching the end. **Note** To delete an access list, use the **no access-list** *access-list-number* global configuration command.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 4	**show access-lists** **Example:** `Switch# show access-lists`	Verifies your entries.
Step 5	**copy running-config startup-config** **Example:** `Switch# copy-running-config startup-config`	(Optional) Saves your entries in the configuration file.

Creating an IPv6 ACL for IPv6 Traffic

Before you begin

Before you perform this task, determine which access lists you will be using for your QoS configuration.

SUMMARY STEPS

1. **configure terminal**
2. **ipv6 access-list** *access-list-name*
3. {**permit**} *protocol* {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [*operator* [*port-number*]] {*destination-ipv6-prefix/ prefix-length* | **any** | **host** *destination-ipv6-address*} [*operator* [*port-number*]] [**dscp** *value*]
4. **end**
5. **show ipv6 access-list**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**ipv6 access-list** *access-list-name* **Example:** `Switch(config)# ipv6 access-list ipv6_Name_ACL`	Creates an IPv6 ACL and enters IPv6 access-list configuration mode. Accesses list names cannot contain a space or quotation mark or begin with a numeric. **Note** To delete an access list, use the **no ipv6 access-list** *access-list-number* global configuration command.

	Command or Action	Purpose
Step 3	{**permit**} *protocol* {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [*operator* [*port-number*]] {*destination-ipv6-prefix/ prefix-length* | **any** | **host** *destination-ipv6-address*} [*operator* [*port-number*]] [**dscp** *value*] **Example:** `Switch(config-ipv6-acl)#` **`permit ip host 10::1 host 11::2 host`**	Enters **permit** to permit the packet if conditions are matched. These are the conditions: For *protocol*, enter the name or number of an Internet protocol: **ahp**, **esp**, **icmp**, **ipv6**, **pcp**, **stcp**, **tcp**, or **udp**, or an integer in the range 0 to 255 representing an IPv6 protocol number. • The *source-ipv6-prefix/prefix-length* or *destination-ipv6-prefix/ prefix-length* is the source or destination IPv6 network or class of networks for which to set permit condition, specified in hexadecimal and using 16-bit values between colons (see RFC 2373). • Enter **any** as an abbreviation for the IPv6 prefix ::/0. • For **host** *source-ipv6-address* or *destination-ipv6-address*, enter the source or destination IPv6 host address for which to set permit condition, specified in hexadecimal using 16-bit values between colons. • (Optional) For *operator*, specify an operand that compares the source or destination ports of the specified protocol. Operands are **lt** (less than), **gt** (greater than), **eq** (equal), **neq** (not equal), and **range**. If the operator follows the *source-ipv6-prefix/prefix-length* argument, it must match the source port. If the operator follows the *destination-ipv6- prefix/prefix-length* argument, it must match the destination port. • (Optional) The *port-number* is a decimal number from 0 to 65535 or the name of a TCP or UDP port. You can use TCP port names only when filtering TCP. You can use UDP port names only when filtering UDP. • (Optional) Enter **dscp** *value* to match a differentiated services code point value against the traffic class value in the Traffic Class field of each IPv6 packet header. The acceptable range is from 0 to 63.

Step 4	**end**
	Example:
	`Switch(config-ipv6-acl)#` **`end`**
		Returns to privileged EXEC mode.

Step 5	**show ipv6 access-list** **Example:**	Verifies the access list configuration.

	Command or Action	Purpose

	`Switch#` **`show ipv6`**
	`access-list`	

Step 6	**copy running-config startup-config**
	Example:
	`Switch#` **`copy-running-config`**
	`startup-config`
		(Optional) Saves your entries in the configuration file.

Creating a Layer 2 MAC ACL for Non-IP Traffic

Before you begin

Before you perform this task, determine that Layer 2 MAC access lists are required for your QoS configuration.

SUMMARY STEPS

1. **configure terminal**
2. **mac access-list extended** *name*
3. {**permit** | **deny**} {**host** *src-MAC-addr mask* | **any** | **host** *dst-MAC-addr* | *dst-MAC-addr mask*} [*type mask*]
4. **end**
5. **show access-lists** [*access-list-number* | *access-list-name*]
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch#` **`configure terminal`**	Enters global configuration mode.

Step 2	**mac access-list extended** *name*
	Example:
	`Switch(config)#` **`mac access-list`**
	`extended maclist1`
		Creates a Layer 2 MAC ACL by specifying the name of the list.
		After entering this command, the mode changes to extended MAC ACL configuration.
		Note To delete an access list, use the **no mac access-list extended** *access-list-name* global configuration command.

Step 3	{**permit** | **deny**} {**host** *src-MAC-addr mask* | **any** | **host** *dst-MAC-addr* | *dst-MAC-addr mask*} [*type mask*] **Example:**	Specifies the type of traffic to permit or deny if the conditions are matched, entering the command as many times as necessary.

	Command or Action	Purpose

	`Switch(config-ext-mac1) # `**`permit 0001.0000.0001 0.0.0 0002.0000.0001 0.0.0`**
	`Switch(config-ext-mac1) # `**`permit 0001.0000.0002 0.0.0 0002.0000.0002 0.0.0 xns-idp`**
		• For *src-MAC-addr*, enter the MAC address of the host from which the packet is being sent. You specify this by using the hexadecimal format (H.H.H), by using the **any** keyword as an abbreviation for *source* 0.0.0, *source-wildcard* ffff.ffff.ffff, or by using the **host** keyword for *source* 0.0.0.
		• For *mask*, enter the wildcard bits by placing ones in the bit positions that you want to ignore.
		• For *dst-MAC-addr*, enter the MAC address of the host to which the packet is being sent. You specify this by using the hexadecimal format (H.H.H), by using the **any** keyword as an abbreviation for *source* 0.0.0, *source-wildcard* ffff.ffff.ffff, or by using the **host** keyword for *source* 0.0.0.
		• (Optional) For *type mask*, specify the Ethertype number of a packet with Ethernet II or SNAP encapsulation to identify the protocol of the packet. For *type*, the range is from 0 to 65535, typically specified in hexadecimal. For *mask*, enter the *don't care* bits applied to the Ethertype before testing for a match.
		When creating an access list, remember that, by default, the end of the access list contains an implicit deny statement for everything if it did not find a match before reaching the end.

Step 4	**end**
	Example:
	`Switch(config-ext-mac1)# `**`end`**
		Returns to privileged EXEC mode.

Step 5	**show access-lists** [*access-list-number* | *access-list-name*] **Example:** `Switch# `**`show access-lists`**	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# `**`copy-running-config startup-config`**	(Optional) Saves your entries in the configuration file.

Classifying Traffic by Using Class Maps

You use the **class-map** global configuration command to name and to isolate a specific traffic flow (or class) from all other traffic. The class map defines the criteria to use to match against a specific traffic flow to further classify it. Match statements can include criteria such as an ACL or DSCP values. The match criterion is defined with one match statement entered within the class-map configuration mode.

Note You can also create class maps during policy map creation by using the **class** policy-map configuration command.

SUMMARY STEPS

1. **configure terminal**
2. Use one of the following:
   - **access-list** *access-list-number* {**permit**} *source* [*source-wildcard*]
   - **access-list** *access-list-number* {**permit**} *protocol source* [*source-wildcard*] *destination* [*destination-wildcard*]
   - **ipv6 access-list** *access-list-name* {**permit**} *protocol* {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [*operator* [*port-number*]] {*destination-ipv6-prefix/ prefix-length* | **any** | **host** *destination-ipv6-address*} [*operator* [*port-number*]] [**dscp** *value*]
   - **mac access-list extended** *name* {**permit** | **deny**} {**host** *src-MAC-addr mask* | **any** | **host** *dst-MAC-addr* | *dst-MAC-addr mask*} [*type mask*]
3. **class-map** [**match-all**] *class-map-name*
4. **match** {**access-group** *acl-index-or-name* | **ip dscp** *dscp-list*}
5. **end**
6. **show class-map**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	Use one of the following: • **access-list** *access-list-number* {**permit**} *source* [*source-wildcard*] • **access-list** *access-list-number* {**permit**} *protocol source* [*source-wildcard*] *destination* [*destination-wildcard*] • **ipv6 access-list** *access-list-name* {**permit**} *protocol* {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [*operator* [*port-number*]]	Creates an IP standard or extended ACL, an IPv6 ACL for IP traffic, or a Layer 2 MAC ACL for non-IP traffic, repeating the command as many times as necessary. When creating an access list, remember that, by default, the end of the access list contains an implicit deny statement for everything if it did not find a match before reaching the end.

	Command or Action	Purpose
	{*destination-ipv6-prefix*/ *prefix-length* | **any** | **host** *destination-ipv6-address*} [*operator* [*port-number*]] [**dscp** *value*] - **mac access-list extended** *name* {**permit** | **deny**} {**host** *src-MAC-addr mask* | **any** | **host** *dst-MAC-addr* | *dst-MAC-addr mask*} [*type mask*] **Example:** `Switch(config)#` **`access-list 103 permit ip any any dscp 10`**	

Step 3	**class-map** [**match-all**] *class-map-name*
	Example:
	`Switch(config)#` **`class-map class1`**
		Creates a class map, and enters class-map configuration mode.
		By default, no class maps are defined.
		- (Optional) Use the **match-all** keyword to perform a logical-AND of all matching statements under this class map. All match criteria in the class map must be matched.
		- For *class-map-name*, specify the name of the class map.
		Note To delete an existing class map, use the **no class-map** [**match-all**] *class-map-name* global configuration command.

Step 4	**match** {**access-group** *acl-index-or-name* | **ip dscp** *dscp-list*}
	Example:
	`Switch(config-cmap)#` **`match ip dscp 10 11 12`**
		Defines the match criterion to classify traffic.
		By default, no match criterion is defined.
		Only one match criterion per class map is supported, and only one ACL per class map is supported.
		- For **access-group** *acl-index-or-name,* specify the number or name of the ACL created in Step 2.
		- To filter IPv6 traffic with the **match access-group** command, create an IPv6 ACL, as described in Step 2.
		- For **ip dscp** *dscp-list*, enter a list of up to eight IP DSCP values to match against incoming packets. Separate each value with a space. The range is 0 to 63.
		Note To remove a match criterion, use the **no match** {**access-group** *acl-index-or-name* | **ip dscp**} class-map configuration command.

Step 5	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config-cmap)# end`	
Step 6	**show class-map** **Example:** `Switch# show class-map`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy-running-config startup-config`	(Optional) Saves your entries in the configuration file.

Classifying, Policing, and Marking Traffic on Physical Ports by Using Policy Maps

You can configure a policy map on a physical port that specifies which traffic class to act on. Actions can include trusting the CoS or DSCP values in the traffic class; setting a specific DSCP value in the traffic class; and specifying the traffic bandwidth limitations for each matched traffic class (policer) and the action to take when the traffic is out of profile (marking).

A policy map also has these characteristics:

- A policy map can contain multiple class statements, each with different match criteria and policers.
- A policy map can contain a predefined default traffic class explicitly placed at the end of the map.
- A separate policy-map class can exist for each type of traffic received through a port.

Follow these guidelines when configuring policy maps on physical ports:

- You can attach only one policy map per ingress port.
- mls qos must be enabled in global configuration mode.
- If you enter or have used the **set ip dscp** command, the switch changes this command to **set dscp** in its configuration.
- A policy-map and a port trust state can both run on a physical interface. The policy-map is applied before the port trust state.
- When you configure a default traffic class by using the **class class-default** policy-map configuration command, unclassified traffic (traffic that does not meet the match criteria specified in the traffic classes) is treated as the default traffic class (class-default).

SUMMARY STEPS

1. **configure terminal**
2. **class-map** *class-map-name*
3. **policy-map** *policy-map-name*
4. **class** [*class-map-name* | **class-default**]

5. **set dscp** *new-dscp*
6. **police** *rate-bps burst-byte* [**exceed-action** {**drop**}]
7. **exit**
8. **exit**
9. **interface** *interface-id*
10. **service-policy input** *policy-map-name*
11. **end**
12. **show policy-map** [*policy-map-name* [**class** *class-map-name*]]
13. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.

Step 2	**class-map** *class-map-name*
	Example:
	`Switch(config)# class-map ipclass1`
		Creates a class map, and enters class-map configuration mode.
		By default, no class maps are defined. For *class-map-name*, specify the name of the class map.

Step 3	**policy-map** *policy-map-name* **Example:** `Switch(config-cmap)# policy-map flowit`	Creates a policy map by entering the policy map name, and enters policy-map configuration mode. By default, no policy maps are defined. The default behavior of a policy map is to set the DSCP to 0 if the packet is an IP packet and to set the CoS to 0 if the packet is tagged. No policing is performed. **Note** To delete an existing policy map, use the **no policy-map** *policy-map-name* global configuration command.

Step 4	**class** [*class-map-name* | **class-default**]
	Example:
	`Switch(config-pmap)# class ipclass1`
		Defines a traffic classification, and enters policy-map class configuration mode.
		By default, no policy map class-maps are defined.
		If a traffic class has already been defined by using the **class-map** global configuration command, specify its name for *class-map-name* in this command.
		A **class-default** traffic class is pre-defined and can be added to any policy. It is always placed at the end of a policy map. With an implied **match any** included in the **class-default** class, all packets that have not already matched the other traffic classes will match **class-default**.

	Command or Action	Purpose
		Note To delete an existing class map, use the **no class** *class-map-name* policy-map configuration command.
Step 5	**set dscp** *new-dscp* **Example:** `Switch(config-pmap-c)# `**`set dscp 45`**	Classifies IP traffic by setting a new value in the packet. • For **dscp** *new-dscp*, enter a new DSCP value to be assigned to the classified traffic. The range is 0 to 63.

Step 6	**police** *rate-bps burst-byte* [**exceed-action** {**drop**}]
	Example:
	`Switch(config-pmap-c)# `**`police 100000`**
	`80000 exceed-action drop`
		Defines a policer for the classified traffic.
		By default, no policer is defined.
		• For *rate-bps,* specify average traffic rate in bits per second (b/s). The range is 8000 to 10000000000.
		• For *burst-byte,* specify the normal burst size in bytes.
		  • If 8000 <= *rate-bps* < 102300000,*burst-byte* range is 8000 to 65535.
		  • If 102300000 <= *rate-bps* <1023000000, *burst-byte* range is 8000 to 524280.
		  • If 1023000000 <= *rate-bps* <= 10Gig, *burst-byte* range is 8000 to 1000000.
		• (Optional) Specifies the action to take when the rates are exceeded. Use the **exceed-action drop** keywords to drop the packet.
		Note To remove an existing policer, use the **no police** *rate-bps burst-byte* [**exceed-action drop**] policy-map configuration command.

Step 7	**exit** **Example:** `Switch(config-pmap-c)# `**`exit`**	Returns to policy map configuration mode.
Step 8	**exit** **Example:** `Switch(config-pmap)# `**`exit`**	Returns to global configuration mode.
Step 9	**interface** *interface-id* **Example:**	Specifies the port to attach to the policy map, and enters interface configuration mode. Valid interfaces include physical ports.

	Command or Action	Purpose
	`Switch(config)# interface gigabitethernet0/1`	
Step 10	**service-policy input** *policy-map-name* **Example:** `Switch(config-if)# service-policy input flowit`	Specifies the policy-map name, and applies it to an ingress port. Only one policy map per ingress port is supported. **Note** To remove the policy map and port association, use the **no service-policy** *input policy-map-name* interface configuration command.

Step 11	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 12	**show policy-map** [*policy-map-name* [**class** *class-map-name*]] **Example:** `Switch# show policy-map`	Verifies your entries.
Step 13	**copy running-config startup-config** **Example:** `Switch# copy-running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Egress Queue Characteristics

Depending on the complexity of your network and your QoS solution, you might need to perform all of the tasks in the following modules. You need to make decisions about these characteristics:

- Which packets are mapped by DSCP or CoS value to each queue and threshold ID?
- What drop percentage thresholds apply to the queue-set (four egress queues per port), and how much reserved and maximum memory is needed for the traffic type?
- Does the bandwidth of the port need to be rate limited?
- How often should the egress queues be serviced and which technique (shaped, shared, or both) should be used?

Configuration Guidelines

Follow these guidelines when the expedite queue is enabled or the egress queues are serviced based on their SRR weights:

- If the egress expedite queue is enabled, it overrides the SRR shaped and shared weights for queue 1.
- If the egress expedite queue is disabled and the SRR shaped and shared weights are configured, the shaped mode overrides the shared mode for queue 1, and SRR services this queue in shaped mode.
- If the egress expedite queue is disabled and the SRR shaped weights are not configured, SRR services this queue in shared mode.

Mapping DSCP or CoS Values to an Egress Queue and to a Threshold ID

You can prioritize traffic by placing packets with particular DSCPs or costs of service into certain queues and adjusting the queue thresholds so that packets with lower priorities are dropped. Default number of queues is 4. You can increase it to 8 using the **mls qos srr-queue output queues 8** command.

Note The egress queue default settings are suitable for most situations. You should change them only when you have a thorough understanding of egress queues and if these settings do not meet your QoS solution.

Beginning in privileged EXEC mode, follow these steps to map DSCP or CoS values to an egress queue and to a threshold ID. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. Use one of the following:
   - **mls qos srr-queue output dscp-map queue** *queue-id* **threshold** *threshold-id dscp1...dscp8*
   - **mls qos srr-queue output cos-map queue** *queue-id* **threshold** *threshold-id cos1...cos8*
3. **mls qos srr-queue output cos-map queue** *queue-id* **threshold** *threshold-id cos1...cos8*
4. **end**
5. **show mls qos maps**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	Use one of the following: • **mls qos srr-queue output dscp-map queue** *queue-id* **threshold** *threshold-id dscp1...dscp8*	Maps DSCP or CoS values to an egress queue and to a threshold ID.

	Command or Action	Purpose
	• **mls qos srr-queue output cos-map queue** *queue-id* **threshold** *threshold-id cos1...cos8* **Example:** `Switch(config)#` **`mls qos srr-queue output dscp-map queue 1 threshold 2 10 11`**	By default, DSCP values 0–15 are mapped to queue 2 and threshold 1. DSCP values 16–31 are mapped to queue 3 and threshold 1. DSCP values 32–39 and 48–63 are mapped to queue 4 and threshold 1. DSCP values 40–47 are mapped to queue 1 and threshold 1. By default, CoS values 0 and 1 are mapped to queue 2 and threshold 1. CoS values 2 and 3 are mapped to queue 3 and threshold 1. CoS values 4, 6, and 7 are mapped to queue 4 and threshold 1. CoS value 5 is mapped to queue 1 and threshold 1. • For *queue-id*, the range is 1 to 4. • For *threshold-id*, the range is 1 to 2. The drop-threshold percentage for threshold 3 is predefined. It is set to the queue-full state. • For *dscp1...dscp8*, enter up to eight values, and separate each value with a space. The range is 0 to 63. • For *cos1...cos8*, enter up to eight values, and separate each value with a space. The range is 0 to 7. **Note** To return to the default DSCP output queue threshold map or the default CoS output queue threshold map, use the **no mls qos srr-queue output dscp-map** or the **no mls qos srr-queue output cos-map** global configuration command.
Step 3	**mls qos srr-queue output cos-map queue** *queue-id* **threshold** *threshold-id cos1...cos8* **Example:** `Switch(config)#` **`mls qos srr-queue output cos-map queue 3 threshold 1 2 3`**	Maps CoS values to an egress queue and to a threshold ID. By default, CoS values 0 and 1 are mapped to queue 2 and threshold 1. CoS values 2 and 3 are mapped to queue 3 and threshold 1. CoS values 4, 6, and 7 are mapped to queue 4 and threshold 1. CoS value 5 is mapped to queue 1 and threshold 1. • For *queue-id*, the range is 1 to 4. • For *threshold-id*, the range is 1 to 2. The drop-threshold percentage for threshold 3 is predefined. It is set to the queue-full state. • For *cos1...cos8*, enter up to eight values, and separate each value with a space. The range is 0 to 7. **Note** To return to the default CoS output queue threshold map, use the **no mls qos srr-queue output cos-map** global configuration command.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show mls qos maps** **Example:** `Switch# show mls qos maps`	Verifies your entries. The DSCP output queue threshold map appears as a matrix. The d1 column specifies the most-significant digit of the DSCP number; the d2 row specifies the least-significant digit in the DSCP number. The intersection of the d1 and the d2 values provides the queue ID and threshold ID; for example, queue 2 and threshold 1 (02-01). The CoS output queue threshold map shows the CoS value in the top row and the corresponding queue ID and threshold ID in the second row; for example, queue 2 and threshold 2 (2-2).
Step 6	**copy running-config startup-config** **Example:** `Switch# copy-running-config startup-config`	(Optional) Saves your entries in the configuration file. To return to the default DSCP output queue threshold map or the default CoS output queue threshold map, use the **no mls qos srr-queue output dscp-map** or the **no mls qos srr-queue output cos-map** global configuration command.

Configuring SRR Shaped Weights on Egress Queues

You can specify how much of the available bandwidth is allocated to each queue. The ratio of the weights is the ratio of frequency in which the SRR scheduler sends packets from each queue.

You can configure the egress queues for shaped or shared weights, or both. Use shaping to smooth bursty traffic or to provide a smoother output over time.

Beginning in privileged EXEC mode, follow these steps to assign the shaped weights and to enable bandwidth shaping on the four egress queues mapped to a port. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **srr-queue bandwidth shape** *weight1 weight2 weight3 weight4*
4. **end**
5. **show mls qos interface** *interface-id* **queueing**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port of the outbound traffic, and enters interface configuration mode.

Step 3	**srr-queue bandwidth shape** *weight1 weight2 weight3 weight4*
	Example:
	`Switch(config-if)# srr-queue`
	`bandwidth shape 8 0 0 0`
		Assigns SRR weights to the egress queues. By default, weight1 is set to 25; weight2, weight3, and weight4 are set to 0, and these queues are in shared mode.
		For *weight1 weight2 weight3 weight4*, enter the weights to control the percentage of the port that is shaped. The inverse ratio (1/weight) controls the shaping bandwidth for this queue. Separate each value with a space. The range is 0 to 65535.
		If you configure a weight of 0, the corresponding queue operates in shared mode. The weight specified with the **srr-queue bandwidth shape** command is ignored, and the weights specified with the **srr-queue bandwidth share** interface configuration command for a queue come into effect. When configuring queues in the same queue-set for both shaping and sharing, make sure that you configure the lowest number queue for shaping.
		The shaped mode overrides the shared mode.
		To return to the default setting, use the **no srr-queue bandwidth shape** interface configuration command.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 5	**show mls qos interface** *interface-id* **queueing**
	Example:
	`Switch# show mls qos interface`
	`interface-id queuing`
		Verifies your entries.

Step 6	**copy running-config startup-config**	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	Example: `Switch# copy running-config startup-config`	To return to the default setting, use the **no srr-queue bandwidth shape** interface configuration command.

Configuring SRR Shared Weights on Egress Queues

In shared mode, the queues share the bandwidth among them according to the configured weights. The bandwidth is guaranteed at this level but not limited to it. For example, if a queue empties and does not require a share of the link, the remaining queues can expand into the unused bandwidth and share it among them. With sharing, the ratio of the weights controls the frequency of dequeuing; the absolute values are meaningless.

Note The egress queue default settings are suitable for most situations. You should change them only when you have a thorough understanding of the egress queues and if these settings do not meet your QoS solution.

Beginning in privileged EXEC mode, follow these steps to assign the shared weights and to enable bandwidth sharing on the four egress queues mapped to a port. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **srr-queue bandwidth share** *weight1 weight2 weight3 weight4*
4. **end**
5. **show mls qos interface** *interface-id* **queueing**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/1`	Specifies the port of the outbound traffic, and enters interface configuration mode.

	Command or Action	Purpose
Step 3	**srr-queue bandwidth share** *weight1 weight2 weight3 weight4* **Example:** `Switch(config-id)# srr-queue bandwidth share 1 2 3 4`	Assigns SRR weights to the egress queues. By default, all four weights are 25 (1/4 of the bandwidth is allocated to each queue). For *weight1 weight2 weight3 weight4*, enter the weights to control the ratio of the frequency in which the SRR scheduler sends packets. Separate each value with a space. The range is 1 to 255. To return to the default setting, use the **no srr-queue bandwidth share** interface configuration command.

Step 4	**end**
	Example:
	`Switch(config-id)# end`
		Returns to privileged EXEC mode.

Step 5	**show mls qos interface** *interface-id* **queueing** **Example:** `Switch# show mls qos interface interface_id queuing`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy-running-config startup-config`	(Optional) Saves your entries in the configuration file. To return to the default setting, use the **no srr-queue bandwidth share** interface configuration command.

Configuring the Egress Expedite Queue

You can ensure that certain packets have priority over all others by queuing them in the egress expedite queue. SRR services this queue until it is empty before servicing the other queues.

Beginning in privileged EXEC mode, follow these steps to enable the egress expedite queue. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **mls qos**
3. **interface** *interface-id*
4. **priority-queue out**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**mls qos** **Example:** `Switch(config)# mls qos`	Enables QoS on a switch.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the egress port, and enters interface configuration mode.
Step 4	**priority-queue out** **Example:** `Switch(config-if)# priority-queue out`	Enables the egress expedite queue, which is disabled by default. When you configure this command, the SRR weight and queue size ratios are affected because there is one fewer queue participating in SRR. This means that *weight1* in the **srr-queue bandwidth shape** or the **srr-queue bandwidth share** command is ignored (not used in the ratio calculation). **Note** To disable the egress expedite queue, use the **no priority-queue out** interface configuration command.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config`	(Optional) Saves your entries in the configuration file. To disable the egress expedite queue, use the **no priority-queue out** interface configuration command.

	Command or Action	Purpose
	`startup-config`	

Limiting the Bandwidth on an Egress Interface

You can limit the bandwidth on an egress port. For example, if a customer pays only for a small percentage of a high-speed link, you can limit the bandwidth to that amount.

Note The egress queue default settings are suitable for most situations. You should change them only when you have a thorough understanding of the egress queues and if these settings do not meet your QoS solution.

Beginning in privileged EXEC mode, follow these steps to limit the bandwidth on an egress port. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **srr-queue bandwidth limit** *weight1*
4. **end**
5. **show mls qos interface** [*interface-id*] **queueing**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be rate-limited, and enters interface configuration mode.
Step 3	**srr-queue bandwidth limit** *weight1* **Example:** `Switch(config-if)# srr-queue bandwidth limit 80`	Specifies the percentage of the port speed to which the port should be limited. The range is 10 to 90. By default, the port is not rate-limited and is set to 100 percent. **Note** To return to the default setting, use the **no srr-queue bandwidth limit** interface configuration command.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 5	**show mls qos interface** [*interface-id*] **queueing** **Example:** `Switch# show mls qos interface interface_id queueing`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy-running-config startup-config`	(Optional) Saves your entries in the configuration file. To return to the default setting, use the **no srr-queue bandwidth limit** interface configuration command.

Monitoring Standard QoS

Table 56: Commands for Monitoring Standard QoS on the Switch

Command	Description
show mls qos	Displays global QoS configuration information.
show mls qos interface [*interface-id*] [**policers** | **queueing** | **statistics**]	Displays QoS information at the port level, including the buffer allocation, which ports have configured policers, the queueing strategy, and the ingress and egress statistics.
show mls qos maps [**cos-output-q** | **dscp-mutation**]	Displays QoS mapping information.
show running-config | include rewrite	Displays the DSCP transparency setting.

Configuration Examples for QoS

Example: Configuring Port to the DSCP-Trusted State and Modifying the DSCP-to-DSCP-Mutation Map

This example shows how to configure a port to the DSCP-trusted state and to modify the DSCP-to-DSCP-mutation map so that incoming DSCP values 10 to 13 are mapped to DSCP 30:

```
Switch(config)# mls qos map dscp-mutation
10 11 12 13 to 30
Switch(config)# interface gigabitethernet0/2
Switch(config-if)# mls qos trust dscp
Switch(config-if)# end
```

Examples: Classifying Traffic by Using ACLs

This example shows how to allow access for only those hosts on the three specified networks. The wildcard bits apply to the host portions of the network addresses. Any host with a source address that does not match the access list statements is rejected.

```
Switch(config)# access-list 1 permit 192.5.255.0 0.0.0.255
Switch(config)# access-list 1 permit 128.88.0.0 0.0.255.255
Switch(config)# access-list 1 permit 36.0.0.0 0.0.0.255
! (Note: all other access implicitly denied)
```

This example shows how to create an ACL that permits IP traffic from any source to any destination that has the DSCP value set to 32:

```
Switch(config)# access-list 100 permit ip any any dscp 32
```

This example shows how to create an ACL that permits IP traffic from a source host at 10.1.1.1 to a destination host at 10.1.1.2 with a precedence value of 5:

```
Switch(config)# access-list 100 permit ip host 10.1.1.1 host 10.1.1.2 precedence 5
```

This example shows how to create an ACL that permits PIM traffic from any source to a destination group address of 224.0.0.2 with a DSCP set to 32:

```
Switch(config)# access-list 102 permit pim any 224.0.0.2 dscp 32
```

This example shows how to create an ACL that permits IPv6 traffic from any source to any destination that has the DSCP value set to 32:

```
Switch(config)# ipv6 access-list 100 permit ip any any dscp 32
```

This example shows how to create an ACL that permits IPv6 traffic from a source host at 10.1.1.1 to a destination host at 10.1.1.2 with a precedence value of 5:

```
Switch(config)# ipv6 access-list ipv6_Name_ACL permit ip host 10::1 host 10.1.1.2
precedence 5
```

This example shows how to create a Layer 2 MAC ACL with two permit statements. The first statement allows traffic from the host with MAC address 0001.0000.0001 to the host with MAC address 0002.0000.0001. The second statement allows only Ethertype XNS-IDP traffic from the host with MAC address 0001.0000.0002 to the host with MAC address 0002.0000.0002.

```
Switch(config)# mac access-list extended maclist1
Switch(config-ext-macl)# permit 0001.0000.0001 0.0.0 0002.0000.0001 0.0.0
Switch(config-ext-macl)# permit 0001.0000.0002 0.0.0 0002.0000.0002 0.0.0 xns-idp
! (Note: all other access implicitly denied)
```

Examples: Classifying Traffic by Using Class Maps

This example shows how to configure the class map called *class1*. The *class1* has one match criterion, which is access list 103. It permits traffic from any host to any destination that matches a DSCP value of 10.

```
Switch(config)# access-list 103 permit ip any any dscp 10
Switch(config)# class-map class1
Switch(config-cmap)# match access-group 103
Switch(config-cmap)# end
Switch#
```

This example shows how to create a class map called *class2*, which matches incoming traffic with DSCP values of 10, 11, and 12.

```
Switch(config)# class-map class2
Switch(config-cmap)# match ip dscp 10 11 12
Switch(config-cmap)# end
Switch#
```

This example shows how to configure a class map to match IP DSCP and IPv6:

```
Switch(config)# Class-map cm-1
Switch(config-cmap)# match ip dscp 10
Switch(config-cmap)# exit
Switch(config)# Class-map cm-2
Switch(config-cmap)# match ip dscp 20
Switch(config-cmap)# exit
Switch(config)# Policy-map pm1
Switch(config-pmap)# class cm-1
Switch(config-pmap-c)# set dscp 4
Switch(config-pmap-c)# exit
Switch(config-pmap)# class cm-2
Switch(config-pmap-c)# set dscp 6
Switch(config-pmap-c)# exit
Switch(config-pmap)# exit
Switch(config)# interface G1/0/1
Switch(config-if)# service-policy input pm1
```

This example shows how to configure a class map that applies to both IPv4 and IPv6 traffic:

```
Switch(config)# ip access-list 101 permit ip any any
Switch(config)# ipv6 access-list ipv6-any permit ip any any
Switch(config)# Class-map cm-1
Switch(config-cmap)# match access-group 101
Switch(config-cmap)# exit
Switch(config)# class-map cm-2
Switch(config-cmap)# match access-group name ipv6-any
Switch(config-cmap)# exit
Switch(config)# Policy-map pm1
Switch(config-pmap)# class cm-1
Switch(config-pmap-c)# set dscp 4
Switch(config-pmap-c)# exit
Switch(config-pmap)# class cm-2
Switch(config-pmap-c)# set dscp 6
Switch(config-pmap-c)# exit
Switch(config-pmap)# exit
Switch(config)# interface G0/1
Switch(config-if)# switch mode access
Switch(config-if)# service-policy input pm1
```

Examples: Classifying, Policing, and Marking Traffic on Physical Ports Using Policy Maps

This example shows how to create a policy map and attach it to an ingress port. In the configuration, the IP standard ACL permits traffic from network 10.1.0.0. For traffic matching this classification, the DSCP value in the incoming packet is trusted. If the matched traffic exceeds an average traffic rate of 48000 b/s and a normal burst size of 8000 bytes, its DSCP is marked down (based on the policed-DSCP map) and sent:

```
Switch(config)# access-list 1 permit 10.1.0.0 0.0.255.255
Switch(config)# class-map ipclass1
Switch(config-cmap)# match access-group 1
Switch(config-cmap)# exit
Switch(config)# policy-map flow1t
Switch(config-pmap)# class ipclass1
Switch(config-pmap-c)# set dscp cs1
Switch(config-pmap-c)# police 1000000 8000 exceed-action drop
Switch(config-pmap-c)# exit
Switch(config-pmap)# exit
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# service-policy input flow1t
```

This example shows how to create a Layer 2 MAC ACL with two permit statements and attach it to an ingress port. The first permit statement allows traffic from the host with MAC address 0001.0000.0001 destined for the host with MAC address 0002.0000.0001. The second permit statement allows only Ethertype XNS-IDP traffic from the host with MAC address 0001.0000.0002 destined for the host with MAC address 0002.0000.0002.

```
Switch(config)# mac access-list extended maclist1
Switch(config-ext-mac)# permit 0001.0000.0001 0.0.0 0002.0000.0001 0.0.0
Switch(config-ext-mac)# permit 0001.0000.0002 0.0.0 0002.0000.0002 0.0.0 xns-idp
Switch(config-ext-mac)# exit
Switch(config)# mac access-list extended maclist2
Switch(config-ext-mac)# permit 0001.0000.0003 0.0.0 0002.0000.0003 0.0.0
Switch(config-ext-mac)# permit 0001.0000.0004 0.0.0 0002.0000.0004 0.0.0 aarp
Switch(config-ext-mac)# exit
Switch(config)# class-map macclass1
Switch(config-cmap)# match access-group maclist1
Switch(config-cmap)# exit
Switch(config)# policy-map macpolicy1
Switch(config-pmap)# class macclass1
Switch(config-pmap-c)# set dscp 63
Switch(config-pmap-c)# exit
Switch(config-pmap)# class macclass2 maclist2
Switch(config-pmap-c)# set dscp 45
Switch(config-pmap-c)# exit
Switch(config-pmap)# exit
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# mls qos trust cos
Switch(config-if)# service-policy input macpolicy1
```

This example shows how to create a class map that applies to both IPv4 and IPv6 traffic with the default class applied to unclassified traffic:

```
Switch(config)# ip access-list 101 permit ip any any
Switch(config)# ipv6 access-list ipv6-any permit ip any any
Switch(config)# class-map cm-1
Switch(config-cmap)# match access-group 101
Switch(config-cmap)# exit
Switch(config)# class-map cm-2
Switch(config-cmap)# match access-group name ipv6-any
Switch(config-cmap)# exit
Switch(config)# policy-map pm1
Switch(config-pmap)# class cm-1
Switch(config-pmap-c)# set dscp 4
Switch(config-pmap-c)# exit
Switch(config-pmap)# class cm-2
Switch(config-pmap-c)# set dscp 6
Switch(config-pmap-c)# exit
Switch(config-pmap)# class class-default
Switch(config-pmap-c)# set dscp 10
Switch(config-pmap-c)# exit
Switch(config-pmap)# exit
Switch(config)# interface G0/1
Switch(config-if)# switch mode access
Switch(config-if)# service-policy input pm1
```

Examples: Configuring DSCP-to-DSCP Mutation Maps

This example shows how to define the DSCP-to-DSCP-mutation map. All the entries that are not explicitly configured are not modified (remains as specified in the null map):

```
Switch(config)# mls qos map dscp-mutation 1 2 3 4 5 6 7 to 0
Switch(config)# mls qos map dscp-mutation 8 9 10 11 12 13 to 10
Switch(config)# mls qos map dscp-mutation 20 21 22 to 20
Switch(config)# mls qos map dscp-mutation 30 31 32 33 34 to 30
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# mls qos trust dscp
Switch(config-if)# end
Switch# show mls qos maps dscp-mutation
Dscp-dscp mutation map:
   mutation1:
     d1 :  d2 0  1  2  3  4  5  6  7  8  9
     ---------------------------------------
      0 :    00 00 00 00 00 00 00 00 10 10
      1 :    10 10 10 10 14 15 16 17 18 19
      2 :    20 20 20 23 24 25 26 27 28 29
      3 :    30 30 30 30 30 35 36 37 38 39
      4 :    40 41 42 43 44 45 46 47 48 49
      5 :    50 51 52 53 54 55 56 57 58 59
      6 :    60 61 62 63
```

Note In the above DSCP-to-DSCP-mutation map, the mutated values are shown in the body of the matrix. The d1 column specifies the most-significant digit of the original DSCP; the d2 row specifies the least-significant digit of the original DSCP. The intersection of the d1 and d2 values provides the mutated value. For example, a DSCP value of 12 corresponds to a mutated value of 10.

Examples: Configuring Egress Queue Characteristics

This example shows how to configure bandwidth shaping on queue 1. Because the weight ratios for queues 2, 3, and 4 are set to 0, these queues operate in shared mode. The bandwidth weight for queue 1 is 1/8, which is 12.5 percent:

```
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# srr-queue bandwidth shape 8 0 0 0
```

This example shows how to configure the weight ratio of the SRR scheduler running on an egress port. Four queues are used, and the bandwidth ratio allocated for each queue in shared mode is 1/(1+2+3+4), 2/(1+2+3+4), 3/(1+2+3+4), and 4/(1+2+3+4), which is 10 percent, 20 percent, 30 percent, and 40 percent for queues 1, 2, 3, and 4. This means that queue 4 has four times the bandwidth of queue 1, twice the bandwidth of queue 2, and one-and-a-third times the bandwidth of queue 3.

```
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# srr-queue bandwidth share 1 2 3 4
```

This example shows how to enable the egress expedite queue when the SRR weights are configured. The egress expedite queue overrides the configured SRR weights.

```
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# srr-queue bandwidth shape 25 0 0 0
Switch(config-if)# srr-queue bandwidth share 30 20 25 25
Switch(config-if)# priority-queue out
Switch(config-if)# end
```

This example shows how to limit the bandwidth on a port to 80 percent:

```
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# srr-queue bandwidth limit 80
```

When you configure this command to 80 percent, the port is idle 20 percent of the time. The line rate drops to 80 percent of the connected speed, which is 800 Mb/s. These values are not exact because the hardware adjusts the line rate in increments of six.

Where to Go Next

Review the auto-QoS documentation to see if you can use these automated capabilities for your QoS configuration.

Feature History and Information for QoS

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 24

Configuring AutoQoS

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for Auto-QoS

Before configuring standard QoS or auto-QoS, you must have a thorough understanding of these items:

- The types of applications used and the traffic patterns on your network.
- Traffic characteristics and needs of your network. Is the traffic bursty? Do you need to reserve bandwidth for voice and video streams?
- Bandwidth requirements and speed of the network.
- Location of congestion points in the network.

Restrictions for Auto-QoS

The following are restrictions for automatic QoS (auto-QoS):

- Ternary content-addressable memory (TCAM) sharing of policy-map (policer/marking) across ports is not supported. Because of this, the number of interfaces on which auto-QoS/QoS policy-map can be applied is limited.
- The same TCAM region must be used for both security Access control lists (ACLs) and ACLs used via policy map.
- Policy-maps with the **match ip dscp** command matches both IPv4 and IPv6 addresses, which limits the scale number to 16 class-maps. One TCAM entry is created for IPv4 and one TCAM entry for IPv6.
- Per ASIC, 8 TCP port comparators and 8 UDP port comparators are supported, and each gt (greater than)/lt (less than)/neq (not equal) operator uses 1 port comparator, and each range operator uses 2 port comparators. A policy-map with this combination affects the TCAM scale and number of interfaces to which the policy-map can be attached.
- The following restrictions apply to IPv4 ACL network interfaces:
    - When controlling access to an interface, you can use a named or numbered ACL.
    - If you apply an ACL to a Layer 3 interface, and routing is not enabled on the switch, the ACL only filters packets that are intended for the CPU, such as SNMP, Telnet, or web traffic.
    - You do not have to enable routing to apply ACLs on Layer 2 interfaces.
- Deny ACLs are not supported on QoS policy-maps.

Information about Configuring Auto-QoS

Auto-QoS Overview

You can use the auto-QoS feature to simplify the deployment of QoS features. Auto-QoS determines the network design and enables QoS configurations so that the switch can prioritize different traffic flows. It uses the egress queues instead of using the default (disabled) QoS behavior. The switch offers best-effort service to each packet, regardless of the packet contents or size, and sends it from a single queue.

When you enable auto-QoS, it automatically classifies traffic based on the traffic type and ingress packet label. The switch uses the classification results to choose the appropriate egress queue.

You can use auto-QoS commands to identify ports connected to the following Cisco devices:

- Cisco IP Phones
- Devices running the Cisco SoftPhone application
- Cisco TelePresence
- Cisco IP Camera
- Cisco digital media player

You also use the auto-QoS commands to identify ports that receive trusted traffic through an uplink. Auto-QoS then performs these functions:

- Detects the presence or absence of auto-QoS devices through conditional trusted interfaces.
- Configures QoS classification
- Configures egress queues

Auto-QoS Compact Overview

When you enter an auto-QoS command, the switch displays all the generated commands as if the commands were entered from the CLI. You can use the auto-QoS compact feature to hide the auto-QoS generated commands from the running configuration. This would make it easier to comprehend the running-configuration and also help to increase efficient usage of memory.

Generated Auto-QoS Configuration

By default, auto-QoS is disabled on all ports. Packets are not modified--the CoS, DSCP and IP precedence values in the packet are not changed.

When you enable the auto-QoS feature on the first port of the interface:

- Ingress packet label is used to categorize traffic, to assign packet labels, and to configure the ingress and egress queues.
- QoS is globally enabled (**mls qos** global configuration command), and other global configuration commands are automatically generated. (See Examples: Global Auto-QoS Configuration, on page 443).
- Switch enables the trusted boundary feature and uses the Cisco Discovery Protocol (CDP) to detect the presence of a supported device.
- Policing is used to determine whether a packet is in or out of profile and specifies the action on the packet.

VoIP Device Specifics

The following activities occur when you issue these auto-QoS commands on a port:

- When you enter the **auto qos voip cisco-phone** command on a port at the network edge connected to a Cisco IP Phone, the switch enables the trusted boundary feature. If the packet does not have a DSCP value of 24, 26, or 46 or is out of profile, the switch changes the DSCP value to 0. When there is no Cisco IP Phone, the ingress classification is set to not trust the QoS label in the packet. The policing is applied to the traffic matching the policy-map classification before the switch enables the trust boundary feature.
- When you enter the **auto qos voip cisco-softphone** interface configuration command on a port at the network edge that is connected to a device running the Cisco SoftPhone, the switch uses policing to determine whether a packet is in or out of profile and to specify the action on the packet. If the packet does not have a DSCP value of 24, 26, or 46 or is out of profile, the switch changes the DSCP value to 0.
- When you enter the **auto qos voip trust** interface configuration command on a port connected to the network interior, the switch trusts the CoS value for nonrouted ports or the DSCP value for routed ports in ingress packets (the assumption is that traffic has already been classified by other edge devices).

Table 57: Traffic Types, Packet Labels, and Queues

<table>
<tr><th></th><th>VoIP Data Traffic</th><th>VoIP Control Traffic</th><th>Routing Protocol Traffic</th><th>STP BPDU Traffic</th><th>Real-Time Video Traffic</th><th colspan="2">All Other Traffic</th></tr>
<tr><td>DSCP value</td><td>46</td><td>24, 26</td><td>48</td><td>56</td><td>34</td><td colspan="2">–</td></tr>
<tr><td>CoS value</td><td>5</td><td>3</td><td>6</td><td>7</td><td>3</td><td colspan="2">–</td></tr>
<tr><td>CoS-to-Egress queue map</td><td>4, 5 (queue 1)</td><td colspan="3">2, 3, 6, 7 (queue 2)</td><td>0 (queue 2)</td><td>2 (queue 3)</td><td>0, 1 (queue 4)</td></tr>
</table>

- When you enable auto-QoS by using the **auto qos voip cisco-phone**, the **auto qos voip cisco-softphone**, or the **auto qos voip trust** interface configuration command, the switch automatically generates a QoS configuration based on the traffic type and ingress packet label and applies the commands listed in Examples: Global Auto-QoS Configuration, on page 443 to the port.

Enhanced Auto-QoS for Video, Trust, and Classification

Auto-QoS is enhanced to support video. Automatic configurations are generated that classify and trust traffic from Cisco TelePresence systems and Cisco IP cameras.

Auto-QoS Configuration Migration

Auto-QoS configuration migration from legacy auto-QoS to enhanced auto-QoS occurs when:

- A switch is booted with a 12.2(55)SE image and QoS is not enabled.

  Any video or voice trust configuration on the interface automatically generates enhanced auto-QoS commands.

- A switch is enabled with QoS, these guidelines take effect:
  - If you configure the interface for conditional trust on a voice device, only the legacy auto-QoS VoIP configuration is generated.
  - If you configure the interface for conditional trust on a video device, the enhanced auto-QoS configuration is generated.
  - If you configure the interface with classification or conditional trust based on the new interface auto-QoS commands, enhanced auto-QoS configuration is generated.

- Auto-QoS migration happens after a new device is connected when the **auto qos srnd4** global configuration command is enabled.

Note If an interface previously configured with legacy auto-QoS migrates to enhanced auto-QoS, voice commands and configuration are updated to match the new global QoS commands.

Auto-QoS configuration migration from enhanced auto-QoS to legacy auto-QoS can occur only when you disable all existing auto-QoS configurations from the interface.

Auto-QoS Configuration Guidelines

Before configuring auto-QoS, you should be aware of this information:

- After auto-QoS is enabled, do not modify a policy map that includes *AutoQoS* in its name. If you need to modify the policy map, make a copy of it, and change the copied policy map. To use this new policy map instead of the generated one, remove the generated policy map from the interface, and apply the new policy map to the interface.
- To take advantage of the auto-QoS defaults, you should enable auto-QoS before you configure other QoS commands. If necessary, you can fine-tune the QoS configuration, but we recommend that you do so only after the auto-QoS configuration is completed.
- You can enable auto-QoS on static, dynamic-access, voice VLAN access, and trunk ports.
- By default, the CDP is enabled on all ports. For auto-QoS to function properly, do not disable CDP.

Auto-QoS VoIP Considerations

Before configuring auto-QoS for VoIP, you should be aware of this information:

- Auto-QoS configures the switch for VoIP with Cisco IP Phones on nonrouted and routed ports. Auto-QoS also configures the switch for VoIP with devices running the Cisco SoftPhone application.

  Note When a device running Cisco SoftPhone is connected to a nonrouted or routed port, the switch supports only one Cisco SoftPhone application per port.

- When enabling auto-QoS with a Cisco IP Phone on a routed port, you must assign a static IP address to the IP phone.
- This release supports only Cisco IP SoftPhone Version 1.3(3) or later.
- Connected devices must use Cisco Call Manager Version 4 or later.

Auto-QoS Enhanced Considerations

Auto-QoS is enhanced to support video. Automatic configurations are generated that classify and trust traffic from Cisco TelePresence systems and Cisco IP cameras.

Before configuring auto-QoS enhanced, you should be aware of this information:

- The **auto qos srnd4** global configuration command is generated as a result of enhanced auto-QoS configuration.

Effects of Auto-QoS on Running Configuration

When auto-QoS is enabled, the **auto qos** interface configuration commands and the generated global configuration are added to the running configuration.

The switch applies the auto-QoS-generated commands as if the commands were entered from the CLI. An existing user configuration can cause the application of the generated commands to fail or to be overridden by the generated commands. These actions may occur without warning. If all the generated commands are successfully applied, any user-entered configuration that was not overridden remains in the running configuration. Any user-entered configuration that was overridden can be retrieved by reloading the switch without saving the current configuration to memory. If the generated commands are not applied, the previous running configuration is restored.

Effects of Auto-Qos Compact on Running Configuration

If auto-QoS compact is enabled:

- Only the auto-QoS commands entered from the CLI are displayed in running-config.
- The generated global and interface configurations are hidden.
- When you save the configuration, only the auto-qos commands you have entered are saved (and not the hidden configuration).
- When you reload the switch, the system detects and re-executes the saved auto-QoS commands and the AutoQoS SRND4.0 compliant config-set is generated .

Note Do not make changes to the auto-QoS-generated commands when auto-QoS compact is enabled, because user-modifications are overridden when the switch reloads.

When auto-qos global compact is enabled:

- **show derived-config** command can be used to view hidden AQC derived commands.
- AQC commands will not be stored to memory. They will be regenerated every time the switch is reloaded.
- When compaction is enabled, auto-qos generated commands should not be modified .
- If the interface is configured with auto-QoS and if AQC needs to be disabled, auto-qos should be disabled at interface level first.

How to Configure Auto-QoS

Configuring Auto-QoS

Enabling Auto-QoS

For optimum QoS performance, enable auto-QoS on all the devices in your network.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. Use one of the following:
   - **auto qos voip** {**cisco-phone** | **cisco-softphone** | **trust**}

- **auto qos video** {**cts** | **ip-camera** | **media-player**}
- **auto qos classify** [**police**]
- **auto qos trust** {**cos** | **dscp**}

4. **exit**
5. **interface** *interface-id*
6. **auto qos trust**
7. **end**
8. **show auto qos interface** *interface-id*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port that is connected to a video device or the uplink port that is connected to another trusted switch or router in the network interior, and enters interface configuration mode.
Step 3	Use one of the following: • **auto qos voip** {**cisco-phone** | **cisco-softphone** | **trust**} • **auto qos video** {**cts** | **ip-camera** | **media-player**} • **auto qos classify** [**police**] • **auto qos trust** {**cos** | **dscp**} **Example:** `Switch(config-if)# auto qos trust dscp`	Enables auto-QoS for VoIP. • **cisco-phone**—If the port is connected to a Cisco IP Phone, the QoS labels of incoming packets are trusted only when the telephone is detected. • **cisco-softphone**—The port is connected to device running the Cisco SoftPhone feature. • **trust**—The uplink port is connected to a trusted switch or router, and the VoIP traffic classification in the ingress packet is trusted. Enables auto-QoS for a video device. • **cts**—A port connected to a Cisco Telepresence system. • **ip-camera**—A port connected to a Cisco video surveillance camera. • **media-player**—A port connected to a CDP-capable Cisco digital media player. QoS labels of incoming packets are trusted only when the system is detected. Enables auto-QoS for classification.

	Command or Action	Purpose
		• **police**—Policing is set up by defining the QoS policy maps and applying them to ports (port-based QoS). Enables auto-QoS for trusted interfaces. • **cos**—Class of service. • **dscp**—Differentiated Services Code Point. • <cr>—Trust interface.
Step 4	**exit** **Example:** `Switch(config-if)# exit`	Returns to global configuration mode.
Step 5	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the switch port identified as connected to a trusted switch or router, and enters interface configuration mode.
Step 6	**auto qos trust** **Example:** `Switch(config-if)# auto qos trust`	Enables auto-QoS on the port, and specifies that the port is connected to a trusted router or switch.

Step 7	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 8	**show auto qos interface** *interface-id* **Example:** `Switch# show auto qos interface gigabitethernet 0/1`	Verifies your entries. This command displays the auto-QoS command on the interface on which auto-QoS was enabled. You can use the **show running-config** privileged EXEC command to display the auto-QoS configuration and the user modifications.

Enabling Auto-Qos Compact

To enable auto-Qos compact, enter this command:

SUMMARY STEPS

1. **configure terminal**
2. **auto qos global compact**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**auto qos global compact** **Example:** `Switch(config)# auto qos global compact`	Enables auto-Qos compact and generates (hidden) the global configurations for auto-QoS. You can then enter the auto-QoS command you want to configure in the interface configuration mode and the interface commands that the system generates are also hidden. To display the auto-QoS configuration that has been applied, use these the privileged EXEC commands: • **show derived-config** • **show policy-map** • **show access-list** • **show class-map** • **show auto-qos** • **show policy-map interface** • **show ip access-lists** These commands will have keyword "**AutoQos-**".

What to do next

To disable auto-QoS compact, remove auto-Qos instances from all interfaces by entering the **no** form of the corresponding auto-QoS commands and then enter the **no auto qos global compact** global configuration command.

Troubleshooting Auto-QoS

To troubleshoot auto-QoS, use the **debug auto qos** privileged EXEC command. For more information, see the **debug auto qos** command in the command reference for this release.

To disable auto-QoS on a port, use the **no** form of the **auto qos** command interface configuration command, such as **no auto qos voip**. Only the auto-QoS-generated interface configuration commands for this port are removed. If this is the last port on which auto-QoS is enabled and you enter the **no auto qos voip** command, auto-QoS is considered disabled even though the auto-QoS-generated global configuration commands remain (to avoid disrupting traffic on other ports affected by the global configuration).

Monitoring Auto-QoS

Table 58: Commands for Monitoring Auto-QoS

Command	Description
show auto qos [**interface** [*interface-type*]]	Displays the initial auto-QoS configuration. You can compare the **show auto qos** and the **show running-config** command output to identify the user-defined QoS settings.
show mls qos [**interface** | **maps**]	Displays information about the QoS configuration that might be affected by auto-QoS.
show mls qos interface [*interface-type* | **queueing** | **statistics**]	Displays information about the QoS interface configuration that might be affected by auto-QoS.
show mls qos maps [**cos-output-q** | **dscp-mutation** | **dscp-output-q**]	Displays information about the QoS maps configuration that might be affected by auto-QoS.
show running-config	Displays information about the QoS configuration that might be affected by auto-QoS. You can compare the **show auto qos** and the **show running-config** command output to identify the user-defined QoS settings.

Configuration Examples for Auto-Qos

Examples: Global Auto-QoS Configuration

The following table describes the automatically generated commands for auto-QoS and enhanced auto-QoS by the switch.

Table 59: Generated Auto-QoS Configuration

Description	Automatically Generated Command {voip}

The switch automatically maps CoS values to an egress queue and to a threshold ID.	`Switch(config)#` **`no mls qos srr-queue output cos-map`**
	`Switch(config)#` **`mls qos srr-queue output cos-map queue 1 threshold 1 4`**
	`Switch(config)#` **`mls qos srr-queue output cos-map queue 2 threshold 1 2 6 7 6 7`**
	`Switch(config)#` **`mls qos srr-queue output cos-map queue 2 threshold 2 3 4`**
	`Switch(config)#` **`mls qos srr-queue output cos-map queue 3 threshold 2 0`**
	`Switch(config)#` **`mls qos srr-queue output cos-map queue 4 threshold 2 1`**

Description	Automatically Generated Command {voip}
The switch automatically maps DSCP values to an egress queue and to a threshold ID.	Switch(config)# **no mls qos srr-queue output dscp-map** Switch(config)# **mls qos srr-queue output dscp-map queue 1 threshold 2 32 33 40 41 42 43 44 45** Switch(config)# **mls qos srr-queue output dscp-map queue 1 threshold 2 46 47** Switch(config)# **mls qos srr-queue output dscp-map queue 2 threshold 1 16 17 18 19 20 21 22 23** Switch(config)# **mls qos srr-queue output dscp-map queue 2 threshold 1 26 27 28 29 30 31 34 35** Switch(config)# **mls qos srr-queue output dscp-map queue 2 threshold 1 36 37 38 39** Switch(config)# **mls qos srr-queue output dscp-map queue 2 threshold 2 24 48 49 50 51 52 53 54** Switch(config)# **mls qos srr-queue output dscp-map queue 2 threshold 2 55 56 57 58 59 60 61 62** Switch(config)# **mls qos srr-queue output dscp-map queue 2 threshold 2 63** Switch(config)# **mls qos srr-queue output dscp-map queue 3 threshold 1 0 1 2 3 4 5 6 7** Switch(config)# **mls qos srr-queue output dscp-map queue 4 threshold 1 8 9 10 11 12 13 14 15**

Examples: Auto-QoS Generated Configuration For Enhanced Video, Trust, and Classify Devices

If you entered the following enhanced auto-QoS commands, the switch configures a CoS-to-DSCP map (maps CoS values in incoming packets to a DSCP value):

- **auto qos video cts**
- **auto qos video ip-camera**
- **auto qos video media-player**
- **auto qos trust**
- **auto qos trust cos**
- **auto qos trust dscp**

If you entered the **auto qos classify** command, the switch automatically creates class maps and policy maps (as shown below).

```
Switch(config)# policy-map AUTOQOS-SRND4-CLASSIFY-POLICY
Switch(config-pmap)# class AUTOQOS_MULTIENHANCED_CONF_CLASS
Switch(config-pmap-c)# set dscp af41
Switch(config-pmap)# class AUTOQOS_BULK_DATA_CLASS
Switch(config-pmap-c)# set dscp af11
Switch(config-pmap)# class AUTOQOS_TRANSACTION_CLASS
Switch(config-pmap-c)# set dscp af21
Switch(config-pmap)# class AUTOQOS_SCAVANGER_CLASS
Switch(config-pmap-c)# set dscp cs1
Switch(config-pmap)# class AUTOQOS_SIGNALING_CLASS
Switch(config-pmap-c)# set dscp cs3
Switch(config-pmap)# class AUTOQOS_DEFAULT_CLASS
Switch(config-pmap-c)# set dscp default
;
Switch(config-if)# service-policy input AUTOQOS-SRND4-CLASSIFY-POLICY
```

If you entered the **auto qos classify police** command, the switch automatically creates class maps and policy maps (as shown below).

```
Switch(config)# class-map match-all AUTOQOS_MULTIENHANCED_CONF_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-MULTIENHANCED-CONF
Switch(config)# class-map match-all AUTOQOS_DEFAULT_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-DEFAULT
Switch(config)# class-map match-all AUTOQOS_TRANSACTION_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-TRANSACTIONAL-DATA
Switch(config)# class-map match-all AUTOQOS_SIGNALING_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-SIGNALING
Switch(config)# class-map match-all AUTOQOS_BULK_DATA_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-BULK-DATA
Switch(config)# class-map match-all AUTOQOS_SCAVANGER_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-SCAVANGER
Switch(config)# policy-map AUTOQOS-SRND4-CLASSIFY-POLICE-POLICY
Switch(config-pmap)# class AUTOQOS_MULTIENHANCED_CONF_CLASS
Switch(config-pmap-c)# set dscp af41
Switch(config-pmap)# police 5000000 8000 exceed-action drop
Switch(config-pmap)# class AUTOQOS_BULK_DATA_CLASS
Switch(config-pmap-c)# set dscp af11
Switch(config-pmap)# class AUTOQOS_TRANSACTION_CLASS
Switch(config-pmap-c)# set dscp af21
Switch(config-pmap)# class AUTOQOS_SCAVANGER_CLASS
Switch(config-pmap-c)# set dscp cs1
Switch(config-pmap)# police 10000000 8000 exceed-action drop
Switch(config-pmap)# class AUTOQOS_SIGNALING_CLASS
Switch(config-pmap-c)# set dscp cs3
Switch(config-pmap)# police 32000 8000 exceed-action drop
Switch(config-pmap)# class AUTOQOS_DEFAULT_CLASS
Switch(config-pmap-c)# set dscp default
```

This is the enhanced configuration for the **auto qos voip cisco-phone** command:

```
Switch(config)# class-map match-all AUTOQOS_VOIP_DATA_CLASS
Switch(config-cmap)# match ip dscp ef
Switch(config)# class-map match-all AUTOQOS_VOIP_VIDEO_CLASS
Switch(config-cmap)# match ip dscp af41
Switch(config)# class-map match-all AUTOQOS_VOIP_SIGNAL_CLASS
Switch(config-cmap)# match ip dscp cs3
Switch(config)# class-map match-all AUTOQOS_DEFAULT_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-DEFAULT
Switch(config)# policy-map AUTOQOS-SRND4-CISCOPHONE-POLICY
Switch(config-pmap)# class AUTOQOS_VOIP_DATA_CLASS
Switch(config-pmap-c)# set dscp ef
Switch(config-pmap)# class AUTOQOS_VOIP_VIDEO_CLASS
Switch(config-pmap-c)# set dscp af41
Switch(config-pmap)# class AUTOQOS_VOIP_SIGNAL_CLASS
Switch(config-pmap-c)# set dscp cs3
Switch(config-pmap)# class AUTOQOS_DEFAULT_CLASS
Switch(config-pmap-c)# set dscp default

Switch(config-if)# service-policy input AUTOQOS-SRND4-CISCOPHONE-POLICY
```

This is the enhanced configuration for the **auto qos voip cisco-softphone** command:

```
Switch(config)# class-map match-all AUTOQOS_VOIP_DATA_CLASS
Switch(config-cmap)# match ip dscp ef
Switch(config)# class-map match-all AUTOQOS_MULTIENHANCED_CONF_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-MULTIENHANCED-CONF
Switch(config)# class-map match-all AUTOQOS_BULK_DATA_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-BULK-DATA
Switch(config)# class-map match-all AUTOQOS_TRANSACTION_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-TRANSACTIONAL-DATA
Switch(config)# class-map match-all AUTOQOS_SCAVANGER_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-SCAVANGER
Switch(config)# class-map match-all AUTOQOS_SIGNALING_CLASS
Switch(config-cmap)# match access-group name AUTOQOS-ACL-SIGNALING

Switch(config)# policy-map AUTOQOS-SRND4-SOFTPHONE-POLICY
Switch(config-pmap)# class AUTOQOS_VOIP_DATA_CLASS
Switch(config-pmap-c)# set dscp ef
Switch(config-pmap)# class AUTOQOS_MULTIENHANCED_CONF_CLASS
Switch(config-pmap-c)# set dscp af41
Switch(config-pmap)#police 5000000 8000 exceed-action drop
Switch(config-pmap)#class AUTOQOS_BULK_DATA_CLASS
Switch(config-pmap-c)# set dscp af11
Switch(config-pmap)# class AUTOQOS_TRANSACTION_CLASS
Switch(config-pmap-c)# set dscp af21
Switch(config-pmap)# class AUTOQOS_SCAVANGER_CLASS
Switch(config-pmap-c)# set dscp cs1
Switch(config-pmap)# police 10000000 8000 exceed-action drop
Switch(config-pmap)# class AUTOQOS_SIGNALING_CLASS
Switch(config-pmap-c)# set dscp cs3
Switch(config-pmap)# police 32000 8000 exceed-action drop
Switch(config-pmap)# class AUTOQOS_DEFAULT_CLASS
Switch(config-pmap-c)# set dscp default
;
Switch(config-if)# service-policy input AUTOQOS-SRND4-SOFTPHONE-POLICY
```

auto qos global compact

The following is an example of the **auto qos global compact** command.

```
Switch# configure terminal
Switch(config)# auto qos global compact
Switch(config)# interface GigabitEthernet0/2
Switch(config-if)# auto qos voip cisco-phone

Switch# show auto-qos
```

```
GigabitEthernet0/2
auto qos voip cisco-phone

Switch# show running-config interface GigabitEthernet0/2

interface GigabitEthernet0/2
auto qos voip cisco-phone
end
```

Where to Go Next for Auto-QoS

Review the QoS documentation if you require any specific QoS changes to your auto-QoS configuration.

Additional References for Auto-QoS

Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	*Cisco IOS Quality of Service Solutions Command Reference*

MIBs

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for Auto-QoS

Release	Modification
Cisco IOS XE Release 15.2(6)Ex	This feature was introduced.

PART VII

Routing

CHAPTER 25

Configuring IP Unicast Routing

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About Configuring IP Unicast Routing

This module describes how to configure IP Version 4 (IPv4) unicast routing on the switch.

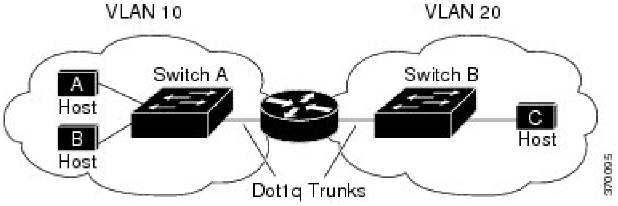
Note In addition to IPv4 traffic, you can also enable IP Version 6 (IPv6) unicast routing and configure interfaces to forward IPv6 traffic .

Information About IP Routing

In some network environments, VLANs are associated with individual networks or subnetworks. In an IP network, each subnetwork is mapped to an individual VLAN. Configuring VLANs helps control the size of the broadcast domain and keeps local traffic local. However, network devices in different VLANs cannot communicate with one another without a Layer 3 device (router) to route traffic between the VLAN, referred to as inter-VLAN routing. You configure one or more routers to route traffic to the appropriate destination VLAN.

Figure 46: Routing Topology Example

This figure shows a basic routing topology. Switch A is in VLAN 10, and Switch B is in VLAN 20. The router has an interface in each VLAN.



When Host A in VLAN 10 needs to communicate with Host B in VLAN 10, it sends a packet addressed to that host. Switch A forwards the packet directly to Host B, without sending it to the router.

When Host A sends a packet to Host C in VLAN 20, Switch A forwards the packet to the router, which receives the traffic on the VLAN 10 interface. The router checks the routing table, finds the correct outgoing interface, and forwards the packet on the VLAN 20 interface to Switch B. Switch B receives the packet and forwards it to Host C.

Types of Routing

Routers and Layer 3 switches can route packets in these ways:

- By using default routing
- By using preprogrammed static routes for the traffic
- By dynamically calculating routes by using a routing protocol

The switch supports static routes and default routes. It does not support routing protocols.

The switch supports static routes and default routes. It supports Routing Information Protocol (RIP) for both IPv4 and IPv6 versions.

Static Unicast Routes

Static unicast routes are user-defined routes that cause packets moving between a source and a destination to take a specified path. Static routes can be important if the router cannot build a route to a particular destination and are useful for specifying a gateway of last resort to which all unroutable packets are sent.

The switch retains static routes until you remove them. However, you can override static routes with dynamic routing information by assigning administrative distance values. Each dynamic routing protocol has a default administrative distance, as listed in Table 41-16. If you want a static route to be overridden by information from a dynamic routing protocol, set the administrative distance of the static route higher than that of the dynamic protocol.

Table 60: Dynamic Routing Protocol Default Administrative Distances

Route Source	Default Distance
Connected interface	0
Static route	1
Enhanced IRGP summary route	5
Internal Enhanced IGRP	90
IGRP	100
OSPF	110
RIP	120
Unknown	225

Static routes that point to an interface are advertised through RIP, IGRP, and other dynamic routing protocols, whether or not static **redistribute** router configuration commands were specified for those routing protocols. These static routes are advertised because static routes that point to an interface are considered in the routing table to be connected and hence lose their static nature. However, if you define a static route to an interface that is not one of the networks defined in a network command, no dynamic routing protocols advertise the route unless a **redistribute** static command is specified for these protocols.

When an interface goes down, all static routes through that interface are removed from the IP routing table. When the software can no longer find a valid next hop for the address specified as the forwarding router's address in a static route, the static route is also removed from the IP routing table.

Default Routes and Networks

A router might not be able to learn the routes to all other networks. To provide complete routing capability, you can use some routers as smart routers and give the remaining routers default routes to the smart router. (Smart routers have routing table information for the entire internetwork.) These default routes can be dynamically learned or can be configured in the individual routers. Most dynamic interior routing protocols include a mechanism for causing a smart router to generate dynamic default information that is then forwarded to other routers.

If a router has a directly connected interface to the specified default network, the dynamic routing protocols running on that device generate a default route. In RIP, it advertises the pseudonetwork 0.0.0.0.

A router that is generating the default for a network also might need a default of its own. One way a router can generate its own default is to specify a static route to the network 0.0.0.0 through the appropriate device.

When default information is passed through a dynamic routing protocol, no further configuration is required. The system periodically scans its routing table to choose the optimal default network as its default route. In IGRP networks, there might be several candidate networks for the system default. Cisco routers use administrative distance and metric information to set the default route or the gateway of last resort.

If dynamic default information is not being passed to the system, candidates for the default route are specified with the **ip default-network** global configuration command. If this network appears in the routing table from any source, it is flagged as a possible choice for the default route. If the router has no interface on the default network, but does have a path to it, the network is considered as a possible candidate, and the gateway to the best default path becomes the gateway of last resort.

Routing Information Protocol

The Routing Information Protocol (RIP) is an interior gateway protocol (IGP) created for use in small, homogeneous networks. It is a distance-vector routing protocol that uses broadcast User Datagram Protocol (UDP) data packets to exchange routing information. The protocol is documented in RFC 1058. You can find detailed information about RIP in *IP Routing Fundamentals,* published by Cisco Press.

Using RIP, the Switch sends routing information updates (advertisements) every 30 seconds. If a router does not receive an update from another router for 180 seconds or more, it marks the routes served by that router as unusable. If there is still no update after 240 seconds, the router removes all routing table entries for the non-updating router.

RIP uses hop counts to rate the value of different routes. The hop count is the number of routers that can be traversed in a route. A directly connected network has a hop count of zero; a network with a hop count of 16 is unreachable. This small range (0 to 15) makes RIP unsuitable for large networks.

If the router has a default network path, RIP advertises a route that links the router to the pseudonetwork 0.0.0.0. The 0.0.0.0 network does not exist; it is treated by RIP as a network to implement the default routing feature. The Switch advertises the default network if a default was learned by RIP or if the router has a gateway of last resort and RIP is configured with a default metric. RIP sends updates to the interfaces in specified networks. If an interface’s network is not specified, it is not advertised in any RIP update.

Summary Addresses and Split Horizon

Routers connected to broadcast-type IP networks and using distance-vector routing protocols normally use the split-horizon mechanism to reduce the possibility of routing loops. Split horizon blocks information about routes from being advertised by a router on any interface from which that information originated. This feature usually optimizes communication among multiple routers, especially when links are broken.

Configuring IP Unicast Routing

By default, IP routing is disabled on the switch. For detailed IP routing configuration information, see the *Cisco IOS IP Configuration Guide, Release 12.2* from the *Cisco.com* page under **Documentation** > **Cisco IOS Software Releases** > **12.2 Mainline** > **Configuration Guides**.

In these procedures, the specified interface can be a switch virtual interface (SVI)-a VLAN interface or a physical port interface created by using the **interface vlan** *vlan_id* or **interface** *type number* global configuration commands respectively, and by default a Layer 3 interface. All Layer 3 interfaces on which routing will occur must have IP addresses assigned to them.

Note The switch supports 16 static routes (including user-configured routes and the default route) and any directly connected routes and default routes for the management interface.

Procedures for configuring routing:

- To support VLAN interfaces, create and configure VLANs on the switch, and assign VLAN membership to Layer 2 interfaces. For more information, see chapter: *Configuring VLANs*.
- Configure Layer 3 interfaces.
- Enable IP routing on the switch.
- Assign IP addresses to the Layer 3 interfaces.
- Configure static routes.

Enabling IP Unicast Routing

By default, the Switch is in Layer 2 switching mode and IP routing is disabled. To use the Layer 3 capabilities of the Switch, you must enable IP routing.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip routing** **Example:** `Switch(config)# ip routing`	Enables IP routing.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.

	Command or Action	Purpose
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Example: Enabling IP Unicast Routing

This example shows how to enable IP unicast routing.

```
Device(config)# ip routing
Device(config)# end
Device# show running-config
Device# copy running-config startup-config
```

Assigning IP Addresses to SVIs

To configure IP routing, you need to assign IP addresses to Layer 3 network interfaces. This enables communication with the hosts of those interfaces that use IP. IP routing is disabled by default, and no IP addresses are assigned to SVIs.

An IP address identifies a location to which IP packets can be sent. Some IP addresses are reserved for special uses and cannot be used for host, subnet, or network addresses. RFC 1166, "Internet Numbers," contains the official description of IP addresses.

An interface can have one primary IP address. A mask identifies the bits that denote the network number in an IP address. When you use the mask to subnet a network, the mask is referred to as a subnet mask. To receive an assigned network number, contact your Internet service provider.

Follow these steps to assign an IP address and a network mask to an SVI:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface vlan** *vlan-id*	Enters interface configuration mode, and specifies the Layer 3 VLAN to configure.
Step 4	**ip address** *ip-address subnet-mask* **Example:** `Switch(config-if)# ip address 10.1.5.1 255.255.255.0`	Configures the IP address and IP subnet mask.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show interfaces** [*interface-id*] **Example:** `Switch# show interfaces gigabitethernet 0/1`	Verifies your entries.
Step 7	**show interfaces vlan** [*vlan-id*] **Example:** `Switch# show interfaces vlan 4`	Verifies your entries.
Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Example: Assigning IP Addresses to SVIs

This example shows how to assign an IP address and a network mask to an SVI.

```
Device(config)# interface vlan 4
Device(config-if)# ip address 10.1.5.1 255.255.255.0
Device(config-if)# exit
Device# show interfaces vlan 4
Device# show running-config
Device# copy running-config startup-config
```

Configuring Static Unicast Routes

Static unicast routes are user-defined routes that cause packets moving between a source and a destination to take a specified path. Static routes can be important if the router cannot build a route to a particular destination and are useful for specifying a gateway of last resort to which all unroutable packets are sent.

Note Static routing is supported on Catalyst 2960-L switches from Cisco IOS Release 15.2(5)E2 and higher.

Follow these steps to configure a static route:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip route prefix mask** {*address* | *interface*} [*distance*] **Example:** `Device(config)# ip route prefix mask gigabitethernet 1/0/4gigabitethernet 0/4`	Establish a static route.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show ip route** **Example:** `Switch# show ip route`	Displays the current state of the routing table to verify the configuration.
Step 6	**copy running-config startup-config** **Example:**	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	`Device# copy running-config startup-config`	

What to do next

Use the **no ip route** *prefix mask* {*address*\| *interface*} global configuration command to remove a static route. The switch retains static routes until you remove them.

Example: Configuring Static Unicast Routes

This example shows how to configure static unicast routes.

```
Device(config)# ip route prefix mask gigabitethernet 0/4
Device(config)# end
Device# show ip route
Device# copy running-config startup-config
```

Configuring Default Routes and Networks

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**ip route** *network number* **Example:** `Switch(config)# ip route 0.0.0.0 0.0.0.0 10.10.10.2`	Specifies a default network.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 4	**show ip route** **Example:** `Switch# show ip route`	Displays the selected default route in the gateway of last resort display.
Step 5	**copy running-config startup-config** **Example:**	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	`Switch# copy running-config startup-config`	

How to Configure RIP

Default RIP Configuration

Table 61: Default RIP Configuration

Feature	Default Setting
Auto summary	Enabled.
Default-information originate	Disabled.
Default metric	Built-in; automatic metric translations.
IP RIP authentication key-chain	No authentication. Authentication mode: clear text.
IP RIP triggered	Disabled
IP split horizon	Varies with media.
Neighbor	None defined.
Network	None specified.
Offset list	Disabled.
Output delay	0 milliseconds.
Timers basic	• Update: 30 seconds. • Invalid: 180 seconds. • Hold-down: 180 seconds. • Flush: 240 seconds.
Validate-update-source	Enabled.
Version	Receives RIP Version 1 and 2 packets; sends Version 1 packets.

Configuring Basic RIP Parameters

To configure RIP, you enable RIP routing for a network and optionally configure other parameters. On the Switch, RIP configuration commands are ignored until you configure the network number.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip routing** **Example:** `Switch(config)# ip routing`	Enables IP routing. (Required only if IP routing is disabled.)
Step 4	**router rip** **Example:** `Switch(config)# router rip`	Enables a RIP routing process, and enter router configuration mode.
Step 5	**network** *network number* **Example:** `Switch(config-router)# network 12.0.0.0`	Associates a network with a RIP routing process. You can specify multiple **network** commands. RIP routing updates are sent and received through interfaces only on these networks. **Note** You must configure a network number for the RIP commands to take effect.
Step 6	**neighbor** *ip-address* **Example:** `Switch(config-router)# neighbor 10.2.5.1`	(Optional) Defines a neighboring router with which to exchange routing information. This step allows routing updates from RIP (normally a broadcast protocol) to reach nonbroadcast networks.
Step 7	**offset-list** [*access-list number* | *name*] {**in** | **out**} *offset* [*type number*] **Example:** `Switch(config-router)# offset-list 103 in 10`	(Optional) Applies an offset list to routing metrics to increase incoming and outgoing metrics to routes learned through RIP. You can limit the offset list with an access list or an interface.

	Command or Action	Purpose
Step 8	**timers basic** *update invalid holddown flush* **Example:** `Switch(config-router)# timers basic 45 360 400 300`	(Optional) Adjusts routing protocol timers. Valid ranges for all timers are 0 to 4294967295 seconds. • *update*—The time between sending routing updates. The default is 30 seconds. • *invalid*—The timer after which a route is declared invalid. The default is 180 seconds. • *holddown*—The time before a route is removed from the routing table. The default is 180 seconds. • *flush*—The amount of time for which routing updates are postponed. The default is 240 seconds.

Step 9	**version** {**1** | **2**}
	Example:
	`Switch(config-router)# version 2`
		(Optional) Configures the switch to receive and send only RIP Version 1 or RIP Version 2 packets. By default, the switch receives Version 1 and 2 but sends only Version 1. You can also use the interface commands **ip rip** {**send** | **receive**} **version 1** | **2** | **1 2**} to control what versions are used for sending and receiving on interfaces.

Step 10	**no auto-summary** **Example:** `Switch(config-router)# no auto-summary`	(Optional) Disables automatic summarization. By default, the switch summarizes subprefixes when crossing classful network boundaries. Disable summarization (RIP Version 2 only) to advertise subnet and host routing information to classful network boundaries.

Step 11	**end**
	Example:
	`Switch(config-router)# end`
		Returns to privileged EXEC mode.

Step 12	**show ip protocols** **Example:** `Switch# show ip protocols`	Verifies your entries.
Step 13	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring RIP Authentication

RIP Version 1 does not support authentication. If you are sending and receiving RIP Version 2 packets, you can enable RIP authentication on an interface. The key chain specifies the set of keys that can be used on the interface. If a key chain is not configured, no authentication is performed, not even the default.

The Switch supports two modes of authentication on interfaces for which RIP authentication is enabled: plain text and MD5. The default is plain text.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Enters interface configuration mode, and specifies the interface to configure.
Step 4	**ip rip authentication key-chain** *name-of-chain* **Example:** `Switch(config-if)# ip rip authentication key-chain trees`	Enables RIP authentication.
Step 5	**ip rip authentication mode** {**text** | **md5**} **Example:** `Switch(config-if)# ip rip authentication mode md5`	Configures the interface to use plain text authentication (the default) or MD5 digest authentication.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:**	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	`Switch# copy running-config startup-config`	

Configuring Summary Addresses and Split Horizon

Note In general, disabling split horizon is not recommended unless you are certain that your application requires it to properly advertise routes.

If you want to configure an interface running RIP to advertise a summarized local IP address pool on a network access server for dial-up clients, use the **ip summary-address rip** interface configuration command.

Note If split horizon is enabled, neither autosummary nor interface IP summary addresses are advertised.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
Step 4	**ip address** *ip-address subnet-mask* **Example:** `Switch(config-if)# ip address 10.1.1.10 255.255.255.0`	Configures the IP address and IP subnet.
Step 5	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 6	**show ip interface** *interface-id* **Example:** `Switch# show ip interface gigabitethernet 0/1`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Split Horizon

Routers connected to broadcast-type IP networks and using distance-vector routing protocols normally use the split-horizon mechanism to reduce the possibility of routing loops. Split horizon blocks information about routes from being advertised by a router on any interface from which that information originated. This feature can optimize communication among multiple routers, especially when links are broken.

Note In general, we do not recommend disabling split horizon unless you are certain that your application requires it to properly advertise routes.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Enters interface configuration mode, and specifies the interface to configure.

	Command or Action	Purpose
Step 4	**ip address** *ip-address subnet-mask* **Example:** `Switch(config-if)# ip address 10.1.1.10 255.255.255.0`	Configures the IP address and IP subnet.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show ip interface** *interface-id* **Example:** `Switch# show ip interface gigabitethernet 0/1`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Example: Configuring Summary Addresses and Split Horizon

In this example, the major net is 10.0.0.0. The summary address 10.2.0.0 overrides the autosummary address of 10.0.0.0 so that 10.2.0.0 is advertised out interface Gigabit Ethernet port 2, and 10.0.0.0 is not advertised. In the example, if the interface is still in Layer 2 mode (the default), you must enter a **no switchport** interface configuration command before entering the **ip address** interface configuration command.

Note If split horizon is enabled, neither autosummary nor interface summary addresses (those configured with the **ip summary-address rip** router configuration command) are advertised.

```
Switch(config)# router rip
Switch(config-router)# interface gigabitethernet0/2
Switch(config-if)# ip address 10.1.5.1 255.255.255.0
Switch(config-if)# exit
Switch(config)# router rip
Switch(config-router)# network 10.0.0.0
Switch(config-router)# end
```

Example: Displaying Current Status of Routing Table

This is an example of the output from the **show ip route** privileged EXEC command:

```
Device# show ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
a - application route
+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is 192.0.2.5 to network 0.0.0.0

S* 0.0.0.0/0 [0/0] via 192.0.2.5
3.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C 3.3.3.0/24 is directly connected, GigabitEthernet0/23
L 3.3.3.2/32 is directly connected, GigabitEthernet0/23
6.0.0.0/24 is subnetted, 1 subnets
S 6.6.6.0 [1/0] via 192.0.2.5
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C 192.0.2.4/24 is directly connected, Vlan1
L 192.0.2.10/24 is directly connected, Vlan1
40.0.0.0/24 is subnetted, 1 subnets
S 40.40.40.0 [1/0] via 192.0.2.5
Device#


S -- Stand for static route.
```

Monitoring and Maintaining the IP Network

You can remove all contents of a particular cache, table, or database. You can also display specific statistics.

Table 62: Commands to Clear IP Routes or Display Route Status

Command	Purpose
show ip route [*address* [*mask*] [**longer-prefixes**]]	Displays the current state of the routing table.
show ip route summary	Displays the current state of the routing table in summary form.

PART VIII

Security

CHAPTER 26

Security Features Overview

Security Features Overview

The security features are as follows:

- Web Authentication—Allows a supplicant (client) that does not support IEEE 802.1x functionality to be authenticated using a web browser.
- Local Web Authentication Banner—A custom banner or an image file displayed at a web authentication login screen.
- IEEE 802.1x Authentication with ACLs and the RADIUS Filter-Id Attribute
- Password-protected access (read-only and read-write access) to management interfaces (device manager, Network Assistant, and the CLI) for protection against unauthorized configuration changes
- Multilevel security for a choice of security level, notification, and resulting actions
- Static MAC addressing for ensuring security
- Protected port option for restricting the forwarding of traffic to designated ports on the same switch
- Port security option for limiting and identifying MAC addresses of the stations allowed to access the port
- VLAN aware port security option to shut down the VLAN on the port when a violation occurs, instead of shutting down the entire port.
- Port security aging to set the aging time for secure addresses on a port.
- Protocol storm protection to control the rate of incoming protocol traffic to a switch by dropping packets that exceed a specified ingress rate.
- BPDU guard for shutting down a Port Fast-configured port when an invalid configuration occurs.
- Standard and extended IP access control lists (ACLs) for defining inbound security policies on Layer 2 interfaces (port ACLs).

- Extended MAC access control lists for defining security policies in the inbound direction on Layer 2 interfaces.
- Source and destination MAC-based ACLs for filtering non-IP traffic.
- DHCP snooping to filter untrusted DHCP messages between untrusted hosts and DHCP servers.
- IP source guard to restrict traffic on nonrouted interfaces by filtering traffic based on the DHCP snooping database and IP source bindings.
- Dynamic ARP inspection to prevent malicious attacks on the switch by not relaying invalid ARP requests and responses to other ports in the same VLAN.
- IEEE 802.1x port-based authentication to prevent unauthorized devices (clients) from gaining access to the network. The following 802.1x features are supported:
    - Support for single-host, multi-host, multi-auth, and multi-domain-auth modes.

Mode	Description
Single-Host	Only one host can be authenticated. Security violation occurs if more than one client tries to authenticate.
Multi-Host	Only first host needs to authenticate. Remaining hosts get access without authentication.
Multi-Auth	Every client must get authenticated.
Multi-Domain-Auth	One VoIP client and one data client is allowed to authenticate. Security violation occurs if more than one client tries to authenticate.

    - Multidomain authentication (MDA) to allow both a data device and a voice device, such as an IP phone (Cisco or non-Cisco), to independently authenticate on the same IEEE 802.1x-enabled switch port.
    - Dynamic voice virtual LAN (VLAN) for MDA to allow a dynamic voice VLAN on an MDA-enabled port.
    - VLAN assignment for restricting 802.1x-authenticated users to a specified VLAN.
    - Support for VLAN assignment on a port configured for multi-auth mode. The RADIUS server assigns a VLAN to the first host to authenticate on the port, and subsequent hosts use the same VLAN. Voice VLAN assignment is supported for one IP phone.
    - Voice VLAN to permit a Cisco IP Phone to access the voice VLAN regardless of the authorized or unauthorized state of the port.
    - IP phone detection enhancement to detect and recognize a Cisco IP phone.
    - Guest VLAN to provide limited services to non-802.1x-compliant users.
    - Restricted VLAN to provide limited services to users who are 802.1x compliant, but do not have the credentials to authenticate via the standard 802.1x processes.
    - 802.1x accounting to track network usage.

  - 802.1x with wake-on-LAN to allow dormant PCs to be powered on based on the receipt of a specific Ethernet frame.
  - 802.1x readiness check to determine the readiness of connected end hosts before configuring IEEE 802.1x on the switch.
  - Voice aware 802.1x security to apply traffic violation actions only on the VLAN on which a security violation occurs.
  - MAC authentication bypass (MAB) to authorize clients based on the client MAC address.
  - Network Admission Control (NAC) Layer 2 802.1x validation of the antivirus condition or posture of endpoint systems or clients before granting the devices network access.
  - Network Edge Access Topology (NEAT) with 802.1X switch supplicant, host authorization with CISP, and auto enablement to authenticate a switch outside a wiring closet as a supplicant to another switch.
  - IEEE 802.1x with open access to allow a host to access the network before being authenticated.
  - IEEE 802.1x authentication with downloadable ACLs and redirect URLs to allow per-user ACL downloads from a RADIUS server or Cisco Identity Services Engine (ISE) to an authenticated switch.
  - Support for dynamic creation or attachment of an auth-default ACL on a port that has no configured static ACLs.
  - Flexible-authentication sequencing to configure the order of the authentication methods that a port tries when authenticating a new host.

- TACACS+, a proprietary feature for managing network security through a TACACS server for both IPv4 and IPv6.
- RADIUS for verifying the identity of, granting access to, and tracking the actions of remote users through authentication, authorization, and accounting (AAA) services.
- Enhancements to RADIUS, TACACS+, and SSH functionality.
- Secure Socket Layer (SSL) Version 3.0 support for the HTTP 1.1 server authentication, encryption, and message integrity and HTTP client authentication to allow secure HTTP communications (requires the cryptographic version of the software).
- IEEE 802.1x Authentication with ACLs and the RADIUS Filter-Id Attribute.
- RADIUS Change of Authorization (CoA) to change the attributes of a certain session after it is authenticated. When there is a change in policy for a user or user group in AAA, administrators can send the RADIUS CoA packets from the AAA server, such as Cisco Identity Services Engine, or Cisco Secure ACS to reinitialize authentication, and apply to the new policies.
- IEEE 802.1x User Distribution to allow deployments with multiple VLANs (for a group of users) to improve scalability of the network by load balancing users across different VLANs. Authorized users are assigned to the least populated VLAN in the group, assigned by RADIUS server.
- Support for critical VLAN—multi-host/multi-auth enabled ports are placed in a critical VLAN in order to permit access to critical resources if AAA server becomes unreachable.
- Support for Network Edge Access Topology (NEAT) to change the port host mode and to apply a standard port configuration on the authenticator switch port.

- MAC address based authentication using MAC Authentication Bypass (MAB). Authenticated hosts are moved to a dynamic VLAN to prevent network access from unauthorized VLANs.
- MAC move to allow hosts (including the hosts connected behind an IP phone) to move across ports within the same switch without any restrictions to enable mobility. With MAC move, the switch treats the reappearance of the same MAC address on another port in the same way as a completely new MAC address.
- Support for 3DES and AES with version 3 of the Simple Network Management Protocol (SNMPv3). This release adds support for the 168-bit Triple Data Encryption Standard (3DES) and the 128-bit, 192-bit, and 256-bit Advanced Encryption Standard (AES) encryption algorithms to SNMPv3.
- Cisco TrustSec SXP protocol is not supported.

Feature Information for Security Features

Release	Feature Information
Cisco IOS Release 15.2(6)E2	The following features were introduced: • IEEE 802.1x authentication with downloadable ACLs and redirect URLs. • Support for dynamic creation or attachment of an auth-default ACL on a port that has no configured static ACLs. • IEEE 802.1x Authentication with ACLs and the RADIUS Filter-Id Attribute. • Support for IP source guard on static hosts. • IEEE 802.1x User Distribution to allow deployments with multiple VLANs

CHAPTER 27

Preventing Unauthorized Access

Preventing Unauthorized Access

You can prevent unauthorized users from reconfiguring your switch and viewing configuration information. Typically, you want network administrators to have access to your switch while you restrict access to users who dial from outside the network through an asynchronous port, connect from outside the network through a serial port, or connect through a terminal or workstation from within the local network.

To prevent unauthorized access into your switch, you should configure one or more of these security features:

- At a minimum, you should configure passwords and privileges at each switch port. These passwords are locally stored on the switch. When users attempt to access the switch through a port or line, they must enter the password specified for the port or line before they can access the switch.

- For an additional layer of security, you can also configure username and password pairs, which are locally stored on the switch. These pairs are assigned to lines or ports and authenticate each user before that user can access the switch. If you have defined privilege levels, you can also assign a specific privilege level (with associated rights and privileges) to each username and password pair.

- If you want to use username and password pairs, but you want to store them centrally on a server instead of locally, you can store them in a database on a security server. Multiple networking devices can then use the same database to obtain user authentication (and, if necessary, authorization) information.

- You can also enable the login enhancements feature, which logs both failed and unsuccessful login attempts. Login enhancements can also be configured to block future login attempts after a set number of unsuccessful attempts are made. For more information, see the Cisco IOS Login Enhancements documentation.

CHAPTER 28

Controlling Switch Access with Passwords and Privilege Levels

Restrictions for Controlling Switch Access with Passwords and Privileges

The following are the restrictions for controlling switch access with passwords and privileges:

- Disabling password recovery will not work if you have set the switch to boot up manually by using the **boot manual** global configuration command. This command produces the boot loader prompt (*switch:*) after the switch is power cycled.

Information About Passwords and Privilege Levels

Default Password and Privilege Level Configuration

A simple way of providing terminal access control in your network is to use passwords and assign privilege levels. Password protection restricts access to a network or network device. Privilege levels define what commands users can enter after they have logged into a network device.

This table shows the default password and privilege level configuration.

Table 63: Default Password and Privilege Levels

Feature	Default Setting
Enable password and privilege level	No password is defined. The default is level 15 (privileged EXEC level). The password is not encrypted in the configuration file.
Enable secret password and privilege level	No password is defined. The default is level 15 (privileged EXEC level). The password is encrypted before it is written to the configuration file.
Line password	No password is defined.

Additional Password Security

To provide an additional layer of security, particularly for passwords that cross the network or that are stored on a Trivial File Transfer Protocol (TFTP) server, you can use either the **enable password** or **enable secret** global configuration commands. Both commands accomplish the same thing; that is, you can establish an encrypted password that users must enter to access privileged EXEC mode (the default) or any privilege level you specify.

We recommend that you use the **enable secret** command because it uses an improved encryption algorithm.

If you configure the **enable secret** command, it takes precedence over the **enable password** command; the two commands cannot be in effect simultaneously.

If you enable password encryption, it applies to all passwords including username passwords, authentication key passwords, the privileged command password, and console and virtual terminal line passwords.

Password Recovery

By default, any end user with physical access to the switch can recover from a lost password by interrupting the boot process while the switch is powering on and then by entering a new password.

The password-recovery disable feature protects access to the switch password by disabling part of this functionality. When this feature is enabled, the end user can interrupt the boot process only by agreeing to set the system back to the default configuration. With password recovery disabled, you can still interrupt the boot process and change the password, but the configuration file (config.text) and the VLAN database file (vlan.dat) are deleted.

If you disable password recovery, we recommend that you keep a backup copy of the configuration file on a secure server in case the end user interrupts the boot process and sets the system back to default values. Do not keep a backup copy of the configuration file on the switch. If the switch is operating in VTP transparent mode, we recommend that you also keep a backup copy of the VLAN database file on a secure server. When the switch is returned to the default system configuration, you can download the saved files to the switch by using the Xmodem protocol.

To re-enable password recovery, use the **service password-recovery** global configuration command.

Terminal Line Telnet Configuration

When you power-up your switch for the first time, an automatic setup program runs to assign IP information and to create a default configuration for continued use. The setup program also prompts you to configure your switch for Telnet access through a password. If you did not configure this password during the setup program, you can configure it when you set a Telnet password for a terminal line.

Username and Password Pairs

You can configure username and password pairs, which are locally stored on the switch. These pairs are assigned to lines or ports and authenticate each user before that user can access the switch. If you have defined privilege levels, you can also assign a specific privilege level (with associated rights and privileges) to each username and password pair.

Privilege Levels

Cisco devices use privilege levels to provide password security for different levels of switch operation. By default, the Cisco IOS software operates in two modes (privilege levels) of password security: user EXEC (Level 1) and privileged EXEC (Level 15). You can configure up to 16 hierarchical levels of commands for each mode. By configuring multiple passwords, you can allow different sets of users to have access to specified commands.

Privilege Levels on Lines

Users can override the privilege level you set using the **privilege level** line configuration command by logging in to the line and enabling a different privilege level. They can lower the privilege level by using the **disable** command. If users know the password to a higher privilege level, they can use that password to enable the higher privilege level. You might specify a high level or privilege level for your console line to restrict line usage.

For example, if you want many users to have access to the **clear line** command, you can assign it level 2 security and distribute the level 2 password fairly widely. But if you want more restricted access to the **configure** command, you can assign it level 3 security and distribute that password to a more restricted group of users.

Command Privilege Levels

When you set a command to a privilege level, all commands whose syntax is a subset of that command are also set to that level. For example, if you set the **show ip traffic** command to level 15, the **show** commands and **show ip** commands are automatically set to privilege level 15 unless you set them individually to different levels.

How to Control Switch Access with Passwords and Privilege Levels

Setting or Changing a Static Enable Password

The enable password controls access to the privileged EXEC mode. Follow these steps to set or change a static enable password:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **enable password** *password*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**enable password** *password* **Example:** `Switch(config)# enable password secret321`	Defines a new password or changes an existing password for access to privileged EXEC mode. By default, no password is defined. For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. It can contain the question mark (?) character if you precede the question mark with the key combination Crtl-v when you create the password; for example, to create the password abc?123, do this: **a.** Enter **abc**. **b.** Enter **Crtl-v**.

	Command or Action	Purpose
		c. Enter **?123**. When the system prompts you to enter the enable password, you need not precede the question mark with the Ctrl-v; you can simply enter abc?123 at the password prompt.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Protecting Enable and Enable Secret Passwords with Encryption

Follow these steps to establish an encrypted password that users must enter to access privileged EXEC mode (the default) or any privilege level you specify:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. Use one of the following:
   - `enable password [level` *level*] {*password encryption-type encrypted-password*}
   - `enable secret [level` *level*] {*password encryption-type encrypted-password*}
4. **service password-encryption**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch>` **`enable`**	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch#` **`configure terminal`**	Enters global configuration mode.
Step 3	Use one of the following: • `enable password [level` *level*`]` {*password encryption-type encrypted-password*} • `enable secret [level` *level*`]` {*password encryption-type encrypted-password*} **Example:** `Switch(config)#` **`enable password example102`** or `Switch(config)#` **`enable secret level 1 password secret123sample`**	• Defines a new password or changes an existing password for access to privileged EXEC mode. • Defines a secret password, which is saved using a nonreversible encryption method. • (Optional) For *level*, the range is from 0 to 15. Level 1 is normal user EXEC mode privileges. The default level is 15 (privileged EXEC mode privileges). • For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined. • (Optional) For *encryption-type*, only type 5, a Cisco proprietary encryption algorithm, is available. If you specify an encryption type, you must provide an encrypted password—an encrypted password that you copy from another switch configuration. **Note** If you specify an encryption type and then enter a clear text password, you can not re-enter privileged EXEC mode. You cannot recover a lost encrypted password by any method.
Step 4	**service password-encryption** **Example:** `Switch(config)#` **`service password-encryption`**	(Optional) Encrypts the password when the password is defined or when the configuration is written. Encryption prevents the password from being readable in the configuration file.

	Command or Action	Purpose

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Disabling Password Recovery

Follow these steps to disable password recovery to protect the security of your switch:

Before you begin

If you disable password recovery, we recommend that you keep a backup copy of the configuration file on a secure server in case the end user interrupts the boot process and sets the system back to default values. Do not keep a backup copy of the configuration file on the switch. If the switch is operating in VTP transparent mode, we recommend that you also keep a backup copy of the VLAN database file on a secure server. When the switch is returned to the default system configuration, you can download the saved files to the switch by using the Xmodem protocol.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **system disable password recovery switch** *<1-9>*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**system disable password recovery switch** *<1-9>* **Example:** `Switch(config)# system disable password recovery switch all`	Disables password recovery. • *all* - Sets the configuration on switches in stack. • *<1-9>* - Sets the configuration on the Switch Number selected. This setting is saved in an area of the flash memory that is accessible by the boot loader and the Cisco IOS image, but it is not part of the file system and is not accessible by any user.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

What to do next

To remove **disable password recovery**, use the **no system disable password recovery switch all** global configuration command.

Setting a Telnet Password for a Terminal Line

Beginning in user EXEC mode, follow these steps to set a Telnet password for the connected terminal line:

Before you begin

- Attach a PC or workstation with emulation software to the switch console port, or attach a PC to the Ethernet management port.
- The default data characteristics of the console port are 9600, 8, 1, no parity. You might need to press the Return key several times to see the command-line prompt.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line vty 0 15**
4. **password** *password*
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	**Note** If a password is required for access to privileged EXEC mode, you will be prompted for it. Enters privileged EXEC mode.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**line vty 0 15** **Example:** `Switch(config)# line vty 0 15`	Configures the number of Telnet sessions (lines), and enters line configuration mode. There are 16 possible sessions on a command-capable Switch. The 0 and 15 mean that you are configuring all 16 possible Telnet sessions.
Step 4	**password** *password* **Example:** `Switch(config-line)# password abcxyz543`	Sets a Telnet password for the line or lines. For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined.

Step 5	**end**
	Example:
	`Switch(config-line)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Username and Password Pairs

Follow these steps to configure username and password pairs:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **username** *name* [**privilege** *level*] {**password** *encryption-type password*}
4. Use one of the following:
   - **line console 0**
   - **line vty 0 15**
5. **login local**
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**username** *name* [**privilege** *level*] {**password** *encryption-type password*}
	Example:
	`Switch(config)# username adamsample privilege 1 password secret456`
	`Switch(config)# username 111111111111 mac attribute`
		Sets the username, privilege level, and password for each user.
		• For *name*, specify the user ID as one word or the MAC address. Spaces and quotation marks are not allowed.
		• You can configure a maximum of 12000 clients each, for both username and MAC filter.
		• (Optional) For *level*, specify the privilege level the user has after gaining access. The range is 0 to 15. Level 15 gives privileged EXEC mode access. Level 1 gives user EXEC mode access.
		• For *encryption-type*, enter 0 to specify that an unencrypted password will follow. Enter 7 to specify that a hidden password will follow.
		• For *password*, specify the password the user must enter to gain access to the Switch. The password must be from 1 to 25 characters, can contain embedded spaces, and must be the last option specified in the **username** command.

	Command or Action	Purpose

Step 4	Use one of the following:
	• **line console 0**
	• **line vty 0 15**
	Example:
	`Switch(config)# line console 0`
	or
	`Switch(config)# line vty 15`
		Enters line configuration mode, and configures the console port (line 0) or the VTY lines (line 0 to 15).

Step 5	**login local** **Example:** `Switch(config-line)# login local`	Enables local password checking at login time. Authentication is based on the username specified in Step 3.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Setting the Privilege Level for a Command

Follow these steps to set the privilege level for a command:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **privilege** *mode* **level** *level command*
4. **enable password level** *level password*
5. **end**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**privilege** *mode* **level** *level command* **Example:** `Switch(config)# privilege exec level 14 configure`	Sets the privilege level for a command. • For *mode*, enter **configure** for global configuration mode, **exec** for EXEC mode, **interface** for interface configuration mode, or **line** for line configuration mode. • For *level*, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. Level 15 is the level of access permitted by the **enable** password. • For *command*, specify the command to which you want to restrict access.
Step 4	**enable password level** *level password* **Example:** `Switch(config)# enable password level 14 SecretPswd14`	Specifies the password to enable the privilege level. • For *level*, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. • For *password*, specify a string from 1 to 25 alphanumeric characters. The string cannot start with a number, is case sensitive, and allows spaces but ignores leading spaces. By default, no password is defined.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Changing the Default Privilege Level for Lines

Follow these steps to change the default privilege level for the specified line:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line vty** *line*
4. **privilege level** *level*
5. **end**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**line vty** *line* **Example:** `Switch(config)# line vty 10`	Selects the virtual terminal line on which to restrict access.
Step 4	**privilege level** *level* **Example:** `Switch(config)# privilege level 15`	Changes the default privilege level for the line. For *level*, the range is from 0 to 15. Level 1 is for normal user EXEC mode privileges. Level 15 is the level of access permitted by the **enable** password.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**copy running-config startup-config** **Example:**	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	`Switch# copy running-config startup-config`	

What to do next

Users can override the privilege level you set using the **privilege level** line configuration command by logging in to the line and enabling a different privilege level. They can lower the privilege level by using the **disable** command. If users know the password to a higher privilege level, they can use that password to enable the higher privilege level. You might specify a high level or privilege level for your console line to restrict line usage.

Logging into and Exiting a Privilege Level

Beginning in user EXEC mode, follow these steps to log into a specified privilege level and exit a specified privilege level.

SUMMARY STEPS

1. **enable** *level*
2. **disable** *level*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** *level* **Example:** `Switch> enable 15`	Logs in to a specified privilege level. Following the example, Level 15 is privileged EXEC mode. For *level*, the range is 0 to 15.
Step 2	**disable** *level* **Example:** `Switch# disable 1`	Exits to a specified privilege level. Following the example, Level 1 is user EXEC mode. For *level*, the range is 0 to 15.

Monitoring Switch Access

Table 64: Commands for Displaying DHCP Information

show privilege	Displays the privilege level configuration.

Configuration Examples for Setting Passwords and Privilege Levels

Example: Setting or Changing a Static Enable Password

This example shows how to change the enable password to *l1u2c3k4y5*. The password is not encrypted and provides access to level 15 (traditional privileged EXEC mode access):

```
Switch(config)# enable password l1u2c3k4y5
```

Example: Protecting Enable and Enable Secret Passwords with Encryption

This example shows how to configure the encrypted password *$1$FaD0$Xyti5Rkls3LoyxzS8* for privilege level 2:

```
Switch(config)# enable secret level 2 5 $1$FaD0$Xyti5Rkls3LoyxzS8
```

Example: Setting a Telnet Password for a Terminal Line

This example shows how to set the Telnet password to *let45me67in89*:

```
Switch(config)# line vty 10
Switch(config-line)# password let45me67in89
```

Example: Setting the Privilege Level for a Command

This example shows how to set the **configure** command to privilege level 14 and define *SecretPswd14* as the password users must enter to use level 14 commands:

```
Switch(config)# privilege exec level 14 configure
Switch(config)# enable password level 14 SecretPswd14
```

Additional References

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

MIBs

MIB	MIBs Link
	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

CHAPTER 29

Configuring TACACS+

TACACS+ is a security application that provides centralized validation of users attempting to gain access to a router or network access server. TACACS+ provides detailed accounting information and flexible administrative control over authentication and authorization processes. TACACS+ is facilitated through authentication, authorization and accounting (AAA) and can be enabled only through AAA commands.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for TACACS+

The following are the prerequisites for set up and configuration of switch access with TACACS+ (must be performed in the order presented):

1. Configure the switches with the TACACS+ server addresses.
2. Set an authentication key.
3. Configure the key from Step 2 on the TACACS+ servers.
4. Enable authentication, authorization, and accounting (AAA).

5. Create a login authentication method list.
6. Apply the list to the terminal lines.
7. Create an authorization and accounting method list.

The following are the prerequisites for controlling switch access with TACACS+:

- You must have access to a configured TACACS+ server to configure TACACS+ features on your switch. Also, you must have access to TACACS+ services maintained in a database on a TACACS+ daemon typically running on a LINUX or Windows workstation.
- You need a system running the TACACS+ daemon software to use TACACS+ on your switch.
- To use TACACS+, it must be enabled.
- Authorization must be enabled on the switch to be used.
- Users must first successfully complete TACACS+ authentication before proceeding to TACACS+ authorization.
- To use any of the AAA commands listed in this section or elsewhere, you must first enable AAA with the **aaa new-model** command.
- At a minimum, you must identify the host or hosts maintaining the TACACS+ daemon and define the method lists for TACACS+ authentication. You can optionally define method lists for TACACS+ authorization and accounting.
- The method list defines the types of authentication to be performed and the sequence in which they are performed; it must be applied to a specific port before any of the defined authentication methods are performed. The only exception is the default method list (which, by coincidence, is named *default*). The default method list is automatically applied to all ports except those that have a named method list explicitly defined. A defined method list overrides the default method list.
- Use TACACS+ for privileged EXEC access authorization if authentication was performed by using TACACS+.
- Use the local database if authentication was not performed by using TACACS+.

Restrictions for TACACS+

TACACS+ can be enabled only through AAA commands.

Information About TACACS+

TACACS+ and Switch Access

This section describes TACACS+. TACACS+ provides detailed accounting information and flexible administrative control over the authentication and authorization processes. It is facilitated through authentication, authorization, accounting (AAA) and can be enabled only through AAA commands.

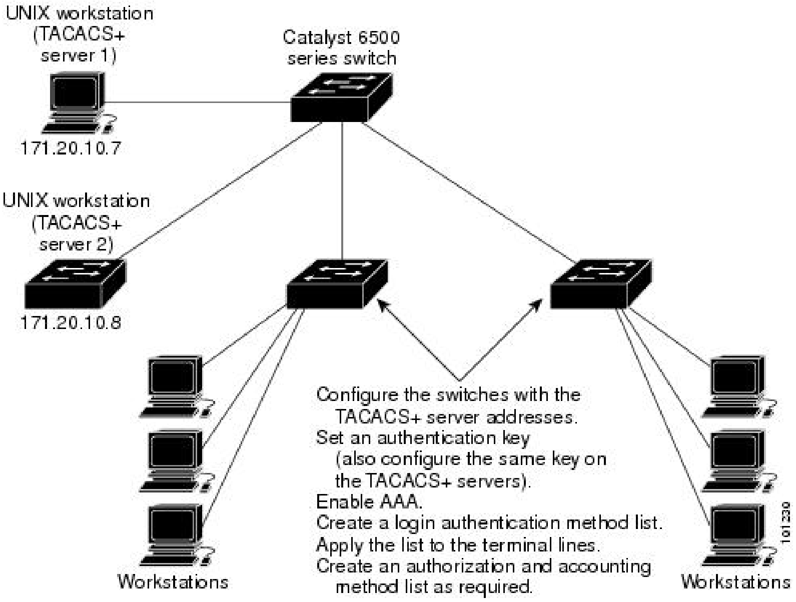
TACACS+ Overview

TACACS+ is a security application that provides centralized validation of users attempting to gain access to your switch.

TACACS+ provides for separate and modular authentication, authorization, and accounting facilities. TACACS+ allows for a single access control server (the TACACS+ daemon) to provide each service—authentication, authorization, and accounting—independently. Each service can be tied into its own database to take advantage of other services available on that server or on the network, depending on the capabilities of the daemon.

The goal of TACACS+ is to provide a method for managing multiple network access points from a single management service. Your switch can be a network access server along with other Cisco routers and access servers.

Figure 47: Typical TACACS+ Network Configuration


UNIX workstation (TACACS+ server 1)
171.20.10.7
Catalyst 6500 series switch
UNIX workstation (TACACS+ server 2)
171.20.10.8
Workstations
Workstations
101230

Configure the switches with the TACACS+ server addresses.
Set an authentication key (also configure the same key on the TACACS+ servers).
Enable AAA.
Create a login authentication method list.
Apply the list to the terminal lines.
Create an authorization and accounting method list as required.

TACACS+, administered through the AAA security services, can provide these services:

- Authentication—Provides complete control of authentication through login and password dialog, challenge and response, and messaging support.

  The authentication facility can conduct a dialog with the user (for example, after a username and password are provided, to challenge a user with several questions, such as home address, mother’s maiden name, service type, and social security number). The TACACS+ authentication service can also send messages to user screens. For example, a message could notify users that their passwords must be changed because of the company’s password aging policy.

- Authorization—Provides fine-grained control over user capabilities for the duration of the user’s session, including but not limited to setting autocommands, access control, session duration, or protocol support. You can also enforce restrictions on what commands a user can execute with the TACACS+ authorization feature.

- Accounting—Collects and sends information used for billing, auditing, and reporting to the TACACS+ daemon. Network managers can use the accounting facility to track user activity for a security audit or to provide information for user billing. Accounting records include user identities, start and stop times, executed commands (such as PPP), number of packets, and number of bytes.

The TACACS+ protocol provides authentication between the switch and the TACACS+ daemon, and it ensures confidentiality because all protocol exchanges between the switch and the TACACS+ daemon are encrypted.

TACACS+ Operation

When a user attempts a simple ASCII login by authenticating to a switch using TACACS+, this process occurs:

1. When the connection is established, the switch contacts the TACACS+ daemon to obtain a username prompt to show to the user. The user enters a username, and the switch then contacts the TACACS+ daemon to obtain a password prompt. The switch displays the password prompt to the user, the user enters a password, and the password is then sent to the TACACS+ daemon.

   TACACS+ allows a dialog between the daemon and the user until the daemon receives enough information to authenticate the user. The daemon prompts for a username and password combination, but can include other items, such as the user’s mother’s maiden name.

2. The switch eventually receives one of these responses from the TACACS+ daemon:

   - ACCEPT—The user is authenticated and service can begin. If the switch is configured to require authorization, authorization begins at this time.
   - REJECT—The user is not authenticated. The user can be denied access or is prompted to retry the login sequence, depending on the TACACS+ daemon.
   - ERROR—An error occurred at some time during authentication with the daemon or in the network connection between the daemon and the switch. If an ERROR response is received, the switch typically tries to use an alternative method for authenticating the user.
   - CONTINUE—The user is prompted for additional authentication information.

   After authentication, the user undergoes an additional authorization phase if authorization has been enabled on the switch. Users must first successfully complete TACACS+ authentication before proceeding to TACACS+ authorization.

3. If TACACS+ authorization is required, the TACACS+ daemon is again contacted, and it returns an ACCEPT or REJECT authorization response. If an ACCEPT response is returned, the response contains data in the form of attributes that direct the EXEC or NETWORK session for that user and the services that the user can access:

   - Telnet, Secure Shell (SSH), rlogin, or privileged EXEC services
   - Connection parameters, including the host or client IP address, access list, and user timeouts

Method List

A method list defines the sequence and methods to be used to authenticate, to authorize, or to keep accounts on a user. You can use method lists to designate one or more security protocols to be used, thus ensuring a backup system if the initial method fails. The software uses the first method listed to authenticate, to authorize, or to keep accounts on users; if that method does not respond, the software selects the next method in the list.

This process continues until there is successful communication with a listed method or the method list is exhausted.

If a method list is configured under VTY lines, the corresponding method list must be added to AAA. The following example shows how to configure a method list under a VTY line:

```
Device# configure terminal
Device(config)# line vty 0 4
Device(config)# authorization commands 15 auth1
```

The following example shows how to configure a method list in AAA:

```
Device# configure terminal
Device(config)# aaa new-model
Device(config)# aaa authorization commands 15 auth1 group tacacs+
```

If no method list is configured under VTY lines, the default method list must be added to AAA. The following example shows a VTY configuration without a method list:

```
Device# configure terminal
Device(config)# line vty 0 4
```

The following example shows how to configure the default method list:

```
Device# configure terminal
Device(config)# aaa new-model
Device(config)# aaa authorization commands 15 default group tacacs+
```

TACACS AV Pairs

The network access server implements TACACS+ authorization and accounting functions by transmitting and receiving TACACS+ attribute-value (AV) pairs for each user session.

TACACS Authentication and Authorization AV Pairs

The following table lists and describes the supported TACACS+ authentication and authorization AV pairs and specifies the Cisco IOS release in which they are implemented.

Table 65: Supported TACACS+ Authentication and Authorization AV Pairs

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
acl=x	ASCII number representing a connection access list. Used only when service=shell.	yes	yes	yes	yes	yes	yes	yes
addr=x	A network address. Used with service=slip, service=ppp, and protocol=ip. Contains the IP address that the remote host should use when connecting via SLIP or PPP/IP. For example, addr=10.2.3.4.	yes	yes	yes	yes	yes	yes	yes

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
addr-pool=x	Specifies the name of a local pool from which to get the address of the remote host. Used with service=ppp and protocol=ip. Note that **addr-pool** works in conjunction with local pooling. It specifies the name of a local pool (which must be preconfigured on the network access server). Use the **ip-local pool** command to declare local pools. For example: ip address-pool local ip local pool boo 10.0.0.1 10.0.0.10 ip local pool moo 10.0.0.1 10.0.0.20 You can then use TACACS+ to return addr-pool=boo or addr-pool=moo to indicate the address pool from which you want to get this remote node's address.	yes	yes	yes	yes	yes	yes	yes
autocmd=x	Specifies an autocommand to be executed at EXEC startup (for example, autocmd=telnet example.com). Used only with service=shell.	yes	yes	yes	yes	yes	yes	yes
callback- dialstring	Sets the telephone number for a callback (for example: callback-dialstring= 408-555-1212). Value is NULL, or a dial-string. A NULL value indicates that the service might choose to get the dial string through other means. Used with service=arap, service=slip, service=ppp, service=shell. Not valid for ISDN.	no	yes	yes	yes	yes	yes	yes
callback-line	The number of a TTY line to use for callback (for example: callback-line=4). Used with service=arap, service=slip, service=ppp, service=shell. Not valid for ISDN.	no	yes	yes	yes	yes	yes	yes
callback-rotary	The number of a rotary group (between 0 and 100 inclusive) to use for callback (for example: callback-rotary=34). Used with service=arap, service=slip, service=ppp, service=shell. Not valid for ISDN.	no	yes	yes	yes	yes	yes	yes
cmd-arg=x	An argument to a shell (EXEC) command. This indicates an argument for the shell command that is to be run. Multiple cmd-arg attributes can be specified, and they are order dependent. **Note** This TACACS+ AV pair cannot be used with RADIUS attribute 26.	yes	yes	yes	yes	yes	yes	yes
cmd=x	A shell (EXEC) command. This indicates the command name for a shell command that is to be run. This attribute must be specified if service equals "shell." A NULL value indicates that the shell itself is being referred to. **Note** This TACACS+ AV pair cannot be used with RADIUS attribute 26.	yes	yes	yes	yes	yes	yes	yes
data-service	Used with the service=outbound and protocol=ip.	no	no	no	no	no	yes	yes

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
dial-number	Defines the number to dial. Used with the service=outbound and protocol=ip.	no	no	no	no	no	yes	yes
dns-servers=	Identifies a DNS server (primary or secondary) that can be requested by Microsoft PPP clients from the network access server during IPCP negotiation. To be used with service=ppp and protocol=ip. The IP address identifying each DNS server is entered in dotted decimal format.	no	no	no	yes	yes	yes	yes
force-56	Determines whether the network access server uses only the 56 K portion of a channel, even when all 64 K appear to be available. To turn on this attribute, use the “true” value (force-56=true). Any other value is treated as false. Used with the service=outbound and protocol=ip.	no	no	no	no	no	yes	yes
gw-password	Specifies the password for the home gateway during the L2F tunnel authentication. Used with service=ppp and protocol=vpdn.	no	no	yes	yes	yes	yes	yes
idletime=x	Sets a value, in minutes, after which an idle session is terminated. A value of zero indicates no timeout.	no	yes	yes	yes	yes	yes	yes
inacl#<n>	ASCII access list identifier for an input access list to be installed and applied to an interface for the duration of the current connection. Used with service=ppp and protocol=ip, and service service=ppp and protocol =ipx. Per-user access lists do not currently work with ISDN interfaces.	no	no	no	yes	yes	yes	yes
inacl=x	ASCII identifier for an interface input access list. Used with service=ppp and protocol=ip. Per-user access lists do not currently work with ISDN interfaces.	yes	yes	yes	yes	yes	yes	yes
interface-config#<n>	Specifies user-specific AAA interface configuration information with Virtual Profiles. The information that follows the equal sign (=) can be any Cisco IOS interface configuration command. Multiple instances of the attributes are allowed, but each instance must have a unique number. Used with service=ppp and protocol=lcp. **Note** This attribute replaces the “interface-config=” attribute.	no	no	no	yes	yes	yes	yes
ip-addresses	Space-separated list of possible IP addresses that can be used for the end-point of a tunnel. Used with service=ppp and protocol=vpdn.	no	no	yes	yes	yes	yes	yes
l2tp-busy-disconnect	If a vpdn-group on an LNS uses a virtual-template that is configured to be pre-cloned, this attribute will control the disposition of a new L2TP session that finds no pre-cloned interface to which to connect. If the attribute is true (the default), the session will be disconnected by the LNS. Otherwise, a new interface will be cloned from the virtual-template. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
l2tp-cm-local-window-size	Specifies the maximum receive window size for L2TP control messages. This value is advertised to the peer during tunnel establishment. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes
l2tp-drop-out-of-order	Respects sequence numbers on data packets by dropping those that are received out of order. This does not ensure that sequence numbers will be sent on data packets, just how to handle them if they are received. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes
l2tp-hello- interval	Specifies the number of seconds for the hello keepalive interval. Hello packets are sent when no data has been sent on a tunnel for the number of seconds configured here. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes
l2tp-hidden-avp	When enabled, sensitive AVPs in L2TP control messages are scrambled or hidden. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes
l2tp-nosession-timeout	Specifies the number of seconds that a tunnel will stay active with no sessions before timing out and shutting down. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes
l2tp-tos-reflect	Copies the IP ToS field from the IP header of each payload packet to the IP header of the tunnel packet for packets entering the tunnel at the LNS. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes
l2tp-tunnel- authen	If this attribute is set, it performs L2TP tunnel authentication. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes
l2tp-tunnel-password	Shared secret used for L2TP tunnel authentication and AVP hiding. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes
l2tp-udp- checksum	This is an authorization attribute and defines whether L2TP should perform UDP checksums for data packets. Valid values are “yes” and “no.” The default is no. Used with service=ppp and protocol=vpdn.	no	no	no	no	no	yes	yes
link- compression=	Defines whether to turn on or turn off “stac” compression over a PPP link. Used with service=ppp. Link compression is defined as a numeric value as follows: • 0: None • 1: Stac • 2: Stac-Draft-9 • 3: MS-Stac	no	no	no	yes	yes	yes	yes

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
load-threshold= <n>	Sets the load threshold for the caller at which additional links are either added to or deleted from the multilink bundle. If the load goes above the specified value, additional links are added. If the load goes below the specified value, links are deleted. Used with service=ppp and protocol=multilink. The range for <n> is from 1 to 255.	no	no	no	yes	yes	yes	yes
map-class	Allows the user profile to reference information configured in a map class of the same name on the network access server that dials out. Used with the service=outbound and protocol=ip.	no	no	no	no	no	yes	yes
max-links=<n>	Restricts the number of links that a user can have in a multilink bundle. Used with service=ppp and protocol=multilink. The range for <n> is from 1 to 255.	no	no	no	yes	yes	yes	yes
min-links	Sets the minimum number of links for MLP. Used with service=ppp and protocol=multilink, protocol=vpdn.	no	no	no	no	no	yes	yes
nas-password	Specifies the password for the network access server during the L2F tunnel authentication. Used with service=ppp and protocol=vpdn.	no	no	yes	yes	yes	yes	yes
nocallback-verify	Indicates that no callback verification is required. The only valid value for this parameter is 1 (for example, nocallback-verify=1). Used with service=arap, service=slip, service=ppp, service=shell. There is no authentication on callback. Not valid for ISDN.	no	yes	yes	yes	yes	yes	yes
noescape=x	Prevents user from using an escape character. Used with service=shell. Can be either true or false (for example, noescape=true).	yes	yes	yes	yes	yes	yes	yes
nohangup=x	Used with service=shell. Specifies the nohangup option, which means that after an EXEC shell is terminated, the user is presented with another login (username) prompt. Can be either true or false (for example, nohangup=false).	yes	yes	yes	yes	yes	yes	yes
old-prompts	Allows providers to make the prompts in TACACS+ appear identical to those of earlier systems (TACACS and Extended TACACS). This allows administrators to upgrade from TACACS or Extended TACACS to TACACS+ transparently to users.	yes	yes	yes	yes	yes	yes	yes
outacl#<n>	ASCII access list identifier for an interface output access list to be installed and applied to an interface for the duration of the current condition. Used with service=ppp and protocol=ip, and service service=ppp and protocol=ipx. Per-user access lists do not currently work with ISDN interfaces.	no	no	no	yes	yes	yes	yes
outacl=x	ASCII identifier for an interface output access list. Used with service=ppp and protocol=ip, and service service=ppp and protocol=ipx. Contains an IP output access list for SLIP or PPP/IP (for example, outacl=4). The access list itself must be preconfigured on the router. Per-user access lists do not currently work with ISDN interfaces.	yes (PPP/IP only)	yes	yes	yes	yes	yes	yes

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
pool-def#<n>	Defines IP address pools on the network access server. Used with service=ppp and protocol=ip.	no	no	no	yes	yes	yes	yes
pool-timeout=	Defines (in conjunction with pool-def) IP address pools on the network access server. During IPCP address negotiation, if an IP pool name is specified for a user (see the addr-pool attribute), a check is made to see if the named pool is defined on the network access server. If it is, the pool is consulted for an IP address. Used with service=ppp and protocol=ip.	no	no	yes	yes	yes	yes	yes
port-type	Indicates the type of physical port the network access server is using to authenticate the user. Physical ports are indicated by a numeric value as follows: • 0: Asynchronous • 1: Synchronous • 2: ISDN-Synchronous • 3: ISDN-Asynchronous (V.120) • 4: ISDN- Asynchronous (V.110) • 5: Virtual Used with service=any and protocol=aaa.	no	no	no	no	no	yes	yes
ppp-vj-slot-compression	Instructs the Cisco router not to use slot compression when sending VJ-compressed packets over a PPP link.	no	no	no	yes	yes	yes	yes
priv-lvl=x	Privilege level to be assigned for the EXEC. Used with service=shell. Privilege levels range from 0 to 15, with 15 being the highest.	yes	yes	yes	yes	yes	yes	yes
protocol=x	A protocol that is a subset of a service. An example would be any PPP NCP. Currently known values are **lcp**, **ip**, **ipx**, **atalk**, **vines**, **lat**, **xremote**, **tn3270**, **telnet**, **rlogin**, **pad**, **vpdn**, **osicp**, **deccp**, **ccp**, **cdp**, **bridging**, **xns**, **nbf**, **bap**, **multilink**, and **unknown**.	yes	yes	yes	yes	yes	yes	yes
proxyacl#<n>	Allows users to configure the downloadable user profiles (dynamic ACLs) by using the authentication proxy feature so that users can have the configured authorization to permit traffic going through the configured interfaces. Used with the service=shell and protocol=exec.	no	no	no	no	no	yes	yes

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
route	Specifies a route to be applied to an interface. Used with service=slip, service=ppp, and protocol=ip. During network authorization, the route attribute can be used to specify a per-user static route, to be installed by TACACS+ as follows: route=”*dst_address mask* [*gateway*]” This indicates a temporary static route that is to be applied. The *dst_address*, *mask*, and *gateway* are expected to be in the usual dotted-decimal notation, with the same meanings as in the familiar **ip route** configuration command on a network access server. If *gateway* is omitted, the peer’s address is the gateway. The route is expunged when the connection terminates.	no	yes	yes	yes	yes	yes	yes
route#<n>	Like the route AV pair, this specifies a route to be applied to an interface, but these routes are numbered, allowing multiple routes to be applied. Used with service=ppp and protocol=ip, and service=ppp and protocol=ipx.	no	no	no	yes	yes	yes	yes
routing=x	Specifies whether routing information is to be propagated to and accepted from this interface. Used with service=slip, service=ppp, and protocol=ip. Equivalent in function to the /routing flag in SLIP and PPP commands. Can either be true or false (for example, routing=true).	yes	yes	yes	yes	yes	yes	yes
rte-fltr-in#<n>	Specifies an input access list definition to be installed and applied to routing updates on the current interface for the duration of the current connection. Used with service=ppp and protocol=ip, and with service=ppp and protocol=ipx.	no	no	no	yes	yes	yes	yes
rte-fltr-out#<n>	Specifies an output access list definition to be installed and applied to routing updates on the current interface for the duration of the current connection. Used with service=ppp and protocol=ip, and with service=ppp and protocol=ipx.	no	no	no	yes	yes	yes	yes
sap#<n>	Specifies static Service Advertising Protocol (SAP) entries to be installed for the duration of a connection. Used with service=ppp and protocol=ipx.	no	no	no	yes	yes	yes	yes
sap-fltr-in#<n>	Specifies an input SAP filter access list definition to be installed and applied on the current interface for the duration of the current connection. Used with service=ppp and protocol=ipx.	no	no	no	yes	yes	yes	yes
sap-fltr-out#<n>	Specifies an output SAP filter access list definition to be installed and applied on the current interface for the duration of the current connection. Used with service=ppp and protocol=ipx.	no	no	no	yes	yes	yes	yes
send-auth	Defines the protocol to use (PAP or CHAP) for username-password authentication following CLID authentication. Used with service=any and protocol=aaa.	no	no	no	no	no	yes	yes

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
send-secret	Specifies the password that the NAS needs to respond to a chap/pap request from the remote end of a connection on an outgoing call. Used with service=ppp and protocol=ip.	no	no	no	no	no	yes	yes
service=x	The primary service. Specifying a service attribute indicates that this is a request for authorization or accounting of that service. Current values are **slip**, **ppp**, **arap**, **shell**, **tty-daemon**, **connection**, and **system**. This attribute must always be included.	yes	yes	yes	yes	yes	yes	yes
source-ip=x	Used as the source IP address of all VPDN packets generated as part of a VPDN tunnel. This is equivalent to the Cisco **vpdn outgoing** global configuration command.	no	no	yes	yes	yes	yes	yes
spi	Carries the authentication information needed by the home agent to authenticate a mobile node during registration. The information is in the same syntax as the **ip mobile secure host <addr>** configuration command. Basically it contains the rest of the configuration command that follows that string, verbatim. It provides the Security Parameter Index (SPI), key, authentication algorithm, authentication mode, and replay protection timestamp range. Used with the service=mobileip and protocol=ip.	no	no	no	no	no	yes	yes
timeout=x	The number of minutes before an EXEC or ARA session disconnects (for example, timeout=60). A value of zero indicates no timeout. Used with service=arap.	yes	yes	yes	yes	yes	yes	yes
tunnel-id	Specifies the username that will be used to authenticate the tunnel over which the individual user MID will be projected. This is analogous to the *remote name* in the **vpdn outgoing** command. Used with service=ppp and protocol=vpdn.	no	no	yes	yes	yes	yes	yes
wins-servers=	Identifies a Windows NT server that can be requested by Microsoft PPP clients from the network access server during IPCP negotiation. To be used with service=ppp and protocol=ip. The IP address identifying each Windows NT server is entered in dotted decimal format.	no	no	no	yes	yes	yes	yes
zonelist=x	A numeric zonelist value. Used with service=arap. Specifies an AppleTalk zonelist for ARA (for example, zonelist=5).	yes	yes	yes	yes	yes	yes	yes

See Configuring TACACS+. module for the documents used to configure TACACS+, and TACACS+ authentication and authorization.

TACACS Accounting AV Pairs

The following table lists and describes the supported TACACS+ accounting AV pairs and specifies the Cisco IOS release in which they are implemented.

Table 66: Supported TACACS+ Accounting AV Pairs

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
Abort-Cause	If the fax session is terminated, indicates the system component that signaled the termination. Examples of system components that could trigger a termination are FAP (Fax Application Process), TIFF (the TIFF reader or the TIFF writer), fax-mail client, fax-mail server, ESMTP client, or ESMTP server.	no	no	no	no	no	yes	yes
bytes_in	The number of input bytes transferred during this connection.	yes	yes	yes	yes	yes	yes	yes
bytes_out	The number of output bytes transferred during this connection.	yes	yes	yes	yes	yes	yes	yes
Call-Type	Describes the type of fax activity: fax receive or fax send.	no	no	no	no	no	yes	yes
cmd	The command the user executed.	yes	yes	yes	yes	yes	yes	yes
data-rate	This AV pair has been renamed. See nas-rx-speed.							
disc-cause	Specifies the reason a connection was taken off-line. The Disconnect-Cause attribute is sent in accounting-stop records. This attribute also causes stop records to be generated without first generating start records if disconnection occurs before authentication is performed. Refer to the following table (Disconnect Cause Extensions) for a list of Disconnect-Cause values and their meanings.	no	no	no	yes	yes	yes	yes
disc-cause-ext	Extends the disc-cause attribute to support vendor-specific reasons why a connection was taken off-line.	no	no	no	yes	yes	yes	yes
elapsed_time	The elapsed time in seconds for the action. Useful when the device does not keep real time.	yes	yes	yes	yes	yes	yes	yes
Email-Server-Address	Indicates the IP address of the e-mail server handling the on-ramp fax-mail message.	no	no	no	no	no	yes	yes
Email-Server-Ack-Flag	Indicates that the on-ramp gateway has received a positive acknowledgment from the e-mail server accepting the fax-mail message.	no	no	no	no	no	yes	yes
event	Information included in the accounting packet that describes a state change in the router. Events described are accounting starting and accounting stopping.	yes	yes	yes	yes	yes	yes	yes
Fax-Account-Id-Origin	Indicates the account ID origin as defined by system administrator for the **mmoip aaa receive-id** or the **mmoip aaa send-id** command.	no	no	no	no	no	yes	yes
Fax-Auth-Status	Indicates whether or not authentication for this fax session was successful. Possible values for this field are success, failed, bypassed, or unknown.	no	no	no	no	no	yes	yes
Fax-Connect-Speed	Indicates the modem speed at which this fax-mail was initially transmitted or received. Possible values are 1200, 4800, 9600, and 14400.	no	no	no	no	no	yes	yes
Fax-Coverpage-Flag	Indicates whether or not a cover page was generated by the off-ramp gateway for this fax session. True indicates that a cover page was generated; false means that a cover page was not generated.	no	no	no	no	no	yes	yes

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
Fax-Dsn-Address	Indicates the address to which DSNs will be sent.	no	no	no	no	no	yes	yes
Fax-Dsn-Flag	Indicates whether or not DSN has been enabled. True indicates that DSN has been enabled; false means that DSN has not been enabled.	no	no	no	no	no	yes	yes
Fax-Mdn-Address	Indicates the address to which MDNs will be sent.	no	no	no	no	no	yes	yes
Fax-Mdn-Flag	Indicates whether or not message delivery notification (MDN) has been enabled. True indicates that MDN had been enabled; false means that MDN had not been enabled.	no	no	no	no	no	yes	yes
Fax-Modem-Time	Indicates the amount of time in seconds the modem sent fax data (x) and the amount of time in seconds of the total fax session (y), which includes both fax-mail and PSTN time, in the form x/y. For example, 10/15 means that the transfer time took 10 seconds, and the total fax session took 15 seconds.	no	no	no	no	no	yes	yes
Fax-Msg-Id=	Indicates a unique fax message identification number assigned by Store and Forward Fax.	no	no	no	no	no	yes	yes
Fax-Pages	Indicates the number of pages transmitted or received during this fax session. This page count includes cover pages.	no	no	no	no	no	yes	yes
Fax-Process-Abort-Flag	Indicates that the fax session was terminated or successful. True means that the session was terminated; false means that the session was successful.	no	no	no	no	no	yes	yes
Fax-Recipient-Count	Indicates the number of recipients for this fax transmission. Until e-mail servers support Session mode, the number should be 1.	no	no	no	no	no	yes	yes
Gateway-Id	Indicates the name of the gateway that processed the fax session. The name appears in the following format: hostname.domain-name	no	no	no	no	no	yes	yes
mlp-links-max	Gives the count of links which are known to have been in a given multilink session at the time the accounting record is generated.	no	no	no	yes	yes	yes	yes
mlp-sess-id	Reports the identification number of the multilink bundle when the session closes. This attribute applies to sessions that are part of a multilink bundle. This attribute is sent in authentication-response packets.	no	no	no	yes	yes	yes	yes
nas-rx-speed	Specifies the average number of bits per second over the course of the connection's lifetime. This attribute is sent in accounting-stop records.	no	no	no	yes	yes	yes	yes
nas-tx-speed	Reports the transmit speed negotiated by the two modems.	no	no	no	yes	yes	yes	yes
paks_in	The number of input packets transferred during this connection.	yes	yes	yes	yes	yes	yes	yes
paks_out	The number of output packets transferred during this connection.	yes	yes	yes	yes	yes	yes	yes
port	The port the user was logged in to.	yes	yes	yes	yes	yes	yes	yes
Port-Used	Indicates the slot/port number of the Cisco AS5300 used to either transmit or receive this fax-mail.	no	no	no	no	no	yes	yes

Attribute	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2
pre-bytes-in	Records the number of input bytes before authentication. This attribute is sent in accounting-stop records.	no	no	no	yes	yes	yes	yes
pre-bytes-out	Records the number of output bytes before authentication. This attribute is sent in accounting-stop records.	no	no	no	yes	yes	yes	yes
pre-paks-in	Records the number of input packets before authentication. This attribute is sent in accounting-stop records.	no	no	no	yes	yes	yes	yes
pre-paks-out	Records the number of output packets before authentication. The Pre-Output-Packets attribute is sent in accounting-stop records.	no	no	no	yes	yes	yes	yes
pre-session-time	Specifies the length of time, in seconds, from when a call first connects to when it completes authentication.	no	no	no	yes	yes	yes	yes
priv_level	The privilege level associated with the action.	yes	yes	yes	yes	yes	yes	yes
protocol	The protocol associated with the action.	yes	yes	yes	yes	yes	yes	yes
reason	Information included in the accounting packet that describes the event that caused a system change. Events described are system reload, system shutdown, or when accounting is reconfigured (turned on or off).	yes	yes	yes	yes	yes	yes	yes
service	The service the user used.	yes	yes	yes	yes	yes	yes	yes
start_time	The time the action started (in seconds since the epoch, 12:00 a.m. Jan 1 1970). The clock must be configured to receive this information.	yes	yes	yes	yes	yes	yes	yes
stop_time	The time the action stopped (in seconds since the epoch.) The clock must be configured to receive this information.	yes	yes	yes	yes	yes	yes	yes
task_id	Start and stop records for the same event must have matching (unique) task_id numbers.	yes	yes	yes	yes	yes	yes	yes
timezone	The time zone abbreviation for all timestamps included in this packet.	yes	yes	yes	yes	yes	yes	yes
xmit-rate	This AV pair has been renamed. See nas-tx-speed.							

The following table lists the cause codes and descriptions for the Disconnect Cause Extended (disc-cause-ext) attribute.

Table 67: Disconnect Cause Extensions

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1000 - No Reason	No reason for the disconnect.	no	no	no	no	yes	yes	yes	yes
1001 - No Disconnect	The event was not a disconnect.	no	no	no	no	yes	yes	yes	yes
1002 - Unknown	The reason for the disconnect is unknown. This code can appear when the remote connection goes down.	no	no	no	no	yes	yes	yes	yes

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1003 - Call Disconnect	The call has disconnected.	no	no	no	no	yes	yes	yes	yes
1004 - CLID Auth Fail	Calling line ID (CLID) authentication has failed.	no	no	no	no	yes	yes	yes	yes
1009 - No Modem Available	The modem is not available.	no	no	no	no	yes	yes	yes	yes
1010 - No Carrier	The modem never detected data carrier detect (DCD). This code can appear if a disconnect occurs during the initial modem connection.	no	no	no	no	yes	yes	yes	yes
1011 - Lost Carrier	The modem detected DCD but became inactive. This code can appear if a disconnect occurs during the initial modem connection.	no	no	no	no	yes	yes	yes	yes
1012 - No Modem Results	The result codes could not be parsed. This code can appear if a disconnect occurs during the initial modem connection.	no	no	no	no	yes	yes	yes	yes
1020 - TS User Exit	The user exited normally from the terminal server. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1021 - Idle Timeout	The user exited from the terminal server because the idle timer expired. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1022 - TS Exit Telnet	The user exited normally from a Telnet session. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1023 - TS No IP Addr	The user could not switch to Serial Line Internet Protocol (SLIP) or PPP because the remote host had no IP address or because the dynamic pool could not assign one. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1024 - TS TCP Raw Exit	The user exited normally from a raw TCP session. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1025 - TS Bad Password	The login process ended because the user failed to enter a correct password after three attempts. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1026 - TS No TCP Raw	The raw TCP option is not enabled. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1027 - TS CNTL-C	The login process ended because the user typed Ctrl-C. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1028 - TS Session End	The terminal server session has ended. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1029 - TS Close Vconn	The user closed the virtual connection. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1030 - TS End Vconn	The virtual connection has ended. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1031 - TS Rlogin Exit	The user exited normally from an Rlogin session. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1032 - TS Rlogin Opt Invalid	The user selected an invalid Rlogin option. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1033 - TS Insuff Resources	The access server has insufficient resources for the terminal server session. This code is related to immediate Telnet and raw TCP disconnects during a terminal server session.	no	no	no	no	yes	yes	yes	yes
1040 - PPP LCP Timeout	PPP link control protocol (LCP) negotiation timed out while waiting for a response from a peer. This code concerns PPP connections.	no	no	no	no	yes	yes	yes	yes
1041 - PPP LCP Fail	There was a failure to converge on PPP LCP negotiations. This code concerns PPP connections.	no	no	no	no	yes	yes	yes	yes
1042 - PPP Pap Fail	PPP Password Authentication Protocol (PAP) authentication failed. This code concerns PPP connections.	no	no	no	no	yes	yes	yes	yes
1043 - PPP CHAP Fail	PPP Challenge Handshake Authentication Protocol (CHAP) authentication failed. This code concerns PPP connections.	no	no	no	no	yes	yes	yes	yes
1044 - PPP Remote Fail	Authentication failed from the remote server. This code concerns PPP sessions.	no	no	no	no	yes	yes	yes	yes
1045 - PPP Receive Term	The peer sent a PPP termination request. This code concerns PPP connections.	no	no	no	no	yes	yes	yes	yes
PPP LCP Close (1046)	LCP got a close request from the upper layer while LCP was in an open state. This code concerns PPP connections.	no	no	no	no	yes	yes	yes	yes
1047 - PPP No NCP	LCP closed because no NCPs were open. This code concerns PPP connections.	no	no	no	no	yes	yes	yes	yes
1048 - PPP MP Error	LCP closed because it could not determine to which Multilink PPP bundle that it should add the user. This code concerns PPP connections.	no	no	no	no	yes	yes	yes	yes

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1049 - PPP Max Channels	LCP closed because the access server could not add any more channels to an MP session. This code concerns PPP connections.	no	no	no	no	yes	yes	yes	yes
1050 - TS Tables Full	The raw TCP or Telnet internal session tables are full. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table.	no	no	no	no	yes	yes	yes	yes
1051 - TS Resource Full	Internal resources are full. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table.	no	no	no	no	yes	yes	yes	yes
1052 - TS Invalid IP Addr	The IP address for the Telnet host is invalid. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table.	no	no	no	no	yes	yes	yes	yes
1053 - TS Bad Hostname	The access server could not resolve the host name. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table.	no	no	no	no	yes	yes	yes	yes
1054 - TS Bad Port	The access server detected a bad or missing port number. This code relates to immediate Telnet and raw TCP disconnects and contains more specific information than the Telnet and TCP codes listed earlier in this table.	no	no	no	no	yes	yes	yes	yes
1060 - TCP Reset	The host reset the TCP connection. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.	no	no	no	no	yes	yes	yes	yes
1061 - TCP Connection Refused	The host refused the TCP connection. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.	no	no	no	no	yes	yes	yes	yes
1062 - TCP Timeout	The TCP connection timed out. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.	no	no	no	no	yes	yes	yes	yes
1063 - TCP Foreign Host Close	A foreign host closed the TCP connection. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.	no	no	no	no	yes	yes	yes	yes
1064 - TCP Net Unreachable	The TCP network was unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.	no	no	no	no	yes	yes	yes	yes

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1065 - TCP Host Unreachable	The TCP host was unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.	no	no	no	no	yes	yes	yes	yes
1066 - TCP Net Admin Unreachable	The TCP network was administratively unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.	no	no	no	no	yes	yes	yes	yes
1067 - TCP Host Admin Unreachable	The TCP host was administratively unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.	no	no	no	no	yes	yes	yes	yes
1068 - TCP Port Unreachable	The TCP port was unreachable. The TCP stack can return this disconnect code during an immediate Telnet or raw TCP session.	no	no	no	no	yes	yes	yes	yes
1100 - Session Timeout	The session timed out because there was no activity on a PPP link. This code applies to all session types.	no	no	no	no	yes	yes	yes	yes
1101 - Security Fail	The session failed for security reasons. This code applies to all session types.	no	no	no	no	yes	yes	yes	yes
1102 - Callback	The session ended for callback. This code applies to all session types.	no	no	no	no	yes	yes	yes	yes
1120 - Unsupported	One end refused the call because the protocol was disabled or unsupported. This code applies to all session types.	no	no	no	no	yes	yes	yes	yes
1150 - Radius Disc	The RADIUS server requested the disconnect.	no	no	no	no	yes	yes	yes	yes
1151 - Local Admin Disc	The local administrator has disconnected.	no	no	no	no	yes	yes	yes	yes
1152 - SNMP Disc	Simple Network Management Protocol (SNMP) has disconnected.	no	no	no	no	yes	yes	yes	yes
1160 - V110 Retries	The allowed retries for V110 synchronization have been exceeded.	no	no	no	no	yes	yes	yes	yes
1170 - PPP Auth Timeout	Authentication timeout. This code applies to PPP sessions.	no	no	no	no	yes	yes	yes	yes
1180 - Local Hangup	The call disconnected as the result of a local hangup.	no	no	no	no	yes	yes	yes	yes
1185 - Remote Hangup	The call disconnected because the remote end hung up.	no	no	no	no	yes	yes	yes	yes
1190 - T1 Quiesced	The call disconnected because the T1 line that carried it was quiesced.	no	no	no	no	yes	yes	yes	yes
1195 - Call Duration	The call disconnected because the call duration exceeded the maximum amount of time allowed by the Max Call Mins or Max DS0 Mins parameter on the access server.	no	no	no	no	yes	yes	yes	yes
1600 - VPDN User Disconnect	The user disconnected. This value applies to virtual private dial-up network (VPDN) sessions.	no	no	no	no	no	no	yes	yes

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1601 - VPDN Carrier Loss	Carrier loss has occurred. This code applies to VPDN sessions.	no	no	no	no	no	no	yes	yes
1602 - VPDN No Resources	There are no resources. This code applies to VPDN sessions.	no	no	no	no	no	no	yes	yes
1603 - VPDN Bad Control Packet	The control packet is invalid. This code applies to VPDN sessions.	no	no	no	no	no	no	yes	yes
1604 - VPDN Admin Disconnect	The administrator disconnected. This code applies to VPDN sessions.	no	no	no	no	no	no	yes	yes
1605 - VPDN Tunnel Down/Setup Fail	The tunnel is down or the setup failed. This code applies to VPDN sessions.	no	no	no	no	no	no	yes	yes
1606 - VPDN Local PPP Disconnect	There was a local PPP disconnect. This code applies to VPDN sessions.	no	no	no	no	no	no	yes	yes
1607 - VPDN Softshut/Session Limit	New sessions cannot be established on the VPN tunnel. This code applies to VPDN sessions.	no	no	no	no	no	no	yes	yes
1608 - VPDN Call Redirected	The call was redirected. This code applies to VPDN sessions.	no	no	no	no	no	no	yes	yes
1801 - Q850 Unassigned Number	The number has not been assigned. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1802 - Q850 No Route	The equipment that is sending this code has received a request to route the call through a particular transit network that it does not recognize. The equipment that is sending this code does not recognize the transit network because either the transit network does not exist or because that particular transit network, while it does exist, does not serve the equipment that is sending this code. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1803 - Q850 No Route To Destination	The called party cannot be reached because the network through which the call has been routed does not serve the destination that is desired. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1806 - Q850 Channel Unacceptable	The channel that has been most recently identified is not acceptable to the sending entity for use in this call. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1816 - Q850 Normal Clearing	The call is being cleared because one of the users who is involved in the call has requested that the call be cleared. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1817 - Q850 User Busy	The called party is unable to accept another call because the user-busy condition has been encountered. This code may be generated by the called user or by the network. In the case of the user, the user equipment is compatible with the call. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1818 - Q850 No User Responding	Used when a called party does not respond to a call-establishment message with either an alerting or connect indication within the prescribed period of time that was allocated. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1819 - Q850 No User Answer	The called party has been alerted but does not respond with a connect indication within a prescribed period of time. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1821 - Q850 Call Rejected	The equipment that is sending this code does not wish to accept this call although it could have accepted the call because the equipment that is sending this code is neither busy nor incompatible. This code may also be generated by the network, indicating that the call was cleared due to a supplementary service constraint. The diagnostic field may contain additional information about the supplementary service and reason for rejection. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1822 - Q850 Number Changed	The number that is indicated for the called party is no longer assigned. The new called party number may optionally be included in the diagnostic field. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1827 - Q850 Destination Out of Order	The destination that was indicated by the user cannot be reached because the interface to the destination is not functioning correctly. The term “not functioning correctly” indicates that a signaling message was unable to be delivered to the remote party. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1828 - Q850 Invalid Number Format	The called party cannot be reached because the called party number is not in a valid format or is not complete. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1829 - Q850 Facility Rejected	This code is returned when a supplementary service that was requested by the user cannot be provided by the network. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1830 - Q850 Responding to Status Enquiry	This code is included in the STATUS message when the reason for generating the STATUS message was the prior receipt of a STATUS ENQUIRY message. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1831 - Q850 Unspecified Cause	No other code applies. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1834 - Q850 No Circuit Available	No circuit or channel is available to handle the call. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1838 - Q850 Network Out of Order	The network is not functioning correctly and the condition is likely to last a relatively long period of time. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1841 - Q850 Temporary Failure	The network is not functioning correctly and the condition is not likely to last a long period of time. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1842 - Q850 Network Congestion	The network is congested. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1843 - Q850 Access Info Discarded	This code indicates that the network could not deliver access information to the remote user as requested. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1844 - Q850 Requested Channel Not Available	This code is returned when the circuit or channel that is indicated by the requesting entity cannot be provided by the other side of the interface. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1845 - Q850 Call Pre-empted	The call was preempted. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1847 - Q850 Resource Unavailable	This code is used to report a resource-unavailable event only when no other code in the resource-unavailable class applies. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1850 - Q850 Facility Not Subscribed	Not a subscribed facility. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
1852 - Q850 Outgoing Call Barred	Although the calling party is a member of the closed user group for the outgoing closed user group call, outgoing calls are not allowed for this member. This code applies to ISDN or modem calls that came in over ISDN.	no	no	no	no	no	no	no	yes
Q850 Incoming Call Barred (1854)	Although the called party is a member of the closed user group for the incoming closed user group call, incoming calls are not allowed to this member. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1858 - Q850 Bearer Capability Not Available	The user has requested a bearer capability that is implemented by the equipment that generated this code but that is not available at this time. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1863 - Q850 Service Not Available	The code is used to report a service- or option-not-available event only when no other code in the service- or option-not-available class applies. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1865 - Q850 Bearer Capability Not Implemented	The equipment that is sending this code does not support the bearer capability that was requested. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1866 - Q850 Channel Not Implemented	The equipment that is sending this code does not support the channel type that was requested. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1869 - Q850 Facility Not Implemented	The supplementary service requested by the user cannot be provided by the network. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1881 - Q850 Invalid Call Reference	The equipment that is sending this code has received a message having a call reference that is not currently in use on the user-network interface. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1882 - Q850 Channel Does Not Exist	The channel most recently identified is not acceptable to the sending entity for use in this call. This code applies to ISDN or modem calls that have come in over ISDN. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1888 - Q850 Incompatible Destination	The equipment that is sending this code has received a request to establish a call that has low-layer compatibility or other compatibility attributes that cannot be accommodated. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1896 - Q850 Mandatory Info Element Is Missing	The equipment that is sending this code has received a message that is missing an information element that must be present in the message before that message can be processed. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1897 - Q850 Non Existent Message Type	The equipment that is sending this code has received a message with a message type that it does not recognize either because this is a message that is not defined or that is defined but not implemented by the equipment that is sending this code. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1898 - Q850 Invalid Message	This code is used to report an invalid message when no other code in the invalid message class applies. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1899 - Q850 Bad Info Element	The information element not recognized. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes

Cause Codes	Description	11.0	11.1	11.2	11.3	12.0	12.1	12.2	12.3
1900 - Q850 Invalid Element Contents	The equipment that is sending this code has received an information element that it has implemented; however, one or more fields in the information element are coded in such a way that has not been implemented by the equipment that is sending this code. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1901 - Q850 Wrong Message for State	The message that was received is incompatible with the call state. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1902 - Q850 Recovery on Timer Expiration	A procedure has been initiated by the expiration of a timer in association with error-handling procedures. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1903 - Q850 Info Element Error	The equipment that is sending this code has received a message that includes information elements or parameters that are not recognized because the information element identifiers or paramenter names are not defined or are defined but not implemented by the equipment that is sending this code. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1911 - Q850 Protocol Error	This code is used to report a protocol error event only when no other code in the protocol error class applies. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes
1927 - Q850 Unspecified Internetworking Event	There has been an error when interworking with a network that does not provide codes for actions that it takes. This code applies to ISDN or modem calls that have come in over ISDN.	no	no	no	no	no	no	no	yes

TACACS+ Configuration Options

You can configure the switch to use a single server or AAA server groups to group existing server hosts for authentication. You can group servers to select a subset of the configured server hosts and use them for a particular service. The server group is used with a global server-host list and contains the list of IP addresses of the selected server hosts.

TACACS+ Login Authentication

A method list describes the sequence and authentication methods to be queried to authenticate a user. You can designate one or more security protocols to be used for authentication, thus ensuring a backup system for authentication in case the initial method fails. The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle—meaning that the security server or local username database responds by denying the user access—the authentication process stops, and no other authentication methods are attempted.

TACACS+ Authorization for Privileged EXEC Access and Network Services

AAA authorization limits the services available to a user. When AAA authorization is enabled, the switch uses information retrieved from the user's profile, which is located either in the local user database or on the security server, to configure the user's session. The user is granted access to a requested service only if the information in the user profile allows it.

TACACS+ Authentication

After you have identified the TACACS+ daemon and defined an associated TACACS+ encryption key, you must define method lists for TACACS+ authentication. Because TACACS+ authentication is operated via AAA, you need to issue the **aaa authentication** command, specifying TACACS+ as the authentication method.

TACACS+ Authorization

AAA authorization enables you to set parameters that restrict a user's access to the network. Authorization via TACACS+ may be applied to commands, network connections, and EXEC sessions. Because TACACS+ authorization is facilitated through AAA, you must issue the **aaa authorization** command, specifying TACACS+ as the authorization method.

TACACS+ Accounting

The AAA accounting feature tracks the services that users are accessing and the amount of network resources that they are consuming. When AAA accounting is enabled, the switch reports user activity to the TACACS+ security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. This data can then be analyzed for network management, client billing, or auditing.

Default TACACS+ Configuration

TACACS+ and AAA are disabled by default.

To prevent a lapse in security, you cannot configure TACACS+ through a network management application. When enabled, TACACS+ can authenticate users accessing the switch through the CLI.

Note Although TACACS+ configuration is performed through the CLI, the TACACS+ server authenticates HTTP connections that have been configured with a privilege level of 15.

How to Configure TACACS+

Identifying the TACACS+ Server Host and Setting the Authentication Key

Follow these steps to identify the TACACS+ server host and set the authentication key:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa group server tacacs+** *group-name*
5. **server** *ip-address*
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA.
Step 4	**aaa group server tacacs+** *group-name* **Example:** `Switch(config)# aaa group server tacacs+ your_server_group`	(Optional) Defines the AAA server-group with a group name. This command puts the Switch in a server group subconfiguration mode.
Step 5	**server** *ip-address* **Example:** `Switch(config)# server 10.1.2.3`	(Optional) Associates a particular TACACS+ server with the defined server group. Repeat this step for each TACACS+ server in the AAA server group. Each server in the group must be previously defined in Step 3.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring TACACS+ Login Authentication

Follow these steps to configure TACACS+ login authentication:

Before you begin

To configure AAA authentication, you define a named list of authentication methods and then apply that list to various ports.

Note To secure the switch for HTTP access by using AAA methods, you must configure the switch with the **ip http authentication aaa** global configuration command. Configuring AAA authentication does not secure the switch for HTTP access by using AAA methods.

For more information about the **ip http authentication** command, see the *Cisco IOS Security Command Reference, Release 12.4*.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]
5. **line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*]
6. **login authentication** {**default** | *list-name*}
7. **end**
8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Switch> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA.
Step 4	**aaa authentication login** {**default** | *list-name*} *method1* [*method2...*] **Example:** `Switch(config)# aaa authentication login default tacacs+ local`	Creates a login authentication method list. • To create a default list that is used when a named list is *not* specified in the **login authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all ports. • For *list-name*, specify a character string to name the list you are creating. • For *method1...*, specify the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails. Select one of these methods: • *enable*—Use the enable password for authentication. Before you can use this authentication method, you must define an enable password by using the **enable** *password* global configuration command. • *group tacacs+*—Uses TACACS+ authentication. Before you can use this authentication method, you must configure the TACACS+ server. • *line* —Use the line password for authentication. Before you can use this authentication method, you must define a line password. Use the **password** *password* line configuration command. • *local*—Use the local username database for authentication. You must enter username information in the database. Use the **username** *password* global configuration command.

	Command or Action	Purpose
		• *local-case*—Use a case-sensitive local username database for authentication. You must enter username information in the database by using the **username** *name* **password** global configuration command. • *none*—Do not use any authentication for login.
Step 5	**line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*] **Example:** `Switch(config)# line 2 4`	Enters line configuration mode, and configures the lines to which you want to apply the authentication list.

Step 6	**login authentication** {**default** | *list-name*}
	Example:
	`Switch(config-line)# login authentication default`
		Applies the authentication list to a line or set of lines.
		• If you specify **default**, use the default list created with the **aaa authentication login** command.
		• For *list-name*, specify the list created with the **aaa authentication login** command.

Step 7	**end**
	Example:
	`Switch(config-line)# end`
		Returns to privileged EXEC mode.

Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring TACACS+ Authorization for Privileged EXEC Access and Network Services

You can use the **aaa authorization** global configuration command with the **tacacs+** keyword to set parameters that restrict a user’s network access to privileged EXEC mode.

Note Authorization is bypassed for authenticated users who log in through the CLI even if authorization has been configured.

Follow these steps to specify TACACS+ authorization for privileged EXEC access and network services:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa authorization network tacacs+**
4. **aaa authorization exec tacacs+**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**aaa authorization network tacacs+** **Example:** `Switch(config)# aaa authorization network tacacs+`	Configures the switch for user TACACS+ authorization for all network-related service requests.
Step 4	**aaa authorization exec tacacs+** **Example:** `Switch(config)# aaa authorization exec tacacs+`	Configures the switch for user TACACS+ authorization if the user has privileged EXEC access. The **exec** keyword might return user profile information (such as **autocommand** information).

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Starting TACACS+ Accounting

Follow these steps to start TACACS+ Accounting:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa accounting network start-stop tacacs+**
4. **aaa accounting exec start-stop tacacs+**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**aaa accounting network start-stop tacacs+** **Example:** `Switch(config)# aaa accounting network start-stop tacacs+`	Enables TACACS+ accounting for all network-related service requests.

	Command or Action	Purpose
Step 4	**aaa accounting exec start-stop tacacs+** **Example:** `Switch(config)# aaa accounting exec start-stop tacacs+`	Enables TACACS+ accounting to send a start-record accounting notice at the beginning of a privileged EXEC process and a stop-record at the end.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

To establish a session with a router if the AAA server is unreachable, use the **aaa accounting system guarantee-first** command. It guarantees system accounting as the first record, which is the default condition. In some situations, users might be prevented from starting a session on the console or terminal connection until after the system reloads, which can take more than 3 minutes.

To establish a console or Telnet session with the router if the AAA server is unreachable when the router reloads, use the **no aaa accounting system guarantee-first** command.

Establishing a Session with a Router if the AAA Server is Unreachable

To establishing a session with a router if the AAA server is unreachable, use the **aaa accounting system guarantee-first** command. It guarantees system accounting as the first record, which is the default condition. In some situations, users might be prevented from starting a session on the console or terminal connection until after the system reloads, which can take more than 3 minutes.

To establish a console or Telnet session with the router if the AAA server is unreachable when the router reloads, use the **no aaa accounting system guarantee-first** command.

Establishing a Session with a Router if the AAA Server is Unreachable

The **aaa accounting system guarantee-first** command guarantees system accounting as the first record, which is the default condition. In some situations, users might be prevented from starting a session on the console or terminal connection until after the system reloads, which can take more than 3 minutes.

To establish a console or Telnet session with the router if the AAA server is unreachable when the router reloads, use the **no aaa accounting system guarantee-first** command.

Configuring Per VRF on a TACACS Server

The initial steps in this procedure are used to configure AAA and a server group, create a VRF routing table, and configure an interface. Steps 10 through 13 are used to configure the per VRF on a TACACS+ server feature:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip vrf** *vrf-name*
4. **rd** *route-distinguisher*
5. **exit**
6. **interface** *interface-name*
7. **ip vrf forwarding** *vrf-name*
8. **ip address** *ip-address mask* [**secondary**]
9. **exit**
10. **aaa group server tacacs+** *group-name*
11. **server-private** {*ip-address* | *name*} [**nat**] [**single-connection**] [**port** *port-number*] [**timeout** *seconds*] [**key** [**0** | **7**] *string*]
12. **ip vrf forwarding** *vrf-name*
13. **ip tacacs source-interface** *subinterface-name*
14. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip vrf** *vrf-name* **Example:**	Configures a VRF table and enters VRF configuration mode.

	Command or Action	Purpose
	`Device(config)# ip vrf cisco`	
Step 4	**rd** *route-distinguisher* **Example:** `Device(config-vrf)# rd 100:1`	Creates routing and forwarding tables for a VRF instance.
Step 5	**exit** **Example:** `Device(config-vrf)# exit`	Exits VRF configuration mode.
Step 6	**interface** *interface-name* **Example:** `Device(config)# interface Loopback0`	Configures an interface and enters interface configuration mode.
Step 7	**ip vrf forwarding** *vrf-name* **Example:** `Device(config-if)# ip vrf forwarding cisco`	Configures a VRF for the interface.
Step 8	**ip address** *ip-address mask* [**secondary**] **Example:** `Device(config-if)# ip address 10.0.0.2 255.0.0.0`	Sets a primary or secondary IP address for an interface.
Step 9	**exit** **Example:** `Device(config-if)# exit`	Exits interface configuration mode.
Step 10	**aaa group server tacacs+** *group-name* **Example:** `Device(config)# aaa group server tacacs+ tacacs1`	Groups different TACACS+ server hosts into distinct lists and distinct methods and enters server-group configuration mode.

Step 11	**server-private** {*ip-address* | *name*} [**nat**] [**single-connection**] [**port** *port-number*] [**timeout** *seconds*] [**key** [**0** | **7**] *string*]
	Example:
	`Device(config-sg-tacacs+)# server-private 10.1.1.1`
	` port 19 key cisco`
		Configures the IP address of the private TACACS+ server for the group server.

Step 12	**ip vrf forwarding** *vrf-name* **Example:**	Configures the VRF reference of a AAA TACACS+ server group.

	Command or Action	Purpose
	`Device(config-sg-tacacs+)# ip vrf forwarding cisco`	
Step 13	**ip tacacs source-interface** *subinterface-name* **Example:** `Device(config-sg-tacacs+)# ip tacacs source-interface Loopback0`	Uses the IP address of a specified interface for all outgoing TACACS+ packets.
Step 14	**exit** **Example:** `Device(config-sg-tacacs)# exit`	Exits server-group configuration mode.

Monitoring TACACS+

Table 68: Commands for Displaying TACACS+ Information

Command	Purpose
show tacacs	Displays TACACS+ server statistics.

Configuration Examples for TACACS+

Example: TACACS Authorization

The following example shows how to configure TACACS+ as the security protocol for PPP authentication using the default method list; it also shows how to configure network authorization via TACACS+:

```
aaa new-model
aaa authentication ppp default if-needed group tacacs+ local
aaa authorization network default group tacacs+
tacacs-server host 10.1.2.3
tacacs-server key goaway
interface serial 0
 ppp authentication chap default
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “default,” to be used on serial interfaces running PPP. The keyword **default** means that PPP authentication is applied by default to all interfaces. The **if-needed** keyword means that if the user has already authenticated by going through the ASCII login procedure, then PPP authentication is not necessary and can be skipped. If authentication is needed, the keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.

- The **aaa authorization** command configures network authorization via TACACS+. Unlike authentication lists, this authorization list always applies to all incoming network connections made to the network access server.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the default method list to this line.

Example: TACACS Accounting

The following example shows how to configure TACACS+ as the security protocol for PPP authentication using the default method list; it also shows how to configure accounting via TACACS+:

```
aaa new-model
aaa authentication ppp default if-needed group tacacs+ local
aaa accounting network default stop-only group tacacs+
tacacs-server host 10.1.2.3
tacacs-server key goaway
interface serial 0
 ppp authentication chap default
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “default,” to be used on serial interfaces running PPP. The keyword **default** means that PPP authentication is applied by default to all interfaces. The **if-needed** keyword means that if the user has already authenticated by going through the ASCII login procedure, then PPP authentication is not necessary and can be skipped. If authentication is needed, the keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **aaa accounting** command configures network accounting via TACACS+. In this example, accounting records describing the session that just terminated will be sent to the TACACS+ daemon whenever a network connection terminates.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the default method list to this line.

Example: TACACS Authentication

The following example shows how to configure TACACS+ as the security protocol for PPP authentication:

```
aaa new-model
aaa authentication ppp test group tacacs+ local
tacacs-server host 10.1.2.3
tacacs-server key goaway
```

```
interface serial 0
 ppp authentication chap pap test
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “test,” to be used on serial interfaces running PPP. The keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the test method list to this line.

The following example shows how to configure TACACS+ as the security protocol for PPP authentication, but instead of the “test” method list, the “default” method list is used.

```
aaa new-model
aaa authentication ppp default if-needed group tacacs+ local
tacacs-server host 10.1.2.3
tacacs-server key goaway
interface serial 0
 ppp authentication chap default
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “default,” to be used on serial interfaces running PPP. The keyword **default** means that PPP authentication is applied by default to all interfaces. The **if-needed** keyword means that if the user has already authenticated by going through the ASCII login procedure, then PPP authentication is not necessary and can be skipped. If authentication is needed, the keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the default method list to this line.

The following example shows how to create the same authentication algorithm for PAP, but it calls the method list “MIS-access” instead of “default”:

```
aaa new-model
aaa authentication pap MIS-access if-needed group tacacs+ local
tacacs-server host 10.1.2.3
tacacs-server key goaway
interface serial 0
 ppp authentication pap MIS-access
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines a method list, “MIS-access,” to be used on serial interfaces running PPP. The method list, “MIS-access,” means that PPP authentication is applied to all interfaces. The **if-needed** keyword means that if the user has already authenticated by going through the ASCII login procedure, then PPP authentication is not necessary and can be skipped. If authentication is needed, the keyword **group tacacs+** means that authentication will be done through TACACS+. If TACACS+ returns an ERROR of some sort during authentication, the keyword **local** indicates that authentication will be attempted using the local database on the network access server.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.1.2.3. The **tacacs-server key** command defines the shared encryption key to be “goaway.”
- The **interface** command selects the line, and the **ppp authentication** command applies the default method list to this line.

The following example shows the configuration for a TACACS+ daemon with an IP address of 10.2.3.4 and an encryption key of “apple”:

```
aaa new-model
aaa authentication login default group tacacs+ local
tacacs-server host 10.2.3.4
tacacs-server key apple
```

The lines in the preceding sample configuration are defined as follows:

- The **aaa new-model** command enables the AAA security services.
- The **aaa authentication** command defines the default method list. Incoming ASCII logins on all interfaces (by default) will use TACACS+ for authentication. If no TACACS+ server responds, then the network access server will use the information contained in the local username database for authentication.
- The **tacacs-server host** command identifies the TACACS+ daemon as having an IP address of 10.2.3.4. The **tacacs-server key** command defines the shared encryption key to be “apple.”

Example: Configuring Per VRF for TACACS Servers

The following output example shows that the group server **tacacs1** is configured for per VRF AAA services:

```
aaa group server tacacs+ tacacs1
    server-private 10.1.1.1 port 19 key cisco
    ip vrf forwarding cisco
    ip tacacs source-interface Loopback0
  ip vrf cisco
   rd 100:1
  interface Loopback0
   ip address 10.0.0.2 255.0.0.0
   ip vrf forwarding cisco
```

Additional References for TACACS+

Related Documents

Related Topic	Document Title
Cisco security commands	- Cisco IOS Security Command Reference: Commands A to C - Cisco IOS Security Command Reference: Commands D to L - Cisco IOS Security Command Reference: Commands M to R - Cisco IOS Security Command Reference: Commands S to Z
IPv6 commands	Cisco IOS IPv6 Command Reference

MIBs

MIB	MIBs Link
	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for TACACS+

Release	Feature Information
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 30

Configuring RADIUS

The RADIUS security system is a distributed client/server system that secures networks against unauthorized access. In the Cisco implementation, RADIUS clients run on Cisco devices and send authentication requests to a central RADIUS server that contains all user authentication and network service access information.

Prerequisites for Configuring RADIUS

This section lists the prerequisites for controlling Switch access with RADIUS.

General:

- RADIUS and Authentication, Authorization, and Accounting (AAA) must be enabled to use any of the configuration commands in this chapter.
- RADIUS is facilitated through AAA and can be enabled only through AAA commands.
- Use the **aaa new-model** global configuration command to enable AAA.
- Use the **aaa authentication** global configuration command to define method lists for RADIUS authentication.
- Use **line** and **interface** commands to enable the defined method lists to be used.
- At a minimum, you must identify the host or hosts that run the RADIUS server software and define the method lists for RADIUS authentication. You can optionally define method lists for RADIUS authorization and accounting.
- You should have access to and should configure a RADIUS server before configuring RADIUS features on your Switch.
- The RADIUS host is normally a multiuser system running RADIUS server software from Cisco (Cisco Secure Access Control Server Version 3.0), Livingston, Merit, Microsoft, or another software provider. For more information, see the RADIUS server documentation.

- To use the Change-of-Authorization (CoA) interface, a session must already exist on the switch. CoA can be used to identify a session and enforce a disconnect request. The update affects only the specified session.

For RADIUS operation:

- Users must first successfully complete RADIUS authentication before proceeding to RADIUS authorization, if it is enabled.

Restrictions for Configuring RADIUS

This topic covers restrictions for controlling Switch access with RADIUS.

General:

- To prevent a lapse in security, you cannot configure RADIUS through a network management application.

RADIUS is not suitable in the following network security situations:

- Multiprotocol access environments. RADIUS does not support AppleTalk Remote Access (ARA), NetBIOS Frame Control Protocol (NBFCP), NetWare Asynchronous Services Interface (NASI), or X.25 PAD connections.
- Switch-to-switch or router-to-router situations. RADIUS does not provide two-way authentication. RADIUS can be used to authenticate from one device to a non-Cisco device if the non-Cisco device requires authentication.
- Networks using a variety of services. RADIUS generally binds a user to one service model.

Information about RADIUS

RADIUS and Switch Access

This section describes how to enable and configure RADIUS. RADIUS provides detailed accounting information and flexible administrative control over the authentication and authorization processes.

RADIUS Overview

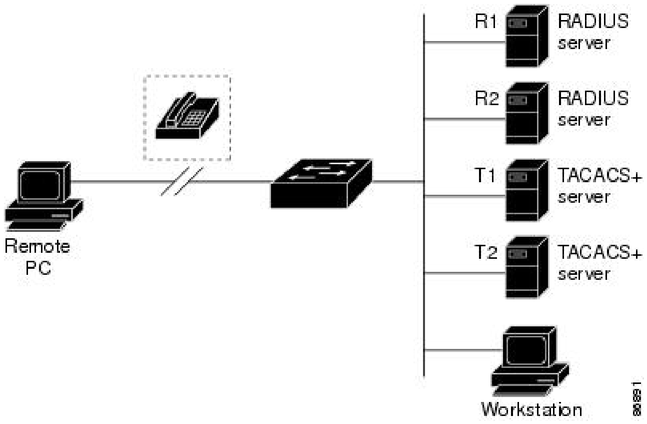
RADIUS is a distributed client/server system that secures networks against unauthorized access. RADIUS clients run on supported Cisco routers and switches. Clients send authentication requests to a central RADIUS server, which contains all user authentication and network service access information.

Use RADIUS in these network environments that require access security:

- Networks with multiple-vendor access servers, each supporting RADIUS. For example, access servers from several vendors use a single RADIUS server-based security database. In an IP-based network with multiple vendors' access servers, dial-in users are authenticated through a RADIUS server that has been customized to work with the Kerberos security system.

- Turnkey network security environments in which applications support the RADIUS protocol, such as in an access environment that uses a *smart card* access control system. In one case, RADIUS has been used with Enigma's security cards to validates users and to grant access to network resources.
- Networks already using RADIUS. You can add a Cisco Switch containing a RADIUS client to the network. This might be the first step when you make a transition to a TACACS+ server. See Figure 2: Transitioning from RADIUS to TACACS+ Services below.
- Network in which the user must only access a single service. Using RADIUS, you can control user access to a single host, to a single utility such as Telnet, or to the network through a protocol such as IEEE 802.1x. For more information about this protocol, see Chapter 11, "Configuring IEEE 802.1x Port-Based Authentication."
- Networks that require resource accounting. You can use RADIUS accounting independently of RADIUS authentication or authorization. The RADIUS accounting functions allow data to be sent at the start and end of services, showing the amount of resources (such as time, packets, bytes, and so forth) used during the session. An Internet service provider might use a freeware-based version of RADIUS access control and accounting software to meet special security and billing needs.

Figure 48: Transitioning from RADIUS to TACACS+ Services



RADIUS Operation

When a user attempts to log in and authenticate to a Switch that is access controlled by a RADIUS server, these events occur:

1. The user is prompted to enter a username and password.
2. The username and encrypted password are sent over the network to the RADIUS server.
3. The user receives one of the following responses from the RADIUS server:
   - ACCEPT—The user is authenticated.
   - REJECT—The user is either not authenticated and is prompted to re-enter the username and password, or access is denied.
   - CHALLENGE—A challenge requires additional data from the user.
   - CHALLENGE PASSWORD—A response requests the user to select a new password.

The ACCEPT or REJECT response is bundled with additional data that is used for privileged EXEC or network authorization. The additional data included with the ACCEPT or REJECT packets includes these items:

- Telnet, SSH, rlogin, or privileged EXEC services
- Connection parameters, including the host or client IP address, access list, and user timeouts

Default RADIUS Configuration

RADIUS and AAA are disabled by default.

To prevent a lapse in security, you cannot configure RADIUS through a network management application. When enabled, RADIUS can authenticate users accessing the switch through the CLI.

RADIUS Server Host

Switch-to-RADIUS-server communication involves several components:

- Hostname or IP address
- Authentication destination port
- Accounting destination port
- Key string
- Timeout period
- Retransmission value

You identify RADIUS security servers by their hostname or IP address, hostname and specific UDP port numbers, or their IP address and specific UDP port numbers. The combination of the IP address and the UDP port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. This unique identifier enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address.

If two different host entries on the same RADIUS server are configured for the same service—for example, accounting—the second host entry configured acts as a fail-over backup to the first one. Using this example, if the first host entry fails to provide accounting services, the %RADIUS-4-RADIUS_DEAD message appears, and then the switch tries the second host entry configured on the same device for accounting services. (The RADIUS host entries are tried in the order that they are configured.)

A RADIUS server and the switch use a shared secret text string to encrypt passwords and exchange responses. To configure RADIUS to use the AAA security commands, you must specify the host running the RADIUS server daemon and a secret text (key) string that it shares with the switch.

The timeout, retransmission, and encryption key values can be configured globally for all RADIUS servers, on a per-server basis, or in some combination of global and per-server settings.

RADIUS Login Authentication

To configure AAA authentication, you define a named list of authentication methods and then apply that list to various ports. The method list defines the types of authentication to be performed and the sequence in which they are performed; it must be applied to a specific port before any of the defined authentication methods are performed. The only exception is the default method list. The default method list is automatically applied to all ports except those that have a named method list explicitly defined.

A method list describes the sequence and authentication methods to be queried to authenticate a user. You can designate one or more security protocols to be used for authentication, thus ensuring a backup system for authentication in case the initial method fails. The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle—meaning that the security server or local username database responds by denying the user access—the authentication process stops, and no other authentication methods are attempted.

AAA Server Groups

You can configure the switch to use AAA server groups to group existing server hosts for authentication. You select a subset of the configured server hosts and use them for a particular service. The server group is used with a global server-host list, which lists the IP addresses of the selected server hosts.

Server groups also can include multiple host entries for the same server if each entry has a unique identifier (the combination of the IP address and UDP port number), allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. This unique identifier enables RADIUS requests to be sent to different UDP ports on a server at the same IP address. If you configure two different host entries on the same RADIUS server for the same service, (for example, accounting), the second configured host entry acts as a fail-over backup to the first one. If the first host entry fails to provide accounting services, the network access server tries the second host entry configured on the same device for accounting services. (The RADIUS host entries are tried in the order in which they are configured.)

AAA Authorization

AAA authorization limits the services available to a user. When AAA authorization is enabled, the switch uses information retrieved from the user's profile, which is in the local user database or on the security server, to configure the user's session. The user is granted access to a requested service only if the information in the user profile allows it.

RADIUS Accounting

The AAA accounting feature tracks the services that users are using and the amount of network resources that they are consuming. When you enable AAA accounting, the switch reports user activity to the RADIUS security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. You can then analyze the data for network management, client billing, or auditing.

Vendor-Specific RADIUS Attributes

The Internet Engineering Task Force (IETF) draft standard specifies a method for communicating vendor-specific information between the switch and the RADIUS server by using the vendor-specific attribute (attribute 26). Vendor-specific attributes (VSAs) allow vendors to support their own extended attributes not suitable for general use. The Cisco RADIUS implementation supports one vendor-specific option by using the format recommended in the specification. Cisco’s vendor-ID is 9, and the supported option has vendor-type 1, which is named *cisco-avpair*. The value is a string with this format:

```
protocol : attribute sep value *
```

Protocol is a value of the Cisco protocol attribute for a particular type of authorization. *Attribute* and *value* are an appropriate attributevalue (AV) pair defined in the Cisco TACACS+ specification, and *sep* is = for mandatory attributes and is * for optional attributes. The full set of features available for TACACS+ authorization can then be used for RADIUS.

For example, the following AV pair causes Cisco’s “multiple named IP address pools” feature to be activated during IP authorization (during PPP’s Internet Protocol Control Protocol (IPCP) address assignment):

```
cisco-avpair= ”ip:addr-pool=first“
```

If you insert an “*”, the AV pair “ip:addr-pool=first” becomes optional. Note that any AV pair can be made optional:

```
cisco-avpair= ”ip:addr-pool*first“
```

The following example shows how to cause a user logging in from a network access server to have immediate access to EXEC commands:

```
cisco-avpair= ”shell:priv-lvl=15“
```

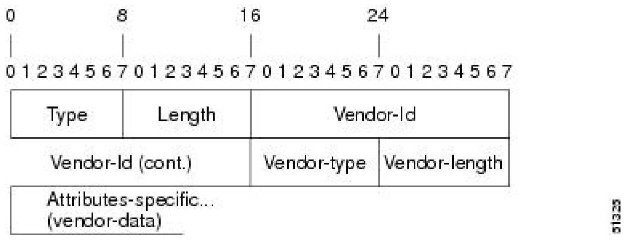
Other vendors have their own unique vendor-IDs, options, and associated VSAs. For more information about vendor-IDs and VSAs, see RFC 2138, “Remote Authentication Dial-In User Service (RADIUS).”

Attribute 26 contains the following three elements:

- Type
- Length
- String (also known as data)
  - Vendor-Id
  - Vendor-Type
  - Vendor-Length
  - Vendor-Data

The figure below shows the packet format for a VSA encapsulated “behind” attribute 26.

Figure 49: VSA Encapsulated Behind Attribute 26



Note It is up to the vendor to specify the format of their VSA. The Attribute-Specific field (also known as Vendor-Data) is dependent on the vendor's definition of that attribute.

The table below describes significant fields listed in the Vendor-Specific RADIUS IETF Attributes table (second table below), which lists supported vendor-specific RADIUS attributes (IETF attribute 26).

Table 69: Vendor-Specific Attributes Table Field Descriptions

Field	Description
Number	All attributes listed in the following table are extensions of IETF attribute 26.
Vendor-Specific Command Codes	A defined code used to identify a particular vendor. Code 9 defines Cisco VSAs, 311 defines Microsoft VSAs, and 529 defines Ascend VSAs.
Sub-Type Number	The attribute ID number. This number is much like the ID numbers of IETF attributes, except it is a "second layer" ID number encapsulated behind attribute 26.
Attribute	The ASCII string name of the attribute.
Description	Description of the attribute.

Table 70: Vendor-Specific RADIUS IETF Attributes

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
MS-CHAP Attributes				
26	311	1	MSCHAP-Response	Contains the response value provided by a PPP MS-CHAP user in response to the challenge. It is only used in Access-Request packets. This attribute is identical to the PPP CHAP Identifier. (RFC 2548
26	311	11	MSCHAP-Challenge	Contains the challenge sent by a network access server to an MS-CHAP user. It can be used in both Access-Request and Access-Challenge packets. (RFC 2548)
VPDN Attributes				

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	l2tp-cm-local-window-size	Specifies the maximum receive window size for L2TP control messages. This value is advertised to the peer during tunnel establishment.
26	9	1	l2tp-drop-out-of-order	Respects sequence numbers on data packets by dropping those that are received out of order. This does not ensure that sequence numbers will be sent on data packets, just how to handle them if they are received.
26	9	1	l2tp-hello-interval	Specifies the number of seconds for the hello keepalive interval. Hello packets are sent when no data has been sent on a tunnel for the number of seconds configured here.
26	9	1	l2tp-hidden-avp	When enabled, sensitive AVPs in L2TP control messages are scrambled or hidden.
26	9	1	l2tp-nosession-timeout	Specifies the number of seconds that a tunnel will stay active with no sessions before timing out and shutting down.
26	9	1	tunnel-tos-reflect	Copies the IP ToS field from the IP header of each payload packet to the IP header of the tunnel packet for packets entering the tunnel at the LNS.
26	9	1	l2tp-tunnel-authen	If this attribute is set, it performs L2TP tunnel authentication.
26	9	1	l2tp-tunnel-password	Shared secret used for L2TP tunnel authentication and AVP hiding.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	l2tp-udp-checksum	This is an authorization attribute and defines whether L2TP should perform UDP checksums for data packets. Valid values are “yes” and “no.” The default is no.
Store and Forward Fax Attributes				
26	9	3	Fax-Account-Id-Origin	Indicates the account ID origin as defined by system administrator for the **mmoip aaa receive-id** or the **mmoip aaa send-id** commands.
26	9	4	Fax-Msg-Id=	Indicates a unique fax message identification number assigned by Store and Forward Fax.
26	9	5	Fax-Pages	Indicates the number of pages transmitted or received during this fax session. This page count includes cover pages.
26	9	6	Fax-Coverpage-Flag	Indicates whether or not a cover page was generated by the off-ramp gateway for this fax session. True indicates that a cover page was generated; false means that a cover page was not generated.
26	9	7	Fax-Modem-Time	Indicates the amount of time in seconds the modem sent fax data (x) and the amount of time in seconds of the total fax session (y), which includes both fax-mail and PSTN time, in the form x/y. For example, 10/15 means that the transfer time took 10 seconds, and the total fax session took 15 seconds.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	8	Fax-Connect-Speed	Indicates the modem speed at which this fax-mail was initially transmitted or received. Possible values are 1200, 4800, 9600, and 14400.
26	9	9	Fax-Recipient-Count	Indicates the number of recipients for this fax transmission. Until e-mail servers support Session mode, the number should be 1.
26	9	10	Fax-Process-Abort-Flag	Indicates that the fax session was cancelled or successful. True means that the session was cancelled; false means that the session was successful.
26	9	11	Fax-Dsn-Address	Indicates the address to which DSNs will be sent.
26	9	12	Fax-Dsn-Flag	Indicates whether or not DSN has been enabled. True indicates that DSN has been enabled; false means that DSN has not been enabled.
26	9	13	Fax-Mdn-Address	Indicates the address to which MDNs will be sent.
26	9	14	Fax-Mdn-Flag	Indicates whether or not message delivery notification (MDN) has been enabled. True indicates that MDN had been enabled; false means that MDN had not been enabled.
26	9	15	Fax-Auth-Status	Indicates whether or not authentication for this fax session was successful. Possible values for this field are success, failed, bypassed, or unknown.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	16	Email-Server-Address	Indicates the IP address of the e-mail server handling the on-ramp fax-mail message.
26	9	17	Email-Server-Ack-Flag	Indicates that the on-ramp gateway has received a positive acknowledgment from the e-mail server accepting the fax-mail message.
26	9	18	Gateway-Id	Indicates the name of the gateway that processed the fax session. The name appears in the following format: hostname.domain-name.
26	9	19	Call-Type	Describes the type of fax activity: fax receive or fax send.
26	9	20	Port-Used	Indicates the slot/port number of the Cisco AS5300 used to either transmit or receive this fax-mail.
26	9	21	Abort-Cause	If the fax session cancels, indicates the system component that signaled the cancel operation. Examples of system components that could trigger a cancel operation are FAP (Fax Application Process), TIFF (the TIFF reader or the TIFF writer), fax-mail client, fax-mail server, ESMTP client, or ESMTP server.
H323 Attributes				
26	9	23	Remote-Gateway-ID (h323-remote-address)	Indicates the IP address of the remote gateway.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	24	Connection-ID (h323-conf-id)	Identifies the conference ID.
26	9	25	Setup-Time (h323-setup-time)	Indicates the setup time for this connection in Coordinated Universal Time (UTC) formerly known as Greenwich Mean Time (GMT) and Zulu time.
26	9	26	Call-Origin (h323-call-origin)	Indicates the origin of the call relative to the gateway. Possible values are originating and terminating (answer).
26	9	27	Call-Type (h323-call-type)	Indicates call leg type. Possible values are **telephony** and **VoIP**.
26	9	28	Connect-Time (h323-connect-time)	Indicates the connection time for this call leg in UTC.
26	9	29	Disconnect-Time (h323-disconnect-time)	Indicates the time this call leg was disconnected in UTC.
26	9	30	Disconnect-Cause (h323-disconnect-cause)	Specifies the reason a connection was taken offline per Q.931 specification.
26	9	31	Voice-Quality (h323-voice-quality)	Specifies the impairment factor (ICPIF) affecting voice quality for a call.
26	9	33	Gateway-ID (h323-gw-id)	Indicates the name of the underlying gateway.
Large Scale Dialout Attributes				
26	9	1	callback-dialstring	Defines a dialing string to be used for callback.
26	9	1	data-service	No description available.
26	9	1	dial-number	Defines the number to dial.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	force-56	Determines whether the network access server uses only the 56 K portion of a channel, even when all 64 K appear to be available.
26	9	1	map-class	Allows the user profile to reference information configured in a map class of the same name on the network access server that dials out.
26	9	1	send-auth	Defines the protocol to use (PAP or CHAP) for username-password authentication following CLID authentication.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	send-name	PPP name authentication. To apply for PAP, do not configure the **ppp pap sent-name password** command on the interface. For PAP, "preauth:send-name" and "preauth:send-secret" will be used as the PAP username and PAP password for outbound authentication. For CHAP, "preauth:send-name" will be used not only for outbound authentication, but also for inbound authentication. For a CHAP inbound case, the NAS will use the name defined in "preauth:send-name" in the challenge packet to the caller box. **Note** The send-name attribute has changed over time: Initially, it performed the functions now provided by both the send-name and remote-name attributes. Because the remote-name attribute has been added, the send-name attribute is restricted to its current behavior.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	send-secret	PPP password authentication. The vendor-specific attributes (VSAs) “preauth:send-name” and “preauth:send-secret” will be used as the PAP username and PAP password for outbound authentication. For a CHAP outbound case, both “preauth:send-name” and “preauth:send-secret” will be used in the response packet.
26	9	1	remote-name	Provides the name of the remote host for use in large-scale dial-out. Dialer checks that the large-scale dial-out remote name matches the authenticated name, to protect against accidental user RADIUS misconfiguration. (For example, dialing a valid phone number but connecting to the wrong device.)
Miscellaneous Attributes				

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	2	Cisco-NAS-Port	Specifies additional vendor specific attribute (VSA) information for NAS-Port accounting. To specify additional NAS-Port information in the form an Attribute-Value Pair (AVPair) string, use the **radius-server vsa send** global configuration command. **Note** This VSA is typically used in Accounting, but may also be used in Authentication (Access-Request) packets.
26	9	1	min-links	Sets the minimum number of links for MLP.
26	9	1	proxyacl#<n>	Allows users to configure the downloadable user profiles (dynamic ACLs) by using the authentication proxy feature so that users can have the configured authorization to permit traffic going through the configured interfaces.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	spi	Carries the authentication information needed by the home agent to authenticate a mobile node during registration. The information is in the same syntax as the **ip mobile secure host <addr>** configuration command. Basically it contains the rest of the configuration command that follows that string, verbatim. It provides the Security Parameter Index (SPI), key, authentication algorithm, authentication mode, and replay protection timestamp range.

RADIUS Disconnect-Cause Attribute Values

Disconnect-cause attribute values specify the reason a connection was taken offline. The attribute values are sent in Accounting request packets. These values are sent at the end of a session, even if the session fails to be authenticated. If the session is not authenticated, the attribute can cause stop records to be generated without first generating start records.

The table below lists the cause codes, values, and descriptions for the Disconnect-Cause (195) attribute.

Note The Disconnect-Cause is incremented by 1000 when it is used in RADIUS AVPairs; for example, disc-cause 4 becomes 1004.

Table 71: Disconnect-Cause Attribute Values

Cause Code	Value	Description
0	No-Reason	No reason is given for the disconnect.
1	No-Disconnect	The event was not disconnected.
2	Unknown	Reason unknown.
3	Call-Disconnect	The call has been disconnected.
4	CLID-Authentication-Failure	Failure to authenticate number of the calling-party.

Cause Code	Value	Description
9	No-Modem-Available	A modem in not available to connect the call.
10	No-Carrier	No carrier detected. **Note** Codes 10, 11, and 12 can be sent if there is a disconnection during initial modem connection.
11	Lost-Carrier	Loss of carrier.
12	No-Detected-Result-Codes	Failure to detect modem result codes.
20	User-Ends-Session	User terminates a session. **Note** Codes 20, 22, 23, 24, 25, 26, 27, and 28 apply to EXEC sessions.
21	Idle-Timeout	Timeout waiting for user input. Codes 21, 100, 101, 102, and 120 apply to all session types.
22	Exit-Telnet-Session	Disconnect due to exiting Telnet session.
23	No-Remote-IP-Addr	Could not switch to SLIP/PPP; the remote end has no IP address.
24	Exit-Raw-TCP	Disconnect due to exiting raw TCP.
25	Password-Fail	Bad passwords.
26	Raw-TCP-Disabled	Raw TCP disabled.
27	Control-C-Detected	Control-C detected.
28	EXEC-Process-Destroyed	EXEC process destroyed.
29	Close-Virtual-Connection	User closes a virtual connection.
30	End-Virtual-Connection	Virtual connected has ended.
31	Exit-Rlogin	User exists Rlogin.
32	Invalid-Rlogin-Option	Invalid Rlogin option selected.
33	Insufficient-Resources	Insufficient resources.
40	Timeout-PPP-LCP	PPP LCP negotiation timed out. **Note** Codes 40 through 49 apply to PPP sessions.
41	Failed-PPP-LCP-Negotiation	PPP LCP negotiation failed.
42	Failed-PPP-PAP-Auth-Fail	PPP PAP authentication failed.
43	Failed-PPP-CHAP-Auth	PPP CHAP authentication failed.
44	Failed-PPP-Remote-Auth	PPP remote authentication failed.

Cause Code	Value	Description
45	PPP-Remote-Terminate	PPP received a Terminate Request from remote end.
46	PPP-Closed-Event	Upper layer requested that the session be closed.
47	NCP-Closed-PPP	PPP session closed because there were no NCPs open.
48	MP-Error-PPP	PPP session closed because of an MP error.
49	PPP-Maximum-Channels	PPP session closed because maximum channels were reached.
50	Tables-Full	Disconnect due to full terminal server tables.
51	Resources-Full	Disconnect due to full internal resources.
52	Invalid-IP-Address	IP address is not valid for Telnet host.
53	Bad-Hostname	Hostname cannot be validated.
54	Bad-Port	Port number is invalid or missing.
60	Reset-TCP	TCP connection has been reset. **Note** Codes 60 through 67 apply to Telnet or raw TCP sessions.
61	TCP-Connection-Refused	TCP connection has been refused by the host.
62	Timeout-TCP	TCP connection has timed out.
63	Foreign-Host-Close-TCP	TCP connection has been closed.
64	TCP-Network-Unreachable	TCP network is unreachable.
65	TCP-Host-Unreachable	TCP host is unreachable.
66	TCP-Network-Admin Unreachable	TCP network is unreachable for administrative reasons.
67	TCP-Port-Unreachable	TCP port in unreachable.
100	Session-Timeout	Session timed out.
101	Session-Failed-Security	Session failed for security reasons.
102	Session-End-Callback	Session terminated due to callback.
120	Invalid-Protocol	Call refused because the detected protocol is disabled.
150	RADIUS-Disconnect	Disconnected by RADIUS request.
151	Local-Admin-Disconnect	Administrative disconnect.
152	SNMP-Disconnect	Disconnected by SNMP request.
160	V110-Retries	Allowed V.110 retries have been exceeded.
170	PPP-Authentication-Timeout	PPP authentication timed out.

Cause Code	Value	Description
180	Local-Hangup	Disconnected by local hangup.
185	Remote-Hangup	Disconnected by remote end hangup.
190	T1-Quiesced	Disconnected because T1 line was quiesced.
195	Call-Duration	Disconnected because the maximum duration of the call was exceeded.
600	VPN-User-Disconnect	Call disconnected by client (through PPP). Code is sent if the LNS receives a PPP terminate request from the client.
601	VPN-Carrier-Loss	Loss of carrier. This can be the result of a physical line going dead. Code is sent when a client is unable to dial out using a dialer.
602	VPN-No-Resources	No resources available to handle the call. Code is sent when the client is unable to allocate memory (running low on memory).
603	VPN-Bad-Control-Packet	Bad L2TP or L2F control packets. This code is sent when an invalid control packet, such as missing mandatory Attribute-Value pairs (AVP), from the peer is received. When using L2TP, the code will be sent after six retransmits; when using L2F, the number of retransmits is user configurable. **Note** VPN-Tunnel-Shut will be sent if there are active sessions in the tunnel.
604	VPN-Admin-Disconnect	Administrative disconnect. This can be the result of a VPN soft shutdown, which is when a client reaches maximum session limit or exceeds maximum hopcount. Code is sent when a tunnel is brought down by issuing the **clear vpdn tunnel** command.
605	VPN-Tunnel-Shut	Tunnel teardown or tunnel setup has failed. Code is sent when there are active sessions in a tunnel and the tunnel goes down. **Note** This code is not sent when tunnel authentication fails.
606	VPN-Local-Disconnect	Call is disconnected by LNS PPP module. Code is sent when the LNS sends a PPP terminate request to the client. It indicates a normal PPP disconnection initiated by the LNS.
607	VPN-Session-Limit	VPN soft shutdown is enabled. Code is sent when a call has been refused due to any of the soft shutdown restrictions previously mentioned.
608	VPN-Call-Redirect	VPN call redirect is enabled.

RADIUS Progress Codes

The RADIUS Progress Codes feature adds additional progress codes to RADIUS attribute 196 (Ascend-Connect-Progress), which indicates a connection state before a call is disconnected through progress codes.

Attribute 196 is sent in network, exec, and resource accounting “start” and “stop” records. This attribute can facilitate call failure debugging because each progress code identifies accounting information relevant to the connection state of a call. The attribute is activated by default; when an accounting “start” or “stop” accounting record is requested, authentication, authorization, and accounting (AAA) adds attribute 196 into the record as part of the standard attribute list. Attribute 196 is valuable because the progress codes, which are sent in accounting “start” and “stop” records, facilitate the debugging of call failures.

Note In accounting “start” records, attribute 196 does not have a value.

Table 72: Newly Supported Progress Codes for Attribute 196

Code	Description
10	Modem allocation and negotiation is complete; the call is up.
30	The modem is up.
33	The modem is waiting for result codes.
41	The max TNT is establishing the TCP connection by setting up a TCP clear call.
60	Link control protocol (LCP) is the open state with PPP and IP Control Protocol (IPCP) negotiation; the LAN session is up.
65	PPP negotiation occurs and, initially, the LCP negotiation occurs; LCP is in the open state.
67	After PPP negotiation with LCP in the open state occurs, IPCP negotiation begins.

Note Progress codes 33, 30, and 67 are generated and seen through debugs on the NAS; all other codes are generated and seen through debugs and the accounting record on the RADIUS server.

Vendor-Proprietary RADIUS Server Communication

Although an IETF draft standard for RADIUS specifies a method for communicating vendor-proprietary information between the switch and the RADIUS server, some vendors have extended the RADIUS attribute set in a unique way. Cisco IOS software supports a subset of vendor-proprietary RADIUS attributes.

As mentioned earlier, to configure RADIUS (whether vendor-proprietary or IETF draft-compliant), you must specify the host running the RADIUS server daemon and the secret text string it shares with the switch. You specify the RADIUS host and secret text string by using the **radius server** global configuration commands.

Enhanced Test Command

The Enhanced Test Command feature allows a named user profile to be created with calling line ID (CLID) or dialed number identification service (DNIS) attribute values. The CLID or DNIS attribute values can be associated with the RADIUS record that is sent with the user profile so that the RADIUS server can access CLID or DNIS attribute information for all incoming calls.

How to Configure RADIUS

Identifying the RADIUS Server Host

To apply these settings globally to all RADIUS servers communicating with the Switch, use the three unique global configuration commands: **radius-server timeout**, **radius-server retransmit**, and **radius-server key**.

You can configure the Switch to use AAA server groups to group existing server hosts for authentication. For more information, see Related Topics below.

You also need to configure some settings on the RADIUS server. These settings include the IP address of the Switch and the key string to be shared by both the server and the Switch. For more information, see the RADIUS server documentation.

Follow these steps to configure per-server RADIUS server communication.

Before you begin

If you configure both global and per-server functions (timeout, retransmission, and key commands) on the switch, the per-server timer, retransmission, and key value commands override global timer, retransmission, and key value commands. For information on configuring these settings on all RADIUS servers, see Related Topics below.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius server** *name*
4. **address** {**ipv4** | **ipv6**} *ip address* {**auth-port** *port number* | **acct-port** *port number*}
5. **key** *string*
6. **retransmit** *value*
7. **timeout** *seconds*
8. **end**
9. **show running-config**
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
	`Switch> enable`	
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**radius server** *name* **Example:** `Switch(config)# radius server ISE`	Specifies the name of the RADIUS server configuration for Protected Access Credential (PAC) provisioning and enters RADIUS server configuration mode. The switch also supports RADIUS for IPv6.

Step 4	**address** {**ipv4** | **ipv6**} *ip address* {**auth-port** *port number* | **acct-port** *port number*}
	Example:
	`Switch(config-radius-server)# address ipv4 10.1.1.1 auth-port 1645 acct-port 1646`
		(Optional) Specifies the RADIUS server parameters.
		For **auth-port** *port-number*, specify the UDP destination port for authentication requests. The default is 1645. The range is 0 to 65536.
		For **acct-port** *port-number*, specify the UDP destination port for authentication requests. The default is 1646.

Step 5	**key** *string* **Example:** `Switch(config-radius-server)#  key cisco123`	(Optional) For **key** *string*, specify the authentication and encryption key used between the Switch and the RADIUS daemon running on the RADIUS server. **Note** The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the **radius server** command. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.
Step 6	**retransmit** *value* **Example:** `Switch(config-radius-server)# retransmit 10`	(Optional) Specifies the number of times a RADIUS request is resent when the server is not responding or responding slowly. The range is 1 to 100. This setting overrides the **radius-server retransmit** global configuration command setting.
Step 7	**timeout** *seconds* **Example:** `Switch(config-radius-server)# timeout 60`	(Optional) Specifies the time interval that the Switch waits for the RADIUS server to reply before sending a request again. The range is 1 to 1000. This setting overrides the **radius-server timeout** global configuration command setting.

	Command or Action	Purpose

Step 8	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 9	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 10	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Settings for All RADIUS Servers

Beginning in privileged EXEC mode, follow these steps to configure settings for all RADIUS servers:

SUMMARY STEPS

1. **configure terminal**
2. **radius-server key** *string*
3. **radius-server retransmit** *retries*
4. **radius-server timeout** *seconds*
5. **radius-server deadtime** *minutes*
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**radius-server key** *string* **Example:**	Specifies the shared secret text string used between the switch and all RADIUS servers.

	Command or Action	Purpose

	`Switch(config)# radius-server key your_server_key`
	`Switch(config)# key your_server_key`
		Note The key is a text string that must match the encryption key used on the RADIUS server. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.

Step 3	**radius-server retransmit** *retries* **Example:** `Switch(config)#  radius-server retransmit 5`	Specifies the number of times the switch sends each RADIUS request to the server before giving up. The default is 3; the range 1 to 1000.
Step 4	**radius-server timeout** *seconds* **Example:** `Switch(config)#  radius-server timeout 3`	Specifies the number of seconds a switch waits for a reply to a RADIUS request before resending the request. The default is 5 seconds; the range is 1 to 1000.
Step 5	**radius-server deadtime** *minutes* **Example:** `Switch(config)#  radius-server deadtime 0`	When a RADIUS server is not responding to authentication requests, this command specifies a time to stop the request on that server. This avoids the wait for the request to timeout before trying the next configured server. The default is 0; the range is 1 to 1440 minutes.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring RADIUS Login Authentication

Follow these steps to configure RADIUS login authentication:

Before you begin

To secure the switch for HTTP access by using AAA methods, you must configure the switch with the **ip http authentication aaa** global configuration command. Configuring AAA authentication does not secure the switch for HTTP access by using AAA methods.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]
5. **line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*]
6. **login authentication** {**default** | *list-name*}
7. **end**
8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA.
Step 4	**aaa authentication login** {**default** | *list-name*} *method1* [*method2...*] **Example:** `Switch(config)# aaa authentication login default local`	Creates a login authentication method list. • To create a default list that is used when a named list is *not* specified in the **login authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all ports. • For *list-name*, specify a character string to name the list you are creating.

	Command or Action	Purpose
		• For *method1...*, specify the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails. Select one of these methods: • *enable*—Use the enable password for authentication. Before you can use this authentication method, you must define an enable password by using the **enable** *password* global configuration command. • *group radius*—Use RADIUS authentication. Before you can use this authentication method, you must configure the RADIUS server. • *line*—Use the line password for authentication. Before you can use this authentication method, you must define a line password. Use the **password** *password* line configuration command. • *local*—Use the local username database for authentication. You must enter username information in the database. Use the **username** *name* **password** global configuration command. • *local-case*—Use a case-sensitive local username database for authentication. You must enter username information in the database by using the **username** *password* global configuration command. • *none*—Do not use any authentication for login.
Step 5	**line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*] **Example:** `Switch(config)# line 1 4`	Enters line configuration mode, and configure the lines to which you want to apply the authentication list.

Step 6	**login authentication** {**default** | *list-name*}
	Example:
	`Switch(config)# login authentication default`
		Applies the authentication list to a line or set of lines.
		• If you specify **default**, use the default list created with the **aaa authentication login** command.
		• For *list-name*, specify the list created with the **aaa authentication login** command.

Step 7	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Defining AAA Server Groups

You use the **server** group server configuration command to associate a particular server with a defined group server. You can either identify the server by its IP address or identify multiple host instances or entries by using the optional **auth-port** and **acct-port** keywords.

Follow these steps to define AAA server groups:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius server** *name*
4. **address** {**ipv4** | **ipv6**} {*ip-address* | *hostname*} **auth-port** *port-number* **acct-port** *port-number*
5. **key** *string*
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 3	**radius server** *name* **Example:** `Switch(config)# radius server ISE`	Specifies the name of the RADIUS server configuration for Protected Access Credential (PAC) provisioning and enters RADIUS server configuration mode. The switch also supports RADIUS for IPv6.
Step 4	**address** {**ipv4** | **ipv6**} {*ip-address* | *hostname*} **auth-port** *port-number* **acct-port** *port-number* **Example:** `Switch(config-radius-server)# address ipv4 10.1.1.1 auth-port 1645 acct-port 1646`	Configures the IPv4 address for the RADIUS server accounting and authentication parameters.
Step 5	**key** *string* **Example:** `Switch(config-radius-server)# key cisco123`	Specifies the authentication and encryption key for all RADIUS communications between the device and the RADIUS server.

Step 6	**end**
	Example:
	`Switch(config-radius-server)# end`
		Exits RADIUS server configuration mode and returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring RADIUS Authorization for User Privileged Access and Network Services

Note Authorization is bypassed for authenticated users who log in through the CLI even if authorization has been configured.

Follow these steps to configure RADIUS authorization for user priviledged access and network services:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa authorization network radius**
4. **aaa authorization exec radius**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**aaa authorization network radius** **Example:** `Switch(config)# aaa authorization network radius`	Configures the switch for user RADIUS authorization for all network-related service requests.
Step 4	**aaa authorization exec radius** **Example:** `Switch(config)# aaa authorization exec radius`	Configures the switch for user RADIUS authorization if the user has privileged EXEC access. The **exec** keyword might return user profile information (such as **autocommand** information).

	Command or Action	Purpose

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

You can use the **aaa authorization** global configuration command with the **radius** keyword to set parameters that restrict a user's network access to privileged EXEC mode.

The **aaa authorization exec radius local** command sets these authorization parameters:

- Use RADIUS for privileged EXEC access authorization if authentication was performed by using RADIUS.
- Use the local database if authentication was not performed by using RADIUS.

Starting RADIUS Accounting

Follow these steps to start RADIUS accounting:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa accounting network start-stop radius**
4. **aaa accounting exec start-stop radius**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Switch> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**aaa accounting network start-stop radius** **Example:** `Switch(config)# aaa accounting network start-stop radius`	Enables RADIUS accounting for all network-related service requests.
Step 4	**aaa accounting exec start-stop radius** **Example:** `Switch(config)# aaa accounting exec start-stop radius`	Enables RADIUS accounting to send a start-record accounting notice at the beginning of a privileged EXEC process and a stop-record at the end.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Verifying Attribute 196

No configuration is required to configure RADIUS Progress Codes. To verify attribute 196 in accounting “start” and “stop” records, perform the following steps.

SUMMARY STEPS

1. **enable**
2. **debug aaa accounting**
3. **show radius statistics**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**debug aaa accounting** **Example:** `Device# debug aaa accounting`	Displays information on accountable events as they occur.
Step 3	**show radius statistics** **Example:** `Device# debug aaa authorization`	Displays the RADIUS statistics for accounting and authentication packets.

Configuring the Switch to Use Vendor-Specific RADIUS Attributes

Follow these steps to configure the switch to use vendor-specific RADIUS attributes:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius-server vsa send** [**accounting** | **authentication**]
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**radius-server vsa send** [**accounting** | **authentication**] **Example:** `Switch(config)# radius-server vsa send accounting`	Enables the switch to recognize and use VSAs as defined by RADIUS IETF attribute 26. • (Optional) Use the **accounting** keyword to limit the set of recognized vendor-specific attributes to only accounting attributes. • (Optional) Use the **authentication** keyword to limit the set of recognized vendor-specific attributes to only authentication attributes. If you enter this command without keywords, both accounting and authentication vendor-specific attributes are used.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring the Switch for Vendor-Proprietary RADIUS Server Communication

Follow these steps to configure the switch to use vendor-proprietary RADIUS server communication:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius-server host** {*hostname* | *ip-address*} **non-standard**
4. **radius-server key** *string*

5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**radius-server host** {*hostname* | *ip-address*} **non-standard** **Example:** `Switch(config)# radius-server host 172.20.30.15 non-standard`	Specifies the IP address or hostname of the remote RADIUS server host and identifies that it is using a vendor-proprietary implementation of RADIUS.
Step 4	**radius-server key** *string* **Example:** `Switch(config)# radius-server key rad124`	Specifies the shared secret text string used between the switch and the vendor-proprietary RADIUS server. The switch and the RADIUS server use this text string to encrypt passwords and exchange responses. **Note** The key is a text string that must match the encryption key used on the RADIUS server. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.

	Command or Action	Purpose
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a User Profile and Associating it with the RADIUS Record

This section describes how to create a named user profile with CLID or DNIS attribute values and associate it with the RADIUS record.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa user profile** *profile-name*
4. **aaa attribute** {**dnis** | **clid**}
5. **exit**
6. **test aaa group** {*group-name* | **radius**} *username password* **new-code** [**profile** *profile-name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa user profile** *profile-name* **Example:** `Device(config)# aaa user profile profilename1`	Creates a user profile.

Step 4	**aaa attribute** {**dnis** | **clid**}
	Example:
	`Device# configure terminal`
		Adds DNIS or CLID attribute values to the user profile and enters AAA-user configuration mode.

Step 5	**exit**	Exit Global Configuration mode.

	Command or Action	Purpose
Step 6	**test aaa group** {*group-name* | **radius**} *username password* **new-code** [**profile** *profile-name*] **Example:** `Device# test aaa group radius secret new-code profile profilename1`	Associates a DNIS or CLID named user profile with the record sent to the RADIUS server. **Note** The *profile-name* must match the profile-name specified in the **aaa user profile** command.

Verifying the Enhanced Test Command Configuration

To verify the Enhanced Test Command configuration, use the following commands in privileged EXEC mode:

Command	Purpose
`Device# debug radius`	Displays information associated with RADIUS.
`Devie# more system:running-config`	Displays the contents of the current running configuration file. (Note that the **more system:running-config** command has replaced the **show running-config** command.)

Configuration Examples for RADIUS

Examples: Identifying the RADIUS Server Host

This example shows how to configure one RADIUS server to be used for authentication and another to be used for accounting:

```
Switch(config)# radius-server host 172.29.36.49 auth-port 1612 key rad1
Switch(config)# radius-server host 172.20.36.50 acct-port 1618 key rad2
```

This example shows how to configure *host1* as the RADIUS server and to use the default ports for both authentication and accounting:

```
Switch(config)# radius-server host host1
```

Example: Using Two Different RADIUS Group Servers

In this example, the switch is configured to recognize two different RADIUS group servers (*group1* and *group2*). Group1 has two different host entries on the same RADIUS server configured for the same services. The second host entry acts as a fail-over backup to the first entry.

```
Switch(config)# radius-server host 172.20.0.1 auth-port 1000 acct-port 1001
Switch(config)# radius-server host 172.10.0.1 auth-port 1645 acct-port 1646
Switch(config)# aaa new-model
Switch(config)# aaa group server radius group1
Switch(config-sg-radius)# server 172.20.0.1 auth-port 1000 acct-port 1001
Switch(config-sg-radius)# exit
Switch(config)# aaa group server radius group2
Switch(config-sg-radius)# server 172.20.0.1 auth-port 2000 acct-port 2001
Switch(config-sg-radius)# exit
```

Examples: AAA Server Groups

The following example shows how to create server group radgroup1 with three different RADIUS server members, each using the default authentication port (1645) and accounting port (1646):

```
aaa group server radius radgroup1
 server 172.16.1.11
 server 172.17.1.21
 server 172.18.1.31
```

The following example shows how to create server group radgroup2 with three RADIUS server members, each with the same IP address but with unique authentication and accounting ports:

```
aaa group server radius radgroup2
 server 172.16.1.1 auth-port 1000 acct-port 1001
 server 172.16.1.1 auth-port 2000 acct-port 2001
 server 172.16.1.1 auth-port 3000 acct-port 3001
```

Troubleshooting Tips for RADIUS Progress Codes

The following example is a sample debug output from the **debug ppp negotiation** command. This debug output is used to verify that accounting “stop” records have been generated and that attribute 196 (Ascend-Connect-Progress) has a value of 65.

```
Tue Aug 7 06:21:03 2001
        NAS-IP-Address = 10.0.58.62
        NAS-Port = 20018
        Vendor-Specific = ""
        NAS-Port-Type = ISDN
        User-Name = "peer_16a"
        Called-Station-Id = "5213124"
        Calling-Station-Id = "5212175"
        Acct-Status-Type = Stop
        Acct-Authentic = RADIUS
        Service-Type = Framed-User
        Acct-Session-Id = "00000014"
        Framed-Protocol = PPP
        Framed-IP-Address = 172.16.0.2
        Acct-Input-Octets = 3180
        Acct-Output-Octets = 3186
        Acct-Input-Packets = 40
        Acct-Output-Packets = 40
        Ascend-Connect-Pr = 65
        Acct-Session-Time = 49
        Acct-Delay-Time = 0
        Timestamp = 997190463
        Request-Authenticator = Unverified
```

Examples: Configuring the Switch to Use Vendor-Specific RADIUS Attributes

For example, this AV pair activates Cisco's *multiple named ip address pools* feature during IP authorization (during PPP IPCP address assignment):

```
cisco-avpair= ″ip:addr-pool=first‶
```

This example shows how to provide a user logging in from a switch with immediate access to privileged EXEC commands:

```
cisco-avpair= ″shell:priv-lvl=15‶
```

This example shows how to specify an authorized VLAN in the RADIUS server database:

```
cisco-avpair= ″tunnel-type(#64)=VLAN(13)″
cisco-avpair= ″tunnel-medium-type(#65)=802 media(6)″
cisco-avpair= ″tunnel-private-group-id(#81)=vlanid″
```

This example shows how to apply an input ACL in ASCII format to an interface for the duration of this connection:

```
cisco-avpair= ‶ip:inacl#1=deny ip 10.10.10.10 0.0.255.255 20.20.20.20 255.255.0.0″
cisco-avpair= ‶ip:inacl#2=deny ip 10.10.10.10 0.0.255.255 any″
cisco-avpair= ‶mac:inacl#3=deny any any decnet-iv″
```

This example shows how to apply an output ACL in ASCII format to an interface for the duration of this connection:

```
cisco-avpair= ‶ip:outacl#2=deny ip 10.10.10.10 0.0.255.255 any″
```

Example: Configuring the Switch for Vendor-Proprietary RADIUS Server Communication

This example shows how to specify a vendor-proprietary RADIUS host and to use a secret key of *rad124* between the switch and the server:

```
Switch(config)# radius-server host 172.20.30.15 nonstandard
Switch(config)# radius-server key rad124
```

Example: User Profile Associated With the test aaa group Command

The following example shows how to configure the dnis = dnisvalue user profile "prfl1" and associate it with a **test aaa group** command. In this example, the **debug radius** command has been enabled and the output follows the configuration.

```
aaa user profile prfl1
  aaa attribute dnis
  aaa attribute dnis dnisvalue
  no aaa attribute clid
! Attribute not found.
  aaa attribute clid clidvalue
  no aaa attribute clid
  exit
!
! Associate the dnis user profile with the test aaa group command.
test aaa group radius user1 pass new-code profile profl1
!
!
!
! debug radius output, which shows that the dnis value has been passed to the radius !
server.
*Dec 31 16:35:48: RADIUS: Sending packet for Unique id = 0
 *Dec 31 16:35:48: RADIUS: Initial Transmit unknown id 8 172.22.71.21:1645, Access-Request,
 len 68
 *Dec 31 16:35:48: RADIUS: code=Access-Request id=08 len=0068
         authenticator=1E CA 13 F2 E2 81 57 4C - 02 EA AF 9D 30 D9 97 90
         T=User-Password[2]                L=12 V=*
         T=User-Name[1]                    L=07 V="test"
         T=Called-Station-Id[30]           L=0B V="dnisvalue"
         T=Service-Type[6]                 L=06 V=Login                     [1]
         T=NAS-IP-Address[4]               L=06 V=10.0.1.81

 *Dec 31 16:35:48: RADIUS: Received from id 8 172.22.71.21:1645, Access-Accept, len 38
 *Dec 31 16:35:48: RADIUS: code=Access-Accept id=08 len=0038
```

Additional References for RADIUS

Related Documents

Related Topic	Document Title
Cisco security commands	• Cisco IOS Security Command Reference: Commands A to C • Cisco IOS Security Command Reference: Commands D to L • Cisco IOS Security Command Reference: Commands M to R • Cisco IOS Security Command Reference: Commands S to Z
IPv6 commands	Cisco IOS IPv6 Command Reference

Standards and RFCs

Standard/RFC	Title
RFC 5176	RADIUS Change of Authorization (CoA) extensions

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for RADIUS

Release	Feature Information
Cisco IOS Release 15.2(5)E	This feature was introduced.
Cisco IOS 15.2(1)E	The RADIUS Progress Codes feature adds additional progress codes to RADIUS attribute 196 (Ascend-Connect-Progress), which indicates a connection state before a call is disconnected through progress codes.

Release	Feature Information
Cisco IOS 15.2(1)E	The Enhanced Test Command feature allows a named user profile to be created with calling line ID (CLID) or Dialed Number Identification Service (DNIS) attribute values. The CLID or DNIS attribute values can be associated with the RADIUS record that is sent with the user profile so that the RADIUS server can access CLID or DNIS attribute information for all incoming calls. The following commands were introduced or modified: **aaa attribute**, **aaa user profile**, and **test aaa group**

CHAPTER 31

Configuring Accounting

The AAA Accounting feature allows the services that users are accessing and the amount of network resources that users are consuming to be tracked. When AAA Accounting is enabled, the network access server reports user activity to the TACACS+ or RADIUS security server (depending on which security method is implemented) in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. This data can then be analyzed for network management, client billing, and auditing.

Prerequisites for Configuring Accounting

The following tasks must be performed before configuring accounting using named method lists:

- Enable AAA on the network access server by using the **aaa new-model**command in global configuration mode.
- Define the characteristics of the RADIUS or TACACS+ security server if RADIUS or TACACS+ authorization is issued. For more information about configuring the Cisco network access server to communicate with the RADIUS security server, see the Configuring RADIUS module. For more information about configuring the Cisco network access server to communicate with the TACACS+ security server, see the Configuring TACACS+ module.

Restrictions for Configuring Accounting

- Accounting information can be sent simultaneously to a maximum of only four AAA servers.
- For Service Selection Gateway (SSG) systems, the **aaa accounting network broadcast** command broadcasts only **start-stop** accounting records. If interim accounting records are configured using the

ssg accounting interval command, the interim accounting records are sent only to the configured default RADIUS server.

Information About Configuring Accounting

Named Method Lists for Accounting

Similar to authentication and authorization method lists, method lists for accounting define the way accounting is performed and the sequence in which these methods are performed.

Named accounting method lists allow particular security protocol to be designated and used on specific lines or interfaces for accounting services. The only exception is the default method list (which is named “default”). The default method list is automatically applied to all interfaces except those that have a named method list explicitly defined. A defined method list overrides the default method list.

A method list is simply a named list describing the accounting methods to be queried (such as RADIUS or TACACS+), in sequence. Method lists allow one or more security protocols to be designated and used for accounting, thus ensuring a backup system for accounting in case the initial method fails. Cisco IOS software uses the first method listed to support accounting; if that method fails to respond, the Cisco IOS software selects the next accounting method listed in the method list. This process continues until there is successful communication with a listed accounting method, or all methods defined are exhausted.

Note The Cisco IOS software attempts accounting with the next listed accounting method only when there is no response from the previous method. If accounting fails at any point in this cycle--meaning that the security server responds by denying the user access--the accounting process stops and no other accounting methods are attempted.

Accounting method lists are specific to the type of accounting being requested. AAA supports seven different types of accounting:

- **Network** --Provides information for all PPP, SLIP, or ARAP sessions, including packet and byte counts.
- **EXEC** --Provides information about user EXEC terminal sessions of the network access server.
- **Commands** --Provides information about the EXEC mode commands that a user issues. Command accounting generates accounting records for all EXEC mode commands, including global configuration commands, associated with a specific privilege level.
- **Connection** --Provides information about all outbound connections made from the network access server, such as Telnet, local-area transport (LAT), TN3270, packet assembler/disassembler (PAD), and rlogin.
- **System** --Provides information about system-level events.
- **Resource** --Provides “start” and “stop” records for calls that have passed user authentication, and provides “stop” records for calls that fail to authenticate.
- **VRRS** --Provides information about Virtual Router Redundancy Service (VRRS).

Note System accounting does not use named accounting lists; only the default list for system accounting can be defined.

Once again, when a named method list is created, a particular list of accounting methods for the indicated accounting type are defined.

Accounting method lists must be applied to specific lines or interfaces before any of the defined methods are performed. The only exception is the default method list (which is named “default”). If the **aaa accounting** command for a particular accounting type is issued without specifying a named method list, the default method list is automatically applied to all interfaces or lines except those that have a named method list explicitly defined (A defined method list overrides the default method list). If no default method list is defined, then no accounting takes place.

This section includes the following subsections:

Method Lists and Server Groups

A server group is a way to group existing LDAP, RADIUS, or TACACS+ server hosts for use in method lists. The figure below shows a typical AAA network configuration that includes four security servers: R1 and R2 are RADIUS servers, and T1 and T2 are TACACS+ servers. R1 and R2 make up the group of RADIUS servers. T1 and T2 make up the group of TACACS+ servers.

Using server groups, a subset of the configured server hosts can be specified and use them for a particular service. For example, server groups allows R1 and R2 to be defined as separate server groups, and T1 and T2 as separate server groups. This allows either R1 and T1 to be specified in the method list or R2 and T2 in the method list, which provides more flexibility in the way that RADIUS and TACACS+ resources are assigned.

Server groups also can include multiple host entries for the same server, as long as each entry has a unique identifier. The combination of an IP address and a UDP port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. In other words, this unique identifier enables RADIUS requests to be sent to different UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service--for example, authorization--the second host entry configured acts as fail-over backup to the first one. Using this example, if the first host entry fails to provide accounting services, the network access server tries the second host entry configured on the same device for accounting services. (The RADIUS host entries are tried in the order they are configured.)

AAA Accounting Methods

The Cisco IOS software supports the following two methods for accounting:

- TACACS+--The network access server reports user activity to the TACACS+ security server in the form of accounting records. Each accounting record contains accounting AV pairs and is stored on the security server.

- RADIUS--The network access server reports user activity to the RADIUS security server in the form of accounting records. Each accounting record contains accounting AV pairs and is stored on the security server.

Note With CSCuc32663, passwords and accounting logs are masked before being sent to the TACACS+ or RADIUS security servers. Use the **aaa accounting commands visible-keys** command to send unmasked information to the TACACS+ or RADIUS security servers.

Accounting Record Types

For minimal accounting, use the **stop-only** keyword, which instructs the specified method (**RADIUS** or **TACACS+**) to send a stop record accounting notice at the end of the requested user process. For more accounting information, use the **start-stop** keyword to send a start accounting notice at the beginning of the requested event and a stop accounting notice at the end of the event. To stop all accounting activities on this line or interface, use the **none** keyword.

AAA Accounting Methods

The Cisco IOS software supports the following two methods for accounting:

- TACACS+--The network access server reports user activity to the TACACS+ security server in the form of accounting records. Each accounting record contains accounting AV pairs and is stored on the security server.
- RADIUS--The network access server reports user activity to the RADIUS security server in the form of accounting records. Each accounting record contains accounting AV pairs and is stored on the security server.

Note With CSCuc32663, passwords and accounting logs are masked before being sent to the TACACS+ or RADIUS security servers. Use the **aaa accounting commands visible-keys** command to send unmasked information to the TACACS+ or RADIUS security servers.

AAA Accounting Types

Network Accounting

Network accounting provides information for all PPP, SLIP, or ARAP sessions, including packet and byte counts.

The following example shows the information contained in a RADIUS network accounting record for a PPP user who comes in through an EXEC session:

```
Wed Jun 27 04:44:45 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 5
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “562”
        Acct-Status-Type = Start
        Acct-Authentic = RADIUS
        Service-Type = Exec-User
        Acct-Session-Id = “0000000D”
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”

Wed Jun 27 04:45:00 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 5
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “562”
        Acct-Status-Type = Start
        Acct-Authentic = RADIUS
        Service-Type = Framed
        Acct-Session-Id = “0000000E”
        Framed-IP-Address = “10.1.1.2”
        Framed-Protocol = PPP
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”
Wed Jun 27 04:47:46 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 5
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “562”
        Acct-Status-Type = Stop
        Acct-Authentic = RADIUS
        Service-Type = Framed
        Acct-Session-Id = “0000000E”
        Framed-IP-Address = “10.1.1.2”
        Framed-Protocol = PPP
        Acct-Input-Octets = 3075
        Acct-Output-Octets = 167
        Acct-Input-Packets = 39
        Acct-Output-Packets = 9
        Acct-Session-Time = 171
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”
Wed Jun 27 04:48:45 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 5
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “408”
        Acct-Status-Type = Stop
        Acct-Authentic = RADIUS
        Service-Type = Exec-User
        Acct-Session-Id = “0000000D”
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”
```

The following example shows the information contained in a TACACS+ network accounting record for a PPP user who first started an EXEC session:

```
Wed Jun 27 04:00:35 2001 172.16.25.15    username1   tty4    562/4327528     starttask_id=28
      service=shell
Wed Jun 27 04:00:46 2001 172.16.25.15    username1   tty4 562/4327528     starttask_id=30
     addr=10.1.1.1   service=ppp
Wed Jun 27 04:00:49 2001 172.16.25.15    username1   tty4    408/4327528     update
task_id=30      addr=10.1.1.1   service=ppp     protocol=ip     addr=10.1.1.1
Wed Jun 27 04:01:31 2001 172.16.25.15    username1   tty4    562/4327528     stoptask_id=30
       addr=10.1.1.1   service=ppp     protocol=ip     addr=10.1.1.1   bytes_in=2844
```

```
  bytes_out=1682  paks_in=36      paks_out=24     elapsed_time=51
Wed Jun 27 04:01:32 2001 172.16.25.15    username1   tty4    562/4327528     stoptask_id=28
       service=shell   elapsed_time=57
```

Note The precise format of accounting packets records may vary depending on the security server daemon.

The following example shows the information contained in a RADIUS network accounting record for a PPP user who comes in through autoselect:

```
Wed Jun 27 04:30:52 2001
        NAS-IP-Address = "172.16.25.15"
        NAS-Port = 3
        User-Name = "username1"
        Client-Port-DNIS = "4327528"
        Caller-ID = "562"
        Acct-Status-Type = Start
        Acct-Authentic = RADIUS
        Service-Type = Framed
        Acct-Session-Id = "0000000B"
        Framed-Protocol = PPP
        Acct-Delay-Time = 0
        User-Id = "username1"
        NAS-Identifier = "172.16.25.15"

Wed Jun 27 04:36:49 2001
        NAS-IP-Address = "172.16.25.15"
        NAS-Port = 3
        User-Name = "username1"
        Client-Port-DNIS = "4327528"
        Caller-ID = "562"
        Acct-Status-Type = Stop
        Acct-Authentic = RADIUS
        Service-Type = Framed
        Acct-Session-Id = "0000000B"
        Framed-Protocol = PPP
        Framed-IP-Address = "10.1.1.1"
        Acct-Input-Octets = 8630
        Acct-Output-Octets = 5722
        Acct-Input-Packets = 94
        Acct-Output-Packets = 64
        Acct-Session-Time = 357
        Acct-Delay-Time = 0
        User-Id = "username1"
        NAS-Identifier = "172.16.25.15"
```

The following example shows the information contained in a TACACS+ network accounting record for a PPP user who comes in through autoselect:

```
Wed Jun 27 04:02:19 2001 172.16.25.15    username1   Async5  562/4327528     starttask_id=35
      service=ppp
Wed Jun 27 04:02:25 2001 172.16.25.15    username1   Async5   562/4327528     update
task_id=35      service=ppp     protocol=ip     addr=10.1.1.2
Wed Jun 27 04:05:03 2001 172.16.25.15    username1   Async5  562/4327528     stoptask_id=35
       service=ppp     protocol=ip     addr=10.1.1.2   bytes_in=3366   bytes_out=2149
  paks_in=42      paks_out=28     elapsed_time=164
```

EXEC Accounting

EXEC accounting provides information about user EXEC terminal sessions (user shells) on the network access server, including username, date, start and stop times, the access server IP address, and (for dial-in users) the telephone number the call originated from.

The following example shows the information contained in a RADIUS EXEC accounting record for a dial-in user:

```
Wed Jun 27 04:26:23 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 1
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “5622329483”
        Acct-Status-Type = Start
        Acct-Authentic = RADIUS
        Service-Type = Exec-User
        Acct-Session-Id = “00000006”
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”
Wed Jun 27 04:27:25 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 1
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “5622329483”
        Acct-Status-Type = Stop
        Acct-Authentic = RADIUS
        Service-Type = Exec-User
        Acct-Session-Id = “00000006”
        Acct-Session-Time = 62
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”
```

The following example shows the information contained in a TACACS+ EXEC accounting record for a dial-in user:

```
Wed Jun 27 03:46:21 2001        172.16.25.15    username1   tty3    5622329430/4327528
start    task_id=2       service=shell
Wed Jun 27 04:08:55 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop     task_id=2       service=shell   elapsed_time=1354
```

The following example shows the information contained in a RADIUS EXEC accounting record for a Telnet user:

```
Wed Jun 27 04:48:32 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 26
        User-Name = “username1”
        Caller-ID = “10.68.202.158”
        Acct-Status-Type = Start
        Acct-Authentic = RADIUS
        Service-Type = Exec-User
        Acct-Session-Id = “00000010”
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”
```

```
Wed Jun 27 04:48:46 2001
        NAS-IP-Address = "172.16.25.15"
        NAS-Port = 26
        User-Name = "username1"
        Caller-ID = "10.68.202.158"
        Acct-Status-Type = Stop
        Acct-Authentic = RADIUS
        Service-Type = Exec-User
        Acct-Session-Id = "00000010"
        Acct-Session-Time = 14
        Acct-Delay-Time = 0
        User-Id = "username1"
        NAS-Identifier = "172.16.25.15"
```

The following example shows the information contained in a TACACS+ EXEC accounting record for a Telnet user:

```
Wed Jun 27 04:06:53 2001        172.16.25.15    username1   tty26   10.68.202.158
starttask_id=41      service=shell
Wed Jun 27 04:07:02 2001        172.16.25.15    username1   tty26   10.68.202.158
stoptask_id=41       service=shell   elapsed_time=9
```

Command Accounting

Command accounting provides information about the EXEC shell commands for a specified privilege level that are being executed on a network access server. Each command accounting record includes a list of the commands executed for that privilege level, as well as the date and time each command was executed, and the user who executed it.

The following example shows the information contained in a TACACS+ command accounting record for privilege level 1:

```
Wed Jun 27 03:46:47 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop     task_id=3       service=shell   priv-lvl=1      cmd=show version <cr>
Wed Jun 27 03:46:58 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop     task_id=4       service=shell   priv-lvl=1      cmd=show interfaces Ethernet 0
<cr>
Wed Jun 27 03:47:03 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop     task_id=5       service=shell   priv-lvl=1      cmd=show ip route <cr>
```

The following example shows the information contained in a TACACS+ command accounting record for privilege level 15:

```
Wed Jun 27 03:47:17 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop     task_id=6       service=shell   priv-lvl=15     cmd=configure terminal <cr>
Wed Jun 27 03:47:21 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop     task_id=7       service=shell   priv-lvl=15     cmd=interface Serial 0 <cr>
Wed Jun 27 03:47:29 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop    task_id=8      service=shell   priv-lvl=15    cmd=ip address 10.1.1.1 255.255.255.0
 <cr>
```

Note The Cisco implementation of RADIUS does not support command accounting.

Connection Accounting

Connection accounting provides information about all outbound connections made from the network access server such as Telnet, LAT, TN3270, PAD, and rlogin.

The following example shows the information contained in a RADIUS connection accounting record for an outbound Telnet connection:

```
Wed Jun 27 04:28:00 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 2
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “5622329477”
        Acct-Status-Type = Start
        Acct-Authentic = RADIUS
        Service-Type = Login
        Acct-Session-Id = “00000008”
        Login-Service = Telnet
        Login-IP-Host = “10.68.202.158”
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”

Wed Jun 27 04:28:39 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 2
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “5622329477”
        Acct-Status-Type = Stop
        Acct-Authentic = RADIUS
        Service-Type = Login
        Acct-Session-Id = “00000008”
        Login-Service = Telnet
        Login-IP-Host = “10.68.202.158”
        Acct-Input-Octets = 10774
        Acct-Output-Octets = 112
        Acct-Input-Packets = 91
        Acct-Output-Packets = 99
        Acct-Session-Time = 39
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”
```

The following example shows the information contained in a TACACS+ connection accounting record for an outbound Telnet connection:

```
Wed Jun 27 03:47:43 2001        172.16.25.15    username1   tty3    5622329430/4327528
start    task_id=10      service=connection      protocol=telnet addr=10.68.202.158 cmd=telnet
 username1-sun
Wed Jun 27 03:48:38 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop     task_id=10      service=connection      protocol=telnet addr=10.68.202.158 cmd=telnet
 username1-sun     bytes_in=4467   bytes_out=96    paks_in=61      paks_out=72 elapsed_time=55
```

The following example shows the information contained in a RADIUS connection accounting record for an outbound rlogin connection:

```
Wed Jun 27 04:29:48 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 2
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “5622329477”
        Acct-Status-Type = Start
        Acct-Authentic = RADIUS
        Service-Type = Login
        Acct-Session-Id = “0000000A”
        Login-Service = Rlogin
        Login-IP-Host = “10.68.202.158”
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”

Wed Jun 27 04:30:09 2001
        NAS-IP-Address = “172.16.25.15”
        NAS-Port = 2
        User-Name = “username1”
        Client-Port-DNIS = “4327528”
        Caller-ID = “5622329477”
        Acct-Status-Type = Stop
        Acct-Authentic = RADIUS
        Service-Type = Login
        Acct-Session-Id = “0000000A”
        Login-Service = Rlogin
        Login-IP-Host = “10.68.202.158”
        Acct-Input-Octets = 18686
        Acct-Output-Octets = 86
        Acct-Input-Packets = 90
        Acct-Output-Packets = 68
        Acct-Session-Time = 22
        Acct-Delay-Time = 0
        User-Id = “username1”
        NAS-Identifier = “172.16.25.15”
```

The following example shows the information contained in a TACACS+ connection accounting record for an outbound rlogin connection:

```
Wed Jun 27 03:48:46 2001        172.16.25.15    username1   tty3    5622329430/4327528
start   task_id=12     service=connection     protocol=rlogin addr=10.68.202.158 cmd=rlogin
 username1-sun /user username1
Wed Jun 27 03:51:37 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop    task_id=12     service=connection     protocol=rlogin addr=10.68.202.158 cmd=rlogin
 username1-sun /user username1 bytes_in=659926 bytes_out=138   paks_in=2378    paks_
out=1251        elapsed_time=171
```

The following example shows the information contained in a TACACS+ connection accounting record for an outbound LAT connection:

```
Wed Jun 27 03:53:06 2001        172.16.25.15    username1   tty3    5622329430/4327528
start    task_id=18      service=connection      protocol=lat    addr=VAX        cmd=lat
VAX
Wed Jun 27 03:54:15 2001        172.16.25.15    username1   tty3    5622329430/4327528
stop     task_id=18      service=connection      protocol=lat    addr=VAX        cmd=lat
VAX  bytes_in=0      bytes_out=0     paks_in=0      paks_out=0      elapsed_time=6
```

System Accounting

System accounting provides information about all system-level events (for example, when the system reboots or when accounting is turned on or off).

The following accounting record shows a typical TACACS+ system accounting record server indicating that AAA Accounting has been turned off:

```
Wed Jun 27 03:55:32 2001        172.16.25.15    unknown unknown unknown start   task_id=25
   service=system  event=sys_acct  reason=reconfigure
```

Note The precise format of accounting packets records may vary depending on the TACACS+ daemon.

The following accounting record shows a TACACS+ system accounting record indicating that AAA Accounting has been turned on:

```
Wed Jun 27 03:55:22 2001        172.16.25.15    unknown unknown unknown stop    task_id=23
   service=system  event=sys_acct  reason=reconfigure
```

Additional tasks for measuring system resources are covered in the Cisco IOS software configuration guides. For example, IP accounting tasks are described in the Configuring IP Services chapter in the *CiscoIOS Application Services Configuration Guide* .

Resource Accounting

The Cisco implementation of AAA accounting provides “start” and “stop” record support for calls that have passed user authentication. The additional feature of generating “stop” records for calls that fail to authenticate as part of user authentication is also supported. Such records are necessary for users employing accounting records to manage and monitor their networks.

This section includes the following subsections:

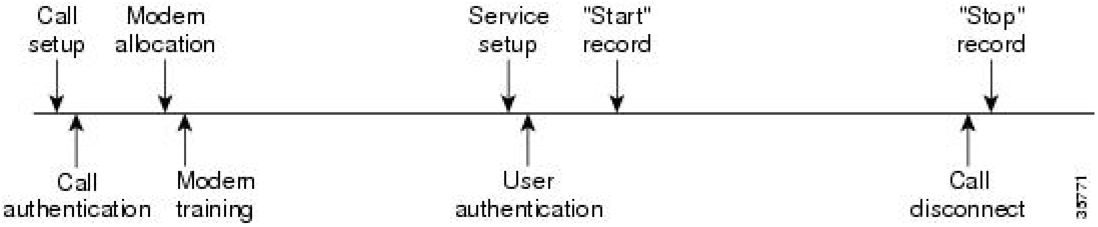
AAA Resource Failure Stop Accounting

Before AAA resource failure stop accounting, there was no method of providing accounting records for calls that failed to reach the user authentication stage of a call setup sequence. Such records are necessary for users employing accounting records to manage and monitor their networks and their wholesale customers.

This functionality generates a “stop” accounting record for any calls that do not reach user authentication; “stop” records are generated from the moment of call setup. All calls that pass user authentication behave as they did before; that is, no additional accounting records are seen.

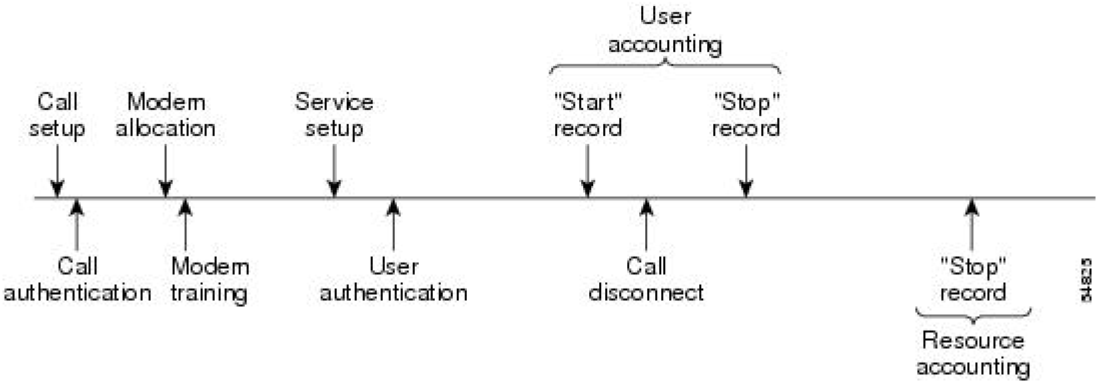
The figure below illustrates a call setup sequence with normal call flow (no disconnect) and without AAA resource failure stop accounting enabled.

Figure 50: Modem Dial-In Call Setup Sequence With Normal Flow and Without Resource Failure Stop Accounting Enabled



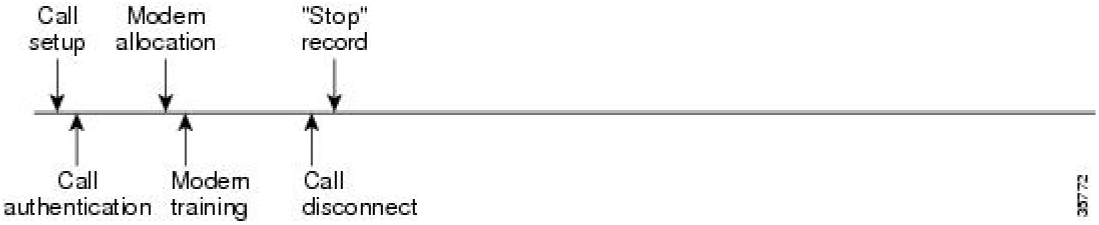
The figure below illustrates a call setup sequence with normal call flow (no disconnect) and with AAA resource failure stop accounting enabled.

Figure 51: Modem Dial-In Call Setup Sequence With Normal Flow and WIth Resource Failure Stop Accounting Enabled



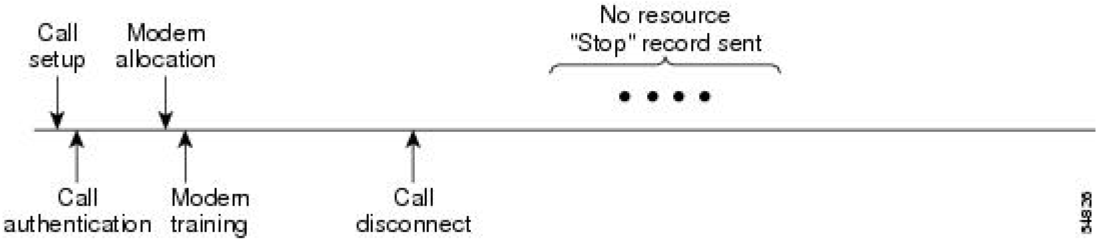
The figure below illustrates a call setup sequence with call disconnect occurring before user authentication and with AAA resource failure stop accounting enabled.

Figure 52: Modem Dial-In Call Setup Sequence With Call Disconnect Occurring Before User Authentication and With Resource Failure Stop Accounting Enabled



The figure below illustrates a call setup sequence with call disconnect occurring before user authentication and without AAA resource failure stop accounting enabled.

Figure 53: Modem Dial-In Call Setup Sequence With Call Disconnect Occurring Before User Authentication and Without Resource Failure Stop Accounting Enabled



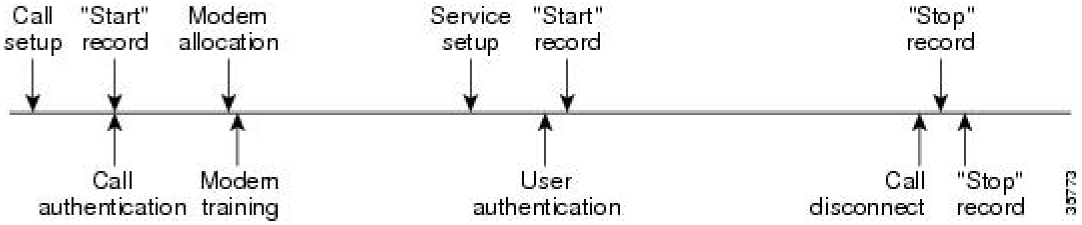
AAA Resource Accounting for Start-Stop Records

AAA resource accounting for start-stop records supports the ability to send a “start” record at each call setup, followed by a corresponding “stop” record at the call disconnect. This functionality can be used to manage and monitor wholesale customers from one source of data reporting, such as accounting records.

With this feature, a call setup and call disconnect “start-stop” accounting record tracks the progress of the resource connection to the device. A separate user authentication “start-stop” accounting record tracks the user management progress. These two sets of accounting records are interlinked by using a unique session ID for the call.

The figure below illustrates a call setup sequence with AAA resource start-stop accounting enabled.

Figure 54: Modem Dial-In Call Setup Sequence With Resource Start-Stop Accounting Enabled



VRRS Accounting

Virtual Router Redundancy Service (VRRS) provides a multiclient information abstraction and management service between a First Hop Redundancy Protocol (FHRP) and a registered client. The VRRS multiclient service provides a consistent interface with FHRP protocols by abstracting over several FHRPs and providing an idealized view of their state. VRRS manages data updates, allowing interested clients to register in one place and receive updates for named FHRP groups or all registered FHRP groups.

VRRS Accounting Plug-in

The VRRS Accounting plug-in provides a configurable AAA method list mechanism that provides updates to a RADIUS server when a VRRS group transitions its state. The VRRS accounting plug-in is an extension of existing AAA system accounting messages. The VRRS Accounting plug-in provides accounting-on and accounting-off messages and an additional Vendor-Specific Attribute (VSA) that sends the configured VRRS name in RADIUS accounting messages. The VRRS name is configured using the **vrrp name** command in interface configuration mode.

The VRRS Accounting plug-in provides a configurable AAA method list mechanism that provides updates to a RADIUS server when a VRRS group transitions its state.

The VRRS accounting plug-in is an extension of existing AAA system accounting messages. The VRRS Accounting plug-in provides accounting-on and accounting-off messages and an additional Vendor-Specific Attribute (VSA) that sends the configured VRRS name in RADIUS accounting messages. The VRRS name is configured using the **vrrp name** command in interface configuration mode. The VRRS Accounting plug-in sends an accounting-on message to RADIUS when a VRRS group transitions to the active state, and it sends an accounting-off message when a VRRS group transitions from the active state.

The following RADIUS attributes are included in VRRS accounting messages by default:

- Attribute 4, NAS-IP-Address
- Attribute 26, Cisco VSA Type 1, VRRS Name
- Attribute 40, Acct-Status-Type
- Attribute 41, Acct-Delay-Time
- Attribute 44, Acct-Session-Id

Accounting messages for a VRRS transitioning out of active state are sent after all PPPoE accounting stop messages for sessions that are part of that VRRS.

AAA Accounting Enhancements

AAA Broadcast Accounting

AAA broadcast accounting allows accounting information to be sent to multiple AAA servers at the same time; that is, accounting information can be broadcast to one or more AAA servers simultaneously. This functionality allows service providers to send accounting information to their own private AAA servers and to the AAA servers of their end customers. It also provides redundant billing information for voice applications.

Broadcasting is allowed among groups of RADIUS or TACACS+ servers, and each server group can define its backup servers for failover independently of other groups.

Thus, service providers and their end customers can use different protocols (RADIUS or TACACS+) for the accounting server. Service providers and their end customers can also specify their backup servers independently. As for voice applications, redundant accounting information can be managed independently through a separate group with its own failover sequence.

AAA Session MIB

The AAA session MIB feature allows customers to monitor and terminate their authenticated client connections using Simple Network Management Protocol (SNMP). The data of the client is presented so that it correlates directly to the AAA Accounting information reported by either the RADIUS or the TACACS+ server. AAA session MIB provides the following information:

- Statistics for each AAA function (when used in conjunction with the **show radius statistics** command)
- Status of servers providing AAA functions
- Identities of external AAA servers
- Real-time information (such as idle times), providing additional criteria for use by SNMP networks for assessing whether or not to terminate an active call

Note This command is supported only on Cisco AS5300 and Cisco AS5800 universal access server platforms.

The table below shows the SNMP user-end data objects that can be used to monitor and terminate authenticated client connections with the AAA session MIB feature.

Table 73: SNMP End-User Data Objects

SessionId	The session identification used by the AAA Accounting protocol (same value as reported by RADIUS attribute 44 (Acct-Session-ID)).
UserId	The user login ID or zero-length string if a login is unavailable.
IpAddr	The IP address of the session or 0.0.0.0 if an IP address is not applicable or unavailable.
IdleTime	The elapsed time in seconds that the session has been idle.
Disconnect	The session termination object used to disconnect the given client.
CallId	The entry index corresponding to this accounting session that the Call Tracker record stored.

The table below describes the AAA summary information provided by the AAA session MIB feature using SNMP on a per-system basis.

Table 74: SNMP AAA Session Summary

ActiveTableEntries	Number of sessions currently active.
ActiveTableHighWaterMark	Maximum number of sessions present at once since last system reinstallation.
TotalSessions	Total number of sessions since last system reinstallation.
DisconnectedSessions	Total number of sessions that have been disconnected using since last system reinstallation.

Accounting Attribute-Value Pairs

The network access server monitors the accounting functions defined in either TACACS+ AV pairs or RADIUS attributes, depending on which security method is implemented.

How to Configure Accounting

Configuring AAA Accounting Using Named Method Lists

To configure AAA Accounting using named method lists, perform the following steps:

Note System accounting does not use named method lists. For system accounting, define only the default method list.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa accounting** {**system** | **network** | **exec** | **connection** | **commands** *level*} {**default** | *list-name*} {**start-stop** | **stop-only** | **none**} [*method1* [*method2...*]]
4. Do one of the following:
   - **line** [**aux** | **console** | **tty** | **vty**] *line-number* [*ending-line-number*]
   - **interface** *interface-type interface-number*
5. Do one of the following:
   - **accounting** {**arap** | **commands** *level* | **connection** | **exec**} {**default** | *list-name*}
   - **ppp accounting**{**default** | *list-name*}
6. Device(config-line)# **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa accounting** {**system** | **network** | **exec** | **connection** | **commands** *level*} {**default** | *list-name*} {**start-stop** | **stop-only** | **none**} [*method1* [*method2...*]] **Example:** `Device(config)# aaa accounting system default start-stop`	Creates an accounting method list and enables accounting. The argument *list-name* is a character string used to name the created list.
Step 4	Do one of the following: - **line** [**aux** | **console** | **tty** | **vty**] *line-number* [*ending-line-number*] - **interface** *interface-type interface-number* **Example:** `Device(config)# line aux line1`	Enters the line configuration mode for the lines to which the accounting method list is applied. or Enters the interface configuration mode for the interfaces to which the accounting method list is applied.
Step 5	Do one of the following: - **accounting** {**arap** | **commands** *level* | **connection** | **exec**} {**default** | *list-name*} - **ppp accounting**{**default** | *list-name*} **Example:** `Device(config-line)# accounting arap default`	Applies the accounting method list to a line or set of lines. or Applies the accounting method list to an interface or set of interfaces.
Step 6	Device(config-line)# **end** **Example:** `Device(config-line)# end`	(Optional) Exits line configuration mode and returns to global configuration mode.

Configuring RADIUS System Accounting

Perform this task to configure RADIUS system accounting on the global RADIUS server:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **radius-server accounting system host-config**
5. **aaa group server radius** *server-name*
6. **server-private** {*host-name* | *ip-address*} **key** {[**0** *server-key* | **7** *server-key*] *server-key*
7. **accounting system host-config**
8. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Device(config)# aaa new-model`	Enables AAA network security services.
Step 4	**radius-server accounting system host-config** **Example:** `Device(config)# radius-server accounting system host-config`	Enables the device to send a system accounting record for the addition and deletion of a RADIUS server.
Step 5	**aaa group server radius** *server-name* **Example:** `Device(config)# aaa group server radius radgroup1`	Adds the RADIUS server and enters server-group configuration mode. • The *server-name* argument specifies the RADIUS server group name.
Step 6	**server-private** {*host-name* | *ip-address*} **key** {[**0** *server-key* | **7** *server-key*] *server-key* **Example:** `Device(config-sg-radius)# server-private 172.16.1.11 key cisco`	Enters the hostname or IP address of the RADIUS server and hidden server key. • (Optional) **0** with the *server-key*argument specifies that an unencrypted (cleartext) hidden server key follows. • (Optional) **7** with the *server-key* argument specifies that an encrypted hidden server key follows.

	Command or Action	Purpose
		• The *server-key* argument specifies the hidden server key. If the *server-key*argument is configured without the **0** or **7** preceding it, it is unencrypted. **Note** Once the **server-private** command is configured, RADIUS system accounting is enabled.
Step 7	**accounting system host-config** **Example:** `Device(config-sg-radius)# accounting system host-config`	Enables the generation of system accounting records for private server hosts when they are added or deleted.

Step 8	**end**
	Example:
	`Device(config-sg-radius)# end`
		Exits server-group configuration mode and returns to privileged EXEC mode.

Suppressing Generation of Accounting Records for Null Username Sessions

When AAA Accounting is activated, the Cisco IOS software issues accounting records for all users on the system, including users whose username string, because of protocol translation, is NULL. An example of this is users who come in on lines where the **aaa authentication login** *method-list* **none** command is applied. To prevent accounting records from being generated for sessions that do not have usernames associated with them, use the following command in global configuration mode:

Command	Purpose
`Device(config)# aaa accounting suppress null-username`	Prevents accounting records from being generated for users whose username string is NULL.

Generating Interim Accounting Records

To enable periodic interim accounting records to be sent to the accounting server, use the following command in global configuration mode:

Command	Purpose
`Device(config)# aaa accounting update [newinfo] [periodic] number`	Enables periodic interim accounting records to be sent to the accounting server.

When the **aaa accounting update**commandis activated, the Cisco IOS software issues interim accounting records for all users on the system. If the keyword **newinfo** is used, interim accounting records are sent to the accounting server every time there is new accounting information to report. An example of this would be when IPCP completes IP address negotiation with the remote peer. The interim accounting record includes the negotiated IP address used by the remote peer.

When used with the keyword **periodic**, interim accounting records are sent periodically as defined by the *number* argument. The interim accounting record contains all of the accounting information recorded for that user up to the time the interim accounting record is sent.

Caution Using the **aaa accounting update periodic** command can cause heavy congestion when many users are logged in to the network.

Generating Accounting Records for Failed Login or Session

When AAA Accounting is activated, the Cisco IOS software does not generate accounting records for system users who fail login authentication, or who succeed in login authentication but fail PPP negotiation for some reason.

To specify that accounting stop records be generated for users who fail to authenticate at login or during session negotiation, use the following command in global configuration mode:

Command	Purpose
`Device(config)# aaa accounting send stop-record authentication failure`	Generates "stop" records for users who fail to authenticate at login or during session negotiation using PPP.
`Device(config)# aaa accounting send stop-record always`	Sends authentication, authorization, and accounting (AAA) stop records regardless of whether a start record was sent earlier.

Specifying Accounting NETWORK-Stop Records Before EXEC-Stop Records

For PPP users who start EXEC terminal sessions, you can specify the NETWORK records to be generated before EXEC-stop records. In cases such as billing customers for specific services, it can be desirable to keep network start and stop records together, essentially "nesting" them within the framework of the EXEC start and stop messages. For example, a user dialing in using PPP can create the following records: EXEC-start, NETWORK-start, EXEC-stop, NETWORK-stop. By nesting the accounting records, NETWORK-stop records follow NETWORK-start messages: EXEC-start, NETWORK-start, NETWORK-stop, EXEC-stop.

To nest accounting records for user sessions, use the following command in global configuration mode:

Command	Purpose
`Device(config)# aaa accounting nested`	Nests network accounting records.

Configuring AAA Resource Failure Stop Accounting

To enable resource failure stop accounting, use the following command in global configuration mode:

Command	Purpose
Device(config)# **aaa accounting resource** *method-list* **stop-failure group** *server-group*	Generates a “stop” record for any calls that do not reach user authentication. **Note** Before configuring this feature, the tasks described in the Prerequisites for Configuring Accounting, on page 575 section must be performed, and SNMP must be enabled on the network access server.

Configuring AAA Resource Accounting for Start-Stop Records

To enable full resource accounting for start-stop records, use the following command in global configuration mode:

Command	Purpose
Device(config)# **aaa accounting resource** *method-list* **start-stop group** *server-group*	Supports the ability to send a “start” record at each call setup. followed with a corresponding “stop” record at the call disconnect. **Note** Before configuring this feature, the tasks described in the Prerequisites for Configuring Accounting, on page 575 section must be performed, and SNMP must be enabled on the network access server.

Configuring AAA Broadcast Accounting

To configure AAA broadcast accounting, use the **aaa accounting** command in global configuration mode:

Command	Purpose
Device(config)# **aaa accounting** {**system** | **network** | **exec** | **connection** | **commands** *level*} {**default** | *list-name*} {**start-stop** | **stop-only** | **none**} [**broadcast**] *method1* [*method2...*]	Enables sending accounting records to multiple AAA servers. Simultaneously sends accounting records to the first server in each group. If the first server is unavailable, failover occurs using the backup servers defined within that group.

Configuring Per-DNIS AAA Broadcast Accounting

To configure AAA broadcast accounting per DNIS, use the **aaa dnis map accounting network**command in global configuration mode:

Command	Purpose
`Device(config)#` **`aaa dnis map`** *`dnis-number`* **`accounting network`** `[`**`start-stop`** `|` **`stop-only`** `|` **`none`**`]` `[`**`broadcast`**`]` *`method1`* `[`*`method2...`*`]`	Allows per-DNIS accounting configuration. This command has precedence over the global **aaa accounting** command. Enables sending accounting records to multiple AAA servers. Simultaneously sends accounting records to the first server in each group. If the first server is unavailable, failover occurs using the backup servers defined within that group.

Configuring AAA Session MIB

The following tasks must be performed before configuring the AAA session MIB feature:

- Configure SNMP.
- Configure AAA.
- Define the RADIUS or TACACS+ server characteristics.

Note Overusing SNMP can affect the overall system performance; therefore, normal network management performance must be considered when this feature is used.

To configure AAA session MIB, use the following command in global configuration mode

SUMMARY STEPS

1. Device (config)# **aaa session-mib disconnect**

DETAILED STEPS

	Command or Action	Purpose
Step 1	Device (config)# **aaa session-mib disconnect**	Monitors and terminates authenticated client connections using SNMP. To terminate the call, the **disconnect** keyword must be used.

Configuring VRRS Accounting

Perform the following task to configure Virtual Router Redundancy Service (VRRS) to send AAA Accounting messages to the AAA server:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa accounting vrrs** {**default** | *list-name*} **start-stop** *method1* [*method2...*]
4. **aaa attribute list** *list-name*

5. **attribute type** *name value* [**service** *service*] [**protocol** *protocol*][**mandatory**][**tag** *tag-value*]
6. **exit**
7. **vrrs** *vrrs-group-name*
8. **accounting delay** *seconds*
9. **accounting method** {**default** | *accounting-method-list*}
10. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa accounting vrrs** {**default** | *list-name*} **start-stop** *method1* [*method2...*] **Example:** `Device(config)# aaa accounting vrrs default start-stop`	Enables AAA accounting for VRRS.
Step 4	**aaa attribute list** *list-name* **Example:** `Device(config)# aaa attribute list list1`	Defines a AAA attribute list locally on a device, and enters attribute list configuration mode.
Step 5	**attribute type** *name value* [**service** *service*] [**protocol** *protocol*][**mandatory**][**tag** *tag-value*] **Example:** `Device(config-attr-list)# attribute type example 1`	Defines an attribute type that is to be added to an attribute list locally on a device.
Step 6	**exit** **Example:** `Device(config-attr-list)# exit`	Exits attribute list configuration mode and returns to global configuration mode.
Step 7	**vrrs** *vrrs-group-name* **Example:** `Device(config)# vrrs vrrs1`	(Optional) Defines a VRRP group and configures parameters for the VRRS group, and enters VRRS configuration mode.

	Command or Action	Purpose
Step 8	**accounting delay** *seconds* **Example:** `Device(config-vrrs)# accounting delay 10`	(Optional) Specifies the delay time for sending accounting-off messages to the VRRS.

Step 9	**accounting method** {**default** | *accounting-method-list*}
	Example:
	`Device(config-vrrs)# accounting method default`
		(Optional) Enables VRRS accounting for a VRRP group.

Step 10	**end**
	Example:
	`Device(config-vrrs)# end`
		Exits VRRS configuration mode and returns to privileged EXEC mode.

Establishing a Session with a Device if the AAA Server is Unreachable

To establish a console or telnet session with a device if the AAA server is unreachable, use the following command in global configuration mode:

Command	Purpose
`Device(config)# no aaa accounting system guarantee-first`	The **aaa accounting system guarantee-first** command guarantees system accounting as the first record, which is the default condition. In some situations, users may be prevented from starting a session on the console or terminal connection until after the system reloads, which can take more than three minutes. To resolve this problem, the **no aaa accounting system guarantee-first** command can be used.

Note Entering the **no aaa accounting system guarantee-first** command is not the only condition by which the console or telnet session can be started. For example, if the privileged EXEC session is being authenticated by TACACS and the TACACS server is not reachable, then the session cannot start.

Monitoring Accounting

No specific **show** command exists for either RADIUS or TACACS+ accounting. To obtain accounting records displaying information about users currently logged in, use the following command in privileged EXEC mode:

Command	Purpose
`Device# show accounting`	Allows display of the active accountable events on the network and helps collect information in the event of a data loss on the accounting server.

Troubleshooting Accounting

To troubleshoot accounting information, use the following command in privileged EXEC mode:

Command	Purpose
`Device# debug aaa accounting`	Displays information on accountable events as they occur.

Configuration Examples for Accounting

Example Configuring Named Method List

The following example shows how to configure a Cisco AS5200 (enabled for AAA and communication with a RADIUS security server) in order for AAA services to be provided by the RADIUS server. If the RADIUS server fails to respond, then the local database is queried for authentication and authorization information, and accounting services are handled by a TACACS+ server.

```
aaa new-model
aaa authentication login admins local
aaa authentication ppp dialins group radius local
aaa authorization network blue1 group radius local
aaa accounting network red1 start-stop group radius group tacacs+
username root password ALongPassword
tacacs-server host 172.31.255.0
tacacs-server key goaway
radius-server host 172.16.2.7
radius-server key myRaDiUSpassWoRd
interface group-async 1
 group-range 1 16
 encapsulation ppp
 ppp authentication chap dialins
 ppp authorization blue1
 ppp accounting red1
line 1 16
 autoselect ppp
 autoselect during-login
 login authentication admins
 modem dialin
```

The lines in this sample RADIUS AAA configuration are defined as follows:

- The **aaa new-model** command enables AAA network security services.
- The **aaa authentication login admins local** command defines a method list “admins”, for login authentication.
- The **aaa authentication ppp dialins group radius local** command defines the authentication method list “dialins”, which specifies that first RADIUS authentication and then (if the RADIUS server does not respond) local authentication is used on serial lines using PPP.
- The **aaa authorization network blue1 group radius local** command defines the network authorization method list named “blue1”, which specifies that RADIUS authorization is used on serial lines using PPP. If the RADIUS server fails to respond, then local network authorization is performed.

- The **aaa accounting network red1 start-stop group radius group tacacs+**command defines the network accounting method list named red1, which specifies that RADIUS accounting services (in this case, start and stop records for specific events) are used on serial lines using PPP. If the RADIUS server fails to respond, accounting services are handled by a TACACS+ server.
- The **username** command defines the username and password to be used for the PPP Password Authentication Protocol (PAP) caller identification.
- The **tacacs-server host** command defines the name of the TACACS+ server host.
- The **tacacs-server key** command defines the shared secret text string between the network access server and the TACACS+ server host.
- The **radius-server host** command defines the name of the RADIUS server host.
- The **radius-server key** command defines the shared secret text string between the network access server and the RADIUS server host.
- The **interface group-async** command selects and defines an asynchronous interface group.
- The **group-range** command defines the member asynchronous interfaces in the interface group.
- The **encapsulation ppp** command sets PPP as the encapsulation method used on the specified interfaces.
- The **ppp authentication chap dialins**command selects Challenge Handshake Authentication Protocol (CHAP) as the method of PPP authentication and applies the “dialins” method list to the specified interfaces.
- The **ppp authorization blue1**command applies the blue1 network authorization method list to the specified interfaces.
- The **ppp accounting red1**command applies the red1 network accounting method list to the specified interfaces.
- The **line** command switches the configuration mode from global configuration to line configuration and identifies the specific lines being configured.
- The **autoselect ppp** command configures the Cisco IOS software to allow a PPP session to start up automatically on these selected lines.
- The **autoselect during-login** command is used to display the username and password prompt without pressing the Return key. After the user logs in, the autoselect function (in this case, PPP) begins.
- The **login authentication admins** command applies the admins method list for login authentication.
- The **modem dialin** command configures modems attached to the selected lines to only accept incoming calls.

The **show accounting**command yields the following output for the preceding configuration:

```
Active Accounted actions on tty1, User username2 Priv 1
 Task ID 5, Network Accounting record, 00:00:52 Elapsed
 task_id=5 service=ppp protocol=ip address=10.0.0.98
```

The table below describes the fields contained in the preceding output.

Table 75: show accounting Field Descriptions

Field	Description
Active Accounted actions on	Terminal line or interface name user with which the user logged in.
User	User’s ID.
Priv	User’s privilege level.
Task ID	Unique identifier for each accounting session.
Accounting record	Type of accounting session.
Elapsed	Length of time (hh:mm:ss) for this session type.
attribute=value	AV pairs associated with this accounting session.

Example Configuring AAA Resource Accounting

The following example shows how to configure the resource failure stop accounting and resource accounting for start-stop records functions:

```
!Enable AAA on your network access server.
aaa new-model
!Enable authentication at login and list the AOL string name to use for login authentication.
aaa authentication login AOL group radius local
!Enable authentication for ppp and list the default method to use for PPP authentication.
aaa authentication ppp default group radius local
!Enable authorization for all exec sessions and list the AOL string name to use for
authorization.
aaa authorization exec AOL group radius if-authenticated
!Enable authorization for all network-related service requests and list the default method
 to use for all network-related authorizations.
aaa authorization network default group radius if-authenticated
!Enable accounting for all exec sessions and list the default method to use for all start-stop
 accounting services.
aaa accounting exec default start-stop group radius
!Enable accounting for all network-related service requests and list the default method to
 use for all start-stop accounting services.
aaa accounting network default start-stop group radius
!Enable failure stop accounting.
aaa accounting resource default stop-failure group radius
!Enable resource accounting for start-stop records.
aaa accounting resource default start-stop group radius
```

Example Configuring AAA Broadcast Accounting

The following example shows how to turn on broadcast accounting using the global **aaa accounting** command:

```
aaa group server radius isp
 server 10.0.0.1
 server 10.0.0.2
aaa group server tacacs+ isp_customer
 server 172.0.0.1
aaa accounting network default start-stop broadcast group isp group isp_customer
```

```
radius-server host 10.0.0.1
radius-server host 10.0.0.2
radius-server key key1
tacacs-server host 172.0.0.1 key key2
```

The **broadcast** keyword causes “start” and “stop” accounting records for network connections to be sent simultaneously to server 10.0.0.1 in the group isp and to server 172.0.0.1 in the group isp_customer. If server 10.0.0.1 is unavailable, failover to server 10.0.0.2 occurs. If server 172.0.0.1 is unavailable, no failover occurs because backup servers are not configured for the group isp_customer.

Example Configuring Per-DNIS AAA Broadcast Accounting

The following example shows how to turn on per DNIS broadcast accounting using the global **aaa dnis map accounting network**command:

```
aaa group server radius isp
 server 10.0.0.1
 server 10.0.0.2
aaa group server tacacs+ isp_customer
 server 172.0.0.1
aaa dnis map enable
aaa dnis map 7777 accounting network start-stop broadcast group isp group isp_customer
radius-server host 10.0.0.1
radius-server host 10.0.0.2
radius-server key key_1
tacacs-server host 172.0.0.1 key key_2
```

The **broadcast** keyword causes “start” and “stop” accounting records for network connection calls having DNIS number 7777 to be sent simultaneously to server 10.0.0.1 in the group isp and to server 172.0.0.1 in the group isp_customer. If server 10.0.0.1 is unavailable, failover to server 10.0.0.2 occurs. If server 172.0.0.1 is unavailable, no failover occurs because backup servers are not configured for the group isp_customer.

Example AAA Session MIB

The following example shows how to set up the AAA session MIB feature to disconnect authenticated client connections for PPP users:

```
aaa new-model
aaa authentication ppp default group radius
aaa authorization network default group radius
aaa accounting network default start-stop group radius
aaa session-mib disconnect
```

Example Configuring VRRS Accounting

The following example shows how to configure VRRS to send AAA Accounting messages to the AAA server:

```
Router# configure terminal
Router(config)# aaa accounting vrrs vrrp-mlist-1 start-stop group radius
Router(config)# aaa attribute list vrrp-1-attr
Router(config-attr-list)# attribute type account-delay 10
Router(config-attr-list)# exit
Router(config)# vrrs vrrp-group-1
Router(config-vrrs)# accounting delay 10
Router(config-vrrs)# accounting method vrrp-mlist-1
Router(config-vrrs)# exit
```

Additional References for Configuring Accounting

Related Documents

Related Topic	Document Title
Cisco security commands	• Cisco IOS Security Command Reference: Commands A to C • Cisco IOS Security Command Reference: Commands D to L • Cisco IOS Security Command Reference: Commands M to R • Cisco IOS Security Command Reference: Commands S to Z

RFCs

RFC	Title
RFC 2903	*Generic AAA Architecture*
RFC 2904	*AAA Authorization Framework*
RFC 2906	*AAA Authorization Requirements*
RFC 2989	*Criteria for Evaluating AAA Protocols for Network Access*

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for Configuring Accounting

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 76: Feature Information for Configuring Accounting

Feature Name	Releases	Feature Information
AAA Broadcast Accounting	Cisco IOS 15.2(1)E	AAA broadcast accounting allows accounting information to be sent to multiple AAA servers at the same time; that is, accounting information can be broadcast to one or more AAA servers simultaneously.
AAA Resource Accounting for Start-Stop Records	Cisco IOS 15.2(1)E	AAA resource accounting for start-stop records supports the ability to send a “start” record at each call setup, followed by a corresponding “stop” record at the call disconnect. This functionality can be used to manage and monitor wholesale customers from one source of data reporting, such as accounting records.
AAA Session MIB	Cisco IOS 15.2(1)E	The AAA session MIB feature allows customers to monitor and terminate their authenticated client connections using SNMP. The data of the client is presented so that it correlates directly to the AAA Accounting information reported by either the RADIUS or the TACACS+ server.
AAA: IPv6 Accounting Delay Enhancements	Cisco IOS 15.2(1)E	VRRS provides a multiclient information abstraction and management service between a First Hop Redundancy Protocol (FHRP) and a registered client.

CHAPTER 32

Configuring Local Authentication and Authorization

How to Configure Local Authentication and Authorization

Configuring the Switch for Local Authentication and Authorization

You can configure AAA to operate without a server by setting the switch to implement AAA in local mode. The switch then handles authentication and authorization. No accounting is available in this configuration.

Note To secure the switch for HTTP access by using AAA methods, you must configure the switch with the **ip http authentication aaa** global configuration command. Configuring AAA authentication does not secure the switch for HTTP access by using AAA methods.

Follow these steps to configure AAA to operate without a server by setting the switch to implement AAA in local mode:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa authentication login default local**
5. **aaa authorization exec default local**
6. **aaa authorization network default local**
7. **username** *name* [**privilege** *level*] {**password** *encryption-type password*}
8. **end**
9. **show running-config**

10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA.
Step 4	**aaa authentication login default local** **Example:** `Switch(config)# aaa authentication login default local`	Sets the login authentication to use the local username database. The **default** keyword applies the local user database authentication to all ports.
Step 5	**aaa authorization exec default local** **Example:** `Switch(config)# aaa authorization exec default local`	Configures user AAA authorization, check the local database, and allow the user to run an EXEC shell.
Step 6	**aaa authorization network default local** **Example:** `Switch(config)# aaa authorization network default local`	Configures user AAA authorization for all network-related service requests.

Step 7	**username** *name* [**privilege** *level*] {**password** *encryption-type password*}
	Example:
	`Switch(config)# username your_user_name privilege 1 password 7 secret567`
		Enters the local database, and establishes a username-based authentication system.
		Repeat this command for each user.
		• For *name*, specify the user ID as one word. Spaces and quotation marks are not allowed.

	Command or Action	Purpose
		• (Optional) For *level*, specify the privilege level the user has after gaining access. The range is 0 to 15. Level 15 gives privileged EXEC mode access. Level 0 gives user EXEC mode access. • For *encryption-type*, enter 0 to specify that an unencrypted password follows. Enter 7 to specify that a hidden password follows. • For *password*, specify the password the user must enter to gain access to the switch. The password must be from 1 to 25 characters, can contain embedded spaces, and must be the last option specified in the **username** command.

Step 8	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 9	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 10	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring Local Authentication and Authorization

To display Local Authentication and Authorization configuration, use the **show running-config** privileged EXEC command.

Additional References

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for Local Authentication and Authorization

Release	Feature Information
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 33

MAC Authentication Bypass

The MAC Authentication Bypass feature is a MAC-address-based authentication mechanism that allows clients in a network to integrate with the Cisco Identity Based Networking Services (IBNS) and Network Admission Control (NAC) strategy using the client MAC address. The MAC Authentication Bypass feature is applicable to the following network environments:

- Network environments in which a supplicant code is not available for a given client platform.
- Network environments in which the end client configuration is not under administrative control, that is, the IEEE 802.1X requests are not supported on these networks.

Prerequisites for Configuring MAC Authentication Bypass

IEEE 802.1x—Port-Based Network Access Control

You should understand the concepts of port-based network access control and have an understanding of how to configure port-based network access control on your Cisco platform.

RADIUS and ACLs

You should understand the concepts of the RADIUS protocol and have an understanding of how to create and apply access control lists (ACLs). For more information, see the documentation for your Cisco platform and the *Securing User Services Configuration Guide Library*.

The device must have a RADIUS configuration and be connected to the Cisco secure access control server (ACS). For more information, see the *User Guide for Secure ACS Appliance 3.2*.

Information About MAC Authentication Bypass

Overview of the Cisco IOS Auth Manager

The capabilities of devices connecting to a given network can be different, thus requiring that the network support different authentication methods and authorization policies. The Cisco IOS Auth Manager handles network authentication requests and enforces authorization policies regardless of authentication method. The Auth Manager maintains operational data for all port-based network connection attempts, authentications, authorizations, and disconnections and, as such, serves as a session manager.

The possible states for Auth Manager sessions are as follows:

- Idle—In the idle state, the authentication session has been initialized, but no methods have yet been run. This is an intermediate state.
- Running—A method is currently running. This is an intermediate state.
- Authc Success—The authentication method has run successfully. This is an intermediate state.
- Authc Failed—The authentication method has failed. This is an intermediate state.
- Authz Success—All features have been successfully applied for this session. This is a terminal state.
- Authz Failed—At least one feature has failed to be applied for this session. This is a terminal state.
- No methods—There were no results for this session. This is a terminal state.

Overview of the Configurable MAB Username and Password

A MAC Authentication Bypass (MAB) operation involves authentication using RADIUS Access-Request packets with both the username and password attributes. By default, the username and the password values are the same and contain the MAC address. The Configurable MAB Username and Password feature enables you to configure both the username and the password attributes in the following scenarios:

- To enable MAB for an existing large database that uses formatted username attributes, the username format in the client MAC needs to be configured. Use the **mab request format attribute 1** command to configure the username format.
- Some databases do not accept authentication if the username and password values are the same. In such instances, the password needs to be configured to ensure that the password is different from the username. Use the **mab request format attribute 2** command to configure the password.

The Configurable MAB Username and Password feature allows interoperability between the Cisco IOS Authentication Manager and the existing MAC databases and RADIUS servers. The password is a global password and hence is the same for all MAB authentications and interfaces. This password is also synchronized across all supervisor devices to achieve high availability.

If the password is not provided or configured, the password uses the same value as the username. The table below describes the formatting of the username and the password:

MAC Address	Username Format (Group Size, Separator)	Username	Password Configured	Password Created
08002b8619de	(1, :) (1, -) (1, .)	0:8:0:0:2:b:8:6:1:9:d:e 0-8-0-0-2-b-8-6-1-9-d-e 0.8.0.0.2.b.8.6.1.9.d.e	None	0:8:0:0:2:b:8:6:1:9:d:e 0-8-0-0-2-b-8-6-1-9-d-e 0.8.0.0.2.b.8.6.1.9.d.e
08002b8619de	(1, :) (1, -) (1, .)	0:8:0:0:2:b:8:6:1:9:d:e 0-8-0-0-2-b-8-6-1-9-d-e 0.8.0.0.2.b.8.6.1.9.d.e	Password	Password
08002b8619de	(2, :) (2, -) (2, .)	08:00:2b:86:19:de 08-00-2b-86-19-de 08.00.2b.86.19.de	None	08:00:2b:86:19:de 08-00-2b-86-19-de 08.00.2b.86.19.de
08002b8619de	(2, :) (2, -) (2, .)	08:00:2b:86:19:de 08-00-2b-86-19-de 08.00.2b.86.19.de	Password	Password
08002b8619de	(4, :) (4, -) (4, .)	0800:2b86:19de 0800-2b86-19de 0800.2b86.19de	None	0800:2b86:19de 0800-2b86-19de 0800.2b86.19de
08002b8619de	(4, :) (4, -) (4, .)	0800:2b86:19de 0800-2b86-19de 0800.2b86.19de	Password	Password
08002b8619de	(12, <not applicable>)	08002b8619de	None	08002b8619de
08002b8619de	(12, <not applicable>)	08002b8619de	Password	Password

How to Configure MAC Authentication Bypass

Enabling MAC Authentication Bypass

Perform this task to enable the MAC Authentication Bypass feature on an 802.1X port.

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **interface** *type slot* / *port*
4. **mab**
5. **end**
6. **show authentication sessions interface** *type slot* / *port* **details**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type slot* / *port* **Example:** `Device(config)# interface Gigabitethernet 2/1`	Enters interface configuration mode.
Step 4	**mab** **Example:** `Device(config-if)# mab`	Enables MAB.

Step 5	**end**
	Example:
	`Device(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**show authentication sessions interface** *type slot* / *port* **details** **Example:** `Device# show authentication session interface Gigabitethernet 2/1 details`	Displays the interface configuration and the authenticator instances on the interface.

Enabling Reauthentication on a Port

By default, ports are not automatically reauthenticated. You can enable automatic reauthentication and specify how often reauthentication attempts are made.

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **interface** *type slot* / *port*
4. **switchport**
5. **switchport mode access**
6. **authentication port-control auto**
7. **mab** [**eap**]
8. **authentication periodic**
9. **authentication timer reauthenticate** {*seconds* | **server**}
10. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type slot* / *port* **Example:** `Device(config)# interface Gigabitethernet 2/1`	Enters interface configuration mode.
Step 4	**switchport** **Example:** `Device(config-if)# switchport`	Places interface in Layer 2 switched mode.
Step 5	**switchport mode access** **Example:** `Device(config-if)# switchport mode access`	Sets the interface type as a nontrunking, nontagged single VLAN Layer 2 interface.
Step 6	**authentication port-control auto** **Example:** `Device(config-if)# authentication port-control auto`	Configures the authorization state of the port.
Step 7	**mab** [**eap**] **Example:** `Device(config-if)# mab`	Enables MAB.

	Command or Action	Purpose
Step 8	**authentication periodic** **Example:** `Device(config-if)# authentication periodic`	Enables reauthentication.

Step 9	**authentication timer reauthenticate** {*seconds* | **server**}
	Example:
	`Device(config-if)# authentication timer reauthenticate 900`
		Configures the time, in seconds, between reauthentication attempts.

Step 10	**end**
	Example:
	`Device(config-if)# end`
		Exits interface configuration mode and returns to privileged EXEC mode.

Specifying the Security Violation Mode

When there is a security violation on a port, the port can be shut down or traffic can be restricted. By default, the port is shut down. You can configure the period of time for which the port is shut down.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot* / *port*
4. **switchport**
5. **switchport mode access**
6. **authentication port-control auto**
7. **mab** [**eap**]
8. **authentication violation** {**restrict** | **shutdown**}
9. **authentication timer restart** *seconds*
10. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Device# configure terminal`	
Step 3	**interface** *type slot* / *port* **Example:** `Device(config)# interface Gigabitethernet 2/1`	Enters interface configuration mode.
Step 4	**switchport** **Example:** `Device(config-if)# switchport`	Places interface in Layer 2 switched mode.
Step 5	**switchport mode access** **Example:** `Device(config-if)# switchport mode access`	Sets the interface type as a nontrunking, nontagged single VLAN Layer 2 interface.
Step 6	**authentication port-control auto** **Example:** `Device(config-if)# authentication port-control auto`	Configures the authorization state of the port.
Step 7	**mab** [**eap**] **Example:** `Device(config-if)# mab`	Enables MAB.

Step 8	**authentication violation** {**restrict** | **shutdown**}
	Example:
	`Device(config-if)# authentication violation shutdown`
		Configures the action to be taken when a security violation occurs on the port.

Step 9	**authentication timer restart** *seconds* **Example:** `Device(config-if)# authentication timer restart 30`	Configures the period of time, in seconds, after which an attempt is made to authenticate an unauthorized port.

Step 10	**end**
	Example:
	`Device(config-if)# end`
		Exits interface configuration mode and returns to privileged EXEC mode.

Enabling Configurable MAB Username and Password

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mab request format attribute 1 groupsize** {**1** | **2** | **4** | **12**} **separator** {**-** | **:** | **.**} [**lowercase** | **uppercase**]
4. **mab request format attribute 2** [**0** | **7**] *password*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**mab request format attribute 1 groupsize** {**1** | **2** | **4** | **12**} **separator** {**-** | **:** | **.**} [**lowercase** | **uppercase**] **Example:** `Device(config)# mab request format attribute 1 groupsize 2 separator :`	Configures the username format for MAB requests.
Step 4	**mab request format attribute 2** [**0** | **7**] *password* **Example:** `Device(config)# mab request format attribute 2 password1`	Configures a global password for all MAB requests.

Step 5	**end**
	Example:
	`Device(config)# end`
		Returns to privileged EXEC mode.

Configuration Examples for MAC Authentication Bypass

Example: MAC Authentication Bypass Configuration

In the following example, the **mab** command has been configured to enable the MAC Authorization Bypass (MAB) feature on the specified interface. The optional **show authentication sessions** command has been enabled to display the interface configuration and the authentication instances on the interface.

```
Device> enable
Device# configure terminal
Device(config)# interface GigabitEthernet2/1
Device(config-if)# mab
Device(config-if)# end
Device# show authentication sessions interface GigabitEthernet2/1 details
```

Example: Enabling Configurable MAB Username and Password

The following example shows how to configure the username format and password for MAC Authentication Bypass (MAB). In this example, the username format is configured as a group of 12 hexadecimal digits with no separator and the global password as **password1**.

```
Device> enable
Device# configure terminal
Device(config)# mab request format attribute 1 groupsize 2 separator :
Device(config)# mab request format attribute 2 password1
Device(config)# end
```

Additional References for MAC Authentication Bypass

MIBs

MIB	MIBs Link
• CISCO-AUTH-FRAMEWORK-MIB • CISCO-MAC-AUTH-BYPASS-MIB • CISCO-PAE-MIB • IEEE8021-PAE-MIB	To locate and download MIBs for selected platforms, Cisco IOS software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
RFC 3580	*IEEE 802.1x Remote Authentication Dial In User Service (RADIUS)*

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for MAC Authentication Bypass

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 77: Feature Information for MAC Authentication Bypass

Feature Name	Releases	Feature Information
MAC Authentication Bypass (MAB)	Cisco IOS 15.2(5)E	The MAC Authentication Bypass feature is a MAC-address-based authentication mechanism that allows clients in a network to integrate with the Cisco IBNS and NAC strategy using the client MAC address. The following commands were introduced or modified: **dot1x mac-auth-bypass**, **show dot1x interface**.
Configurable MAB Username and Password	Cisco IOS 15.2(5)E	The Configurable MAB Username and Password feature enables you to configure MAC Authentication Bypass (MAB) username format and password to allow interoperability between the Cisco IOS Authentication Manager and existing MAC databases and RADIUS servers. The following commands were introduced or modified: **mab request format attribute 1**, **mab request format attribute 2**.

CHAPTER 34

Password Strength and Management for Common Criteria

The Password Strength and Management for Common Criteria feature is used to specify password policies and security mechanisms for storing, retrieving, and providing rules to specify user passwords.

For local users, the user profile and the password information with the key parameters are stored on the Cisco device, and this profile is used for local authentication of users. The user can be an administrator (terminal access) or a network user (for example, PPP users being authenticated for network access).

For remote users, where the user profile information is stored in a remote server, a third-party authentication, authorization, and accounting (AAA) server may be used for providing AAA services, both for administrative and network access.

Restrictions for Password Strength and Management for Common Criteria

Only four concurrent users can log on to the system by using vty at any moment.

Information About Password Strength and Management for Common Criteria

Password Composition Policy

The password composition policy allows you to create passwords of any combination of upper and lowercase characters, numbers, and special characters that include “!”, “@”, “#”, “$”, “%”,“^”, “&”, “*”, “(“, and “)”.

Password Length Policy

The administrator has the flexibility to set the password's minimum and maximum length. The recommended minimum password length is 8 characters. The administrator can specify both the minimum (1) and the maximum (64) length for the password.

Password Lifetime Policy

The security administrator can provide a configurable option for a password to have a maximum lifetime. If the lifetime parameter is not configured, the configured password will never expire. The maximum lifetime can be configured by providing the configurable value in years, months, days, hours, minutes, and seconds. The lifetime configuration will survive across reloads as it is a part of the configuration, but every time the system reboots, the password creation time will be updated to the new time. For example, if a password is configured with a lifetime of one month and on the 29th day, the system reboots, then the password will be valid for one month after the system reboots.

Password Expiry Policy

If the user attempts to log on and if the user's password credentials have expired, then the following happens:

1. The user is prompted to set the new password after successfully entering the expired password.
2. When the user enters the new password, the password is validated against the password security policy.
3. If the new password matches the password security policy, then the AAA database is updated, and the user is authenticated with the new password.
4. If the new password does not match the password security policy, then the user is prompted again for the password. From AAA perspective, there is no restriction on the number of retries. The number of retries for password prompt in case of unsuccessful authentication is controlled by the respective terminal access interactive module. For example, for telnet, after three unsuccessful attempts, the session will be terminated.

If the password's lifetime is not configured for a user and the user has already logged on and if the security administrator configures the lifetime for that user, then the lifetime will be set in the database. When the same user is authenticated the next time, the system will check for password expiry. The password expiry is checked only during the authentication phase.

If the user has been already authenticated and logged on to the system and if the password expires, then no action will be taken. The user will be prompted to change the password only during the next authentication for the same user.

Password Change Policy

The new password must contain a minimum of 4 character changes from the previous password. A password change can be triggered by the following scenarios:

- The security administrator wants to change the password.
- The user is trying to get authenticated using a profile, and the password for that profile has expired.

When the security administrator changes the password security policy and the existing profile does not meet the password security policy rules, no action will be taken if the user has already logged on to the system.

The user will be prompted to change the password only when the user tries to get authenticated using the profile that does not meet the password security restriction.

When the user changes the password, the lifetime parameters set by the security administrator for the old profile will be the lifetime parameters for the new password.

For noninteractive clients such as dot1x, when the password expires, appropriate error messages will be sent to the clients, and the clients must contact the security administrator to renew the password.

User Reauthentication Policy

Users are reauthenticated when they change their passwords.

When users change their passwords on expiry, they will be authenticated against the new password. In such cases, the actual authentication happens based on the previous credentials, and the new password is updated in the database.

Note Users can change their passwords only when they are logging on and after the expiry of the old password; however, a security administrator can change the user's password at any time.

Support for Framed (Noninteractive) Session

When a client such as dot1x uses the local database for authentication, the Password Strength and Management for Common Criteria feature will be applicable; however, upon password expiry, clients will not be able to change the password. An appropriate failure message will be sent to such clients, and the user must request the security administrator to change the password.

How to Configure Password Strength and Management for Common Criteria

Configuring the Password Security Policy

Perform this task to create a password security policy and to apply the policy to a specific user profile.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa common-criteria policy** *policy-name*
5. **char-changes** *number*
6. **max-length** *number*
7. **min-length** *number*
8. **numeric-count** *number*
9. **special-case** *number*

10. **exit**
11. **username** *username* **common-criteria-policy** *policy-name* **password** *password*
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Device(config)# aaa new-model`	Enables AAA globally.
Step 4	**aaa common-criteria policy** *policy-name* **Example:** `Device(config)# aaa common-criteria policy policy1`	Creates the AAA security password policy and enters common criteria configuration policy mode.
Step 5	**char-changes** *number* **Example:** `Device(config-cc-policy)# char-changes 4`	(Optional) Specifies the number of changed characters between old and new passwords.
Step 6	**max-length** *number* **Example:** `Device(config-cc-policy)# max-length 25`	(Optional) Specifies the maximum length of the password.
Step 7	**min-length** *number* **Example:** `Device(config-cc-policy)# min-length 8`	(Optional) Specifies the minimum length of the password.
Step 8	**numeric-count** *number* **Example:** `Device(config-cc-policy)# numeric-count 4`	(Optional) Specifies the number of numeric characters in the password.

	Command or Action	Purpose
Step 9	**special-case** *number* **Example:** `Device(config-cc-policy)# special-case 3`	(Optional) Specifies the number of special characters in the password.
Step 10	**exit** **Example:** `Device(config-cc-policy)# exit`	(Optional) Exits common criteria configuration policy mode and returns to global configuration mode.
Step 11	**username** *username* **common-criteria-policy** *policy-name* **password** *password* **Example:** `Device(config)# username user1 common-criteria-policy policy1 password password1`	(Optional) Applies a specific policy and password to a user profile.

Step 12	**end**
	Example:
	`Device(config)# end`
		Returns to privileged EXEC mode.

Verifying the Common Criteria Policy

Perform this task to verify all the common criteria security policies.

SUMMARY STEPS

1. **enable**
2. **show aaa common-criteria policy name** *policy-name*
3. **show aaa common-criteria policy all**

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 **show aaa common-criteria policy name** *policy-name*

Displays the password security policy information for a specific policy.

Example:

```
Device# show aaa common-criteria policy name policy1

Policy name: policy1
Minimum length: 1
Maximum length: 64
Upper Count: 20
Lower Count: 20
Numeric Count: 5
Special Count: 2
Number of character changes 4
Valid forever. User tied to this policy will not expire.
```

Step 3 **show aaa common-criteria policy all**

Displays password security policy information for all the configured policies.

Example:

```
Device# show aaa common-criteria policy all
====================================================================
Policy name: policy1
Minimum length: 1
Maximum length: 64
Upper Count: 20
Lower Count: 20
Numeric Count: 5
Special Count: 2
Number of character changes 4
Valid forever. User tied to this policy will not expire.
====================================================================
Policy name: policy2
Minimum length: 1
Maximum length: 34
Upper Count: 10
Lower Count: 5
Numeric Count: 4
Special Count: 2
Number of character changes 2
Valid forever. User tied to this policy will not expire.
=====================================================================
```

Configuration Examples for Password Strength and Management for Common Criteria

Example: Password Strength and Management for Common Criteria

The following example shows how to create a common criteria security policy and apply the specific policy to a user profile:

```
Device> enable
Device# configure terminal
Device(config)# aaa new-model
Device(config)# aaa common-criteria policy policy1
Device(config-cc-policy)# char-changes 4
Device(config-cc-policy)# max-length 20
Device(config-cc-policy)# min-length 6
Device(config-cc-policy)# numeric-count 2
Device(config-cc-policy)# special-case 2
Device(config-cc-policy)# exit
Device(config)# username user1 common-criteria-policy policy1 password password1
Device(config)# end
```

Additional References for Password Strength and Management for Common Criteria

The following sections provide references related to the RADIUS Packet of Disconnect feature.

RFCs

RFC	Title
RFC 2865	*Remote Authentication Dial-in User Service*
RFC 3576	*Dynamic Authorization Extensions to RADIUS*

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/techsupport

Feature Information for Password Strength and Management for Common Criteria

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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Table 78: Feature Information for Password Strength and Management for Common Criteria

Feature Name	Releases	Feature Information
Password Strength and Management for Common Criteria	Cisco IOS 15.2(5)E	The Password Strength and Management for Common Criteria feature is used to specify password policies and security mechanisms for storing, retrieving, and providing rules to specify user passwords. The following commands were introduced or modified: **aaa common-criteria policy**, **debug aaa common-criteria**, and **show aaa common-criteria policy**.

CHAPTER 35

AAA-SERVER-MIB Set Operation

The AAA-SERVER-MIB Set Operation feature allows the authentication, authorization, and accounting (AAA) server configuration to be extended or expanded by using the CISCO-AAA-SERVER-MIB to create and add new AAA servers, modify the “KEY” under the CISCO-AAA-SERVER-MIB, and delete the AAA server configuration.

Prerequisites for AAA-SERVER-MIB Set Operation

AAA must have been enabled on the router, that is, the **aaa new-model** command must have been configured. If this configuration has not been accomplished, the set operation fails.

Restrictions for AAA-SERVER-MIB Set Operation

Currently, the CISCO SNMP set operation is supported only for the RADIUS protocol. Therefore, only RADIUS servers in global configuration mode can be added, modified, or deleted.

Information About AAA-SERVER-MIB Set Operation

CISCO-AAA-SERVER-MIB

The CISCO-AAA-SERVER-MIB provides that statistics reflect both the state of the AAA server operation with the server itself and of AAA communications with external servers. The CISCO-AAA-SERVER-MIB provides the following information:

- Statistics for each AAA operation

- Status of servers that are providing AAA functions
- Identities of external AAA servers

CISCO-AAA-SERVER-MIB Set Operation

With the SET operation, you can do the following:

- Create or add a new AAA server.
- Modify the KEY under the CISCO-AAA-SERVER-MIB. This “secret key” is used for secure connectivity to the AAA server, which is present with the network access server (NAS) and the AAA server.
- Delete the AAA server configuration.

How to Configure AAA-SERVER-MIB Set Operation

Configuring AAA-SERVER-MIB Set Operations

No special configuration is required for this feature. The Simple Network Management Protocol (SNMP) framework can be used to manage MIBs. See the Additional References section for a reference to configuring SNMP.

Verifying SNMP Values

SNMP values can be verified by performing the following steps.

SUMMARY STEPS

1. **enable**
2. **show running-config | include radius-server host**
3. **show aaa servers**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show running-config | include radius-server host** **Example:** `Device# show running-config | include radius-server host`	Displays all the RADIUS servers that are configured in the global configuration mode.

	Command or Action	Purpose
Step 3	**show aaa servers** **Example:** `Device# show aaa servers`	Displays information about the number of requests sent to and received from authentication, authorization, and accounting (AAA) servers.

Configuration Examples for AAA-SERVER-MIB Set Operation

RADIUS Server Configuration and Server Statistics Example

The following sample output shows the RADIUS server configuration and server statistics before and after the set operation.

Before the Set Operation

```
Device# show running-config | include radius-server host

! The following line is for server 1.
radius-server host 172.19.192.238 auth-port 2095 acct-port 2096 key cisco2
! The following line is for server 2.
radius-server host 172.19.192.238 auth-port 1645 acct-port 1646
```

Server Statistics

```
Device# show aaa servers

RADIUS: id 2, priority 1, host 172.19.192.238, auth-port 2095, acct-port 2096
State: current UP, duration 25s, previous duration 0s
     Dead: total time 0s, count 7
Authen: request 8, timeouts 8
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 2
Author: request 0, timeouts 0
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 0
Account: request 0, timeouts 0
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 0
Elapsed time since counters last cleared: 5m
RADIUS: id 3, priority 2, host 172.19.192.238, auth-port 1645, acct-port 1646
State: current UP, duration 5s, previous duration 0s
     Dead: total time 0s, count 2
Authen: request 8, timeouts 8
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 4
Author: request 0, timeouts 0
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 0
Account: request 0, timeouts 0
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 0
Elapsed time since counters last cleared: 3m
```

SNMP Get Operation to Check the Configuration and Statistics of the RADIUS Servers

```
aaa-server5:/users/smetri> getmany 10.0.1.42 casConfigTable
casAddress.2.2 = 172.19.192.238
casAddress.2.3 = 172.19.192.238
casAuthenPort.2.2 = 2095
casAuthenPort.2.3 = 1645
casAcctPort.2.2 = 2096
casAcctPort.2.3 = 1646
casKey.2.2 =
casKey.2.3 =
! The following line shows priority for server 1.
casPriority.2.2 = 1
! The following line shows priority for server 2.
casPriority.2.3 = 2
casConfigRowStatus.2.2 = active(1)
casConfigRowStatus.2.3 = active(1)
aaa-server5:/users/smetri>
```

SNMP Set Operation

The key of the existing RADIUS server is being changed. The index “1” is being used. That index acts as a wildcard for addition, deletion, or modification of any entries.

```
Change the key for server 1:=>
aaa-server5:/users/smetri>  setany -v2c 10.0.1.42 public casAddress.2.1 -a 172.19.192.238
casAuthenPort.2.1 -i 2095 casAcctPort.2.1 -i 2096 casKey.2.1 -o king
casAddress.2.1 = 172.19.192.238
casAuthenPort.2.1 = 2095
casAcctPort.2.1 = 2096
casKey.2.1 = king
aaa-server5:/users/smetri>
```

After the Set Operation

After the above SNMP set operation, the configurations on the device change. The following output shows the output after the set operation.

```
Device# show running-config | include radius-server host

radius-server host 172.19.192.238 auth-port 1645 acct-port 1646
! The following line shows a change in the key value to “king.”
radius-server host 172.19.192.238 auth-port 2095 acct-port 2096 key king
```

```
Device# show aaa servers

RADIUS: id 3, priority 1, host 172.19.192.238, auth-port 1645, acct-port 1646
State: current UP, duration 189s, previous duration 0s
     Dead: total time 0s, count 2
Authen: request 8, timeouts 8
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 4
Author: request 0, timeouts 0
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 0
Account: request 0, timeouts 0
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 0
Elapsed time since counters last cleared: 6m
```

```
! The following line shows a new server with new statistics.
RADIUS: id 4, priority 2, host 172.19.192.238, auth-port 2095, acct-port 2096
State: current UP, duration 209s, previous duration 0s
     Dead: total time 0s, count 7
Authen: request 0, timeouts 0
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 0
Author: request 0, timeouts 0
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
     Transaction: success 0, failure 0
Account: request 0, timeouts 0
     Response: unexpected 0, server error 0, incorrect 0, time 0ms
```

Additional References for AAA-SERVER-MIB Set Operation

The following sections provide references related to the AAA-SERVER-MIB Set Operation feature.

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for AAA-SERVER-MIB Set Operation

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 79: Feature Information for AAA-SERVER-MIB Set Operation

Feature Name	Releases	Feature Information
AAA-SERVER-MIB Set Operation	Cisco IOS 15.2(5)E	The AAA-SERVER-MIB Set Operation feature allows the authentication, authorization, and accounting (AAA) server configuration to be extended or expanded by using the CISCO-AAA-SERVER-MIB to create and add new AAA servers, modify the “KEY” under the CISCO-AAA-SERVER-MIB, and delete the AAA server configuration. The following commands were introduced or modified: **show aaa servers, show running-config, show running-config vrf.**

CHAPTER 36

Configuring Secure Shell

The Secure Shell (SSH) feature is an application and a protocol that provides a secure replacement to the Berkeley r-tools. The protocol secures sessions using standard cryptographic mechanisms, and the application can be used similarly to the Berkeley rexec and rsh tools. Two versions of SSH are available: SSH Version 1 and SSH Version 2.

Prerequisites for Configuring Secure Shell

The following are the prerequisites for configuring the switch for secure shell (SSH):

- For SSH to work, the switch needs an Rivest, Shamir, and Adleman (RSA) public/private key pair. This is the same with Secure Copy Protocol (SCP), which relies on SSH for its secure transport.
- Before enabling SCP, you must correctly configure SSH, authentication, and authorization on the switch.
- Because SCP relies on SSH for its secure transport, the router must have an Rivest, Shamir, and Adelman (RSA) key pair.
- SCP relies on SSH for security.
- SCP requires that authentication, authorization, and accounting (AAA) authorization be configured so the router can determine whether the user has the correct privilege level.
- A user must have appropriate authorization to use SCP.
- A user who has appropriate authorization can use SCP to copy any file in the Cisco IOS File System (IFS) to and from a switch by using the **copy** command. An authorized administrator can also do this from a workstation.
- The Secure Shell (SSH) server requires an IPsec (Data Encryption Standard [DES] or 3DES) encryption software image; the SSH client requires an IPsec (DES or 3DES) encryption software image.)

- Configure a hostname and host domain for your device by using the **hostname** and **ip domain-name** commands in global configuration mode.

Restrictions for Configuring Secure Shell

The following are restrictions for configuring the Switch for secure shell.

- The switch supports Rivest, Shamir, and Adelman (RSA) authentication.
- SSH supports only the execution-shell application.
- The SSH server and the SSH client are supported only on Data Encryption Standard (DES) (56-bit) and 3DES (168-bit) data encryption software. In DES software images, DES is the only encryption algorithm available. In 3DES software images, both DES and 3DES encryption algorithms are available.
- The Switch supports the Advanced Encryption Standard (AES) encryption algorithm with a 128-bit key, 192-bit key, or 256-bit key. However, symmetric cipher AES to encrypt the keys is not supported.
- When using SCP, you cannot enter the password into the **copy** command. You must enter the password when prompted.
- The login banner is not supported in Secure Shell Version 1. It is supported in Secure Shell Version 2.
- The -l keyword and userid :{number} {ip-address} delimiter and arguments are mandatory when configuring the alternative method of Reverse SSH for console access.

Information About Configuring Secure Shell

Secure Shell (SSH) is a protocol that provides a secure, remote connection to a device. SSH provides more security for remote connections than Telnet does by providing strong encryption when a device is authenticated. This software release supports SSH Version 1 (SSHv1) and SSH Version 2 (SSHv2).

SSH and Switch Access

Secure Shell (SSH) is a protocol that provides a secure, remote connection to a device. SSH provides more security for remote connections than Telnet does by providing strong encryption when a device is authenticated. This software release supports SSH Version 1 (SSHv1) and SSH Version 2 (SSHv2).

SSH functions the same in IPv6 as in IPv4. For IPv6, SSH supports IPv6 addresses and enables secure, encrypted connections with remote IPv6 nodes over an IPv6 transport.

SSH Servers, Integrated Clients, and Supported Versions

The Secure Shell (SSH) Integrated Client feature is an application that runs over the SSH protocol to provide device authentication and encryption. The SSH client enables a Cisco device to make a secure, encrypted connection to another Cisco device or to any other device running the SSH server. This connection provides functionality similar to that of an outbound Telnet connection except that the connection is encrypted. With authentication and encryption, the SSH client allows for secure communication over an unsecured network.

The SSH server and SSH integrated client are applications that run on the switch. The SSH server works with the SSH client supported in this release and with non-Cisco SSH clients. The SSH client works with publicly and commercially available SSH servers. The SSH client supports the ciphers of Data Encryption Standard (DES), 3DES, and password authentication.

The switch supports an SSHv1 or an SSHv2 server.

The switch supports an SSHv1 client.

Note The SSH client functionality is available only when the SSH server is enabled.

User authentication is performed like that in the Telnet session to the device. SSH also supports the following user authentication methods:

- TACACS+
- RADIUS
- Local authentication and authorization

RSA Authentication Support

Rivest, Shamir, and Adleman (RSA) authentication available in Secure Shell (SSH) clients is not supported on the SSH server for Cisco software by default.

SSL Configuration Guidelines

When SSL is used in a switch cluster, the SSL session terminates at the cluster commander. Cluster member switches must run standard HTTP.

Before you configure a CA trustpoint, you should ensure that the system clock is set. If the clock is not set, the certificate is rejected due to an incorrect date.

Secure Copy Protocol Overview

The Secure Copy Protocol (SCP) feature provides a secure and authenticated method for copying switch configurations or switch image files. SCP relies on Secure Shell (SSH), an application and a protocol that provides a secure replacement for the Berkeley r-tools.

For SSH to work, the switch needs an RSA public/private key pair. This is the same with SCP, which relies on SSH for its secure transport.

Because SSH also relies on AAA authentication, and SCP relies further on AAA authorization, correct configuration is necessary.

- Before enabling SCP, you must correctly configure SSH, authentication, and authorization on the switch.
- Because SCP relies on SSH for its secure transport, the router must have an Rivest, Shamir, and Adelman (RSA) key pair.

Note When using SCP, you cannot enter the password into the copy command. You must enter the password when prompted.

Secure Copy Protocol

Isn't Secure Copy Protocol related closely enough to SSH that it could be used in this book? I have moved all of the item in this topic to prerequisites or restrictions.

The Secure Copy Protocol (SCP) feature provides a secure and authenticated method for copying switch configurations or switch image files. The behavior of SCP is similar to that of remote copy (rcp), which comes from the Berkeley r-tools suite, except that SCP relies on SSH for security. SCP also requires that authentication, authorization, and accounting (AAA) authorization be configured so the switch can determine whether the user has the correct privilege level. To configure the Secure Copy feature, you should understand the SCP concepts.

How Secure Copy Works

The behavior of Secure Copy (SCP) is similar to that of remote copy (RCP), which comes from the Berkeley r-tools suite (Berkeley university's own set of networking applications), except that SCP relies on Secure Shell (SSH) for security. In addition, SCP requires that authentication, authorization, and accounting (AAA) authorization be configured so that the device can determine whether the user has the correct privilege level.

SCP allows a user only with a privilege level of 15 to copy any file that exists in the Cisco IOS File System (IFS) to and from a device by using the **copy** command. An authorized administrator may also perform this action from a workstation.

Note Enable the SCP option while using the pscp.exe file with the Cisco software.

Reverse Telnet

Reverse telnet allows you to telnet to a certain port range and connect to terminal or auxiliary lines. Reverse telnet has often been used to connect a Cisco device that has many terminal lines to the consoles of other Cisco devices. Telnet makes it easy to reach the device console from anywhere simply by telnet to the terminal server on a specific line. This telnet approach can be used to configure a device even if all network connectivity to that device is disconnected. Reverse telnet also allows modems that are attached to Cisco devices to be used for dial-out (usually with a rotary device).

Reverse SSH

Reverse telnet can be accomplished using SSH. Unlike reverse telnet, SSH provides for secure connections. The Reverse SSH Enhancements feature provides you with a simplified method of configuring SSH. Using this feature, you no longer have to configure a separate line for every terminal or auxiliary line on which you want to enable SSH. The previous method of configuring reverse SSH limited the number of ports that can be accessed to 100. The Reverse SSH Enhancements feature removes the port number limitation.

How to Configure Secure Shell

Setting Up the Switch to Run SSH

Follow these steps to set up your Switch to run SSH:

Before you begin

Configure user authentication for local or remote access. This step is required. For more information, see Related Topics below.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **hostname** *hostname*
4. **ip domain-name** *domain_name*
5. **crypto key generate rsa**
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**hostname** *hostname* **Example:** `Switch(config)# hostname your_hostname`	Configures a hostname and IP domain name for your Switch. **Note** Follow this procedure only if you are configuring the Switch as an SSH server.
Step 4	**ip domain-name** *domain_name* **Example:**	Configures a host domain for your Switch.

	Command or Action	Purpose
	`Switch(config)# ip domain-name your_domain`	
Step 5	**crypto key generate rsa** **Example:** `Switch(config)# crypto key generate rsa`	Enables the SSH server for local and remote authentication on the Switch and generates an RSA key pair. Generating an RSA key pair for the Switch automatically enables SSH. We recommend that a minimum modulus size of 1024 bits. When you generate RSA keys, you are prompted to enter a modulus length. A longer modulus length might be more secure, but it takes longer to generate and to use. **Note** Follow this procedure only if you are configuring the Switch as an SSH server.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring the SSH Server

Follow these steps to configure the SSH server:

Note This procedure is only required if you are configuring the Switch as an SSH server.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip ssh version** [**1** | **2**]
4. **ip ssh** {**time-out** *seconds* | **authentication-retries** *number*}

5. Use one or both of the following:
    - `line vty`*line_number*[*ending_line_number*]
    - **transport input ssh**
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip ssh version** [**1** | **2**] **Example:** `Switch(config)# ip ssh version 1`	(Optional) Configures the Switch to run SSH Version 1 or SSH Version 2. • **1**—Configure the Switch to run SSH Version 1. • **2**—Configure the Switch to run SSH Version 2. If you do not enter this command or do not specify a keyword, the SSH server selects the latest SSH version supported by the SSH client. For example, if the SSH client supports SSHv1 and SSHv2, the SSH server selects SSHv2.

Step 4	**ip ssh** {**time-out** *seconds* | **authentication-retries** *number*}
	Example:
	`Switch(config)# ip ssh time-out 90`
	`OR`
	`Switch(config)# ip ssh authentication-retries 2`
		Configures the SSH control parameters:
		• **time-out** *seconds*: Specify the time-out value in seconds; the default is 120 seconds. The range is 0 to 120 seconds. This parameter applies to the SSH negotiation phase. After the connection is established, the Switch uses the default time-out values of the CLI-based sessions.
		By default, up to five simultaneous, encrypted SSH connections for multiple CLI-based sessions over the network are available (session 0 to session 4). After the execution shell starts, the CLI-based session time-out value returns to the default of 10 minutes.

	Command or Action	Purpose
		• **authentication-retries** *number*: Specify the number of times that a client can re-authenticate to the server. The default is 3; the range is 0 to 5. Repeat this step when configuring both parameters.

Step 5	Use one or both of the following:
	• `line vty`*line_number*[*ending_line_number*]
	• **transport input ssh**
	Example:
	`Switch(config)# line vty 1 10`
	or
	`Switch(config-line)# transport input ssh`
		(Optional) Configures the virtual terminal line settings.
		• Enters line configuration mode to configure the virtual terminal line settings. For *line_number* and *ending_line_number*, specify a pair of lines. The range is 0 to 15.
		• Specifies that the Switch prevent non-SSH Telnet connections. This limits the router to only SSH connections.

Step 6	**end**
	Example:
	`Switch(config-line)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Troubleshooting Tips

- If your Secure Shell (SSH) configuration commands are rejected as illegal commands, you have not successfully generated an Rivest, Shamir, and Adleman (RSA) key pair for your device. Make sure that you have specified a hostname and domain. Then use the **crypto key generate rsa** command to generate an RSA key pair and enable the SSH server.
- When configuring the RSA key pair, you might encounter the following error messages:
  - No hostname specified.

    You must configure a hostname for the device using the **hostname** global configuration command.
  - No domain specified.

You must configure a host domain for the device using the **ip domain-name** global configuration command.

- The number of allowable SSH connections is limited to the maximum number of vtys configured for the device. Each SSH connection uses a vty resource.
- SSH uses either local security or the security protocol that is configured through AAA on your device for user authentication. When configuring Authentication, Authorization, and Accounting (AAA), you must ensure that AAA is disabled on the console for user authentication. AAA authorization is disabled on the console by default. If AAA authorization is enabled on the console, disable it by configuring the **no aaa authorization console** command during the AAA configuration stage.

Configuring Reverse SSH for Console Access

To configure reverse SSH console access on the SSH server, perform the following steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line** *line-number* *ending-line-number*
4. **no exec**
5. **login authentication** *listname*
6. **transport input ssh**
7. **exit**
8. **exit**
9. **ssh -l** *userid* **:** {*number*} {*ip-address*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**line** *line-number* *ending-line-number* **Example:** `Device# line 1 3`	Identifies a line for configuration and enters line configuration mode.

	Command or Action	Purpose
Step 4	**no exec** **Example:** `Device(config-line)# no exec`	Disables EXEC processing on a line.
Step 5	**login authentication** *listname* **Example:** `Device(config-line)# login authentication default`	Defines a login authentication mechanism for the lines. **Note** The authentication method must use a username and password.
Step 6	**transport input ssh** **Example:** `Device(config-line)# transport input ssh`	Defines which protocols to use to connect to a specific line of the device. • The **ssh** keyword must be used for the Reverse SSH Enhancements feature.
Step 7	**exit** **Example:** `Device(config-line)# exit`	Exits line configuration mode.
Step 8	**exit** **Example:** `Device(config)# exit`	Exits global configuration mode.

Step 9	**ssh -l** *userid* **:** {*number*} {*ip-address*}
	Example:
	`Device# ssh -l lab:1 router.example.com`
		Specifies the user ID to use when logging in on the remote networking device that is running the SSH server.
		• *userid* --User ID.
		• **:** --Signifies that a port number and terminal IP address will follow the userid argument.
		• *number* --Terminal or auxiliary line number.
		• *ip-address* --Terminal server IP address.
		Note The *userid* argument and **:rotary**{*number*}{*ip-address*} delimiter and arguments are mandatory when configuring the alternative method of Reverse SSH for modem access.

Configuring Reverse SSH for Modem Access

In this configuration, reverse SSH is being configured on a modem used for dial-out lines. To get any of the dial-out modems, you can use any SSH client and start a SSH session as shown (in Step 10) to get to the next available modem from the rotary device.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line** *line-number* *ending-line-number*
4. **no exec**
5. **login authentication** *listname*
6. **rotary** *group*
7. **transport input ssh**
8. **exit**
9. **exit**
10. **ssh -l** *userid* **:rotary** {*number*} {*ip-address*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**line** *line-number* *ending-line-number* **Example:** `Device# line 1 200`	Identifies a line for configuration and enters line configuration mode.
Step 4	**no exec** **Example:** `Device(config-line)# no exec`	Disables EXEC processing on a line.
Step 5	**login authentication** *listname* **Example:** `Device(config-line)# login authentication default`	Defines a login authentication mechanism for the lines. **Note** The authentication method must use a username and password.
Step 6	**rotary** *group* **Example:** `Device(config-line)# rotary 1`	Defines a group of lines consisting of one or more virtual terminal lines or one auxiliary port line.
Step 7	**transport input ssh** **Example:**	Defines which protocols to use to connect to a specific line of the device.

	Command or Action	Purpose
	`Device(config-line)# transport input ssh`	• The **ssh** keyword must be used for the Reverse SSH Enhancements feature.
Step 8	**exit** **Example:** `Device(config-line)# exit`	Exits line configuration mode.
Step 9	**exit** **Example:** `Device(config)# exit`	Exits global configuration mode.

Step 10	**ssh -l** *userid* **:rotary** {*number*} {*ip-address*}
	Example:
	`Device# ssh -l lab:rotary1 router.example.com`
		Specifies the user ID to use when logging in on the remote networking device that is running the SSH server.
		• *userid* --User ID.
		• **:** --Signifies that a port number and terminal IP address will follow the *userid* argument.
		• *number* --Terminal or auxiliary line number.
		• *ip-address* --Terminal server IP address.
		Note The *userid* argument and **:rotary**{*number*}{*ip-address*} delimiter and arguments are mandatory when configuring the alternative method of Reverse SSH for modem access.

Troubleshooting Reverse SSH on the Client

To troubleshoot the reverse SSH configuration on the client (remote device), perform the following steps.

SUMMARY STEPS

1. **enable**
2. **debug ip ssh client**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**debug ip ssh client** **Example:** `Device# debug ip ssh client`	Displays debugging messages for the SSH client.

Troubleshooting Reverse SSH on the Server

To troubleshoot the reverse SSH configuration on the terminal server, perform the following steps. The steps may be configured in any order or independent of one another.

SUMMARY STEPS

1. **enable**
2. **debug ip ssh**
3. **show ssh**
4. **show line**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**debug ip ssh** **Example:** `Device# debug ip ssh`	Displays debugging messages for the SSH server.
Step 3	**show ssh** **Example:** `Device# show ssh`	Displays the status of the SSH server connections.
Step 4	**show line** **Example:** `Device# show line`	Displays parameters of a terminal line.

Monitoring the SSH Configuration and Status

This table displays the SSH server configuration and status.

Table 80: Commands for Displaying the SSH Server Configuration and Status

Command	Purpose
show ip ssh	Shows the version and configuration information for the SSH server.
show ssh	Shows the status of the SSH server.

Configuring Secure Copy

To configure a Cisco device for Secure Copy (SCP) server-side functionality, perform the following steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]
5. **aaa authorization** {**network** | **exec** | **commands** *level* | **reverse-access** | **configuration**} {**default** | *list-name*} [*method1* [*method2...*]]
6. **username** *name* [**privilege** *level*] **password** *encryption-type encrypted-password*
7. **ip scp server enable**
8. **exit**
9. **show running-config**
10. **debug ip scp**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Device(config)# aaa new-model`	Sets AAA authentication at login.

	Command or Action	Purpose
Step 4	**aaa authentication login** {**default** | *list-name*} *method1* [*method2...*] **Example:** `Device(config)# aaa authentication login default group tacacs+`	Enables the AAA access control system.
Step 5	**aaa authorization** {**network** | **exec** | **commands** *level* | **reverse-access** | **configuration**} {**default** | *list-name*} [*method1* [*method2...*]] **Example:** `Device(config)# aaa authorization exec default group tacacs+`	Sets parameters that restrict user access to a network. **Note** The **exec** keyword runs authorization to determine if the user is allowed to run an EXEC shell; therefore, you must use the **exec** keyword when you configure SCP.
Step 6	**username** *name* [**privilege** *level*] **password** *encryption-type encrypted-password* **Example:** `Device(config)# username superuser privilege 2 password 0 superpassword`	Establishes a username-based authentication system. **Note** You may omit this step if a network-based authentication mechanism, such as TACACS+ or RADIUS, has been configured.
Step 7	**ip scp server enable** **Example:** `Device(config)# ip scp server enable`	Enables SCP server-side functionality.
Step 8	**exit** **Example:** `Device(config)# exit`	Exits global configuration mode and returns to privileged EXEC mode.
Step 9	**show running-config** **Example:** `Device# show running-config`	(Optional) Displays the SCP server-side functionality.
Step 10	**debug ip scp** **Example:** `Device# debug ip scp`	(Optional) Troubleshoots SCP authentication problems.

Configuration Examples for Secure Shell

Example: Secure Copy Configuration Using Local Authentication

The following example shows how to configure the server-side functionality of Secure Copy (SCP). This example uses a locally defined username and password.

```
! AAA authentication and authorization must be configured properly in order for SCP to work.
aaa new-model
aaa authentication login default local
aaa authorization exec default local
username user1 privilege 15 password 0 lab
! SSH must be configured and functioning properly.
ip scp server enable
```

Example: SCP Server-Side Configuration Using Network-Based Authentication

The following example shows how to configure the server-side functionality of SCP using a network-based authentication mechanism:

```
! AAA authentication and authorization must be configured properly for SCP to work.
aaa new-model
aaa authentication login default group tacacs+
aaa authorization exec default group tacacs+
! SSH must be configured and functioning properly.
ip ssh time-out 120
ip ssh authentication-retries 3
ip scp server enable
```

Example Reverse SSH Console Access

The following configuration example shows that reverse SSH has been configured for console access for terminal lines 1 through 3:

Terminal Server Configuration

```
line 1 3
   no exec
   login authentication default
   transport input ssh
```

Client Configuration

The following commands configured on the SSH client will form the reverse SSH session with lines 1, 2, and 3, respectively:

```
ssh -l lab:1 router.example.com
ssh -l lab:2 router.example.com
ssh -l lab:3 router.example.com
```

Example Reverse SSH Modem Access

The following configuration example shows that dial-out lines 1 through 200 have been grouped under rotary group 1 for modem access:

```
line 1 200
   no exec
   login authentication default
   rotary 1
   transport input ssh
   exit
```

The following command shows that reverse SSH will connect to the first free line in the rotary group:

```
ssh -l lab:rotary1 router.example.com
```

Example: Monitoring the SSH Configuration and Status

To verify that the Secure Shell (SSH) server is enabled and to display the version and configuration data for your SSH connection, use the **show ip ssh** command. The following example shows that SSH is enabled:

```
Device# show ip ssh

SSH Enabled - version 1.5
Authentication timeout: 120 secs; Authentication retries: 3
```

The following example shows that SSH is disabled:

```
Device# show ip ssh

%SSH has not been enabled
```

To verify the status of your SSH server connections, use the **show ssh** command. The following example shows the SSH server connections on the device when SSH is enabled:

```
Device# show ssh

Connection      Version     Encryption State Username
 0 1.5 3DES Session Started  guest
```

The following example shows that SSH is disabled:

```
Device# show ssh

%No SSH server connections running.
```

Additional References for Secure Shell

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for Configuring Secure Shell

Release	Feature Information
Cisco IOS Release 15.2(5)E	This feature was introduced.
Cisco IOS 15.2(1)E	The Reverse SSH Enhancements feature, which is supported for SSH Version 1 and 2, provides an alternative way to configure reverse Secure Shell (SSH) so that separate lines do not need to be configured for every terminal or auxiliary line on which SSH must be enabled. This feature also eliminates the rotary-group limitation. This feature was supported on CAT4500-X, CAT4500E-SUP6E, CAT4500E-SUP6L-E, CAT4500E-SUP7E, CAT4500E-SUP7L-E. The following command was introduced: **ssh**.

CHAPTER 37

Secure Shell Version 2 Support

The Secure Shell Version 2 Support feature allows you to configure Secure Shell (SSH) Version 2. (SSH Version 1 support was implemented in an earlier Cisco software release.) SSH runs on top of a reliable transport layer and provides strong authentication and encryption capabilities. The only reliable transport that is defined for SSH is TCP. SSH provides a means to securely access and securely execute commands on another computer over a network. The Secure Copy Protocol (SCP) feature that is provided with SSH allows for the secure transfer of files.

Information About Secure Shell Version 2 Support

Secure Shell Version 2

The Secure Shell Version 2 Support feature allows you to configure SSH Version 2.

The configuration for the SSH Version 2 server is similar to the configuration for SSH Version 1. The **ip ssh version** command defines the SSH version to be configured. If you do not configure this command, SSH by default runs in compatibility mode; that is, both SSH Version 1 and SSH Version 2 connections are honored.

Note SSH Version 1 is a protocol that has never been defined in a standard. If you do not want your device to fall back to the undefined protocol (Version 1), you should use the **ip ssh version** command and specify Version 2.

The **ip ssh rsa keypair-name** command enables an SSH connection using the Rivest, Shamir, and Adleman (RSA) keys that you have configured. Previously, SSH was linked to the first RSA keys that were generated (that is, SSH was enabled when the first RSA key pair was generated). This behavior still exists, but by using the **ip ssh rsa keypair-name** command, you can overcome this behavior. If you configure the **ip ssh rsa keypair-name** command with a key pair name, SSH is enabled if the key pair exists or SSH will be enabled if the key pair is generated later. If you use this command to enable SSH, you are not forced to configure a hostname and a domain name, which was required in SSH Version 1 of the Cisco software.

Note The login banner is supported in SSH Version 2, but it is not supported in Secure Shell Version 1.

Secure Shell Version 2 Enhancements for RSA Keys

Cisco SSH Version 2 supports keyboard-interactive and password-based authentication methods. The SSH Version 2 Enhancements for RSA Keys feature also supports RSA-based public key authentication for the client and the server.

User authentication—RSA-based user authentication uses a private/public key pair associated with each user for authentication. The user must generate a private/public key pair on the client and configure a public key on the Cisco SSH server to complete the authentication.

An SSH user trying to establish credentials provides an encrypted signature using the private key. The signature and the user's public key are sent to the SSH server for authentication. The SSH server computes a hash over the public key provided by the user. The hash is used to determine if the server has a matching entry. If a match is found, an RSA-based message verification is performed using the public key. Hence, the user is authenticated or denied access based on the encrypted signature.

Server authentication—While establishing an SSH session, the Cisco SSH client authenticates the SSH server by using the server host keys available during the key exchange phase. SSH server keys are used to identify the SSH server. These keys are created at the time of enabling SSH and must be configured on the client.

For server authentication, the Cisco SSH client must assign a host key for each server. When the client tries to establish an SSH session with a server, the client receives the signature of the server as part of the key exchange message. If the strict host key checking flag is enabled on the client, the client checks if it has the host key entry corresponding to the server. If a match is found, the client tries to validate the signature by using the server host key. If the server is successfully authenticated, the session establishment continues; otherwise, it is terminated and displays a "Server Authentication Failed" message.

Note Storing public keys on a server uses memory; therefore, the number of public keys configurable on an SSH server is restricted to ten users, with a maximum of two public keys per user.

Note RSA-based user authentication is supported by the Cisco server, but Cisco clients cannot propose public key as an authentication method. If the Cisco server receives a request from an open SSH client for RSA-based authentication, the server accepts the authentication request.

Note For server authentication, configure the RSA public key of the server manually and configure the **ip ssh stricthostkeycheck** command on the Cisco SSH client.

SNMP Trap Generation

Depending on your release, Simple Network Management Protocol (SNMP) traps are generated automatically when an SSH session terminates if the traps have been enabled and SNMP debugging has been enabled. For information about enabling SNMP traps, see the “Configuring SNMP Support” module in the *SNMP Configuration Guide*.

Note When you configure the **snmp-server host** command, the IP address must be the address of the PC that has the SSH (telnet) client and that has IP connectivity to the SSH server.

You must also enable SNMP debugging using the **debug snmp packet** command to display the traps. The trap information includes information such as the number of bytes sent and the protocol that was used for the SSH session.

The following example shows that an SNMP trap is set. The trap notification is generated automatically when the SSH session terminates. In the example, a.b.c.d is the IP address of the SSH client.

```
snmp-server
snmp-server host a.b.c.d public tty
```

The following is sample output from the **debug snmp packet** command. The output provides SNMP trap information for an SSH session.

```
Switch# debug snmp packet

SNMP packet debugging is on
Device1# ssh -l lab 10.0.0.2
Password:

Switch# exit

[Connection to 10.0.0.2 closed by foreign host]
Device1#
*Jul 18 10:18:42.619: SNMP: Queuing packet to 10.0.0.2
*Jul 18 10:18:42.619: SNMP: V1 Trap, ent cisco, addr 10.0.0.1, gentrap 6, spectrap 1
local.9.3.1.1.2.1 = 6
tcpConnEntry.1.10.0.0.1.22.10.0.0.2.55246 = 4
ltcpConnEntry.5.10.0.0.1.22.10.0.0.2.55246 = 1015
ltcpConnEntry.1.10.0.0.1.22.10.0.0.2.55246 = 1056
ltcpConnEntry.2.10.0.0.1.22.10.0.0.2.55246 = 1392
local.9.2.1.18.2 = lab
*Jul 18 10:18:42.879: SNMP: Packet sent via UDP to 10.0.0.2

Switch#
```

SSH Keyboard Interactive Authentication

The SSH Keyboard Interactive Authentication feature, also known as Generic Message Authentication for SSH, is a method that can be used to implement different types of authentication mechanisms. Basically, any currently supported authentication method that requires only user input can be performed with this feature. The feature is automatically enabled.

The following methods are supported:

- Password

- SecurID and hardware tokens printing a number or a string in response to a challenge sent by the server
- Pluggable Authentication Module (PAM)
- S/KEY (and other One-Time-Pads)

How to Configure Secure Shell Version 2 Support

Configuring a Device for SSH Version 2 Using a Hostname and Domain Name

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **hostname** *name*
4. **ip domain-name** *name*
5. **crypto key generate rsa**
6. **ip ssh** [**time-out** *seconds* | **authentication-retries** *integer*]
7. **ip ssh version** [**1** | **2**]
8. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**hostname** *name* **Example:** `Device(config)# hostname cisco7200`	Configures a hostname for your device.
Step 4	**ip domain-name** *name* **Example:** `cisco7200(config)# ip domain-name example.com`	Configures a domain name for your device.
Step 5	**crypto key generate rsa** **Example:**	Enables the SSH server for local and remote authentication.

	Command or Action	Purpose
	`cisco7200(config)# crypto key generate rsa`	
Step 6	**ip ssh** [**time-out** *seconds* | **authentication-retries** *integer*] **Example:** `cisco7200(config)# ip ssh time-out 120`	(Optional) Configures SSH control variables on your device.
Step 7	**ip ssh version** [**1** | **2**] **Example:** `cisco7200(config)# ip ssh version 1`	(Optional) Specifies the version of SSH to be run on your device.
Step 8	**exit** **Example:** `cisco7200(config)# exit`	Exits global configuration mode and enters privileged EXEC mode. • Use **no hostname** command to return to the default host.

Configuring a Device for SSH Version 2 Using RSA Key Pairs

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip ssh rsa keypair-name** *keypair-name*
4. **crypto key generate rsa usage-keys label** *key-label* **modulus** *modulus-size*
5. **ip ssh** [**time-out** *seconds* | **authentication-retries** *integer*]
6. **ip ssh version 2**
7. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip ssh rsa keypair-name** *keypair-name* **Example:**	Specifies the RSA key pair to be used for SSH. **Note** A Cisco device can have many RSA key pairs.

	Command or Action	Purpose
	`Device(config)# ip ssh rsa keypair-name sshkeys`	
Step 4	**crypto key generate rsa usage-keys label** *key-label* **modulus** *modulus-size* **Example:** `Device(config)# crypto key generate rsa usage-keys label sshkeys modulus 768`	Enables the SSH server for local and remote authentication on the device. • For SSH Version 2, the modulus size must be at least 768 bits. **Note** To delete the RSA key pair, use the **crypto key zeroize rsa** command. When you delete the RSA key pair, you automatically disable the SSH server.
Step 5	**ip ssh** [**time-out** *seconds* | **authentication-retries** *integer*] **Example:** `Device(config)# ip ssh time-out 12`	Configures SSH control variables on your device.
Step 6	**ip ssh version 2** **Example:** `Device(config)# ip ssh version 2`	Specifies the version of SSH to be run on the device.
Step 7	**exit** **Example:** `Device(config)# exit`	Exits global configuration mode and enters privileged EXEC mode.

Configuring the Cisco SSH Server to Perform RSA-Based User Authentication

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **hostname** *name*
4. **ip domain-name** *name*
5. **crypto key generate rsa**
6. **ip ssh pubkey-chain**
7. **username** *username*
8. **key-string**
9. **key-hash** *key-type key-name*
10. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**hostname** *name* **Example:** `Device(config)# hostname host1`	Specifies the hostname.
Step 4	**ip domain-name** *name* **Example:** `host1(config)# ip domain-name name1`	Defines a default domain name that the Cisco software uses to complete unqualified hostnames.
Step 5	**crypto key generate rsa** **Example:** `host1(config)# crypto key generate rsa`	Generates RSA key pairs.
Step 6	**ip ssh pubkey-chain** **Example:** `host1(config)# ip ssh pubkey-chain`	Configures SSH-RSA keys for user and server authentication on the SSH server and enters public-key configuration mode. • The user authentication is successful if the RSA public key stored on the server is verified with the public or the private key pair stored on the client.
Step 7	**username** *username* **Example:** `host1(conf-ssh-pubkey)# username user1`	Configures the SSH username and enters public-key user configuration mode.
Step 8	**key-string** **Example:** `host1(conf-ssh-pubkey-user)# key-string`	Specifies the RSA public key of the remote peer and enters public-key data configuration mode. **Note** You can obtain the public key value from an open SSH client; that is, from the .ssh/id_rsa.pub file.
Step 9	**key-hash** *key-type* *key-name*	(Optional) Specifies the SSH key type and version.

	Command or Action	Purpose
	Example: `host1(conf-ssh-pubkey-data)# key-hash ssh-rsa key1`	• The key type must be ssh-rsa for the configuration of private public key pairs. • This step is optional only if the **key-string** command is configured. • You must configure either the **key-string** command or the **key-hash** command. **Note** You can use a hashing software to compute the hash of the public key string, or you can also copy the hash value from another Cisco device. Entering the public key data using the **key-string** command is the preferred way to enter the public key data for the first time.

Step 10	**end**
	Example:
	`host1(conf-ssh-pubkey-data)# end`
		Exits public-key data configuration mode and returns to privileged EXEC mode.
		• Use **no hostname** command to return to the default host.

Configuring the Cisco IOS SSH Client to Perform RSA-Based Server Authentication

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **hostname** *name*
4. **ip domain-name** *name*
5. **crypto key generate rsa**
6. **ip ssh pubkey-chain**
7. **server** *server-name*
8. **key-string**
9. **exit**
10. **key-hash** *key-type key-name*
11. **end**
12. **configure terminal**
13. **ip ssh stricthostkeycheck**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Device> enable`	• Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**hostname** *name* **Example:** `Device(config)# hostname host1`	Specifies the hostname.
Step 4	**ip domain-name** *name* **Example:** `host1(config)# ip domain-name name1`	Defines a default domain name that the Cisco software uses to complete unqualified hostnames.
Step 5	**crypto key generate rsa** **Example:** `host1(config)# crypto key generate rsa`	Generates RSA key pairs.
Step 6	**ip ssh pubkey-chain** **Example:** `host1(config)# ip ssh pubkey-chain`	Configures SSH-RSA keys for user and server authentication on the SSH server and enters public-key configuration mode.
Step 7	**server** *server-name* **Example:** `host1(conf-ssh-pubkey)# server server1`	Enables the SSH server for public-key authentication on the device and enters public-key server configuration mode.
Step 8	**key-string** **Example:** `host1(conf-ssh-pubkey-server)# key-string`	Specifies the RSA public-key of the remote peer and enters public key data configuration mode. **Note** You can obtain the public key value from an open SSH client; that is, from the .ssh/id_rsa.pub file.
Step 9	**exit** **Example:** `host1(conf-ssh-pubkey-data)# exit`	Exits public-key data configuration mode and enters public-key server configuration mode.
Step 10	**key-hash** *key-type* *key-name* **Example:**	(Optional) Specifies the SSH key type and version.

	Command or Action	Purpose
	`host1(conf-ssh-pubkey-server)# key-hash ssh-rsa key1`	• The key type must be ssh-rsa for the configuration of private/public key pairs. • This step is optional only if the **key-string** command is configured. • You must configure either the **key-string** command or the **key-hash** command. **Note** You can use a hashing software to compute the hash of the public key string, or you can copy the hash value from another Cisco device. Entering the public key data using the **key-string** command is the preferred way to enter the public key data for the first time.

Step 11	**end**
	Example:
	`host1(conf-ssh-pubkey-server)# end`
		Exits public-key server configuration mode and returns to privileged EXEC mode.

Step 12	**configure terminal** **Example:** `host1# configure terminal`	Enters global configuration mode.
Step 13	**ip ssh stricthostkeycheck** **Example:** `host1(config)# ip ssh stricthostkeycheck`	Ensures that server authentication takes place. • The connection is terminated in case of a failure. • Use **no hostname** command to return to the default host.

Starting an Encrypted Session with a Remote Device

Note The device with which you want to connect must support a Secure Shell (SSH) server that has an encryption algorithm that is supported in Cisco software. Also, you need not enable your device. SSH can be run in disabled mode.

SUMMARY STEPS

1. **ssh** [**-v** {**1** | **2**} | **-c** {**aes128-ctr** | **aes192-ctr** | **aes256-ctr** | **aes128-cbc** | **3des** | **aes192-cbc** | **aes256-cbc**} | **-l** *user-id* | **-l** *user-id***:***vrf-name number ip-address ip-address* | **-l** *user-id***:***rotary number ip-address* | **-m** {**hmac-md5-128** | **hmac-md5-96** | **hmac-sha1-160** | **hmac-sha1-96**} | **-o numberofpasswordprompts** *n* | **-p** *port-num*] {*ip-addr* | *hostname*} [**command** | **-vrf**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**ssh** [**-v** {**1** | **2**} | **-c** {**aes128-ctr** | **aes192-ctr** | **aes256-ctr** | **aes128-cbc** | **3des** | **aes192-cbc** | **aes256-cbc**} | **-l** *user-id* | **-l** *user-id***:***vrf-name number ip-address ip-address* | **-l** *user-id***:***rotary number ip-address* | **-m** {**hmac-md5-128** | **hmac-md5-96** | **hmac-sha1-160** | **hmac-sha1-96**} | **-o numberofpasswordprompts** *n* | **-p** *port-num*] {*ip-addr* | *hostname*} [**command** | **-vrf**] **Example:** `Device# ssh -v 2 -c aes256-ctr -m hmac-sha1-96 -l user2 10.76.82.24`	Starts an encrypted session with a remote networking device.

Enabling Secure Copy Protocol on the SSH Server

Note The following task configures the server-side functionality for SCP. This task shows a typical configuration that allows the device to securely copy files from a remote workstation.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa authentication login default local**
5. **aaa authorization exec defaultlocal**
6. **username***name* **privilege** *privilege-level* **password** *password*
7. **ip ssh time-out***seconds*
8. **ip ssh authentication-retries** *integer*
9. **ip scpserverenable**
10. **exit**
11. **debug ip scp**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Device# configure terminal`	
Step 3	**aaa new-model** **Example:** `Device(config)# aaa new-model`	Enables the AAA access control model.
Step 4	**aaa authentication login default local** **Example:** `Device(config)# aaa authentication login default local`	Sets AAA authentication at login to use the local username database for authentication.
Step 5	**aaa authorization exec defaultlocal** **Example:** `Device(config)# aaa authorization exec default local`	Sets the parameters that restrict user access to a network, runs the authorization to determine if the user ID is allowed to run an EXEC shell, and specifies that the system must use the local database for authorization.
Step 6	**username***name* **privilege** *privilege-level* **password** *password* **Example:** `Device(config)# username samplename privilege 15 password password1`	Establishes a username-based authentication system, and specifies the username, privilege level, and an unencrypted password. **Note** The minimum value for the *privilege-level* argument is 15. A privilege level of less than 15 results in the connection closing.
Step 7	**ip ssh time-out***seconds* **Example:** `Device(config)# ip ssh time-out 120`	Sets the time interval (in seconds) that the device waits for the SSH client to respond.
Step 8	**ip ssh authentication-retries** *integer* **Example:** `Device(config)# ip ssh authentication-retries 3`	Sets the number of authentication attempts after which the interface is reset.
Step 9	**ip scpserverenable** **Example:** `Device(config)# ip scp server enable`	Enables the device to securely copy files from a remote workstation.
Step 10	**exit** **Example:** `Device(config)# exit`	Exits global configuration mode and returns to privileged EXEC mode.

	Command or Action	Purpose
Step 11	**debug ip scp** **Example:** `Device# debug ip scp`	(Optional) Provides diagnostic information about SCP authentication problems.

Verifying the Status of the Secure Shell Connection

SUMMARY STEPS

1. **enable**
2. **show ssh**
3. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ssh** **Example:** `Device# show ssh`	Displays the status of SSH server connections.
Step 3	**exit** **Example:** `Device# exit`	Exits privileged EXEC mode and returns to user EXEC mode.

Examples

The following sample output from the **show ssh** command displays status of various SSH Version 1 and Version 2 connections for Version 1 and Version 2 connections:

```
-----------------------------------------------------------------------
Device# show ssh

Connection      Version Encryption      State                   Username
 0              1.5     3DES            Session started         lab
Connection Version Mode Encryption  Hmac                State
Username
1          2.0     IN   aes128-cbc  hmac-md5     Session started       lab
1          2.0     OUT  aes128-cbc  hmac-md5     Session started       lab
-------------------------------------------------------------------------
```

The following sample output from the **show ssh** command displays status of various SSH Version 1 and Version 2 connections for a Version 2 connection with no Version 1 connection:

```
-------------------------------------------------------------------------
Device# show ssh

Connection Version Mode Encryption  Hmac               State
Username
1          2.0     IN   aes128-cbc  hmac-md5     Session started       lab
1          2.0     OUT  aes128-cbc  hmac-md5     Session started       lab
%No SSHv1 server connections running.
-------------------------------------------------------------------------
```

The following sample output from the **show ssh** command displays status of various SSH Version 1 and Version 2 connections for a Version 1 connection with no Version 2 connection:

```
-------------------------------------------------------------------------
Device# show ssh

Connection      Version Encryption      State                   Username
 0              1.5     3DES            Session started         lab
%No SSHv2 server connections running.
-------------------------------------------------------------------------
```

Verifying the Secure Shell Status

SUMMARY STEPS

1. **enable**
2. **show ip ssh**
3. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show ip ssh** **Example:** `Device# show ip ssh`	Displays the version and configuration data for SSH.
Step 3	**exit** **Example:** `Device# exit`	Exits privileged EXEC mode and returns to user EXEC mode.

Examples

The following sample output from the **show ip ssh** command displays the version of SSH that is enabled, the authentication timeout values, and the number of authentication retries for Version 1 and Version 2 connections:

```
-----------------------------------------------------------------------
Device# show ip ssh

SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
-----------------------------------------------------------------------
```

The following sample output from the **show ip ssh** command displays the version of SSH that is enabled, the authentication timeout values, and the number of authentication retries for a Version 2 connection with no Version 1 connection:

```
------------------------------------------------------------------------
Device# show ip ssh

SSH Enabled - version 2.0
Authentication timeout: 120 secs; Authentication retries: 3
------------------------------------------------------------------------
```

The following sample output from the **show ip ssh** command displays the version of SSH that is enabled, the authentication timeout values, and the number of authentication retries for a Version 1 connection with no Version 2 connection:

```
------------------------------------------------------------------------
Device# show ip ssh

3d06h: %SYS-5-CONFIG_I: Configured from console by console
SSH Enabled - version 1.5
Authentication timeout: 120 secs; Authentication retries: 3
------------------------------------------------------------------------
```

Monitoring and Maintaining Secure Shell Version 2

SUMMARY STEPS

1. **enable**
2. **debug ip ssh**
3. **debug snmp packet**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**debug ip ssh** **Example:** `Device# debug ip ssh`	Enables debugging of SSH.
Step 3	**debug snmp packet** **Example:** `Device# debug snmp packet`	Enables debugging of every SNMP packet sent or received by the device.

Example

The following sample output from the **debug ip ssh** command shows the connection is an SSH Version 2 connection:

```
Device# debug ip ssh

00:33:55: SSH1: starting SSH control process
00:33:55: SSH1: sent protocol version id SSH-1.99-Cisco-1.25
00:33:55: SSH1: protocol version id is - SSH-2.0-OpenSSH_2.5.2p2
00:33:55: SSH2 1: send: len 280 (includes padlen 4)
00:33:55: SSH2 1: SSH2_MSG_KEXINIT sent
00:33:55: SSH2 1: ssh_receive: 536 bytes received
00:33:55: SSH2 1: input: packet len 632
00:33:55: SSH2 1: partial packet 8, need 624, maclen 0
00:33:55: SSH2 1: ssh_receive: 96 bytes received
00:33:55: SSH2 1: partial packet 8, need 624, maclen 0
00:33:55: SSH2 1: input: padlen 11
00:33:55: SSH2 1: received packet type 20
00:33:55: SSH2 1: SSH2_MSG_KEXINIT received
00:33:55: SSH2: kex: client->server aes128-cbc hmac-md5 none
00:33:55: SSH2: kex: server->client aes128-cbc hmac-md5 none
00:33:55: SSH2 1: expecting SSH2_MSG_KEXDH_INIT
00:33:55: SSH2 1: ssh_receive: 144 bytes received
00:33:55: SSH2 1: input: packet len 144
00:33:55: SSH2 1: partial packet 8, need 136, maclen 0
00:33:55: SSH2 1: input: padlen 5
00:33:55: SSH2 1: received packet type 30
00:33:55: SSH2 1: SSH2_MSG_KEXDH_INIT received
00:33:55: SSH2 1: signature length 111
00:33:55: SSH2 1: send: len 384 (includes padlen 7)
00:33:55: SSH2: kex_derive_keys complete
00:33:55: SSH2 1: send: len 16 (includes padlen 10)
00:33:55: SSH2 1: newkeys: mode 1
00:33:55: SSH2 1: SSH2_MSG_NEWKEYS sent
00:33:55: SSH2 1: waiting for SSH2_MSG_NEWKEYS
00:33:55: SSH2 1: ssh_receive: 16 bytes received
00:33:55: SSH2 1: input: packet len 16
00:33:55: SSH2 1: partial packet 8, need 8, maclen 0
00:33:55: SSH2 1: input: padlen 10
00:33:55: SSH2 1: newkeys: mode 0
00:33:55: SSH2 1: received packet type 2100:33:55: SSH2 1: SSH2_MSG_NEWKEYS received
00:33:56: SSH2 1: ssh_receive: 48 bytes received
00:33:56: SSH2 1: input: packet len 32
00:33:56: SSH2 1: partial packet 16, need 16, maclen 16
```

```
00:33:56: SSH2 1: MAC #3 ok
00:33:56: SSH2 1: input: padlen 10
00:33:56: SSH2 1: received packet type 5
00:33:56: SSH2 1: send: len 32 (includes padlen 10)
00:33:56: SSH2 1: done calc MAC out #3
00:33:56: SSH2 1: ssh_receive: 64 bytes received
00:33:56: SSH2 1: input: packet len 48
00:33:56: SSH2 1: partial packet 16, need 32, maclen 16
00:33:56: SSH2 1: MAC #4 ok
00:33:56: SSH2 1: input: padlen 9
00:33:56: SSH2 1: received packet type 50
00:33:56: SSH2 1: send: len 32 (includes padlen 13)
00:33:56: SSH2 1: done calc MAC out #4
00:34:04: SSH2 1: ssh_receive: 160 bytes received
00:34:04: SSH2 1: input: packet len 64
00:34:04: SSH2 1: partial packet 16, need 48, maclen 16
00:34:04: SSH2 1: MAC #5 ok
00:34:04: SSH2 1: input: padlen 13
00:34:04: SSH2 1: received packet type 50
00:34:04: SSH2 1: send: len 16 (includes padlen 10)
00:34:04: SSH2 1: done calc MAC out #5
00:34:04: SSH2 1: authentication successful for lab
00:34:04: SSH2 1: input: packet len 64
00:34:04: SSH2 1: partial packet 16, need 48, maclen 16
00:34:04: SSH2 1: MAC #6 ok
00:34:04: SSH2 1: input: padlen 6
00:34:04: SSH2 1: received packet type 2
00:34:04: SSH2 1: ssh_receive: 64 bytes received
00:34:04: SSH2 1: input: packet len 48
00:34:04: SSH2 1: partial packet 16, need 32, maclen 16
00:34:04: SSH2 1: MAC #7 ok
00:34:04: SSH2 1: input: padlen 19
00:34:04: SSH2 1: received packet type 90
00:34:04: SSH2 1: channel open request
00:34:04: SSH2 1: send: len 32 (includes padlen 10)
00:34:04: SSH2 1: done calc MAC out #6
00:34:04: SSH2 1: ssh_receive: 192 bytes received
00:34:04: SSH2 1: input: packet len 64
00:34:04: SSH2 1: partial packet 16, need 48, maclen 16
00:34:04: SSH2 1: MAC #8 ok
00:34:04: SSH2 1: input: padlen 13
00:34:04: SSH2 1: received packet type 98
00:34:04: SSH2 1: pty-req request
00:34:04: SSH2 1: setting TTY - requested: height 24, width 80; set: height 24,
width 80
00:34:04: SSH2 1: input: packet len 96
00:34:04: SSH2 1: partial packet 16, need 80, maclen 16
00:34:04: SSH2 1: MAC #9 ok
00:34:04: SSH2 1: input: padlen 11
00:34:04: SSH2 1: received packet type 98
00:34:04: SSH2 1: x11-req request
00:34:04: SSH2 1: ssh_receive: 48 bytes received
00:34:04: SSH2 1: input: packet len 32
00:34:04: SSH2 1: partial packet 16, need 16, maclen 16
00:34:04: SSH2 1: MAC #10 ok
00:34:04: SSH2 1: input: padlen 12
00:34:04: SSH2 1: received packet type 98
00:34:04: SSH2 1: shell request
00:34:04: SSH2 1: shell message received
00:34:04: SSH2 1: starting shell for vty
00:34:04: SSH2 1: send: len 48 (includes padlen 18)
00:34:04: SSH2 1: done calc MAC out #7
00:34:07: SSH2 1: ssh_receive: 48 bytes received
00:34:07: SSH2 1: input: packet len 32
```

```
00:34:07: SSH2 1: partial packet 16, need 16, maclen 16
00:34:07: SSH2 1: MAC #11 ok
00:34:07: SSH2 1: input: padlen 17
00:34:07: SSH2 1: received packet type 94
00:34:07: SSH2 1: send: len 32 (includes padlen 17)
00:34:07: SSH2 1: done calc MAC out #8
00:34:07: SSH2 1: ssh_receive: 48 bytes received
00:34:07: SSH2 1: input: packet len 32
00:34:07: SSH2 1: partial packet 16, need 16, maclen 16
00:34:07: SSH2 1: MAC #12 ok
00:34:07: SSH2 1: input: padlen 17
00:34:07: SSH2 1: received packet type 94
00:34:07: SSH2 1: send: len 32 (includes padlen 17)
00:34:07: SSH2 1: done calc MAC out #9
00:34:07: SSH2 1: ssh_receive: 48 bytes received
00:34:07: SSH2 1: input: packet len 32
00:34:07: SSH2 1: partial packet 16, need 16, maclen 16
00:34:07: SSH2 1: MAC #13 ok
00:34:07: SSH2 1: input: padlen 17
00:34:07: SSH2 1: received packet type 94
00:34:07: SSH2 1: send: len 32 (includes padlen 17)
00:34:07: SSH2 1: done calc MAC out #10
00:34:08: SSH2 1: ssh_receive: 48 bytes received
00:34:08: SSH2 1: input: packet len 32
00:34:08: SSH2 1: partial packet 16, need 16, maclen 16
00:34:08: SSH2 1: MAC #14 ok
00:34:08: SSH2 1: input: padlen 17
00:34:08: SSH2 1: received packet type 94
00:34:08: SSH2 1: send: len 32 (includes padlen 17)
00:34:08: SSH2 1: done calc MAC out #11
00:34:08: SSH2 1: ssh_receive: 48 bytes received
00:34:08: SSH2 1: input: packet len 32
00:34:08: SSH2 1: partial packet 16, need 16, maclen 16
00:34:08: SSH2 1: MAC #15 ok
00:34:08: SSH2 1: input: padlen 17
00:34:08: SSH2 1: received packet type 94
00:34:08: SSH2 1: send: len 32 (includes padlen 16)
00:34:08: SSH2 1: done calc MAC out #12
00:34:08: SSH2 1: send: len 48 (includes padlen 18)
00:34:08: SSH2 1: done calc MAC out #13
00:34:08: SSH2 1: send: len 16 (includes padlen 6)
00:34:08: SSH2 1: done calc MAC out #14
00:34:08: SSH2 1: send: len 16 (includes padlen 6)
00:34:08: SSH2 1: done calc MAC out #15
00:34:08: SSH1: Session terminated normally
```

Configuration Examples for Secure Shell Version 2 Support

Example: Configuring Secure Shell Version 2

```
Device# configure terminal
Device(config)# ip ssh version 2
```

Example: Starting an Encrypted Session with a Remote Device

```
Device# ssh -v 2 -c aes256-cbc -m hmac-sha1-160 -l shaship 10.76.82.24
```

Example: Configuring Server-Side SCP

The following example shows how to configure the server-side functionality for SCP. This example also configures AAA authentication and authorization on the device. This example uses a locally defined username and password.

```
Device# configure terminal
Device(config)# aaa new-model
Device(config)# aaa authentication login default local
Device(config)# aaa authorization exec default local
Device(config)# username samplename privilege 15 password password1
Device(config)# ip ssh time-out 120
Device(config)# ip ssh authentication-retries 3
Device(config)# ip scp server enable
```

Example: Setting an SNMP Trap

The following example shows that an SNMP trap is set. The trap notification is generated automatically when the SSH session terminates. In the example, a.b.c.d is the IP address of the SSH client.

```
snmp-server
snmp-server host a.b.c.d public tty
```

The following is sample output from the **debug snmp packet** command. The output provides SNMP trap information for an SSH session.

```
Device1# debug snmp packet

SNMP packet debugging is on
Device1# ssh -l lab 10.0.0.2
Password:

Device2# exit

[Connection to 10.0.0.2 closed by foreign host]
Device1#
*Jul 18 10:18:42.619: SNMP: Queuing packet to 10.0.0.2
*Jul 18 10:18:42.619: SNMP: V1 Trap, ent cisco, addr 10.0.0.1, gentrap 6, spectrap 1
local.9.3.1.1.2.1 = 6
tcpConnEntry.1.10.0.0.1.22.10.0.0.2.55246 = 4
ltcpConnEntry.5.10.0.0.1.22.10.0.0.2.55246 = 1015
ltcpConnEntry.1.10.0.0.1.22.10.0.0.2.55246 = 1056
ltcpConnEntry.2.10.0.0.1.22.10.0.0.2.55246 = 1392
local.9.2.1.18.2 = lab
*Jul 18 10:18:42.879: SNMP: Packet sent via UDP to 10.0.0.2

Device1#
```

Examples: SSH Keyboard Interactive Authentication

Example: Enabling Client-Side Debugs

The following example shows that the client-side debugs are turned on, and the maximum number of prompts is six (three for the SSH keyboard interactive authentication method and three for the password authentication method).

```
Password:
Password:
Password:
Password:
Password:
Password: cisco123
Last login: Tue Dec 6 13:15:21 2005 from 10.76.248.213
user1@courier:~> exit
logout
[Connection to 10.76.248.200 closed by foreign host]
Device1# debug ip ssh client

SSH Client debugging is on

Device1# ssh -l lab 10.1.1.3

Password:
*Nov 17 12:50:53.199: SSH0: sent protocol version id SSH-1.99-Cisco-1.25
*Nov 17 12:50:53.199: SSH CLIENT0: protocol version id is - SSH-1.99-Cisco-1.25
*Nov 17 12:50:53.199: SSH CLIENT0: sent protocol version id SSH-1.99-Cisco-1.25
*Nov 17 12:50:53.199: SSH CLIENT0: protocol version exchange successful
*Nov 17 12:50:53.203: SSH0: protocol version id is - SSH-1.99-Cisco-1.25
*Nov 17 12:50:53.335: SSH CLIENT0: key exchange successful and encryption on
*Nov 17 12:50:53.335: SSH2 CLIENT 0: using method keyboard-interactive
Password:
Password:
Password:
*Nov 17 12:51:01.887: SSH2 CLIENT 0: using method password authentication
Password:
Password: lab
Device2>

*Nov 17 12:51:11.407: SSH2 CLIENT 0: SSH2_MSG_USERAUTH_SUCCESS message received
*Nov 17 12:51:11.407: SSH CLIENT0: user authenticated
*Nov 17 12:51:11.407: SSH2 CLIENT 0: pty-req request sent
*Nov 17 12:51:11.411: SSH2 CLIENT 0: shell request sent
*Nov 17 12:51:11.411: SSH CLIENT0: session open
```

Example: Enabling ChPass with a Blank Password Change

In the following example, the ChPass feature is enabled, and a blank password change is accomplished using the SSH Keyboard Interactive Authentication method. A TACACS+ access control server (ACS) is used as the back-end AAA server.

```
Device1# ssh -l cisco 10.1.1.3

Password:
Old Password: cisco
New Password: cisco123
Re-enter New password: cisco123
```

```
Device2> exit

[Connection to 10.1.1.3 closed by foreign host]
```

Example: Enabling ChPass and Changing the Password on First Login

In the following example, the ChPass feature is enabled and TACACS+ ACS is used as the back-end server. The password is changed on the first login using the SSH keyboard interactive authentication method.

```
Device1# ssh -l cisco 10.1.1.3

Password: cisco
Your password has expired.
Enter a new one now.
New Password: cisco123
Re-enter New password: cisco123

Device2> exit

[Connection to 10.1.1.3 closed by foreign host]

Device1# ssh -l cisco 10.1.1.3

Password:cisco1
Your password has expired.
Enter a new one now.
New Password: cisco
Re-enter New password: cisco12
The New and Re-entered passwords have to be the same.
Try again.
New Password: cisco
Re-enter New password: cisco

Device2>
```

Example: Enabling ChPass and Expiring the Password After Three Logins

In the following example, the ChPass feature is enabled and TACACS+ ACS is used as the back-end AAA server. The password expires after three logins using the SSH keyboard interactive authentication method.

```
Device# ssh -l cisco. 10.1.1.3

Password: cisco

Device2> exit

[Connection to 10.1.1.3 closed by foreign host]

Device1# ssh -l cisco 10.1.1.3

Password: cisco

Device2> exit

Device1# ssh -l cisco 10.1.1.3

Password: cisco

Device2> exit
```

```
[Connection to 10.1.1.3 closed by foreign host]

Device1# ssh -l cisco 10.1.1.3

Password: cisco
Your password has expired.
Enter a new one now.
New Password: cisco123
Re-enter New password: cisco123

Device2>
```

Example: SNMP Debugging

The following is sample output from the **debug snmp packet** command. The output provides SNMP trap information for an SSH session.

```
Device1# debug snmp packet

SNMP packet debugging is on
Device1# ssh -l lab 10.0.0.2
Password:

Device2# exit

[Connection to 10.0.0.2 closed by foreign host]
Device1#
*Jul 18 10:18:42.619: SNMP: Queuing packet to 10.0.0.2
*Jul 18 10:18:42.619: SNMP: V1 Trap, ent cisco, addr 10.0.0.1, gentrap 6, spectrap 1
local.9.3.1.1.2.1 = 6
tcpConnEntry.1.10.0.0.1.22.10.0.0.2.55246 = 4
ltcpConnEntry.5.10.0.0.1.22.10.0.0.2.55246 = 1015
ltcpConnEntry.1.10.0.0.1.22.10.0.0.2.55246 = 1056
ltcpConnEntry.2.10.0.0.1.22.10.0.0.2.55246 = 1392
local.9.2.1.18.2 = lab
*Jul 18 10:18:42.879: SNMP: Packet sent via UDP to 10.0.0.2

Device1#
```

Examples: SSH Debugging Enhancements

The following is sample output from the **debug ip ssh detail** command. The output provides debugging information about the SSH protocol and channel requests.

```
Device# debug ip ssh detail

00:04:22: SSH0: starting SSH control process
00:04:22: SSH0: sent protocol version id SSH-1.99-Cisco-1.25
00:04:22: SSH0: protocol version id is - SSH-1.99-Cisco-1.25
00:04:22: SSH2 0: SSH2_MSG_KEXINIT sent
00:04:22: SSH2 0: SSH2_MSG_KEXINIT received
00:04:22: SSH2:kex: client->server enc:aes128-cbc mac:hmac-sha1
00:04:22: SSH2:kex: server->client enc:aes128-cbc mac:hmac-sha1
00:04:22: SSH2 0: expecting SSH2_MSG_KEXDH_INIT
00:04:22: SSH2 0: SSH2_MSG_KEXDH_INIT received
00:04:22: SSH2: kex_derive_keys complete
00:04:22: SSH2 0: SSH2_MSG_NEWKEYS sent
00:04:22: SSH2 0: waiting for SSH2_MSG_NEWKEYS
00:04:22: SSH2 0: SSH2_MSG_NEWKEYS received
```

```
00:04:24: SSH2 0: authentication successful for lab
00:04:24: SSH2 0: channel open request
00:04:24: SSH2 0: pty-req request
00:04:24: SSH2 0: setting TTY - requested: height 24, width 80; set: height 24, width 80
00:04:24: SSH2 0: shell request
00:04:24: SSH2 0: shell message received
00:04:24: SSH2 0: starting shell for vty
00:04:38: SSH0: Session terminated normally
```

The following is sample output from the **debug ip ssh packet** command. The output provides debugging information about the SSH packet.

```
Device# debug ip ssh packet

00:05:43: SSH2 0: send:packet of  length 280 (length also includes padlen of 4)
00:05:43: SSH2 0: ssh_receive: 64 bytes received
00:05:43: SSH2 0: input: total packet length of 280 bytes
00:05:43: SSH2 0: partial packet length(block size)8 bytes,needed 272 bytes, maclen 0
00:05:43: SSH2 0: ssh_receive: 64 bytes received
00:05:43: SSH2 0: partial packet length(block size)8 bytes,needed 272 bytes, maclen 0
00:05:43: SSH2 0: ssh_receive: 64 bytes received
00:05:43: SSH2 0: partial packet length(block size)8 bytes,needed 272 bytes, maclen 0
00:05:43: SSH2 0: ssh_receive: 64 bytes received
00:05:43: SSH2 0: partial packet length(block size)8 bytes,needed 272 bytes, maclen 0
00:05:43: SSH2 0: ssh_receive: 24 bytes received
00:05:43: SSH2 0: partial packet length(block size)8 bytes,needed 272 bytes, maclen 0
00:05:43: SSH2 0: input: padlength 4 bytes
00:05:43: SSH2 0: ssh_receive: 64 bytes received
00:05:43: SSH2 0: input: total packet length of 144 bytes
00:05:43: SSH2 0: partial packet length(block size)8 bytes,needed 136 bytes, maclen 0
00:05:43: SSH2 0: ssh_receive: 64 bytes received
00:05:43: SSH2 0: partial packet length(block size)8 bytes,needed 136 bytes, maclen 0
00:05:43: SSH2 0: ssh_receive: 16 bytes received
00:05:43: SSH2 0: partial packet length(block size)8 bytes,needed 136 bytes, maclen 0
00:05:43: SSH2 0: input: padlength 6 bytes
00:05:43: SSH2 0: signature length 143
00:05:43: SSH2 0: send:packet of  length 448 (length also includes padlen of 7)
00:05:43: SSH2 0: send:packet of  length 16 (length also includes padlen of 10)
00:05:43: SSH2 0: newkeys: mode 1
00:05:43: SSH2 0: ssh_receive: 16 bytes received
00:05:43: SSH2 0: input: total packet length of 16 bytes
00:05:43: SSH2 0: partial packet length(block size)8 bytes,needed 8 bytes, maclen 0
00:05:43: SSH2 0: input: padlength 10 bytes
00:05:43: SSH2 0: newkeys: mode 0
00:05:43: SSH2 0: ssh_receive: 52 bytes received
00:05:43: SSH2 0: input: total packet length of 32 bytes
00:05:43: SSH2 0: partial packet length(block size)16 bytes,needed 16 bytes, maclen 20
00:05:43: SSH2 0: MAC compared for #3 :ok
```

Additional References for Secure Shell Version 2 Support

Standards

Standards	Title
IETF Secure Shell Version 2 Draft Standards	Internet Engineering Task Force website

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

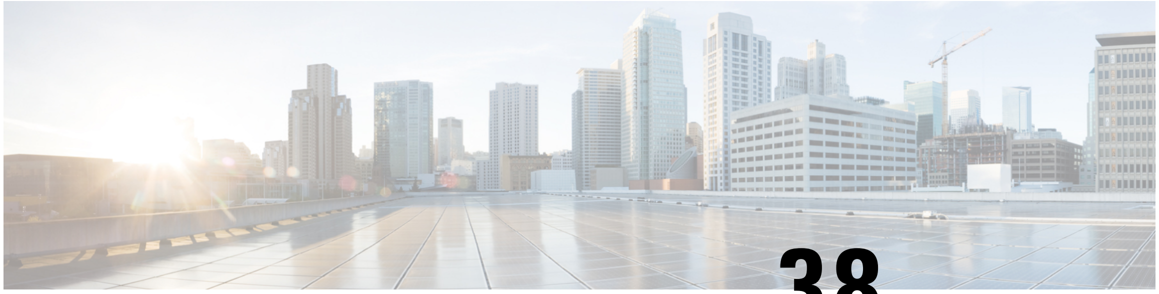
Feature Information for Secure Shell Version 2 Support

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 81: Feature Information for Secure Shell Version 2 Support

Feature Name	Releases	Feature Information
Secure Shell Version 2 Client and Server Support	Cisco IOS Release 15.2(5)E	The Cisco image was updated to provide for the automatic generation of SNMP traps when an SSH session terminates.



CHAPTER 38

X.509v3 Certificates for SSH Authentication

The X.509v3 Certificates for SSH Authentication feature uses public key algorithm (PKI) for server and user authentication, and allows the Secure Shell (SSH) protocol to verify the identity of the owner of a key pair via digital certificates, signed and issued by a Certificate Authority (CA).

This module describes how to configure server and user certificate profiles for a digital certificate.

Prerequisites for X.509v3 Certificates for SSH Authentication

The X.509v3 Certificates for SSH Authentication feature replaces the **ip ssh server authenticate user** command with the **ip ssh server algorithm authentication** command. Configure the **default ip ssh server authenticate user** command to remove the **ip ssh server authenticate user** command from the configuration. The IOS secure shell (SSH) server will start using the **ip ssh server algorithm authentication** command.

When you configure the **ip ssh server authenticate user** command, the following message is displayed:

Warning SSH command accepted; but this CLI will be deprecated soon. Please move to new CLI **ip ssh server algorithm authentication**. Please configure the “**default ip ssh server authenticate user**” to make the CLI ineffective.

Restrictions for X.509v3 Certificates for SSH Authentication

- The X.509v3 Certificates for SSH Authentication feature implementation is applicable only on the Cisco IOS Secure Shell (SSH) server side.

- The Cisco IOS SSH server supports only the x509v3-ssh-rsa algorithm-based certificate for server and user authentication.

Information About X.509v3 Certificates for SSH Authentication

X.509v3 Certificates for SSH Authentication Overview

The Secure Shell (SSH) protocol provides a secure remote access connection to network devices. The communication between the client and server is encrypted.

There are two SSH protocols that use public key cryptography for authentication. The Transport Layer Protocol, uses a digital signature algorithm (called the public key algorithm) to authenticate the server to the client. And the User Authentication Protocol uses a digital signature to authenticate (public key authentication) the client to the server.

The validity of the authentication depends upon the strength of the linkage between the public signing key and the identity of the signer. Digital certificates, such as those in X.509 Version 3 (X.509v3), are used to provide identity management. X.509v3 uses a chain of signatures by a trusted root certification authority and intermediate certificate authorities to bind a public signing key to a specific digital identity. This implementation allows the use of a public key algorithm for server and user authentication, and allows SSH to verify the identity of the owner of a key pair via digital certificates, signed and issued by a Certificate Authority (CA).

Server and User Authentication Using X.509v3

For server authentication, the Secure shell (SSH) server sends its own certificate to the SSH client for verification. This server certificate is associated with the trustpoint configured in the server certificate profile (ssh-server-cert-profile-server configuration mode).

For user authentication, the SSH client sends the user's certificate to the IOS SSH server for verification. The SSH server validates the incoming user certificate using public key infrastructure (PKI) trustpoints configured in the server certificate profile (ssh-server-cert-profile-user configuration mode).

By default, certificate-based authentication is enabled for server and user at the IOS SSH server end.

OCSP Response Stapling

The Online Certificate Status Protocol (OCSP) enables applications to determine the (revocation) state of an identified certificate. This protocol specifies the data that needs to be exchanged between an application checking the status of a certificate and the server providing that status. An OCSP client issues a status request to an OCSP responder and suspends acceptance of the certificate until a response is received. An OCSP response at a minimum consists of a responseStatus field that indicates the processing status of the a request.

For the public key algorithms, the key format consists of a sequence of one or more X.509v3 certificates followed by a sequence of zero or more OCSP responses.

The X.509v3 Certificate for SSH Authentication feature uses OCSP Response Stapling. By using OCSP response stapling, a device obtains the revocation information of its own certificate by contacting the OCSP server and then stapling the result along with its certificates and sending the information to the peer rather than having the peer contact the OCSP responder.

How to Configure X.509v3 Certificates for SSH Authentication

Configuring Digital Certificates for Server Authentication

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip ssh server algorithm hostkey** {**x509v3-ssh-rsa** [**ssh-rsa**] | **ssh-rsa** [**x509v3-ssh-rsa**]}
4. **ip ssh server certificate profile**
5. **server**
6. **trustpoint sign** *PKI-trustpoint-name*
7. **ocsp-response include**
8. **end**
9. **line vty line_number** [*ending_line_number*]
10. **transport input ssh**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip ssh server algorithm hostkey** {**x509v3-ssh-rsa** [**ssh-rsa**] | **ssh-rsa** [**x509v3-ssh-rsa**]} **Example:** `Switch(config)# ip ssh server algorithm hostkey x509v3-ssh-rsa`	Defines the order of host key algorithms. Only the configured algorithm is negotiated with the Secure Shell (SSH) client. **Note** The IOS SSH server must have at least one configured host key algorithm: • **x509v3-ssh-rsa**—certificate-based authentication • **ssh-rsa**—public key-based authentication
Step 4	**ip ssh server certificate profile** **Example:** `Switch(config)# ip ssh server certificate profile`	Configures server and user certificate profiles and enters SSH certificate profile configuration mode.

	Command or Action	Purpose
Step 5	**server** **Example:** `Switch(ssh-server-cert-profile)# server`	Configures server certificate profile and enters SSH server certificate profile server configuration mode. • The server profile is used to send out the certificate of the server to the SSH client during server authentication.
Step 6	**trustpoint sign** *PKI-trustpoint-name* **Example:** `Switch(ssh-server-cert-profile-server)# trustpoint sign trust1`	Attaches the public key infrastructure (PKI) trustpoint to the server certificate profile. • The SSH server uses the certificate associated with this PKI trustpoint for server authentication.
Step 7	**ocsp-response include** **Example:** `Switch(ssh-server-cert-profile-server)# ocsp-response include`	(Optional) Sends the Online Certificate Status Protocol (OCSP) response or OCSP stapling along with the server certificate. **Note** By default, no OCSP response is sent along with the server certificate.

Step 8	**end**
	Example:
	`Switch(ssh-server-cert-profile-server)# end`
		Exits SSH server certificate profile server configuration mode and returns to privileged EXEC mode.

Step 9	**line vty line_number** [*ending_line_number*] **Example:** `Switch(config)# line vty line_number [ending_line_number]`	Enters line configuration mode to configure the virtual terminal line settings. For line_number and ending_line_number, specify a pair of lines. The range is 0 to 15.
Step 10	**transport input ssh** **Example:** `Switch(config-line)#transport input ssh`	Specifies that the Switch prevent non-SSH Telnet connections. This limits the router to only SSH connections.

Configuring Digital Certificates for User Authentication

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip ssh server algorithm authentication** {**publickey** | **keyboard** | **password**}
4. **ip ssh server algorithm publickey** {**x509v3-ssh-rsa** [**ssh-rsa**] | **ssh-rsa** [**x509v3-ssh-rsa**]}
5. **ip ssh server certificate profile**
6. **user**
7. **trustpoint verify** *PKI-trustpoint-name*
8. **ocsp-response required**

9. **end**
10. **line vty line_number** [*ending_line_number*]
11. **transport input ssh**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip ssh server algorithm authentication** {**publickey** | **keyboard** | **password**} **Example:** `Switch(config)# ip ssh server algorithm authentication publickey`	Defines the order of user authentication algorithms. Only the configured algorithm is negotiated with the Secure Shell (SSH) client. **Note** • The IOS SSH server must have at least one configured user authentication algorithm. • To use the certificate method for user authentication, the **publickey** keyword must be configured.
Step 4	**ip ssh server algorithm publickey** {**x509v3-ssh-rsa** [**ssh-rsa**] | **ssh-rsa** [**x509v3-ssh-rsa**]} **Example:** `Switch(config)# ip ssh server algorithm publickey x509v3-ssh-rsa`	Defines the order of public key algorithms. Only the configured algorithm is accepted by the SSH client for user authentication. **Note** The IOS SSH client must have at least one configured public key algorithm: • **x509v3-ssh-rsa**—Certificate-based authentication • **ssh-rsa**—Public-key-based authentication
Step 5	**ip ssh server certificate profile** **Example:** `Switch(config)# ip ssh server certificate profile`	Configures server certificate profile and user certificate profile and enters SSH certificate profile configuration mode.
Step 6	**user** **Example:** `Switch(ssh-server-cert-profile)# user`	Configures user certificate profile and enters SSH server certificate profile user configuration mode.
Step 7	**trustpoint verify** *PKI-trustpoint-name* **Example:**	Configures the public key infrastructure (PKI) trustpoint that is used to verify the incoming user certificate.

	Command or Action	Purpose
	`Switch(ssh-server-cert-profile-user)# trustpoint verify trust2`	**Note** Configure multiple trustpoints by executing the same command multiple times. A maximum of 10 trustpoints can be configured.
Step 8	**ocsp-response required** **Example:** `Switch(ssh-server-cert-profile-user)# ocsp-response required`	(Optional) Mandates the presence of the Online Certificate Status Protocol (OCSP) response with the incoming user certificate. **Note** By default, the user certificate is accepted without an OCSP response.

Step 9	**end**
	Example:
	`Switch(ssh-server-cert-profile-user)# end`
		Exits SSH server certificate profile user configuration mode and returns to privileged EXEC mode.

Step 10	**line vty line_number** [*ending_line_number*] **Example:** `Switch(config)# line vty line_number [ending_line_number]`	Enters line configuration mode to configure the virtual terminal line settings. For line_number and ending_line_number, specify a pair of lines. The range is 0 to 15.
Step 11	**transport input ssh** **Example:** `Switch(config-line)#transport input ssh`	Specifies that the Switch prevent non-SSH Telnet connections. This limits the router to only SSH connections.

Verifying the Server and User Authentication Using Digital Certificates

SUMMARY STEPS

1. **enable**
2. **show ip ssh**
3. **debug ip ssh detail**
4. **show log**
5. **debug ip packet**
6. **show log**

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode.

- Enter your password if prompted.

Example:

```
Device> enable
```

Step 2 **show ip ssh**

Displays the currently configured authentication methods. To confirm the use of certificate-based authentication, ensure that the x509v3-ssh-rsa algorithm is the configured host key algorithm.

Example:

```
Device# show ip ssh

SSH Enabled - version 1.99
Authentication methods:publickey,keyboard-interactive,password
Authentication Publickey Algorithms:x509v3-ssh-rsa,ssh-rsa
Hostkey Algorithms:x509v3-ssh-rsa,ssh-rsa
Authentication timeout: 120 secs; Authentication retries: 3
Minimum expected Diffie Hellman key size : 1024 bits
```

Step 3 **debug ip ssh detail**

Turns on debugging messages for SSH details.

Example:

```
Device# debug ip ssh detail

ssh detail messages debugging is on
```

Step 4 **show log**

Shows the debug message log.

Example:

```
Device# show log

Syslog logging: enabled (0 messages dropped, 9 messages rate-limited, 0 flushes, 0 overruns, xml
disabled, filtering disabled)

No Active Message Discriminator.



No Inactive Message Discriminator.


    Console logging: disabled
    Monitor logging: level debugging, 0 messages logged, xml disabled,
                     filtering disabled
    Buffer logging:  level debugging, 233 messages logged, xml disabled,
                    filtering disabled
    Exception Logging: size (4096 bytes)
    Count and timestamp logging messages: disabled
    File logging: disabled
    Persistent logging: disabled

No active filter modules.

    Trap logging: level informational, 174 message lines logged
        Logging Source-Interface:       VRF Name:
```

```
Log Buffer (4096 bytes):
5 IST: SSH2 CLIENT 0: SSH2_MSG_KEXINIT sent
*Sep  6 14:44:08.496 IST: SSH0: protocol version id is - SSH-1.99-Cisco-1.25
*Sep  6 14:44:08.496 IST: SSH2 0: kexinit sent: kex algo =
diffie-hellman-group-exchange-sha1,diffie-hellman-group14-sha1
*Sep  6 14:44:08.496 IST: SSH2 0: Server certificate trustpoint not found. Skipping hostkey algo =
x509v3-ssh-rsa
*Sep  6 14:44:08.496 IST: SSH2 0: kexinit sent: hostkey algo = ssh-rsa
*Sep  6 14:44:08.496 IST: SSH2 0: kexinit sent: encryption algo = aes128-ctr,aes192-ctr,aes256-ctr
*Sep  6 14:44:08.496 IST: SSH2 0: kexinit sent: mac algo =
hmac-sha2-256,hmac-sha2-512,hmac-sha1,hmac-sha1-96
*Sep  6 14:44:08.496 IST: SSH2 0: SSH2_MSG_KEXINIT sent
*Sep  6 14:44:08.496 IST: SSH2 0: SSH2_MSG_KEXINIT received
*Sep  6 14:44:08.496 IST: SSH2 0: kex: client->server enc:aes128-ctr mac:hmac-sha2-256
*Sep  6 14:44:08.496 IST: SSH2 0: kex: server->client enc:aes128-ctr mac:hmac-sha2-256
*Sep  6 14:44:08.496 IST: SSH2 0: Using hostkey algo = ssh-rsa
*Sep  6 14:44:08.496 IST: SSH2 0: Using kex_algo = diffie-hellman-group-exchange-sha1
*Sep  6 14:44:08.497 IST: SSH2 CLIENT 0: SSH2_MSG_KEXINIT received
*Sep  6 14:44:08.497 IST: SSH2 CLIENT 0: kex: server->client enc:aes128-ctr mac:hmac-sha2-256
*Sep  6 14:44:08.497 IST: SSH2 CLIENT 0: kex: client->server enc:aes128-ctr mac:hmac-sha2-256
*Sep  6 14:44:08.497 IST: SSH2 CLIENT 0: Using hostkey algo = ssh-rsa
*Sep  6 14:44:08.497 IST: SSH2 CLIENT 0: Using kex_algo = diffie-hellman-group-exchange-sha1
*Sep  6 14:44:08.497 IST: SSH2 CLIENT 0: SSH2_MSG_KEX_DH_GEX_REQUEST sent
*Sep  6 14:44:08.497 IST: SSH2 CLIENT 0: Range sent- 2048  < 2048  < 4096
*Sep  6 14:44:08.497 IST: SSH2 0: SSH2_MSG_KEX_DH_GEX_REQUEST received
*Sep  6 14:44:08.497 IST: SSH2 0: Range sent by client is - 2048 < 2048 < 4096
*Sep  6 14:44:08.497 IST: SSH2 0:  Modulus size established : 2048 bits
*Sep  6 14:44:08.510 IST: SSH2 0: expecting SSH2_MSG_KEX_DH_GEX_INIT
*Sep  6 14:44:08.510 IST: SSH2 CLIENT 0: SSH2_MSG_KEX_DH_GEX_GROUP received
*Sep  6 14:44:08.510 IST: SSH2 CLIENT 0: Server has chosen 2048 -bit dh keys
*Sep  6 14:44:08.523 IST: SSH2 CLIENT 0: expecting SSH2_MSG_KEX_DH_GEX_REPLY
*Sep  6 14:44:08.524 IST: SSH2 0: SSH2_MSG_KEXDH_INIT received
*Sep  6 14:44:08.555 IST: SSH2: kex_derive_keys complete
*Sep  6 14:44:08.555 IST: SSH2 0: SSH2_MSG_NEWKEYS sent
*Sep  6 14:44:08.555 IST: SSH2 0: waiting for SSH2_MSG_NEWKEYS
*Sep  6 14:44:08.555 IST: SSH2 CLIENT 0: SSH2_MSG_KEX_DH_GEX_REPLY received
*Sep  6 14:44:08.555 IST: SSH2 CLIENT 0: Skipping ServerHostKey Validation
*Sep  6 14:44:08.571 IST: SSH2 CLIENT 0: signature length 271
*Sep  6 14:44:08.571 IST: SSH2: kex_derive_keys complete
*Sep  6 14:44:08.571 IST: SSH2 CLIENT 0: SSH2_MSG_NEWKEYS sent
*Sep  6 14:44:08.571 IST: SSH2 CLIENT 0: waiting for SSH2_MSG_NEWKEYS
*Sep  6 14:44:08.571 IST: SSH2 CLIENT 0: SSH2_MSG_NEWKEYS received
*Sep  6 14:44:08.571 IST: SSH2 0: SSH2_MSG_NEWKEYS received
*Sep  6 14:44:08.571 IST: SSH2 0: Authentications that can continue =
publickey,keyboard-interactive,password
*Sep  6 14:44:08.572 IST: SSH2 0: Using method = none
*Sep  6 14:44:08.572 IST: SSH2 0: Authentications that can continue =
publickey,keyboard-interactive,password
*Sep  6 14:44:08.572 IST: SSH2 0: Using method = keyboard-interactive
*Sep  6 14:44:11.983 IST: SSH2 0: authentication successful for cisco
*Sep  6 14:44:11.984 IST: %SEC_LOGIN-5-LOGIN_SUCCESS: Login Success [user: cisco] [Source:
192.168.121.40] [localport: 22] at 14:44:11 IST Thu Sep 6 2018
*Sep  6 14:44:11.984 IST: SSH2 0: channel open request
*Sep  6 14:44:11.985 IST: SSH2 0: pty-req request
*Sep  6 14:44:11.985 IST: SSH2 0: setting TTY - requested: height 24, width 80; set: height 24, width
 80
*Sep  6 14:44:11.985 IST: SSH2 0: shell request
*Sep  6 14:44:11.985 IST: SSH2 0: shell message received
*Sep  6 14:44:11.985 IST: SSH2 0: starting shell for vty
*Sep  6 14:44:22.066 IST: %SYS-6-LOGOUT: User cisco has exited tty session 1(192.168.121.40)
*Sep  6 14:44:22.166 IST: SSH0: Session terminated normally
*Sep  6 14:44:22.167 IST: SSH CLIENT0: Session terminated normally
```

Step 5 **debug ip packet**

Turns on debugging for IP packet details.

Example:

```
Device# debug ip packet
```

Step 6 **show log**

Shows the debug message log.

Example:

```
Device# show log

yslog logging: enabled (0 messages dropped, 9 messages rate-limited, 0 flushes, 0 overruns, xml
disabled, filtering disabled)

No Active Message Discriminator.



No Inactive Message Discriminator.


    Console logging: disabled
    Monitor logging: level debugging, 0 messages logged, xml disabled,
                     filtering disabled
    Buffer logging:  level debugging, 1363 messages logged, xml disabled,
                    filtering disabled
    Exception Logging: size (4096 bytes)
    Count and timestamp logging messages: disabled
    File logging: disabled
    Persistent logging: disabled

No active filter modules.

    Trap logging: level informational, 176 message lines logged
        Logging Source-Interface:       VRF Name:

Log Buffer (4096 bytes):
bleid=0, s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.177 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, sending
*Sep  6 14:45:45.177 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, output feature, NAT Inside(8), rtype 1, forus FALSE, sendself FALSE, mtu 0, fwdchk FALSE
*Sep  6 14:45:45.177 IST: IP: tableid=0, s=192.168.121.40 (FortyGigabitEthernet1/0/1), d=192.168.121.40
 (FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.177 IST: IP: tableid=0, s=192.168.121.40 (FortyGigabitEthernet1/0/1), d=192.168.121.40
 (FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.177 IST: IP: s=192.168.121.40 (local), d=192.168.121.40, len 40, local feature,
feature skipped, NAT(2), rtype 0, forus FALSE, sendself FALSE, mtu 0, fwdchk FALSE
*Sep  6 14:45:45.178 IST: IP: tableid=0, s=192.168.121.40 (local), d=192.168.121.40
(FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.178 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, sending
*Sep  6 14:45:45.178 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, output feature, NAT Inside(8), rtype 1, forus FALSE, sendself FALSE, mtu 0, fwdchk FALSE
*Sep  6 14:45:45.178 IST: IP: tableid=0, s=192.168.121.40 (FortyGigabitEthernet1/0/1), d=192.168.121.40
 (FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.178 IST: IP: s=192.168.121.40 (local), d=192.168.121.40, len 40, local feature,
feature skipped, NAT(2), rtype 0, forus FALSE, sendself FALSE, mtu 0, fwdchk FALSE
*Sep  6 14:45:45.178 IST: IP: tableid=0, s=192.168.121.40 (local), d=192.168.121.40
```

```
(FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.178 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, sending
*Sep  6 14:45:45.178 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, output feature, NAT Inside(8), rtype 1, forus FALSE, sendself FALSE, mtu 0, fwdchk FALSE
*Sep  6 14:45:45.178 IST: IP: tableid=0, s=192.168.121.40 (FortyGigabitEthernet1/0/1), d=192.168.121.40
 (FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.178 IST: IP: tableid=0, s=192.168.121.40 (FortyGigabitEthernet1/0/1), d=192.168.121.40
 (FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.178 IST: IP: tableid=0, s=192.168.121.40 (FortyGigabitEthernet1/0/1), d=192.168.121.40
 (FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.178 IST: IP: s=192.168.121.40 (local), d=192.168.121.40, len 40, local feature,
feature skipped, NAT(2), rtype 0, forus FALSE, sendself FALSE, mtu 0, fwdchk FALSE
*Sep  6 14:45:45.178 IST: IP: tableid=0, s=192.168.121.40 (local), d=192.168.121.40
(FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.178 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, sending
*Sep  6 14:45:45.178 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, output feature, NAT Inside(8), rtype 1, forus FALSE, sendself FALSE, mtu 0, fwdchk FALSE
*Sep  6 14:45:45.179 IST: IP: tableid=0, s=192.168.121.40 (FortyGigabitEthernet1/0/1), d=192.168.121.40
 (FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.179 IST: IP: s=192.168.121.40 (local), d=192.168.121.40, len 40, local feature,
feature skipped, NAT(2), rtype 0, forus FALSE, sendself FALSE, mtu 0, fwdchk FALSE
*Sep  6 14:45:45.179 IST: IP: tableid=0, s=192.168.121.40 (local), d=192.168.121.40
(FortyGigabitEthernet1/0/1), routed via RIB
*Sep  6 14:45:45.179 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, sending
*Sep  6 14:45:45.179 IST: IP: s=192.168.121.40 (local), d=192.168.121.40 (FortyGigabitEthernet1/0/1),
 len 40, output feature, NAT Inside(8), rtype 1, forus FALSE, sendself FALSE, mtu 0, fwdchk FALSE
*Sep  6 14:45:45.179 IST: IP: tableid=0, s=192.168.121.40 (FortyGigabitEthernet1/0/1), d=192.168.121.40
 (FortyGigabitEthernet1/0/1), routed via RIB
```

Configuration Examples for X.509v3 Certificates for SSH Authentication

Example: Configuring Digital Certificates for Server Authentication

```
Switch> enable
Switch# configure terminal
Switch(config)# ip ssh server algorithm hostkey x509v3-ssh-rsa
Switch(config)# ip ssh server certificate profile
Switch(ssh-server-cert-profile)# server
Switch(ssh-server-cert-profile-server)# trustpoint sign trust1
Switch(ssh-server-cert-profile-server)# exit
```

Example: Configuring Digital Certificate for User Authentication

```
Switch> enable
Switch# configure terminal
```

```
Switch(config)# ip ssh server algorithm authentication publickey
Switch(config)# ip ssh server algorithm publickey x509v3-ssh-rsa
Switch(config)# ip ssh server certificate profile
Switch(ssh-server-cert-profile)# user
Switch(ssh-server-cert-profile-user)# trustpoint verify trust2
Switch(ssh-server-cert-profile-user)# end
```

Additional References for X.509v3 Certificates for SSH Authentication

Related Documents

Related Topic	Document Title
PKI configuration	Configuring and Managing a Cisco IOS Certificate Server for PKI Deployment

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for X.509v3 Certificates for SSH Authentication

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 82: Feature Information for X509v3 Certificates for SSH Authentication

Feature Name	Releases	Feature Information
X.509v3 Certificates for SSH Authentication	Cisco IOS 15.2(4)E1	The X.509v3 Certificates for SSH Authentication feature uses the X5.09v3 digital certificates in server and user authentication at the SSH server side. The following commands were introduced or modified: **ip ssh server algorithm hostkey**, **ip ssh server algorithm authentication**, and **ip ssh server certificate profile**. This feature was implemented on the following platforms: • Catalyst 2960C, 2960CX, 2960P, 2960X, and 2960XR Series Switches • Catalyst 3560CX and 3560X Series Switches • Catalyst 3750X Series Switches • Catalyst 4500E Sup7-E, Sup7L-E, Sup8-E, and 4500X Series Switches • Catalyst 4900M, 4900F-E Series Switches

CHAPTER 39

Configuring Secure Socket Layer HTTP

This feature provides Secure Socket Layer (SSL) version 3.0 support for the HTTP 1.1 server and HTTP 1.1 client within Cisco IOS software. SSL provides server authentication, encryption, and message integrity to allow secure HTTP communications. SSL also provides HTTP client authentication. HTTP over SSL is abbreviated as HTTPS.

Information About Secure Socket Layer HTTP

Secure HTTP Servers and Clients Overview

On a secure HTTP connection, data to and from an HTTP server is encrypted before being sent over the Internet. HTTP with SSL encryption provides a secure connection to allow such functions as configuring a switch from a Web browser. Cisco's implementation of the secure HTTP server and secure HTTP client uses an implementation of SSL Version 3.0 with application-layer encryption. HTTP over SSL is abbreviated as HTTPS; the URL of a secure connection begins with https:// instead of http://.

Note SSL evolved into Transport Layer Security (TLS) in 1999, but is still used in this particular context.

The primary role of the HTTP secure server (the switch) is to listen for HTTPS requests on a designated port (the default HTTPS port is 443) and pass the request to the HTTP 1.1 Web server. The HTTP 1.1 server processes requests and passes responses (pages) back to the HTTP secure server, which, in turn, responds to the original request.

The primary role of the HTTP secure client (the web browser) is to respond to Cisco IOS application requests for HTTPS User Agent services, perform HTTPS User Agent services for the application, and pass the response back to the application.

Certificate Authority Trustpoints

Certificate authorities (CAs) manage certificate requests and issue certificates to participating network devices. These services provide centralized security key and certificate management for the participating devices. Specific CA servers are referred to as *trustpoints*.

When a connection attempt is made, the HTTPS server provides a secure connection by issuing a certified X.509v3 certificate, obtained from a specified CA trustpoint, to the client. The client (usually a Web browser), in turn, has a public key that allows it to authenticate the certificate.

For secure HTTP connections, we highly recommend that you configure a CA trustpoint. If a CA trustpoint is not configured for the device running the HTTPS server, the server certifies itself and generates the needed RSA key pair. Because a self-certified (self-signed) certificate does not provide adequate security, the connecting client generates a notification that the certificate is self-certified, and the user has the opportunity to accept or reject the connection. This option is useful for internal network topologies (such as testing).

If you do not configure a CA trustpoint, when you enable a secure HTTP connection, either a temporary or a persistent self-signed certificate for the secure HTTP server (or client) is automatically generated.

- If the switch is not configured with a hostname and a domain name, a temporary self-signed certificate is generated. If the switch reboots, any temporary self-signed certificate is lost, and a new temporary new self-signed certificate is assigned.
- If the switch has been configured with a host and domain name, a persistent self-signed certificate is generated. This certificate remains active if you reboot the switch or if you disable the secure HTTP server so that it will be there the next time you re-enable a secure HTTP connection.

Note The certificate authorities and trustpoints must be configured on each device individually. Copying them from other devices makes them invalid on the switch.

When a new certificate is enrolled, the new configuration change is not applied to the HTTPS server until the server is restarted. You can restart the server using either the CLI or by physical reboot. On restarting the server, the switch starts using the new certificate.

If a self-signed certificate has been generated, this information is included in the output of the **show running-config** privileged EXEC command. This is a partial sample output from that command displaying a self-signed certificate.

```
Switch# show running-config
Building configuration...

<output truncated>

crypto pki trustpoint TP-self-signed-3080755072
 enrollment selfsigned
 subject-name cn=IOS-Self-Signed-Certificate-3080755072
 revocation-check none
 rsakeypair TP-self-signed-3080755072
!
!
crypto ca certificate chain TP-self-signed-3080755072
 certificate self-signed 01
  3082029F 30820208 A0030201 02020101 300D0609 2A864886 F70D0101 04050030
  59312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274
  69666963 6174652D 33303830 37353530 37323126 30240609 2A864886 F70D0109
  02161743 45322D33 3535302D 31332E73 756D6D30 342D3335 3530301E 170D3933
  30333031 30303030 35395A17 0D323030 31303130 30303030 305A3059 312F302D

<output truncated>
```

You can remove this self-signed certificate by disabling the secure HTTP server and entering the **no crypto pki trustpoint TP-self-signed-30890755072** global configuration command. If you later re-enable a secure HTTP server, a new self-signed certificate is generated.

Note The values that follow *TP self-signed* depend on the serial number of the device.

You can use an optional command (**ip http secure-client-auth**) to allow the HTTPS server to request an X.509v3 certificate from the client. Authenticating the client provides more security than server authentication by itself.

CipherSuites

A CipherSuite specifies the encryption algorithm and the digest algorithm to use on a SSL connection. When connecting to the HTTPS server, the client Web browser offers a list of supported CipherSuites, and the client and server negotiate the best encryption algorithm to use from those on the list that are supported by both. For example, Netscape Communicator 4.76 supports U.S. security with RSA Public Key Cryptography, MD2, MD5, RC2-CBC, RC4, DES-CBC, and DES-EDE3-CBC.

For the best possible encryption, you should use a client browser that supports 128-bit encryption, such as Microsoft Internet Explorer Version 5.5 (or later) or Netscape Communicator Version 4.76 (or later). The SSL_RSA_WITH_DES_CBC_SHA CipherSuite provides less security than the other CipherSuites, as it does not offer 128-bit encryption.

The more secure and more complex CipherSuites require slightly more processing time. This list defines the CipherSuites supported by the switch and ranks them from fastest to slowest in terms of router processing load (speed):

1. SSL_RSA_WITH_DES_CBC_SHA—RSA key exchange (RSA Public Key Cryptography) with DES-CBC for message encryption and SHA for message digest
2. SSL_RSA_WITH_NULL_SHA key exchange with NULL for message encryption and SHA for message digest (only for SSL 3.0).
3. SSL_RSA_WITH_NULL_MD5 key exchange with NULL for message encryption and MD5 for message digest (only for SSL 3.0).
4. SSL_RSA_WITH_RC4_128_MD5—RSA key exchange with RC4 128-bit encryption and MD5 for message digest
5. SSL_RSA_WITH_RC4_128_SHA—RSA key exchange with RC4 128-bit encryption and SHA for message digest
6. SSL_RSA_WITH_3DES_EDE_CBC_SHA—RSA key exchange with 3DES and DES-EDE3-CBC for message encryption and SHA for message digest
7. SSL_RSA_WITH_AES_128_CBC_SHA—RSA key exchange with AES 128-bit encryption and SHA for message digest (only for SSL 3.0).

8. SSL_RSA_WITH_AES_256_CBC_SHA—RSA key exchange with AES 256-bit encryption and SHA for message digest (only for SSL 3.0).
9. SSL_RSA_WITH_DHE_AES_128_CBC_SHA—RSA key exchange with AES 128-bit encryption and SHA for message digest (only for SSL 3.0).
10. SSL_RSA_WITH_DHE_AES_256_CBC_SHA—RSA key exchange with AES 256-bit encryption and SHA for message digest (only for SSL 3.0).

Note The latest versions of Chrome do not support the four original cipher suites, thus disallowing access to both web GUI and guest portals.

RSA (in conjunction with the specified encryption and digest algorithm combinations) is used for both key generation and authentication on SSL connections. This usage is independent of whether or not a CA trustpoint is configured.

Default SSL Configuration

The standard HTTP server is enabled.

SSL is enabled.

No CA trustpoints are configured.

No self-signed certificates are generated.

SSL Configuration Guidelines

When SSL is used in a switch cluster, the SSL session terminates at the cluster commander. Cluster member switches must run standard HTTP.

Before you configure a CA trustpoint, you should ensure that the system clock is set. If the clock is not set, the certificate is rejected due to an incorrect date.

How to Configure Secure Socket Layer HTTP

Configuring the Secure HTTP Server

Beginning in privileged EXEC mode, follow these steps to configure a secure HTTP server:

Before you begin

If you are using a certificate authority for certification, you should use the previous procedure to configure the CA trustpoint on the switch before enabling the HTTP server. If you have not configured a CA trustpoint, a self-signed certificate is generated the first time that you enable the secure HTTP server. After you have configured the server, you can configure options (path, access list to apply, maximum number of connections, or timeout policy) that apply to both standard and secure HTTP servers.

To verify the secure HTTP connection by using a Web browser, enter https://*URL*, where the URL is the IP address or hostname of the server switch. If you configure a port other than the default port, you must also specify the port number after the URL. For example:

Note AES256_SHA2 is not supported.

```
https://209.165.129:1026
```

or

```
https://host.domain.com:1026
```

The existing **ip http access-class** *access-list-number* command for specifying the access-list(Only IPv4 ACLs) is going to be deprecated. You can still use this command to specify an access list to allow access to the HTTP server. Two new commands have been introduced to enable support for specifying IPv4 and IPv6 ACLs. These are **ip http access-class ipv4** *access-list-name* | *access-list-number* for specifying IPv4 ACLs and **ip http access-class ipv6** *access-list-name* for specifying IPv6 ACLs. We recommend using the new CLI to avoid receiving warning messages.

Note the following considerations for specifying access-lists:

- If you specify an access-list that does not exist, the configuration takes place but you receive the below warning message:

  ```
  ACL being attached does not exist, please configure it
  ```
- If you use the **ip http access-class** command for specifying an access-list for the HTTP server, the below warning message appears:

  ```
  This CLI will be deprecated soon, Please use new CLI ip http
  access-class ipv4/ipv6 <access-list-name>| <access-list-number>
  ```
- If you use **ip http access-class ipv4** *access-list-name* | *access-list-number* or **ip http access-class ipv6** *access-list-name* , and an access-list was already configured using **ip http access-class** , the below warning message appears:

  ```
  Removing ip http access-class <access-list-number>
  ```

ip http access-class *access-list-number* and **ip http access-class ipv4** *access-list-name* | *access-list-number* share the same functionality. Each command overrides the configuration of the previous command. The following combinations between the configuration of the two commands explain the effect on the running configuration:

- If **ip http access-class** *access-list-number* is already configured and you try to configure using **ip http access-class ipv4** *access-list-number* command, the configuration of **ip http access-class** *access-list-number* will be removed and the configuration of **ip http access-class ipv4** *access-list-number* will be added to the running configuration.

- If **ip http access-class** *access-list-number* is already configured and you try to configure using **ip http access-class ipv4** *access-list-name* command, the configuration of **ip http access-class** *access-list-number* will be removed and the configuration of **ip http access-class ipv4** *access-list-name* will be added to the running configuration.

- If **ip http access-class ipv4** *access-list-number* is already configured and you try to configure using **ip http access-class** *access-list-name*, the configuration of **ip http access-class ipv4** *access-list-number* will be removed from configuration and the configuration of **ip http access-class** *access-list-name* will be added to the running configuration.
- If **ip http access-class ipv4** *access-list-name* is already configured and you try to configure using **ip http access-class** *access-list-number*, the configuration of **ip http access-class ipv4** *access-list-name* will be removed from the configuration and the configuration of **ip http access-class** *access-list-number* will be added to the running configuration.

SUMMARY STEPS

1. **show ip http server status**
2. **configure terminal**
3. **ip http secure-server**
4. **ip http secure-port** *port-number*
5. **ip http secure-ciphersuite** {[**3des-ede-cbc-sha**] [**rc4-128-md5**] [**rc4-128-sha**] [**des-cbc-sha**]}
6. **ip http secure-client-auth**
7. **ip http secure-trustpoint** *name*
8. **ip http path** *path-name*
9. **ip http access-class** *access-list-number*
10. **ip http access-class** { **ipv4** {*access-list-number* | *access-list-name*} | **ipv6** {*access-list-name*} }
11. **ip http max-connections** *value*
12. **ip http timeout-policy idle** *seconds* **life** *seconds* **requests** *value*
13. **end**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**show ip http server status**
	Example:
	`Switch# show ip http server status`
		(Optional) Displays the status of the HTTP server to determine if the secure HTTP server feature is supported in the software. You should see one of these lines in the output:
		`HTTP secure server capability: Present`
		or
		`HTTP secure server capability: Not present`

Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**ip http secure-server** **Example:** `Switch(config)# ip http secure-server`	Enables the HTTPS server if it has been disabled. The HTTPS server is enabled by default.
Step 4	**ip http secure-port** *port-number* **Example:** `Switch(config)# ip http secure-port 443`	(Optional) Specifies the port number to be used for the HTTPS server. The default port number is 443. Valid options are 443 or any number in the range 1025 to 65535.

Step 5	**ip http secure-ciphersuite** {[**3des-ede-cbc-sha**] [**rc4-128-md5**] [**rc4-128-sha**] [**des-cbc-sha**]}
	Example:
	`Switch(config)# ip http secure-ciphersuite rc4-128-md5`
		(Optional) Specifies the CipherSuites (encryption algorithms) to be used for encryption over the HTTPS connection. If you do not have a reason to specify a particularly CipherSuite, you should allow the server and client to negotiate a CipherSuite that they both support. This is the default.

Step 6	**ip http secure-client-auth** **Example:** `Switch(config)# ip http secure-client-auth`	(Optional) Configures the HTTP server to request an X.509v3 certificate from the client for authentication during the connection process. The default is for the client to request a certificate from the server, but the server does not attempt to authenticate the client.
Step 7	**ip http secure-trustpoint** *name* **Example:** `Switch(config)# ip http secure-trustpoint your_trustpoint`	Specifies the CA trustpoint to use to get an X.509v3 security certificate and to authenticate the client certificate connection. **Note** Use of this command assumes you have already configured a CA trustpoint according to the previous procedure.
Step 8	**ip http path** *path-name* **Example:** `Switch(config)# ip http path /your_server:80`	(Optional) Sets a base HTTP path for HTML files. The path specifies the location of the HTTP server files on the local system (usually located in system flash memory).
Step 9	**ip http access-class** *access-list-number* **Example:** `Switch(config)# ip http access-class 2`	(Optional) Specifies an access list to use to allow access to the HTTP server.
Step 10	**ip http access-class** { **ipv4** {*access-list-number* | *access-list-name*} | **ipv6** {*access-list-name*} } **Example:**	(Optional)Specifies an access list to use to allow access to the HTTP server.

	Command or Action	Purpose
	`Switch(config)# ip http access-class ipv4 4`	
Step 11	**ip http max-connections** *value* **Example:** `Switch(config)# ip http max-connections 4`	(Optional) Sets the maximum number of concurrent connections that are allowed to the HTTP server. We recommend that the value be at least 10 and not less. This is required for the UI to function as expected.
Step 12	**ip http timeout-policy idle** *seconds* **life** *seconds* **requests** *value* **Example:** `Switch(config)# ip http timeout-policy idle 120 life 240 requests 1`	(Optional) Specifies how long a connection to the HTTP server can remain open under the defined circumstances: • **idle**—the maximum time period when no data is received or response data cannot be sent. The range is 1 to 600 seconds. The default is 180 seconds (3 minutes). • **life**—the maximum time period from the time that the connection is established. The range is 1 to 86400 seconds (24 hours). The default is 180 seconds. • **requests**—the maximum number of requests processed on a persistent connection. The maximum value is 86400. The default is 1.

Step 13	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Configuring the Secure HTTP Client

Beginning in privileged EXEC mode, follow these steps to configure a secure HTTP client:

Before you begin

The standard HTTP client and secure HTTP client are always enabled. A certificate authority is required for secure HTTP client certification. This procedure assumes that you have previously configured a CA trustpoint on the switch. If a CA trustpoint is not configured and the remote HTTPS server requires client authentication, connections to the secure HTTP client fail.

SUMMARY STEPS

1. **configure terminal**
2. **ip http client secure-trustpoint** *name*
3. **ip http client secure-ciphersuite** {[**3des-ede-cbc-sha**] [**rc4-128-md5**] [**rc4-128-sha**] [**des-cbc-sha**]}
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**ip http client secure-trustpoint** *name* **Example:** `Switch(config)# ip http client secure-trustpoint your_trustpoint`	(Optional) Specifies the CA trustpoint to be used if the remote HTTP server requests client authentication. Using this command assumes that you have already configured a CA trustpoint by using the previous procedure. The command is optional if client authentication is not needed or if a primary trustpoint has been configured.
Step 3	**ip http client secure-ciphersuite** {[**3des-ede-cbc-sha**] [**rc4-128-md5**] [**rc4-128-sha**] [**des-cbc-sha**]} **Example:** `Switch(config)# ip http client secure-ciphersuite rc4-128-md5`	(Optional) Specifies the CipherSuites (encryption algorithms) to be used for encryption over the HTTPS connection. If you do not have a reason to specify a particular CipherSuite, you should allow the server and client to negotiate a CipherSuite that they both support. This is the default.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Configuring a CA Trustpoint

For secure HTTP connections, we recommend that you configure an official CA trustpoint. A CA trustpoint is more secure than a self-signed certificate.

Beginning in privileged EXEC mode, follow these steps to configure a CA Trustpoint:

SUMMARY STEPS

1. **configure terminal**
2. **hostname** *hostname*
3. **ip domain-name** *domain-name*
4. **crypto key generate rsa**
5. **crypto ca trustpoint** *name*
6. **enrollment url** *url*
7. **enrollment http-proxy** *host-name port-number*
8. **crl query** *url*
9. **primary** *name*
10. **exit**

11. **crypto ca authentication** *name*
12. **crypto ca enroll** *name*
13. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**hostname** *hostname* **Example:** `Switch(config)# hostname your_hostname`	Specifies the hostname of the switch (required only if you have not previously configured a hostname). The hostname is required for security keys and certificates.
Step 3	**ip domain-name** *domain-name* **Example:** `Switch(config)# ip domain-name your_domain`	Specifies the IP domain name of the switch (required only if you have not previously configured an IP domain name). The domain name is required for security keys and certificates.
Step 4	**crypto key generate rsa** **Example:** `Switch(config)# crypto key generate rsa`	(Optional) Generates an RSA key pair. RSA key pairs are required before you can obtain a certificate for the switch. RSA key pairs are generated automatically. You can use this command to regenerate the keys, if needed.
Step 5	**crypto ca trustpoint** *name* **Example:** `Switch(config)# crypto ca trustpoint your_trustpoint`	Specifies a local configuration name for the CA trustpoint and enter CA trustpoint configuration mode.
Step 6	**enrollment url** *url* **Example:** `Switch(ca-trustpoint)# enrollment url http://your_server:80`	Specifies the URL to which the switch should send certificate requests.
Step 7	**enrollment http-proxy** *host-name port-number* **Example:** `Switch(ca-trustpoint)# enrollment http-proxy`	(Optional) Configures the switch to obtain certificates from the CA through an HTTP proxy server. • For *host-name* , specify the proxy server used to get the CA.

	Command or Action	Purpose
	`your_host 49`	- For *port-number*, specify the port number used to access the CA.
Step 8	**crl query** *url* **Example:** `Switch(ca-trustpoint)# crl query ldap://your_host:49`	Configures the switch to request a certificate revocation list (CRL) to ensure that the certificate of the peer has not been revoked.
Step 9	**primary** *name* **Example:** `Switch(ca-trustpoint)# primary your_trustpoint`	(Optional) Specifies that the trustpoint should be used as the primary (default) trustpoint for CA requests. - For *name*, specify the trustpoint that you just configured.
Step 10	**exit** **Example:** `Switch(ca-trustpoint)# exit`	Exits CA trustpoint configuration mode and return to global configuration mode.
Step 11	**crypto ca authentication** *name* **Example:** `Switch(config)# crypto ca authentication your_trustpoint`	Authenticates the CA by getting the public key of the CA. Use the same name used in Step 5.
Step 12	**crypto ca enroll** *name* **Example:** `Switch(config)# crypto ca enroll your_trustpoint`	Obtains the certificate from the specified CA trustpoint. This command requests a signed certificate for each RSA key pair.

Step 13	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Monitoring Secure HTTP Server and Client Status

To monitor the SSL secure server and client status, use the privileged EXEC commands in the following table.

Table 83: Commands for Displaying the SSL Secure Server and Client Status

Command	Purpose
show ip http client secure status	Shows the HTTP secure client configuration.

Command	Purpose
show ip http server secure status	Shows the HTTP secure server configuration.
show running-config	Shows the generated self-signed certificate for secure HTTP connections.

Configuration Examples for Secure Socket Layer HTTP

Example: Configuring Secure Socket Layer HTTP

The following example shows a configuration session in which the secure HTTP server is enabled, the port for the secure HTTP server is configured as 1025, and the remote CA trustpoint server "CA-trust-local" is used for certification.

```
Device# show ip http server status

HTTP server status: Disabled
HTTP server port: 80
HTTP server authentication method: enable
HTTP server access class: 0
HTTP server base path:
Maximum number of concurrent server connections allowed: 5
Server idle time-out: 600 seconds
Server life time-out: 600 seconds
Maximum number of requests allowed on a connection: 1
HTTP secure server capability: Present
HTTP secure server status: Disabled
HTTP secure server port: 443
HTTP secure server ciphersuite: 3des-ede-cbc-sha des-cbc-sha rc4-128-md5 rc4-12a
HTTP secure server client authentication: Disabled
HTTP secure server trustpoint:


Device# configure terminal
Device(config)# ip http secure-server
Device(config)# ip http client secure-trustpoint CA-trust-local
Device(config)# ip http secure-port 1024
Invalid secure port value.
Device(config)# ip http secure-port 1025
Device(config)# ip http secure-ciphersuite rc4-128-sha rc4-128-md5
Device(config)# end



Device# show ip http serversecure status

HTTP secure server status: Enabled
HTTP secure server port: 1025
HTTP secure server ciphersuite: rc4-128-md5 rc4-128-sha
HTTP secure server client authentication: Disabled
HTTP secure server trustpoint: CA-trust-local
```

In the following example, the CA trustpoint CA-trust-local is specified, and the HTTPS client is configured to use this trustpoint for client authentication requests:

```
Device# config terminal
Device(config)# crypto ca trustpoint CA-trust-local
Device(ca-trustpoint)# enrollment url http://example.com
Device(ca-trustpoint)# crl query ldap://example.com
Device(ca-trustpoint)# primary
Device(ca-trustpoint)# exit
Device(config)# ip http client secure-trustpoint CA-trust-local
Device(config)# end
Device# copy running-config startup-config
```

Additional References for Secure Socket Layer HTTP

Related Documents

Related Topic	Document Title
Cisco IOS commands	*Cisco IOS Master Command List, All Releases*

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for Secure Socket Layer HTTP

Release	Feature Information
Cisco IOS Release 15.2(5)E	This feature was introduced.

Glossary

RSA—RSA is a widely used Internet encryption and authentication system that uses public and private keys for encryption and decryption. The RSA algorithm was invented in 1978 by Ron Rivest, Adi Shamir, and Leonard Adleman. The abbreviation RSA comes from the first letter of the last names of the three original developers. The RSA algorithm is included in many applications, such as the web browsers from Microsoft and Netscape. The RSA encryption system is owned by RSA Security.

SHA —The Secure Hash Algorithm. SHA was developed by NIST and is specified in the Secure Hash Standard (SHS, FIPS 180). Often used as an alternative to Digest 5 algorithm.

signatures, digital —In the context of SSL, “signing” means to encrypt with a private key. In digital signing, one-way hash functions are used as input for a signing algorithm. In RSA signing, a 36-byte structure of two hashes (one SHA and one MD5) is signed (encrypted with the private key).

SSL 3.0 —Secure Socket Layer version 3.0. SSL is a security protocol that provides communications privacy over the Internet. The protocol allows client and server applications to communicate in a way that is designed to prevent eavesdropping, tampering, or message forgery. SSL uses a program layer located between the Internet’s HTTP and TCP layers. SSL is included as part of most web server products and as part of most Internet browsers. The SSL 3.0 specification can be found at https://tools.ietf.org/html/rfc6101.

CHAPTER 40

Certification Authority Interoperability

This chapter describes how to configure certification authority (CA) interoperability, which is provided in support of the IPSec protocol. CA interoperability permits Cisco IOS devices and CAs to communicate so that your Cisco IOS device can obtain and use digital certificates from the CA. Although IPSec can be implemented in your network without the use of a CA, using a CA provides manageability and scalability for IPSec.

Prerequisites For Certification Authority

You need to have a certification authority (CA) available to your network before you configure this interoperability feature. The CA must support the Public Key Infrastructure (PKI) protocol, and the Simple Certificate Enrollment Protocol (SCEP) .

Restrictions for Certification Authority

When configuring your CA, the following restrictions apply:

- This feature should be configured only when you also configure both IPsec and Internet Key Exchange (IKE) in your network.
- The Cisco IOS software does not support CA server public keys greater than 2048 bits.

Information About Certification Authority

CA Supported Standards

Without certification authority (CA) interoperability, Cisco IOS devices could not use CAs when deploying IPSec. CAs provide a manageable, scalable solution for IPSec networks.

Cisco supports the following standards with this feature:

- IPSec—IPSec is a framework of open standards that provides data confidentiality, data integrity, and data authentication between participating peers. IPSec provides these security services at the IP layer; it uses Internet Key Exchange to handle negotiation of protocols and algorithms based on local policy, and to generate the encryption and authentication keys to be used by IPSec. IPSec can be used to protect one or more data flows between a pair of hosts, between a pair of security gateways, or between a security gateway and a host.
- Internet Key Exchange (IKE)—A hybrid protocol that implements Oakley and Skeme key exchanges inside the Internet Security Association Key Management Protocol (ISAKMP) framework. Although IKE can be used with other protocols, its initial implementation is with the IPSec protocol. IKE provides authentication of the IPSec peers, negotiates IPSec keys, and negotiates IPSec security associations.
- Public-Key Cryptography Standard #7 (PKCS #7)—A standard from RSA Data Security, Inc., used to encrypt and sign certificate enrollment messages.
- Public-Key Cryptography Standard #10 (PKCS #10)—A standard syntax from RSA Data Security, Inc. for certificate requests.
- RSA Keys—RSA is the public key cryptographic system developed by Ron Rivest, Adi Shamir, and Leonard Adleman. RSA keys come in pairs: one public key and one private key.
- X.509v3 certificates—Certificate support that allows the IPSec-protected network to scale by providing the equivalent of a digital ID card to each device. When two devices wish to communicate, they exchange digital certificates to prove their identity (thus removing the need to manually exchange public keys with each peer or to manually specify a shared key at each peer). These certificates are obtained from a CA. X.509 is part of the X.500 standard of the ITU.

Purpose of CAs

Certificate authorities (CAs) are responsible for managing certificate requests and issuing certificates to participating IPSec network devices. These services provide centralized key management for the participating devices.

CAs simplify the administration of IPSec network devices. You can use a CA with a network containing multiple IPSec-compliant devices such as routers.

Digital signatures, enabled by public key cryptography, provide a means of digitally authenticating devices and individual users. In public key cryptography, such as the RSA encryption system, each user has a key pair containing both a public and a private key. The keys act as complements, and anything encrypted with one of the keys can be decrypted with the other. In simple terms, a signature is formed when data is encrypted with a user's private key. The receiver verifies the signature by decrypting the message with the sender's public key. The fact that the message could be decrypted using the sender's public key indicates that the holder of the private key, the sender, must have created the message. This process relies on the receiver's having a copy of the sender's public key and knowing with a high degree of certainty that it really does belong to the sender and not to someone pretending to be the sender.

Digital certificates provide the link. A digital certificate contains information to identify a user or device, such as the name, serial number, company, department, or IP address. It also contains a copy of the entity's public key. The certificate is itself signed by a certification authority (CA), a third party that is explicitly trusted by the receiver to validate identities and to create digital certificates.

In order to validate the signature of the CA, the receiver must first know the CA's public key. Normally this process is handled out-of-band or through an operation done at installation. For instance, most web browsers are configured with the public keys of several CAs by default. The Internet Key Exchange (IKE), an essential component of IPSec, can use digital signatures to scalably authenticate peer devices before setting up security associations.

Without digital signatures, one must manually exchange either public keys or secrets between each pair of devices that use IPSec to protect communications between them. Without certificates, every new device added to the network requires a configuration change on every other device with which it communicates securely. With digital certificates, each device is enrolled with a certification authority. When two devices wish to communicate, they exchange certificates and digitally sign data to authenticate each other. When a new device is added to the network, one simply enrolls that device with a CA, and none of the other devices needs modification. When the new device attempts an IPSec connection, certificates are automatically exchanged and the device can be authenticated.

Registration Authorities

Some CAs have a registration authority (RA) as part of their implementation. An RA is essentially a server that acts as a proxy for the CA so that CA functions can continue when the CA is offline.

Some of the configuration tasks described in this document differ slightly, depending on whether your CA supports an RA.

How to Configure Certification Authority

Managing NVRAM Memory Usage

Certificates and certificate revocation lists (CRLs) are used by your device when a CA is used. Normally certain certificates and all CRLs are stored locally in the NVRAM of the device, and each certificate and CRL uses a moderate amount of memory.

The following certificates are normally stored at your device:

- Certificate of your device
- Certificate of the CA
- Root certificates obtained from CA servers (all root certificates are saved in RAM after the device has been initialized)
- Two registration authority (RA) certificates (only if the CA supports an RA)

CRLs are normally stored at your device according to the following conditions:

- If your CA does not support an RA, only one CRL gets stored in the device.
- If your CA supports an RA, multiple CRLs can be stored in the device.

In some cases, storing these certificates and CRLs locally will not present any difficulty. In other cases, memory might become a problem—particularly if the CA supports an RA and a large number of CRLs have to be stored on the device. If the NVRAM is too small to store root certificates, only the fingerprint of the root certificate is saved.

To save NVRAM space, specify that certificates and CRLs should not be stored locally, but should be retrieved from the CA when needed. This alternative will save NVRAM space but could result in a slight performance impact. To specify that certificates and CRLs should not be stored locally on your device, but should be retrieved when required, enable query mode.

If you do not enable query mode now, you can do it later even if certificates and CRLs have are already stored on the device. In this case, when you enable query mode, the stored certificates and CRLs are deleted from the device after you save the configuration. (If you copy the configuration to a TFTP site prior to enabling query mode, you can save any stored certificates and CRLs at the TFTP site.)

Before disabling query mode, perform the **copy system:running-config nvram:startup-config** command to save all current certificates and CRLs to NVRAM. Otherwise they could be lost during a reboot.

To specify that certificates and CRLs should not be stored locally on your device, but should be retrieved when required, enable query mode by using the following command in global configuration mode:

Note Query mode may affect availability if the CA is down.

SUMMARY STEPS

1. **crypto ca certificate query**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**crypto ca certificate query** **Example:** `Device(config)# crypto ca certificate query`	Enables query mode, which causes certificates and CRLs not to be stored locally.

Configuring the Device Host Name and IP Domain Name

You must configure the host name and IP domain name of a device if this has not already been done. This is required because the device assigns a fully qualified domain name (FQDN) to the keys and certificates used by IPsec, and the FQDN is based on the host name and IP domain name assigned to the device. For example, a certificate named "device20.example.com" is based on a device host name of "device20" and a device IP domain name of "example.com".

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **hostname** *name*
4. **ip domain-name** *name*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**hostname** *name* **Example:** `Device(config)# hostname device1`	Configures the host name of the device.
Step 4	**ip domain-name** *name* **Example:** `Device(config)# ip domain-name domain.com`	Configures the IP domain name of the device.

Step 5	**end**
	Example:
	`Device(config)# end`
		Exits global configuration and returns to privileged EXEC mode.

Generating an RSA Key Pair

Rivest, Shamir, and Adelman (RSA) key pairs are used to sign and encrypt IKE key management messages and are required before obtaining a certificate for your device.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto key generate rsa** [**usage-keys**]
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto key generate rsa** [**usage-keys**] **Example:** `Device(config)# crypto key generate rsa usage-keys`	Generates an RSA key pair. • Use the **usage-keys** keyword to specify special-usage keys instead of general-purpose keys.

Step 4	**end**
	Example:
	`Device(config)# end`
		Exits global configuration and returns to privileged EXEC mode.

Declaring a Certification Authority

You should declare one certification authority (CA) to be used by the device.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto ca trustpoint** *name*
4. **enrollment url** *url*
5. **enrollment command**
6. **exit**
7. **crypto pki trustpoint** *name*
8. **crl query ldap**://*url*:[*port*]
9. **enrollment** {**mode ra** | **retry count** *number* | **retry period** *minutes* | **url** *url*}
10. **enrollment** {**mode ra** | **retry count** *number* | **retry period** *minutes* | **url** *url*}
11. **revocation-check** *method1* [*method2 method3*]
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto ca trustpoint** *name* **Example:** `Device(config)# crypto ca trustpoint ka`	Declares the certification authority (CA) that your device should use and enters the CA profile enroll configuration mode.
Step 4	**enrollment url** *url* **Example:** `Device(ca-profile-enroll)# enrollment url http://entrust:81`	Specifies the URL of the CA server to which enrollment requests are sent.
Step 5	**enrollment command** **Example:** `Device(ca-profile-enroll)# enrollment command`	Specifies the HTTP command that is sent to the CA for enrollment.
Step 6	**exit** **Example:** `Device(ca-profile-enroll)# exit`	Exit CA profile enroll configuration mode and returns to global configuration mode.

	Command or Action	Purpose
Step 7	**crypto pki trustpoint** *name* **Example:** `Device(config)# crypto pki trustpoint ka`	Declares the trustpoint that your device should use and enters Ca-trustpoint configuration mode.
Step 8	**crl query ldap**://*url*:[*port*] **Example:** `Device(ca-trustpoint)# crl query ldap://bar.cisco.com:3899`	Queries the certificate revocation list (CRL) to ensure that the certificate of the peer is not revoked.

Step 9	**enrollment** {**mode ra** | **retry count** *number* | **retry period** *minutes* | **url** *url*}
	Example:
	`Device(ca-trustpoint)# enrollment retry period 2`
		Specifies the enrollment wait period between certificate request retries.

Step 10	**enrollment** {**mode ra** | **retry count** *number* | **retry period** *minutes* | **url** *url*}
	Example:
	`Device(ca-trustpoint)# enrollment retry count 8`
		Specifies the number of times a device will resend a certificate request when it does not receive a response from the previous request.

Step 11	**revocation-check** *method1* [*method2 method3*] **Example:** `Device(ca-trustpoint)# revocation-check crl ocsp`	Checks the revocation status of a certificate.

Step 12	**end**
	Example:
	`Device(ca-trustpoint)# end`
		Exit CA trustpoint configuration mode and returns to privileged EXEC mode.

Configuring a Root CA (Trusted Root)

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto ca trustpoint** *name*
4. **revocation-check** *method1* [*method2 method3*]
5. **root tftp** *server-hostname filename*
6. **enrollment http-proxy** *hostname port-number*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto ca trustpoint** *name* **Example:** `Device(config)# crypto ca trustpoint ka`	Declares the trustpoint that your device should use and enters CA trustpoint configuration mode.
Step 4	**revocation-check** *method1* [*method2 method3*] **Example:** `Device(ca-trustpoint)# revocation-check ocsp`	Checks the revocation status of a certificate.
Step 5	**root tftp** *server-hostname filename* **Example:** `Device(ca-trustpoint)# root tftp server1 file1`	Obtains the certification authority (CA) certificate via TFTP.
Step 6	**enrollment http-proxy** *hostname port-number* **Example:** `Device(ca-trustpoint)# enrollment http-proxy host2 8080`	Accesses the certification authority (CA) by HTTP through the proxy server.

Step 7	**end**
	Example:
	`Device(ca-trustpoint)# end`
		Exits CA trustpoint configuration mode and returns to privileged EXEC mode.

Authenticating the CA

The device must authenticate the certification authority (CA). It does this by obtaining the self-signed certificate of the CA, which contains the public key of the CA. Because the certificate of the CA is self-signed (the CA signs its own certificate) the public key of the CA should be manually authenticated by contacting the CA administrator to compare the fingerprint of the CA certificate when you perform this step.

Perform the following task to get the public key of the CA:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto pki authenticate***name*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto pki authenticate***name* **Example:** `Device(config)# crypto pki authenticate myca`	Authenticates the CA by getting the certificate of the CA.

Step 4	**end**
	Example:
	`Device(config)# end`
		Exits global configuration mode and returns to privileged EXEC mode.

Requesting Signed Certificates

You must obtain a signed certificate from the certification authority (CA) for each of the RSA key pairs on your device. If you generated general-purpose RSA keys, your device has only one RSA key pair and needs only one certificate. If you previously generated special-usage RSA keys, your device has two RSA key pairs and needs two certificates.

Perform the following task to request signed certificates from the CA:

Note If your device reboots after you have issued the **crypto pki enroll** command, but before you have received the certificates, you must reissue the command and notify the CA administrator.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto pki enroll** *number*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto pki enroll** *number* **Example:** `Device(config)# crypto pki enroll myca`	Obtains certificates for your device from the CA.

Step 4	**end**
	Example:
	`Device(config)# end`
		Exits global configuration mode and returns to privileged EXEC mode.

What to do next

Saving Your Configuration

Always remember to save your work when you make configuration changes.

Use the **copy system:running-config nvram:startup-config** command to save your configuration. This command includes saving RSA keys to private NVRAM. RSA keys are not saved with your configuration when you use a **copy system:running-config rcp:** or copy **system:running-config tftp:** command.

Monitoring and Maintaining Certification Authority

Requesting a Certificate Revocation List

You can request a certificate revocation list (CRL) only if the certification authority (CA) does not support a registration authority (RA). The following task applies only when the CA does not support an RA.

When a device receives a certificate from a peer, your device will download a CRL from the CA. The device then checks the CRL to make sure the certificate that the peer sent has not been revoked. (If the certificate appears on the CRL, the device will not accept the certificate and will not authenticate the peer.)

A CRL can be reused with subsequent certificates until the CRL expires if query mode is off. If the device receives a peer's certificate after the applicable CRL has expired, the device will download the new CRL.

If the device has a CRL that has not yet expired, but you suspect that the contents of the CRL are out of date, you can request that the latest CRL be downloaded immediately to replace the old CRL.

-

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto pki crl request** *name*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto pki crl request** *name* **Example:** `Device(config)# crypto pki crl request myca`	Requests that a new certificate revocation list (CRL) be obtained immediately from the CA.

Step 4	**end**
	Example:
	`Device(config)# end`
		Exits global configuration mode and returns to privileged EXEC mode.

Querying a Certification Revocation List

You can query a certificate revocation list (CRL) only when you configure your device with a trusted root. When your device receives a certificate from a peer from another domain (with a different CA), the CRL downloaded from the CA of the device will not include certificate information about the peer. Therefore, you should check the CRL published by the configured root with the LDAP URL to ensure that the certificate of the peer has not been revoked.

If you would like CRL of the root certificate to be queried when the device reboots, you must enter the **crl query** command.

Perform the following task to query the CRL published by the configured root with the LDAP URL:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto pki trustpoint** *name*
4. **crl query ldap** ://*url* : [*port*]
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto pki trustpoint** *name* **Example:** `Device(ca-trustpoint)# crypto pki trustpoint mytp`	Declares the trustpoint that your device should use and enters CA trustpoint configuration mode.
Step 4	**crl query ldap** ://*url* : [*port*] **Example:** `Device(ca-trustpoint)# crl query ldap://url:[port]`	Queries the CRL to ensure that the certificate of the peer has not been revoked.

Step 5	**end**
	Example:
	`Device(ca-trustpoint)# end`
		Exits CA trustpoint configuration mode and returns to privileged EXEC mode.

Deleting RSA Keys from a Device

Under certain circumstances you may want to delete RSA keys from your device. For example, if you believe the RSA keys were compromised in some way and should no longer be used, you should delete the keys.

]

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto key zeroize rsa** [*key-pair-label*]
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto key zeroize rsa** [*key-pair-label*] **Example:** `Device(config)# crypto key zeroize rsa`	Deletes all Rivest, Shamir, and Adelman (RSA) keys from your device.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Device(config)# end`
		Exits global configuration mode and returns to privileged EXEC mode.

What to do next

After you delete RSA keys from the device, you should also complete the following two additional tasks:

- Ask the CA administrator to revoke the device certificates at the CA; you must supply the challenge password that you created when you originally obtained the device certificates with the **crypto pki enroll** command.
- Manually remove the device certificates from the device configuration.

Deleting Public Keys for a Peer

Under certain circumstances you may want to delete RSA public keys of peer devices from your device configuration. For example, if you no longer trust the integrity of the public key of a peer, you should delete the key.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto key pubkey-chain rsa**
4. **no named key** *key-name* [**encryption** | **signature**]
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto key pubkey-chain rsa** **Example:** `Device(config)# crypto key pubkey-chain rsa`	Enters public key chain configuration mode, so that you can manually specify other devices' RSA public keys.
Step 4	**no named key** *key-name* [**encryption** | **signature**] **Example:** `Device(config-pubkey-c)# no named-key otherpeer.example.com`	Deletes the RSA public key of a remote peer and enters public key configuration mode.

	Command or Action	Purpose

Step 5	**end**
	Example:
	`Device(config-pubkey)# end`
		Exits public key configuration mode and returns to privileged EXEC mode.

Deleting Certificates from the Configuration

If the need arises, you can delete certificates that are saved in your device. Your devices saves its own certificates, the certificate of the CA, and any RA certificates .

To delete the CA's certificate, you must remove the entire CA identity, which also removes all certificates associated with the CA—your router's certificate, the CA certificate, and any RA certificates.

SUMMARY STEPS

1. **enable**
2. **show crypto pki certificates**
3. **configure terminal**
4. **crypto pki certificate chain** *name*
5. **no certificate** *certificate-serial-number*
6. **exit**
7. **no crypto pki import** *name* **certificate**
8. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show crypto pki certificates** **Example:** `Device# show crypto pki certificates`	Displays information about your device certificate, the certification authority (CA) certificate, and any registration authority (RA) certificates.
Step 3	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 4	**crypto pki certificate chain** *name* **Example:** `Device(config)# crypto pki certificate chain myca`	Enters certificate chain configuration mode.
Step 5	**no certificate** *certificate-serial-number* **Example:**	Deletes the certificate.

	Command or Action	Purpose
	`Device(config-cert-chain)# no certificate 0123456789ABCDEF0123456789ABCDEF`	
Step 6	**exit** **Example:** `Device(config-cert-chain)# exit`	Exits certificate chain configuration mode and returns to global configuration mode.
Step 7	**no crypto pki import** *name* **certificate** **Example:** `Device(config)# no crypto pki import MS certificate`	Deletes a certificate manually.
Step 8	**exit** **Example:** `Device(config)# exit`	Exits global configuration mode and returns to privileged EXEC mode.

Viewing Keys and Certificates

Perform the following task toview keys and certificates:

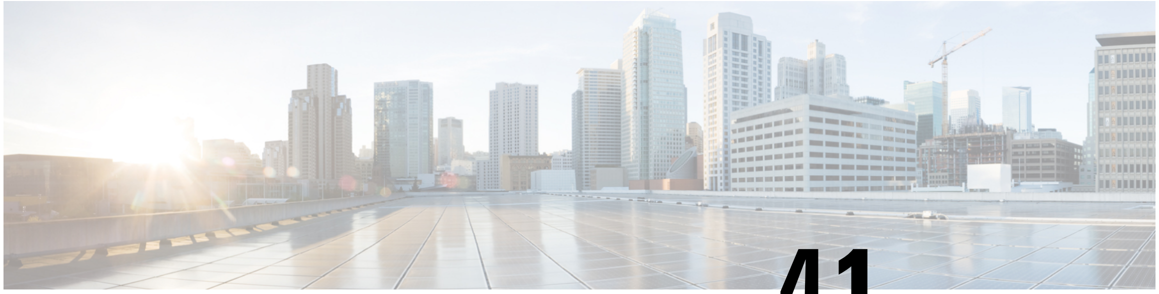
SUMMARY STEPS

1. **enable**
2. **show crypto key mypubkey rsa** [*keyname*]
3. **show crypto key pubkey-chain rsa**
4. **show crypto key pubkey-chain rsa** [**name** *key-name* | **address** *key-address*]
5. **show crypto pki certificates**
6. **show crypto pki trustpoints**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show crypto key mypubkey rsa** [*keyname*] **Example:** `Device# show crypto key mypubkey rsa [keyname]`	Displays the RSA public keys configured on a device.
Step 3	**show crypto key pubkey-chain rsa** **Example:** `Device# show crypto key pubkey-chain rsa`	Displays the RSA public keys of the peer that are stored on a device.
Step 4	**show crypto key pubkey-chain rsa** [**name** *key-name* | **address** *key-address*]	Displays the address of a specific key.

	Command or Action	Purpose
	Example: `Device# show crypto key pubkey-chain rsa address 209.165.202.129`	
Step 5	**show crypto pki certificates** **Example:** `Device# show crypto pki certificates`	Displays information about the device certificate, the certification authority (CA) certificate, and any registration authority (RA) certificates
Step 6	**show crypto pki trustpoints** **Example:** `Device# show crypto pki certificates`	Displays trustpoints that are configured on a device.



CHAPTER 41

Access Control List Overview

Access lists filter network traffic by controlling the forwarding or blocking of packets at the interface of a device. A device examines each packet to determine whether to forward or drop that packet, based on the criteria specified in access lists.

The criteria that can be specified in an access list include the source address of the traffic, the destination address of the traffic, and the upper-layer protocol.

Note Some users might successfully evade basic access lists because these lists require no authentication.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About Access Control Lists

Definition of an Access List

An access list is a sequential list consisting of at least one **permit** statement and possibly one or more **deny** statements. In the case of IP access lists, the statements can apply to IP addresses, upper-layer IP protocols, or other fields in IP packets. The access list is identified and referenced by a name or a number. Access list acts as a packet filter, filtering packets based on the criteria defined in the access list.

An access list may be configured, but it does not take effect until the access list is either applied to an interface, a virtual terminal line (vty), or referenced by some command that accepts an access list. Multiple commands can reference the same access list.

The following configuration example shows how to create an IP access list named branchoffices. The ACL is applied to gigabitEthernet on incoming packets. No sources other than those on the networks specified by each source address and mask pair can access this interface. The destinations for packets coming from sources on network 172.20.7.0 are unrestricted. The destination for packets coming from sources on network 172.29.2.0 must be 172.25.5.4.

```
ip access-list extended branchoffices
 10 permit 172.20.7.0 0.0.0.3 any
 20 permit 172.29.2.0 0.0.0.255 host 172.25.5.4
!
gigabitEthernet 0/1
 ip access-group branchoffices in
```

Functions of an Access Control List

There are many reasons to configure access lists; for example, to restrict contents of routing updates or to provide traffic flow control. One of the most important reasons to configure access lists is to provide security for your network, which is the focus of this module.

Use access lists to provide a basic level of security for accessing your network. If you do not configure access lists on your device, all packets passing through the device are allowed access to all parts of your network.

Access lists can allow a host to access a part of your network and prevent another host from accessing the same area. In the figure below, Host A is allowed to access the Human Resources network, but Host B is prevented from accessing the Human Resources network.

You can also use access lists to define the type of traffic that is forwarded or blocked at device interfaces. For example, you can permit e-mail traffic to be routed but at the same time block all Telnet traffic.

Purpose of IP Access Lists

Access lists perform packet filtering to control which packets move through the network and where. Such control can help limit network traffic and restrict the access of users and devices to the network. Access lists have many uses, and therefore many commands accept a reference to an access list in their command syntax. Access lists can be used to do the following:

- Filter incoming packets on an interface.
- Filter outgoing packets on an interface.
- Limit debug output based on an address or protocol.
- Control virtual terminal line access.
- Identify or classify traffic for advanced features, such as congestion avoidance, congestion management, and priority and custom queuing.

Reasons to Configure ACLs

There are many reasons to configure access lists; for example, you can use access lists to restrict contents of switching updates or to provide traffic flow control. One of the most important reasons to configure access lists is to provide a basic level of security for your network by controlling access to it. If you do not configure access lists on your device, all packets passing through the device could be allowed onto all parts of your network.

An access list can allow one host to access a part of your network and prevent another host from accessing the same area. For example, by applying an appropriate access list to interfaces of a device, Host A is allowed to access the human resources network and Host B is prevented from accessing the human resources network.

You can use access lists on a device that is positioned between two parts of your network, to control traffic entering or exiting a specific part of your internal network.

To provide some security benefits of access lists, you should at least configure access lists on border devices—devices located at the edges of your networks. Such an access list provides a basic buffer from the outside network or from a less controlled area of your own network into a more sensitive area of your network. On these border devices, you should configure access lists for each network protocol configured on the device interfaces. You can configure access lists so that inbound traffic or outbound traffic or both are filtered on an interface.

Access lists are defined on a per-protocol basis. In other words, you should define access lists for every protocol enabled on an interface if you want to control traffic flow for that protocol.

Software Processing of an Access List

The following general steps describe how the an access list is processed when it is applied to an interface, a vty, or referenced by any command. These steps apply to an access list that has 13 or fewer access list entries.

- The software receives an IP packet and tests parts of each packet being filtered against the conditions in the access list, one condition (**permit** or **deny** statement) at a time. For example, the software tests the source and destination addresses of the packet against the source and destination addresses in a **permit** or **deny** statement.

- If a packet does not match an access list statement, the packet is then tested against the next statement in the list.

- If a packet and an access list statement match, the rest of the statements in the list are skipped and the packet is permitted or denied as specified in the matched statement. The first entry that the packet matches determines whether the software permits or denies the packet. That is, after the first match, no subsequent entries are considered.

- If no conditions match, the software drops the packet. This is because each access list ends with an unwritten, implicit **deny** statement. That is, if the packet has not been permitted by the time it was tested against each statement, it is denied.

An access list with more than 13 entries is processed using a trie-based lookup algorithm. This process will happen automatically; it does not need to be configured.

Access List Rules

The following rules apply to access control lists (ACLs):

- Only one access list per interface, per protocol, and per direction is allowed.
- An access list must contain at least one **permit** statement or all packets are denied entry into the network.
- The order in which access list conditions or match criteria are configured is important. While deciding whether to forward or block a packet, Cisco software tests the packet against each criteria statement in the order in which these statements are created. After a match is found, no more criteria statements are checked. The same **permit** or **deny** statements specified in a different order can result in a packet being passed under one circumstance and denied in another circumstance.
- If an access list is referenced by a name, but the access list does not exist, all packets pass. An interface or command with an empty access list applied to it permits all traffic into the network.
- Standard access lists and extended access lists cannot have the same name.
- Inbound access lists process packets before packets are sent to an outbound interface. Inbound access lists that have filtering criteria that deny packet access to a network saves the overhead of a route lookup. Packets that are permitted access to a network based on the configured filtering criteria are processed for routing. For inbound access lists, when you configure a **permit** statement, packets are processed after they are received, and when you configure a **deny** statement, packets are discarded.
- Outbound access lists process packets before they leave the device. Incoming packets are routed to the outbound interface and then processed by the outbound access list. For outbound access lists, when you configure a **permit** statement, packets are sent to the output buffer, and when you configure a **deny** statement, packets are discarded.
- An access list can control traffic arriving at a device or leaving a device, but not traffic originating at a device.

Helpful Hints for Creating IP Access Lists

The following tips will help you avoid unintended consequences and help you create more efficient access lists.

- Create the access list before applying it to an interface (or elsewhere), because if you apply a nonexistent access list to an interface and then proceed to configure the access list, the first statement is put into effect, and the implicit **deny** statement that follows could cause you immediate access problems.
- Another reason to configure an access list before applying it is because an interface with an empty access list applied to it permits all traffic.
- All access lists need at least one **permit** statement; otherwise, all packets are denied and no traffic passes.
- Because the software stops testing conditions after it encounters the first match (to either a **permit** or **deny** statement), you will reduce processing time and resources if you put the statements that packets are most likely to match at the beginning of the access list. Place more frequently occurring conditions before less frequent conditions.
- Organize your access list so that more specific references in a network or subnet appear before more general ones.
- Use the statement **permit any any** if you want to allow all other packets not already denied. Using the statement **permit any any** in effect avoids denying all other packets with the implicit deny statement at the end of an access list. Do not make your first access list entry **permit any any** because all traffic will

get through; no packets will reach the subsequent testing. In fact, once you specify **permit any any**, all traffic not already denied will get through.

- Although all access lists end with an implicit **deny** statement, we recommend use of an explicit **deny** statement (for example, **deny ip any any**). On most platforms, you can display the count of packets denied by issuing the **show access-list**command, thus finding out more information about who your access list is disallowing. Only packets denied by explicit **deny** statements are counted, which is why the explicit **deny** statement will yield more complete data for you.

- While you are creating an access list or after it is created, you might want to delete an entry.
    - You cannot delete an entry from a numbered access list; trying to do so will delete the entire access list. If you need to delete an entry, you need to delete the entire access list and start over.
    - You can delete an entry from a named access list. Use the **no permit** or **no deny** command to delete the appropriate entry.

- In order to make the purpose of individual statements more scannable and easily understood at a glance, you can write a helpful remark before or after any statement by using the **remark** command.

- If you want to deny access to a particular host or network and find out if someone from that network or host is attempting to gain access, include the **log** keyword with the corresponding **deny** statement so that the packets denied from that source are logged for you.

- This hint applies to the placement of your access list. When trying to save resources, remember that an inbound access list applies the filter conditions before the routing table lookup. An outbound access list applies the filter conditions after the routing table lookup.

IP Packet Fields You Can Filter to Control Access

You can use an extended access list to filter on any of the following fields in an IP packet. Source address and destination address are the two most frequently specified fields on which to base an access list:

- Source address--Specifies a source address to control packets coming from certain networking devices or hosts.

- Destination address--Specifies a destination address to control packets being sent to certain networking devices or hosts.

-

Source and Destination Addresses

Source and destination address fields in an IP packet are two typical fields on which to base an access list. Specify source addresses to control the packets being sent from certain networking devices or hosts. Specify destination addresses to control the packets being sent to certain networking devices or hosts.

Wildcard Mask for Addresses in an Access List

Address filtering uses wildcard masking to indicate to the software whether to check or ignore corresponding IP address bits when comparing the address bits in an access list entry to a packet being submitted to the access list. By carefully setting wildcard masks, you can specify one or more IP addresses for permit or deny tests.

Wildcard masking for IP address bits uses the number 1 and the number 0 to specify how the software treats the corresponding IP address bits. A wildcard mask is sometimes referred to as an inverted mask because a 1 and 0 mean the opposite of what they mean in a subnet (network) mask.

- A wildcard mask bit 0 means check the corresponding bit value; they must match.
- A wildcard mask bit 1 means ignore that corresponding bit value; they need not match.

If you do not supply a wildcard mask with a source or destination address in an access list statement, the software assumes an implicit wildcard mask of 0.0.0.0, meaning all values must match.

Unlike subnet masks, which require contiguous bits indicating network and subnet to be ones, wildcard masks allow noncontiguous bits in the mask.

The table below shows examples of IP addresses and masks from an access list, along with the corresponding addresses that are considered a match.

Table 84: Sample IP Addresses, Wildcard Masks, and Match Results

Address	Wildcard Mask	Match Results
0.0.0.0	255.255.255.255	All addresses will match the access list conditions.
172.18.0.0/16	0.0.255.255	Network 172.18.0.0
172.18.5.2/16	0.0.0.0	Only host 172.18.5.2 matches
172.18.8.0	0.0.0.7	Only subnet 172.18.8.0/29 matches
172.18.8.8	0.0.0.7	Only subnet 172.18.8.8/29 matches
172.18.8.15	0.0.0.3	Only subnet 172.18.8.15/30 matches
10.1.2.0	0.0.254.255 (noncontiguous bits in mask)	Matches any even-numbered network in the range of 10.1.2.0 to 10.1.254.0

Access List Sequence Numbers

The ability to apply sequence numbers to IP access list entries simplifies access list changes. Prior to the IP Access List Entry Sequence Numbering feature, there was no way to specify the position of an entry within an access list. If you wanted to insert an entry in the middle of an existing list, all of the entries after the desired position had to be removed, then the new entry was added, and then all the removed entries had to be reentered. This method was cumbersome and error prone.

This feature allows users to add sequence numbers to access list entries and resequence them. When you add a new entry, you specify the sequence number so that it is in a desired position in the access list. If necessary, entries currently in the access list can be resequenced to create room to insert the new entry.

ACL Supported Types

The switch supports IP ACLs and Ethernet (MAC) ACLs:

- IP ACLs filter IPv4 traffic, including TCP, User Datagram Protocol (UDP), Internet Group Management Protocol (IGMP), and Internet Control Message Protocol (ICMP).

- Ethernet ACLs filter non-IP traffic.

Supported ACLs

The switch supports the following type of ACL to filter traffic:

- Port ACLs access-control traffic entering a Layer 2 interface. You can apply port ACLs to a Layer 2 interface in each input direction to each access list type — IPv4 and MAC.

Port ACLs

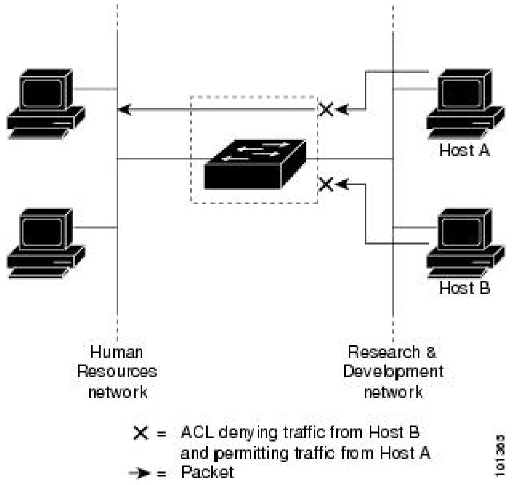
Port ACLs are ACLs that are applied to Layer 2 interfaces on a switch. Port ACLs are supported only on physical interfaces and not on EtherChannel interfaces. Port ACLs can be applied to the interface in inbound direction. The following access lists are supported:

- Standard IP access lists using source addresses
- Extended IP access lists using source and destination addresses and optional protocol type information
- MAC extended access lists using source and destination MAC addresses and optional protocol type information

The switch examines ACLs on an interface and permits or denies packet forwarding based on how the packet matches the entries in the ACL. In this way, ACLs control access to a network or to part of a network.

Figure 56: Using ACLs to Control Traffic in a Network

This is an example of using port ACLs to control access to a network when all workstations are in the same VLAN. ACLs applied at the Layer 2 input would allow Host A to access the Human Resources network, but prevent Host B from accessing the same network. Port ACLs can only be applied to Layer 2 interfaces in the inbound direction.


Host A
Host B
Human Resources network
Research & Development network
X = ACL denying traffic from Host B and permitting traffic from Host A
→ = Packet
101363

When you apply a port ACL to a trunk port, the ACL filters traffic on all VLANs present on the trunk port. When you apply a port ACL to a port with voice VLAN, the ACL filters traffic on both data and voice VLANs.

With port ACLs, you can filter IP traffic by using IP access lists and non-IP traffic by using MAC addresses. You can filter both IP and non-IP traffic on the same Layer 2 interface by applying both an IP access list and a MAC access list to the interface.

Note You cannot apply more than one IP access list and one MAC access list to a Layer 2 interface. If an IP access list or MAC access list is already configured on a Layer 2 interface and you apply a new IP access list or MAC access list to the interface, the new ACL replaces the previously configured one.

Access Control Entries

An ACL contains an ordered list of access control entries (ACEs). Each ACE specifies *permit* or *deny* and a set of conditions the packet must satisfy in order to match the ACE. The meaning of *permit* or *deny* depends on the context in which the ACL is used.

ACEs and Fragmented and Unfragmented Traffic

IP packets can be fragmented as they cross the network. When this happens, only the fragment containing the beginning of the packet contains the Layer 4 information, such as TCP or UDP port numbers, ICMP type and code, and so on. All other fragments are missing this information.

Some access control entries (ACEs) do not check Layer 4 information and therefore can be applied to all packet fragments. ACEs that do test Layer 4 information cannot be applied in the standard manner to most of the fragments in a fragmented IP packet. When the fragment contains no Layer 4 information and the ACE tests some Layer 4 information, the matching rules are modified:

- Permit ACEs that check the Layer 3 information in the fragment (including protocol type, such as TCP, UDP, and so on) are considered to match the fragment regardless of what the missing Layer 4 information might have been.

  Note For TCP ACEs with L4 Ops, the fragmented packets will be dropped per RFC 1858.

- Deny ACEs that check Layer 4 information never match a fragment unless the fragment contains Layer 4 information.

ACEs and Fragmented and Unfragmented Traffic Examples

Consider access list 102, configured with these commands, applied to three fragmented packets:

```
Switch(config)# access-list 102 permit tcp any host 10.1.1.1 eq smtp
Switch(config)# access-list 102 deny tcp any host 10.1.1.2 eq telnet
Switch(config)# access-list 102 permit tcp any host 10.1.1.2
Switch(config)# access-list 102 deny tcp any any
```

Note In the first and second ACEs in the examples, the *eq* keyword after the destination address means to test for the TCP-destination-port well-known numbers equaling Simple Mail Transfer Protocol (SMTP) and Telnet, respectively.

- Packet A is a TCP packet from host 10.2.2.2., port 65000, going to host 10.1.1.1 on the SMTP port. If this packet is fragmented, the first fragment matches the first ACE (a permit) as if it were a complete packet because all Layer 4 information is present. The remaining fragments also match the first ACE, even though they do not contain the SMTP port information, because the first ACE only checks Layer 3 information when applied to fragments. The information in this example is that the packet is TCP and that the destination is 10.1.1.1.
- Packet B is from host 10.2.2.2, port 65001, going to host 10.1.1.2 on the Telnet port. If this packet is fragmented, the first fragment matches the second ACE (a deny) because all Layer 3 and Layer 4 information is present. The remaining fragments in the packet do not match the second ACE because they are missing Layer 4 information. Instead, they match the third ACE (a permit).

  Because the first fragment was denied, host 10.1.1.2 cannot reassemble a complete packet, so packet B is effectively denied. However, the later fragments that are permitted will consume bandwidth on the network and resources of host 10.1.1.2 as it tries to reassemble the packet.
- Fragmented packet C is from host 10.2.2.2, port 65001, going to host 10.1.1.3, port ftp. If this packet is fragmented, the first fragment matches the fourth ACE (a deny). All other fragments also match the fourth ACE because that ACE does not check any Layer 4 information and because Layer 3 information in all fragments shows that they are being sent to host 10.1.1.3, and the earlier permit ACEs were checking different hosts.

CHAPTER 42

Configuring IPv4 Access Control Lists

Access control lists (ACLs) perform packet filtering to control which packets move through the network and where. Such control provides security by helping to limit network traffic, restrict the access of users and devices to the network, and prevent traffic from leaving a network. IP access lists can reduce the chance of spoofing and denial-of-service attacks and allow dynamic, temporary user access through a firewall.

IP access lists can also be used for purposes other than security, such as bandwidth control, limiting debug output, and identifying or classifying traffic for quality of service (QoS) features. This module provides an overview of IP access lists.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for Configuring IPv4 Access Control Lists

General Network Security

The following are restrictions for configuring network security with ACLs:

- Router ACL and VLAN ACLs are not supported.
- Not all commands that accept a numbered ACL accept a named ACL. ACLs for packet filters and route filters on interfaces can use a name.
- A standard ACL and an extended ACL cannot have the same name.
- Though visible in the command-line help strings, **AppleTalk** is not supported as a matching condition for the **deny** and **permit** MAC access-list configuration mode commands.
- ACL wild card is not supported in downstream client policy.
- Per ASIC, 8 TCP port comparators and 8 UDP port comparators are supported, and each gt (greater than)/lt (less than)/neq (not equal) operator uses 1 port comparator, and each range operator uses 2 port comparators.

IPv4 ACL Network Interfaces

The following restrictions apply to IPv4 ACLs to network interfaces:

- When controlling access to an interface, you can use a named or numbered ACL.
- You do not have to enable routing to apply ACLs to Layer 2 interfaces.
- On Layer 3 ports and SVIs, ACLs are not supported.

MAC ACLs on a Layer 2 Interface

After you create a MAC ACL, you can apply it to a Layer 2 interface to filter non-IP traffic coming in that interface. When you apply the MAC ACL, consider these guidelines:

- You can apply no more than one IP access list and one MAC access list to the same Layer 2 interface. The IP access list filters only IP packets, and the MAC access list filters non-IP packets.
- A Layer 2 interface can have only one MAC access list. If you apply a MAC access list to a Layer 2 interface that has a MAC ACL configured, the new ACL replaces the previously configured one.

Note The **mac access-group** interface configuration command is only valid when applied to a physical Layer 2 interface. You cannot use the command on EtherChannel port channels.

IP Access List Entry Sequence Numbering

- This feature does not support dynamic, reflexive, or firewall access lists.

Information About Configuring IPv4 Access Control Lists

ACL Overview

Packet filtering can help limit network traffic and restrict network use by certain users or devices. ACLs filter traffic as it passes through a router or switch and permit or deny packets crossing specified interfaces or VLANs. An ACL is a sequential collection of permit and deny conditions that apply to packets. When a packet is received on an interface, the switch compares the fields in the packet against any applied ACLs to verify that the packet has the required permissions to be forwarded, based on the criteria specified in the access lists. One by one, it tests packets against the conditions in an access list. The first match decides whether the switch accepts or rejects the packets. Because the switch stops testing after the first match, the order of conditions in the list is critical. If no conditions match, the switch rejects the packet. If there are no restrictions, the switch forwards the packet; otherwise, the switch drops the packet. The switch can use ACLs on all packets it forwards, including packets bridged within a VLAN.

You configure access lists on a router to provide basic security for your network. If you do not configure ACLs, all packets passing through the switch could be allowed onto all parts of the network. You can use ACLs to control which hosts can access different parts of a network or to decide which types of traffic are forwarded or blocked at router interfaces. For example, you can allow e-mail traffic to be forwarded but not Telnet traffic. ACLs can be configured to block inbound traffic, outbound traffic, or both.

Standard and Extended IPv4 ACLs

This section describes IP ACLs.

An ACL is a sequential collection of permit and deny conditions. One by one, the switch tests packets against the conditions in an access list. The first match determines whether the switch accepts or rejects the packet. Because the switch stops testing after the first match, the order of the conditions is critical. If no conditions match, the switch denies the packet.

The software supports these types of ACLs or access lists for IPv4:

- Standard IP access lists use source addresses for matching operations.
- Extended IP access lists use source and destination addresses for matching operations and optional protocol-type information for finer granularity of control.

IPv4 ACL Switch Unsupported Features

Configuring IPv4 ACLs on the switch is the same as configuring IPv4 ACLs on other Cisco switches and routers.

The following ACL-related features are not supported:

- Non-IP protocol ACLs or bridge-group ACLs
- IP accounting
- Inbound and outbound rate limiting (except with QoS ACLs)
- Reflexive ACLs and dynamic ACLs are not supported. (except for some specialized dynamic ACLs used by the switch clustering feature)

- ACL logging for VLAN maps

Access List Numbers

The number you use to denote your ACL shows the type of access list that you are creating.

This lists the access-list number and corresponding access list type and shows whether or not they are supported in the switch. The switch supports IPv4 standard and extended access lists, numbers 1 to 199 and 1300 to 2699.

Table 85: Access List Numbers

Access List Number	Type	Supported
1–99	IP standard access list	Yes
100–199	IP extended access list	Yes
200–299	Protocol type-code access list	No
300–399	DECnet access list	No
400–499	XNS standard access list	No
500–599	XNS extended access list	No
600–699	AppleTalk access list	No
700–799	48-bit MAC address access list	No
800–899	IPX standard access list	No
900–999	IPX extended access list	No
1000–1099	IPX SAP access list	No
1100–1199	Extended 48-bit MAC address access list	No
1200–1299	IPX summary address access list	No
1300–1999	IP standard access list (expanded range)	Yes
2000–2699	IP extended access list (expanded range)	Yes

In addition to numbered standard and extended ACLs, you can also create standard and extended named IP ACLs by using the supported numbers. That is, the name of a standard IP ACL can be 1 to 99; the name of an extended IP ACL can be 100 to 199. The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

Numbered Standard IPv4 ACLs

When creating an ACL, remember that, by default, the end of the ACL contains an implicit deny statement for all packets that it did not find a match for before reaching the end. With standard access lists, if you omit the mask from an associated IP host address ACL specification, 0.0.0.0 is assumed to be the mask.

The switch always rewrites the order of standard access lists so that entries with **host** matches and entries with matches having a *don't care* mask of 0.0.0.0 are moved to the top of the list, above any entries with non-zero *don't care* masks. Therefore, in **show** command output and in the configuration file, the ACEs do not necessarily appear in the order in which they were entered.

Numbered Extended IPv4 ACLs

Although standard ACLs use only source addresses for matching, you can use extended ACL source and destination addresses for matching operations and optional protocol type information for finer granularity of control. When you are creating ACEs in numbered extended access lists, remember that after you create the ACL, any additions are placed at the end of the list. You cannot reorder the list or selectively add or remove ACEs from a numbered list.

The switch does not support dynamic or reflexive access lists. It also does not support filtering based on the type of service (ToS) minimize-monetary-cost bit.

Some protocols also have specific parameters and keywords that apply to that protocol.

You can define an extended TCP, UDP, ICMP, IGMP, or other IP ACL. The switch also supports these IP protocols:

Note ICMP echo-reply cannot be filtered. All other ICMP codes or types can be filtered.

These IP protocols are supported:

- Authentication Header Protocol (**ahp**)
- Encapsulation Security Payload (**esp**)
- Enhanced Interior Gateway Routing Protocol (**eigrp**)
- generic routing encapsulation (**gre**)
- Internet Control Message Protocol (**icmp**)
- Internet Group Management Protocol (**igmp**)
- any Interior Protocol (**ip**)
- IP in IP tunneling (**ipinip**)
- KA9Q NOS-compatible IP over IP tunneling (**nos**)
- Open Shortest Path First routing (**ospf**)
- Payload Compression Protocol (**pcp**)
- Protocol-Independent Multicast (**pim**)
- Transmission Control Protocol (**tcp**)

- User Datagram Protocol (**udp**)

Named IPv4 ACLs

You can identify IPv4 ACLs with an alphanumeric string (a name) rather than a number. You can use named ACLs to configure more IPv4 access lists in a router than if you were to use numbered access lists. If you identify your access list with a name rather than a number, the mode and command syntax are slightly different. However, not all commands that use IP access lists accept a named access list.

Note The name you give to a standard or extended ACL can also be a number in the supported range of access list numbers. That is, the name of a standard IP ACL can be 1 to 99 and . The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

Consider these guidelines before configuring named ACLs:

- Numbered ACLs are also available.
- A standard ACL and an extended ACL cannot have the same name.

Benefits of Using the Named ACL Support for Noncontiguous Ports on an Access Control Entry Feature

The Named ACL Support for Noncontiguous Ports on an Access Control Entry feature allows you to specify noncontiguous ports in a single access control entry, which greatly reduces the number of entries required in an access control list when several entries have the same source address, destination address, and protocol, but differ only in the ports.

This feature greatly reduces the number of access control entries (ACEs) required in an access control list to handle multiple entries for the same source address, destination address, and protocol. If you maintain large numbers of ACEs, use this feature to consolidate existing groups of access list entries wherever it is possible and when you create new access list entries. When you configure access list entries with noncontiguous ports, you will have fewer access list entries to maintain.

Benefits of IP Access List Entry Sequence Numbering

The ability to apply sequence numbers to IP access list entries simplifies access list changes. Prior to the IP Access List Entry Sequence Numbering feature, there was no way to specify the position of an entry within an access list. If a user wanted to insert an entry (statement) in the middle of an existing list, all of the entries after the desired position had to be removed, then the new entry was added, and then all the removed entries had to be reentered. This method was cumbersome and error prone.

This feature allows users to add sequence numbers to access list entries and resequence them. When a user adds a new entry, the user chooses the sequence number so that it is in a desired position in the access list. If necessary, entries currently in the access list can be resequenced to create room to insert the new entry.

Sequence Numbering Behavior

- For backward compatibility with previous releases, if entries with no sequence numbers are applied, the first entry is assigned a sequence number of 10, and successive entries are incremented by 10. The maximum sequence number is 2147483647. If the generated sequence number exceeds this maximum number, the following message is displayed:

```
Exceeded maximum sequence number.
```

- If the user enters an entry without a sequence number, it is assigned a sequence number that is 10 greater than the last sequence number in that access list and is placed at the end of the list.
- If the user enters an entry that matches an already existing entry (except for the sequence number), then no changes are made.
- If the user enters a sequence number that is already present, the following error message is generated:

```
Duplicate sequence number.
```

- If a new access list is entered from global configuration mode, then sequence numbers for that access list are generated automatically.
- Distributed support is provided so that the sequence numbers of entries in the Route Processor (RP) and line card are in synchronization at all times.
- Sequence numbers are not nvgened. That is, the sequence numbers themselves are not saved. In the event that the system is reloaded, the configured sequence numbers revert to the default sequence starting number and increment. The function is provided for backward compatibility with software releases that do not support sequence numbering.
- This feature works with named and numbered, standard and extended IP access lists.

Including comments in ACLs

You can use the **remark** keyword to include comments (remarks) about entries in any IP standard or extended ACL. The remarks make the ACL easier for you to understand and scan. Each remark line is limited to 100 characters.

The remark can go before or after a permit or deny statement. You should be consistent about where you put the remark so that it is clear which remark describes which permit or deny statement. For example, it would be confusing to have some remarks before the associated permit or deny statements and some remarks after the associated statements.

To include a comment for IP numbered standard or extended ACLs, use the **access-list** *access-list number* **remark** *remark* global configuration command. To remove the remark, use the **no** form of this command.

The following is an example of a remark that describes function of the subsequent deny statement:

```
ip access-list extended telnetting
  remark Do not allow host1 subnet to telnet out
  deny tcp host 172.16.2.88 any eq telnet
```

Hardware and Software Treatment of IP ACLs

ACL processing is performed at the hardware side. If the hardware reaches its capacity to store ACL configurations, the packets are sent to the CPU, where ACL is processed at the software side. When sent for software ACL, the data packets are not sent at the line rate; instead, they are sent at a very low rate via rate limiting.

Note If an ACL configuration cannot be implemented in hardware due to an out-of-resource condition on a switch, then only the traffic in that VLAN arriving on that switch is affected. Software forwarding of packets might adversely impact the performance of the switch, depending on the number of CPU cycles that this consumes.

When traffic flows are both logged and forwarded, forwarding is done by hardware, but logging must be done by software. Because of the difference in packet handling capacity between hardware and software, if the sum of all flows being logged (both permitted flows and denied flows) is of great enough bandwidth, not all of the packets that are forwarded can be logged.

When you enter the **show ip access-lists** privileged EXEC command, the match count displayed does not account for packets that are access controlled in hardware. ACLs function as follows:

- The hardware controls permit and deny actions of standard and extended ACLs (input and output) for security access control.
- If **log** has not been specified, the flows that match a *deny* statement in a security ACL are dropped by the hardware if *ip unreachables* is disabled. The flows matching a *permit* statement are switched in hardware.
- Adding the **log** keyword to an ACE in an ACL causes a copy of the packet to be sent to the CPU for logging only. If the ACE is a *permit* statement, the packet is still switched in hardware.

Time Ranges for ACLs

You can selectively apply extended ACLs based on the time of day and the week by using the **time-range** global configuration command. First, define a time-range name and set the times and the dates or the days of the week in the time range. Then enter the time-range name when applying an ACL to set restrictions to the access list. You can use the time range to define when the permit or deny statements in the ACL are in effect, for example, during a specified time period or on specified days of the week. The **time-range** keyword and argument are referenced in the named and numbered extended ACL task tables.

These are some benefits of using time ranges:

- You have more control over permitting or denying a user access to resources, such as an application (identified by an IP address/mask pair and a port number).
- You can control logging messages. ACL entries can be set to log traffic only at certain times of the day. Therefore, you can simply deny access without needing to analyze many logs generated during peak hours.

Time-based access lists trigger CPU activity because the new configuration of the access list must be merged with other features and the combined configuration loaded into the hardware memory. For this reason, you should be careful not to have several access lists configured to take affect in close succession (within a small number of minutes of each other.)

Note The time range relies on the switch system clock; therefore, you need a reliable clock source. We recommend that you use Network Time Protocol (NTP) to synchronize the switch clock.

IPv4 ACL Interface Considerations

For inbound ACLs, after receiving a packet, the switch checks the packet against the ACL. If the ACL permits the packet, the switch continues to process the packet. If the ACL rejects the packet, the switch discards the packet.

For outbound ACLs, after receiving and routing a packet to a controlled interface, the switch checks the packet against the ACL. If the ACL permits the packet, the switch sends the packet. If the ACL rejects the packet, the switch discards the packet.

When you apply an undefined ACL to an interface, the switch acts as if the ACL has not been applied to the interface and permits all packets. Remember this behavior if you use undefined ACLs for network security.

Apply an Access Control List to an Interface

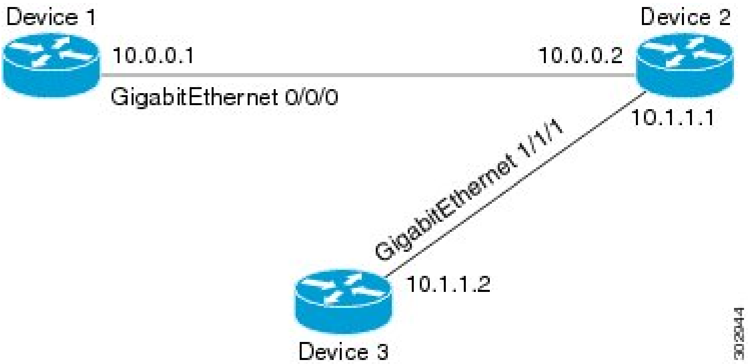
With some protocols, you can apply up to two access lists to an interface: one inbound access list and one outbound access list. With other protocols, you apply only one access list that checks both inbound and outbound packets.

If the access list is inbound, when a device receives a packet, Cisco software checks the access list's criteria statements for a match. If the packet is permitted, the software continues to process the packet. If the packet is denied, the software discards the packet.

If the access list is outbound, after receiving and routing a packet to the outbound interface, Cisco software checks the access list's criteria statements for a match. If the packet is permitted, the software transmits the packet. If the packet is denied, the software discards the packet.

Note Access lists that are applied to interfaces on a device do not filter traffic that originates from that device.

Figure 57: Topology for Applying Access Control Lists



The figure above shows that Device 2 is a bypass device that is connected to Device 1 and Device 3. An outbound access list is applied to Gigabit Ethernet interface 0/0/0 on Device 1. When you ping Device 3 from Device 1, the access list does not check for packets going outbound because the traffic is locally generated.

The access list check is bypassed for locally generated packets, which are always outbound.

By default, an access list that is applied to an outbound interface for matching locally generated traffic will bypass the outbound access list check; but transit traffic is subjected to the outbound access list check.

Note The behavior described above applies to all single-CPU platforms that run Cisco software.

ACL Logging

The switch software can provide logging messages about packets permitted or denied by a standard IP access list. That is, any packet that matches the ACL causes an informational logging message about the packet to be sent to the console. The level of messages logged to the console is controlled by the **logging console** commands controlling the syslog messages.

Note Because routing is done in hardware and logging is done in software, if a large number of packets match a *permit* or *deny* ACE containing a **log** keyword, the software might not be able to match the hardware processing rate, and not all packets will be logged.

The first packet that triggers the ACL causes a logging message right away, and subsequent packets are collected over 5-minute intervals before they appear or logged. The logging message includes the access list number, whether the packet was permitted or denied, the source IP address of the packet, and the number of packets from that source permitted or denied in the prior 5-minute interval.

Note The logging facility might drop some logging message packets if there are too many to be handled or if there is more than one logging message to be handled in 1 second. This behavior prevents the router from crashing due to too many logging packets. Therefore, the logging facility should not be used as a billing tool or an accurate source of the number of matches to an access list.

How to Configure ACLs

Configuring IPv4 ACLs

Follow the procedure given below to use IP ACLs on the switch:

SUMMARY STEPS

1. Create an ACL by specifying an access list number or name and the access conditions.
2. Apply the ACL to interfaces.

DETAILED STEPS

Step 1 Create an ACL by specifying an access list number or name and the access conditions.

Step 2 Apply the ACL to interfaces.

Creating a Numbered Standard ACL

Follow these steps to create a numbered standard ACL:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **access-list** *access-list-number* {**deny** | **permit**} *source source-wildcard* [**log**]
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**access-list** *access-list-number* {**deny** | **permit**} *source source-wildcard* [**log**] **Example:** `Switch(config)# access-list 2 deny your_host`	Defines a standard IPv4 access list by using a source address and wildcard. The *access-list-number* is a decimal number from 1 to 99 or 1300 to 1999. Enter **deny** or **permit** to specify whether to deny or permit access if conditions are matched. The *source* is the source address of the network or host from which the packet is being sent specified as: • The 32-bit quantity in dotted-decimal format. • The keyword **any** as an abbreviation for *source* and *source-wildcard* of 0.0.0.0 255.255.255.255. You do not need to enter a source-wildcard. • The keyword **host** as an abbreviation for source and *source-wildcard* of *source* 0.0.0.0. (Optional) The *source-wildcard* applies wildcard bits to the source.

	Command or Action	Purpose
		(Optional) Enter **log** to cause an informational logging message about the packet that matches the entry to be sent to the console. **Note** Logging is supported only on ACLs attached to Layer 3 interfaces.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Creating a Numbered Extended ACL

Follow these steps to create a numbered extended ACL:

SUMMARY STEPS

1. **configure terminal**
2. **access-list** *access-list-number* {**deny** | **permit**} *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*] [**tos** tos] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*]
3. **access-list** *access-list-number* {**deny** | **permit**} **tcp** *source source-wildcard* [*operator port*] *destination destination-wildcard* [*operator port*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] [*flag*]
4. **access-list** *access-list-number* {**deny** | **permit**} **udp** *source source-wildcard* [*operator port*] *destination destination-wildcard* [*operator port*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*]
5. **access-list** *access-list-number* {**deny** | **permit**} **icmp** *source source-wildcard destination destination-wildcard* [*icmp-type* | [[*icmp-type icmp-code*] | [*icmp-message*]] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*]
6. **access-list** *access-list-number* {**deny** | **permit**} **igmp** *source source-wildcard destination destination-wildcard* [*igmp-type*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*]
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**access-list** *access-list-number* {**deny** | **permit**} *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*] [**tos** tos] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] **Example:** `Switch(config)# access-list 101 permit ip host 10.1.1.2 any precedence 0 tos 0 log`	Defines an extended IPv4 access list and the access conditions. The *access-list-number* is a decimal number from 100 to 199 or 2000 to 2699. Enter **deny** or **permit** to specify whether to deny or permit the packet if conditions are matched. For *protocol*, enter the name or number of an P protocol: **ahp**, **eigrp**, **esp**, **gre**, **icmp**, **igmp**, **igrp**, **ip**, **ipinip**, **nos**, **ospf**, **pcp**, **pim**, **tcp**, or **udp**, or an integer in the range 0 to 255 representing an IP protocol number. To match any Internet protocol (including ICMP, TCP, and UDP), use the keyword **ip**. **Note** This step includes options for most IP protocols. For additional specific parameters for TCP, UDP, ICMP, and IGMP, see the following steps. The *source* is the number of the network or host from which the packet is sent. The *source-wildcard* applies wildcard bits to the source. The *destination* is the network or host number to which the packet is sent. The *destination-wildcard* applies wildcard bits to the destination. Source, source-wildcard, destination, and destination-wildcard can be specified as: • The 32-bit quantity in dotted-decimal format. • The keyword **any** for 0.0.0.0 255.255.255.255 (any host). • The keyword **host** for a single host 0.0.0.0. The other keywords are optional and have these meanings: • **precedence**—Enter to match packets with a precedence level specified as a number from 0 to 7 or by name: **routine** (0), **priority** (1), **immediate** (2), **flash** (3), **flash-override** (4), **critical** (5), **internet** (6), **network** (7).

	Command or Action	Purpose
		• **fragments**—Enter to check non-initial fragments. • **tos**—Enter to match by type of service level, specified by a number from 0 to 15 or a name: **normal** (0), **max-reliability** (2), **max-throughput** (4), **min-delay** (8). • **time-range**—Specify the time-range name. • **dscp**—Enter to match packets with the DSCP value specified by a number from 0 to 63, or use the question mark (?) to see a list of available values. **Note** If you enter a **dscp** value, you cannot enter **tos** or **precedence**. You can enter both a **tos** and a **precedence** value with no **dscp**.
Step 3	**access-list** *access-list-number* {**deny** | **permit**} **tcp** *source source-wildcard* [*operator port*] *destination destination-wildcard* [*operator port*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] [*flag*] **Example:** `Switch(config)# access-list 101 permit tcp any any eq 500`	Defines an extended TCP access list and the access conditions. The parameters are the same as those described for an extended IPv4 ACL, with these exceptions: (Optional) Enter an *operator* and *port* to compare source (if positioned after *source source-wildcard*) or destination (if positioned after *destination destination-wildcard*) port. Possible operators include **eq** (equal), **gt** (greater than), **lt** (less than), **neq** (not equal), and **range** (inclusive range). Operators require a port number (range requires two port numbers separated by a space). Enter the *port* number as a decimal number (from 0 to 65535) or the name of a TCP port. Use only TCP port numbers or names when filtering TCP. The other optional keywords have these meanings: • *flag*—Enter one of these flags to match by the specified TCP header bits: **ack** (acknowledge), **fin** (finish), **psh** (push), **rst** (reset), **syn** (synchronize), or **urg** (urgent).
Step 4	**access-list** *access-list-number* {**deny** | **permit**} **udp** *source source-wildcard* [*operator port*] *destination destination-wildcard* [*operator port*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] **Example:** `Switch(config)# access-list 101 permit udp any any eq 100`	(Optional) Defines an extended UDP access list and the access conditions. The UDP parameters are the same as those described for TCP except that the [operator [port]] port number or name must be a UDP port number or name, and the **flag** keyword is not valid for UDP.

	Command or Action	Purpose
Step 5	**access-list** *access-list-number* {**deny** | **permit**} **icmp** *source source-wildcard destination destination-wildcard* [*icmp-type* | [[*icmp-type icmp-code*] | [*icmp-message*]] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] **Example:** `Switch(config)# access-list 101 permit icmp any any 200`	Defines an extended ICMP access list and the access conditions. The ICMP parameters are the same as those described for most IP protocols in an extended IPv4 ACL, with the addition of the ICMP message type and code parameters. These optional keywords have these meanings: • *icmp-type*—Enter to filter by ICMP message type, a number from 0 to 255. • *icmp-code*—Enter to filter ICMP packets that are filtered by the ICMP message code type, a number from 0 to 255. • *icmp-message*—Enter to filter ICMP packets by the ICMP message type name or the ICMP message type and code name.
Step 6	**access-list** *access-list-number* {**deny** | **permit**} **igmp** *source source-wildcard destination destination-wildcard* [*igmp-type*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] **Example:** `Switch(config)# access-list 101 permit igmp any any 14`	(Optional) Defines an extended IGMP access list and the access conditions. The IGMP parameters are the same as those described for most IP protocols in an extended IPv4 ACL, with this optional parameter. *igmp-type*—To match IGMP message type, enter a number from 0 to 15, or enter the message name: **dvmrp**, **host-query**, **host-report**, **pim**, or **trace**.

Step 7	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Creating Named Standard ACLs

Follow these steps to create a standard ACL using names:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip access-list standard** *name*
4. Use one of the following:
   - **deny** {*source* [*source-wildcard*] | **host** *source* | **any**} [**log**]
   - **permit** {*source* [*source-wildcard*] | **host** *source* | **any**} [**log**]
5. **end**

6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip access-list standard** *name* **Example:** `Switch(config)# ip access-list standard 20`	Defines a standard IPv4 access list using a name, and enter access-list configuration mode. The name can be a number from 1 to 99.

Step 4	Use one of the following:
	• **deny** {*source* [*source-wildcard*] | **host** *source* | **any**} [**log**]
	• **permit** {*source* [*source-wildcard*] | **host** *source* | **any**} [**log**]
	Example:
	`Switch(config-std-nacl)# deny 192.168.0.0 0.0.255.255 255.255.0.0 0.0.255.255`
	or
	`Switch(config-std-nacl)# permit 10.108.0.0 0.0.0.0 255.255.255.0 0.0.0.0`
		In access-list configuration mode, specify one or more conditions denied or permitted to decide if the packet is forwarded or dropped.
		• **host** *source*—A source and source wildcard of *source* 0.0.0.0.
		• **any**—A source and source wildcard of 0.0.0.0 255.255.255.255.

Step 5	**end**
	Example:
	`Switch(config-std-nacl)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:**	Verifies your entries.

	Command or Action	Purpose
	`Switch# show running-config`	
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Creating Extended Named ACLs

Follow the procedure given below to create an extended ACL using names:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip access-list extended** *name*
4. {**deny** | **permit**} *protocol* {*source* [*source-wildcard*] | **host** *source* | **any**} {*destination* [*destination-wildcard*] | host *destination* | **any**} [**precedence** *precedence*] [**tos** *tos*] [**log**] [**time-range** *time-range-name*]
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip access-list extended** *name* **Example:** `Switch(config)# ip access-list extended 150`	Defines an extended IPv4 access list using a name, and enter access-list configuration mode. The name can be a number from 100 to 199.

	Command or Action	Purpose
Step 4	{**deny** | **permit**} *protocol* {*source* [*source-wildcard*] | **host** *source* | **any**} {*destination* [*destination-wildcard*] | host *destination* | **any**} [**precedence** *precedence*] [**tos** *tos*] [**log**] [**time-range** *time-range-name*] **Example:** `Switch(config-ext-nacl)# ` **`permit 0 any any`**	In access-list configuration mode, specify the conditions allowed or denied. Use the **log** keyword to get access list logging messages, including violations. • **host** *source*—A source and source wildcard of *source* 0.0.0.0. • **host** *destintation*—A destination and destination wildcard of *destination* 0.0.0.0. • **any**—A source and source wildcard or destination and destination wildcard of 0.0.0.0 255.255.255.255.

Step 5	**end**
	Example:
	`Switch(config-ext-nacl)# ` **`end`**
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# ` **`show running-config`**	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# ` **`copy running-config startup-config`**	(Optional) Saves your entries in the configuration file.

When you are creating extended ACLs, remember that, by default, the end of the ACL contains an implicit deny statement for everything if it did not find a match before reaching the end. For standard ACLs, if you omit the mask from an associated IP host address access list specification, 0.0.0.0 is assumed to be the mask.

After you create an ACL, any additions are placed at the end of the list. You cannot selectively add ACL entries to a specific ACL. However, you can use **no permit** and **no deny** access-list configuration mode commands to remove entries from a named ACL.

Being able to selectively remove lines from a named ACL is one reason you might use named ACLs instead of numbered ACLs.

What to do next

After creating a named ACL, you can apply it to interfaces.

Sequencing Access-List Entries and Revising the Access List

This task shows how to assign sequence numbers to entries in a named IP access list and how to add or delete an entry to or from an access list. When completing this task, keep the following points in mind:

- Resequencing the access list entries is optional. The resequencing step in this task is shown as required because that is one purpose of this feature and this task demonstrates that functionality.
- In the following procedure, the **permit** command is shown in Step 5 and the **deny** command is shown in Step 6. However, that order can be reversed. Use the order that suits the need of your configuration.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip access-list resequence** *access-list-name starting-sequence-number increment*
4. **ip access-list** {**standard**| **extended**} *access-list-name*
5. Do one of the following:
    - *sequence-number* **permit** *source source-wildcard*
    - *sequence-number* **permit** *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*][**tos** *tos*] [**log**] [**time-range** *time-range-name*] [**fragments**]
6. Do one of the following:
    - *sequence-number* **deny** *source source-wildcard*
    - *sequence-number* **deny** *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*][**tos** *tos*] [**log**] [**time-range** *time-range-name*] [**fragments**]
7. Do one of the following:
    - *sequence-number* **permit** *source source-wildcard*
    - *sequence-number* **permit** *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*][**tos** *tos*] [**log**] [**time-range** *time-range-name*] [**fragments**]
8. Do one of the following:
    - *sequence-number* **deny** *source source-wildcard*
    - *sequence-number* **deny** *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*][**tos** *tos*] [**log**] [**time-range** *time-range-name*] [**fragments**]
9. Repeat Step 5 and/or Step 6 to add sequence number statements, as applicable.
10. **end**
11. **show ip access-lists** *access-list-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose

Step 3	**ip access-list resequence** *access-list-name starting-sequence-number increment*
	Example:
	`Device(config)# ip access-list resequence kmd1`
	`100 15`
		Resequences the specified IP access list using the starting sequence number and the increment of sequence numbers.

Step 4	**ip access-list** {**standard**| **extended**} *access-list-name* **Example:** `Device(config)# ip access-list standard kmd1`	Specifies the IP access list by name and enters named access list configuration mode. • If you specify **standard**, make sure you subsequently specify **permit** and/or **deny** statements using the standard access list syntax. • If you specify **extended**, make sure you subsequently specify **permit** and/or **deny** statements using the extended access list syntax.

Step 5	Do one of the following:
	• *sequence-number* **permit** *source source-wildcard*
	• *sequence-number* **permit** *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*][**tos** *tos*] [**log**] [**time-range** *time-range-name*] [**fragments**]
	Example:
	`Device(config-std-nacl)# 105 permit 10.5.5.5 0.0.0`
	` 255`
		Specifies a permit statement in named IP access list mode.
		• This access list happens to use a **permit** statement first, but a **deny** statement could appear first, depending on the order of statements you need.
		• As the prompt indicates, this access list was a standard access list. If you had specified **extended** in Step 4, the prompt for this step would be Device(config-ext-nacl) and you would use the extended **permit** command syntax.

Step 6	Do one of the following:
	• *sequence-number* **deny** *source source-wildcard*
	• *sequence-number* **deny** *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*][**tos** *tos*] [**log**] [**time-range** *time-range-name*] [**fragments**]
	Example:
	`Device(config-std-nacl)# 105 deny 10.6.6.7 0.0.0`
	` 255`
		(Optional) Specifies a deny statement in named IP access list mode.
		• This access list uses a **permit** statement first, but a **deny** statement could appear first, depending on the order of statements you need.
		• As the prompt indicates, this access list was a standard access list. If you had specified **extended** in Step 4, the prompt for this step would be Device(config-ext-nacl) and you would use the extended **deny** command syntax.

Step 7	Do one of the following: • *sequence-number* **permit** *source source-wildcard* • *sequence-number* **permit** *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*][**tos** *tos*] [**log**] [**time-range** *time-range-name*] [**fragments**] **Example:**	Specifies a permit statement in named IP access list mode. • This access list happens to use a **permit**statement first, but a **deny** statement could appear first, depending on the order of statements you need. • See the permit (IP) command for additional command syntax to permit upper layer protocols (ICMP, IGMP, TCP, and UDP).

	Command or Action	Purpose
	`Device(config-ext-nacl)# 150 permit tcp any any log`	- Use the **no** *sequence-number* command to delete an entry.
Step 8	Do one of the following: - *sequence-number* **deny** *source source-wildcard* - *sequence-number* **deny** *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*][**tos** *tos*] [**log**] [**time-range** *time-range-name*] [**fragments**] **Example:** `Device(config-ext-nacl)# 150 deny tcp any any log`	(Optional) Specifies a deny statement in named IP access list mode. - This access list happens to use a **permit**statement first, but a **deny** statement could appear first, depending on the order of statements you need. - See the deny (IP) command for additional command syntax to permit upper layer protocols (ICMP, IGMP, TCP, and UDP). - Use the **no** *sequence-number* command to delete an entry.
Step 9	Repeat Step 5 and/or Step 6 to add sequence number statements, as applicable.	Allows you to revise the access list.

Step 10	**end**
	Example:
	`Device(config-std-nacl)# end`
		(Optional) Exits the configuration mode and returns to privileged EXEC mode.

Step 11	**show ip access-lists** *access-list-name* **Example:** `Device# show ip access-lists kmd1`	(Optional) Displays the contents of the IP access list.

Examples

Review the output of the **show ip access-lists** command to see that the access list includes the new entries:

```
Device# show ip access-lists kmd1

Standard IP access list kmd1
100 permit 10.4.4.0, wildcard bits 0.0.0.255
105 permit 10.5.5.0, wildcard bits 0.0.0.255
115 permit 10.0.0.0, wildcard bits 0.0.0.255
130 permit 10.5.5.0, wildcard bits 0.0.0.255
145 permit 10.0.0.0, wildcard bits 0.0.0.255
```

Configuring Commented IP ACL Entries

Either use a named or numbered access list configuration. You must apply the access list to an interface or terminal line after the access list is created for the configuration to work.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip access-list** {**standard** | **extended**} {*name* | *number*}
4. **remark** *remark*
5. **deny** *protocol* **host** *host-address* **any eq** *port*
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 3	**ip access-list** {**standard** | **extended**} {*name* | *number*}
	Example:
	`Device(config)# ip access-list extended telnetting`
		Identifies the access list by a name or number and enters extended named access list configuration mode.

Step 4	**remark** *remark* **Example:** `Device(config-ext-nacl)# remark Do not allow host1 subnet to telnet out`	Adds a remark for an entry in a named IP access list. • The remark indicates the purpose of the **permit** or **deny** statement.
Step 5	**deny** *protocol* **host** *host-address* **any eq** *port* **Example:** `Device(config-ext-nacl)# deny tcp host 172.16.2.88 any eq telnet`	Sets conditions in a named IP access list that denies packets.

Step 6	**end**
	Example:
	`Device(config-ext-nacl)# end`
		Exits extended named access list configuration mode and enters privileged EXEC mode.

Configuring Time Ranges for ACLs

Follow these steps to configure a time-range parameter for an ACL:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **time-range** *time-range-name*

4. Use one of the following:
   - **absolute** [**start** *time date*] [**end** *time date*]
   - **periodic** *day-of-the-week hh:mm to* [*day-of-the-week*] *hh:mm*
   - **periodic** {**weekdays** | **weekend** | **daily**} *hh:mm to hh:mm*
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch(config)# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**time-range** *time-range-name* **Example:** `Switch(config)# time-range workhours`	Assigns a meaningful name (for example, *workhours*) to the time range to be created, and enter time-range configuration mode. The name cannot contain a space or quotation mark and must begin with a letter.

Step 4	Use one of the following:
	• **absolute** [**start** *time date*] [**end** *time date*]
	• **periodic** *day-of-the-week hh:mm to* [*day-of-the-week*] *hh:mm*
	• **periodic** {**weekdays** | **weekend** | **daily**} *hh:mm to hh:mm*
	Example:
	`Switch(config-time-range)# absolute start 00:00 1 Jan 2006 end 23:59 1 Jan 2006`
	or
	`Switch(config-time-range)# periodic weekdays 8:00 to 12:00`
		Specifies when the function it will be applied to is operational.
		• You can use only one **absolute** statement in the time range. If you configure more than one absolute statement, only the one configured last is executed.
		• You can enter multiple **periodic** statements. For example, you could configure different hours for weekdays and weekends.
		See the example configurations.

	Command or Action	Purpose

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

Repeat the steps if you have multiple items that you want in effect at different times.

Applying an IPv4 ACL to a Terminal Line

You can use numbered ACLs to control access to one or more terminal lines. You cannot apply named ACLs to lines. You must set identical restrictions on all the virtual terminal lines because a user can attempt to connect to any of them.

Follow these steps to restrict incoming and outgoing connections between a virtual terminal line and the addresses in an ACL:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line** [**console** | **vty**] *line-number*
4. **access-class** *access-list-number* {**in**}
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
	`Switch(config)# enable`	
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**line** [**console** | **vty**] *line-number* **Example:** `Switch(config)# line console 0`	Identifies a specific line to configure, and enter in-line configuration mode. • **console**—Specifies the console terminal line. The console port is DCE. • **vty**—Specifies a virtual terminal for remote console access. The *line-number* is the first line number in a contiguous group that you want to configure when the line type is specified. The range is from 0 to 16.

Step 4	**access-class** *access-list-number* {**in**}
	Example:
	`Switch(config-line)# access-class 10 in`
		Restricts incoming connections between a particular virtual terminal line (into a device) and the addresses in an access list.

Step 5	**end**
	Example:
	`Switch(config-line)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Applying an IPv4 ACL to an Interface (CLI)

This section describes how to apply IPv4 ACLs to network interfaces.

Beginning in privileged EXEC mode, follow the procedure given below to control access to an interface:

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **ip access-group** {*access-list-number* | *name*} {**in**}
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet 0/1`	Identifies a specific interface for configuration, and enter interface configuration mode. The interface can be a Layer 2 interface (port ACL).

Step 3	**ip access-group** {*access-list-number* | *name*} {**in**}
	Example:
	`Device(config-if)# ip access-group 2 in`
		Controls access to the specified interface.

Step 4	**end**
	Example:
	`Device(config-if)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Device# show running-config`	Displays the access list configuration.
Step 6	**copy running-config startup-config** **Example:** `Device# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring IPv4 ACLs

You can monitor IPv4 ACLs by displaying the ACLs that are configured on the switch, and displaying the ACLs that have been applied to interfaces.

When you use the **ip access-group** interface configuration command to apply ACLs to a Layer 2 or 3 interface, you can display the access groups on the interface. You can also display the MAC ACLs applied to a Layer 2 interface. You can use the privileged EXEC commands as described in this table to display this information.

Table 86: Commands for Displaying Access Lists and Access Groups

Command	Purpose
show access-lists [*number* | *name*]	Displays the contents of one or all current IP and MAC address access lists or a specific access list (numbered or named).
show ip access-lists [*number* | *name*]	Displays the contents of all current IP access lists or a specific IP access list (numbered or named).
show ip interface *interface-id*	Displays detailed configuration and status of an interface. If IP is enabled on the interface and ACLs have been applied by using the **ip access-group** interface configuration command, the access groups are included in the display.
show running-config [**interface** *interface-id*]	Displays the contents of the configuration file for the switch or the specified interface, including all configured MAC and IP access lists and which access groups are applied to an interface.
show mac access-group [**interface** *interface-id*]	Displays MAC access lists applied to all Layer 2 interfaces or the specified Layer 2 interface.

Configuration Examples for ACLs

Example: Numbered ACLs

In this example, network 10.0.0.0 is a Class A network whose second octet specifies a subnet; that is, its subnet mask is 255.255.0.0. The third and fourth octets of a network 10.0.0.0 address specify a particular host. Using access list 2, the switch accepts one address on subnet 48 and reject all others on that subnet. The last line of the list shows that the switch accepts addresses on all other network 10.0.0.0 subnets. The ACL is applied to packets entering a port.

```
Switch(config)# access-list 2 permit 10.48.0.3
Switch(config)# access-list 2 deny 10.48.0.0 0.0.255.255
Switch(config)# access-list 2 permit 10.0.0.0 0.255.255.255
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# ip access-group 2 in
```

Examples: Extended ACLs

In this example, the first line permits any incoming TCP connections with destination ports greater than 1023. The second line permits incoming TCP connections to the Simple Mail Transfer Protocol (SMTP) port of host 128.88.1.2. The third line permits incoming ICMP messages for error feedback.

```
Switch(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 gt 1023
Switch(config)# access-list 102 permit tcp any host 128.88.1.2 eq 25
Switch(config)# access-list 102 permit icmp any any
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# ip access-group 102 in
```

In this example, suppose that you have a network connected to the Internet, and you want any host on the network to be able to form TCP connections to any host on the Internet. However, you do not want IP hosts to be able to form TCP connections to hosts on your network, except to the mail (SMTP) port of a dedicated mail host.

SMTP uses TCP port 25 on one end of the connection and a random port number on the other end. The same port numbers are used throughout the life of the connection. Mail packets coming in from the Internet have a destination port of 25. Because the secure system of the network always accepts mail connections on port 25, the incoming are separately controlled.

```
Switch(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 eq 23
Switch(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 eq 25
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# ip access-group 102 in
```

In this example, the network is a Class B network with the address 128.88.0.0, and the mail host address is 128.88.1.2. The **ACK** or **RST** keywords are used to match ACK or RST bits set, which show that the packet belongs to an existing connection.

```
Switch(config)# access-list 102 permit tcp any 128.88.0.0 0.0.255.255 RST
Switch(config)# access-list 102 permit tcp any host 128.88.1.2 eq 25
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# ip access-group 102 in
```

Examples: Named ACLs

Creating named standard and extended ACLs

This example creates a standard ACL named *internet_filter* and an extended ACL named *marketing_group*. The *internet_filter* ACL allows all traffic from the source address 1.2.3.4.

```
Switch(config)# ip access-list standard Internet_filter
Switch(config-ext-nacl)# permit 1.2.3.4
Switch(config-ext-nacl)# exit
```

The *marketing_group* ACL allows any TCP Telnet traffic to the destination address and wildcard 171.69.0.0 0.0.255.255 and denies any other TCP traffic. It permits ICMP traffic, denies UDP traffic from any source to the destination address range 171.69.0.0 through 179.69.255.255 with a destination port less than 1024, denies any other IP traffic, and provides a log of the result.

```
Switch(config)# ip access-list extended marketing_group
Switch(config-ext-nacl)# permit tcp any 171.69.0.0 0.0.255.255 eq telnet
Switch(config-ext-nacl)# deny tcp any any
Switch(config-ext-nacl)# permit icmp any any
Switch(config-ext-nacl)# deny udp any 171.69.0.0 0.0.255.255 lt 1024
Switch(config-ext-nacl)# deny ip any any log
Switch(config-ext-nacl)# exit
```

Deleting individual ACEs from named ACLs

This example shows how you can delete individual ACEs from the named access list *border-list*:

```
Switch(config)# ip access-list extended border-list
Switch(config-ext-nacl)# no permit ip host 10.1.1.3 any
```

Example Resequencing Entries in an Access List

The following example shows an access list before and after resequencing. The starting value is 1, and increment value is 2. The subsequent entries are ordered based on the increment values that users provide, and the range is from 1 to 2147483647.

When an entry with no sequence number is entered, by default it has a sequence number of 10 more than the last entry in the access list.

```
Router# show access-list carls
Extended IP access list carls
    10 permit ip host 10.3.3.3 host 172.16.5.34
    20 permit icmp any any
    30 permit tcp any host 10.3.3.3
    40 permit ip host 10.4.4.4 any
    50 Dynamic test permit ip any any
    60 permit ip host 172.16.2.2 host 10.3.3.12
    70 permit ip host 10.3.3.3 any log
    80 permit tcp host 10.3.3.3 host 10.1.2.2
    90 permit ip host 10.3.3.3 any
    100 permit ip any any
Router(config)# ip access-list extended carls
Router(config)# ip access-list resequence carls 1 2
Router(config)# end
Router# show access-list carls
Extended IP access list carls
    1 permit ip host 10.3.3.3 host 172.16.5.34
    3 permit icmp any any
    5 permit tcp any host 10.3.3.3
    7 permit ip host 10.4.4.4 any
    9 Dynamic test permit ip any any
    11 permit ip host 172.16.2.2 host 10.3.3.12
    13 permit ip host 10.3.3.3 any log
    15 permit tcp host 10.3.3.3 host 10.1.2.2
    17 permit ip host 10.3.3.3 any
    19 permit ip any any
```

Example Adding an Entry with a Sequence Number

In the following example, an new entry (sequence number 15) is added to an access list:

```
Router# show ip access-list
Standard IP access list tryon
2 permit 10.4.4.2, wildcard bits 0.0.255.255
5 permit 10.0.0.44, wildcard bits 0.0.0.255
10 permit 10.0.0.1, wildcard bits 0.0.0.255
20 permit 10.0.0.2, wildcard bits 0.0.0.255
Router(config)# ip access-list standard tryon
Router(config-std-nacl)# 15 permit 10.5.5.5 0.0.0.255
Router# show ip access-list
Standard IP access list tryon
2 permit 10.4.0.0, wildcard bits 0.0.255.255
5 permit 10.0.0.0, wildcard bits 0.0.0.255
10 permit 10.0.0.0, wildcard bits 0.0.0.255
15 permit 10.5.5.0, wildcard bits 0.0.0.255
20 permit 10.0.0.0, wildcard bits 0.0.0.255
```

Example Adding an Entry with No Sequence Number

The following example shows how an entry with no specified sequence number is added to the end of an access list. When an entry is added without a sequence number, it is automatically given a sequence number that puts it at the end of the access list. Because the default increment is 10, the entry will have a sequence number 10 higher than the last entry in the existing access list.

```
Router(config)# ip access-list standard resources
Router(config-std-nacl)# permit 10.1.1.1 0.0.0.255
Router(config-std-nacl)# permit 10.2.2.2 0.0.0.255
Router(config-std-nacl)# permit 10.3.3.3 0.0.0.255
Router# show access-list
Standard IP access list resources
10 permit 10.1.1.1, wildcard bits 0.0.0.255
20 permit 10.2.2.2, wildcard bits 0.0.0.255
30 permit 10.3.3.3, wildcard bits 0.0.0.255
Router(config)# ip access-list standard resources
Router(config-std-nacl)# permit 10.4.4.4 0.0.0.255
Router(config-std-nacl)# end
Router# show access-list
Standard IP access list resources
10 permit 10.1.1.1, wildcard bits 0.0.0.255
20 permit 10.2.2.2, wildcard bits 0.0.0.255
30 permit 10.3.3.3, wildcard bits 0.0.0.255
40 permit 10.4.4.4, wildcard bits 0.0.0.255
```

Examples: Configuring Commented IP ACL Entries

In this example of a numbered ACL, the workstation that belongs to Jones is allowed access, and the workstation that belongs to Smith is not allowed access:

```
Switch(config)# access-list 1 remark Permit only Jones workstation through
Switch(config)# access-list 1 permit 171.69.2.88
Switch(config)# access-list 1 remark Do not allow Smith workstation through
Switch(config)# access-list 1 deny 171.69.3.13
```

In this example of a numbered ACL, the Winter and Smith workstations are not allowed to browse the web:

```
Switch(config)# access-list 100 remark Do not allow Winter to browse the web
Switch(config)# access-list 100 deny host 171.69.3.85 any eq www
Switch(config)# access-list 100 remark Do not allow Smith to browse the web
Switch(config)# access-list 100 deny host 171.69.3.13 any eq www
```

In this example of a named ACL, the Jones subnet is not allowed access:

```
Switch(config)# ip access-list standard prevention
Switch(config-std-nacl)# remark Do not allow Jones subnet through
Switch(config-std-nacl)# deny 171.69.0.0 0.0.255.255
```

In this example of a named ACL, the Jones subnet is not allowed to use outbound Telnet:

```
Switch(config)# ip access-list extended telnetting
Switch(config-ext-nacl)# remark Do not allow Jones subnet to telnet out
Switch(config-ext-nacl)# deny tcp 171.69.0.0 0.0.255.255 any eq telnet
```

Examples: Using Time Ranges with ACLs

This example shows how to verify after you configure time ranges for *workhours* and to configure January 1, 2006, as a company holiday.

```
Switch# show time-range
time-range entry: new_year_day_2003 (inactive)
   absolute start 00:00 01 January 2006 end 23:59 01 January 2006
time-range entry: workhours (inactive)
   periodic weekdays 8:00 to 12:00
   periodic weekdays 13:00 to 17:00
```

To apply a time range, enter the time-range name in an extended ACL that can implement time ranges. This example shows how to create and verify extended access list 188 that denies TCP traffic from any source to any destination during the defined holiday times and permits all TCP traffic during work hours.

```
Switch(config)# access-list 188 deny tcp any any time-range new_year_day_2006
Switch(config)# access-list 188 permit tcp any any time-range workhours
Switch(config)# end
Switch# show access-lists
Extended IP access list 188
   10 deny tcp any any time-range new_year_day_2006 (inactive)
   20 permit tcp any any time-range workhours (inactive)
```

This example uses named ACLs to permit and deny the same traffic.

```
Switch(config)# ip access-list extended deny_access
Switch(config-ext-nacl)# deny tcp any any time-range new_year_day_2006
Switch(config-ext-nacl)# exit
Switch(config)# ip access-list extended may_access
Switch(config-ext-nacl)# permit tcp any any time-range workhours
Switch(config-ext-nacl)# end
Switch# show ip access-lists
Extended IP access list lpip_default
```

```
    10 permit ip any any
Extended IP access list deny_access
    10 deny tcp any any time-range new_year_day_2006 (inactive)
Extended IP access list may_access
    10 permit tcp any any time-range workhours (inactive)
```

Examples: Time Range Applied to an IP ACL

This example denies HTTP traffic on IP on Monday through Friday between the hours of 8:00 a.m. and 6:00 p.m (18:00). The example allows UDP traffic only on Saturday and Sunday from noon to 8:00 p.m. (20:00).

```
Switch(config)# time-range no-http
Switch(config)# periodic weekdays 8:00 to 18:00
!
Switch(config)# time-range udp-yes
Switch(config)# periodic weekend 12:00 to 20:00
!
Switch(config)# ip access-list extended strict
Switch(config-ext-nacl)# deny tcp any any eq www time-range no-http
Switch(config-ext-nacl)# permit udp any any time-range udp-yes
!
Switch(config-ext-nacl)# exit
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# ip access-group strict in
```

Examples: ACL Logging

Two variations of logging are supported on ACLs. The **log** keyword sends an informational logging message to the console about the packet that matches the entry; the **log-input** keyword includes the input interface in the log entry.

In this example, standard named access list *stan1* denies traffic from 10.1.1.0 0.0.0.255, allows traffic from all other sources, and includes the **log** keyword.

```
Switch(config)# ip access-list standard stan1
Switch(config-std-nacl)# deny 10.1.1.0 0.0.0.255 log
Switch(config-std-nacl)# permit any log
Switch(config-std-nacl)# exit
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# ip access-group stan1 in
Switch(config-if)# end
Switch# show logging
Syslog logging: enabled (0 messages dropped, 0 flushes, 0 overruns)
    Console logging: level debugging, 37 messages logged
    Monitor logging: level debugging, 0 messages logged
    Buffer logging: level debugging, 37 messages logged
    File logging: disabled
    Trap logging: level debugging, 39 message lines logged

Log Buffer (4096 bytes):

00:00:48: NTP: authentication delay calculation problems

<output truncated>

00:09:34:%SEC-6-IPACCESSLOGS:list stan1 permitted 0.0.0.0 1 packet
```

```
00:09:59:%SEC-6-IPACCESSLOGS:list stan1 denied 10.1.1.15 1 packet
00:10:11:%SEC-6-IPACCESSLOGS:list stan1 permitted 0.0.0.0 1 packet
```

This example is a named extended access list *ext1* that permits ICMP packets from any source to 10.1.1.0 0.0.0.255 and denies all UDP packets.

```
Switch(config)# ip access-list extended ext1
Switch(config-ext-nacl)# permit icmp any 10.1.1.0 0.0.0.255 log
Switch(config-ext-nacl)# deny udp any any log
Switch(config-std-nacl)# exit
Switch(config)# interface gigabitethernet 0/2
Switch(config-if)# ip access-group ext1 in
```

This is a an example of a log for an extended ACL:

```
01:24:23:%SEC-6-IPACCESSLOGDP:list ext1 permitted icmp 10.1.1.15 -> 10.1.1.61 (0/0), 1
packet
01:25:14:%SEC-6-IPACCESSLOGDP:list ext1 permitted icmp 10.1.1.15 -> 10.1.1.61 (0/0), 7
packets
01:26:12:%SEC-6-IPACCESSLOGP:list ext1 denied udp 0.0.0.0(0) -> 255.255.255.255(0), 1 packet
01:31:33:%SEC-6-IPACCESSLOGP:list ext1 denied udp 0.0.0.0(0) -> 255.255.255.255(0), 8 packets
```

Note that all logging entries for IP ACLs start with %SEC-6-IPACCESSLOG with minor variations in format depending on the kind of ACL and the access entry that has been matched.

This is an example of an output message when the **log-input** keyword is entered:

```
00:04:21:%SEC-6-IPACCESSLOGDP:list inputlog permitted icmp 10.1.1.10 (Vlan1 0001.42ef.a400)
 ->
10.1.1.61 (0/0), 1 packet
```

A log message for the same sort of packet using the **log** keyword does not include the input interface information:

```
00:05:47:%SEC-6-IPACCESSLOGDP:list inputlog permitted icmp 10.1.1.10 -> 10.1.1.61 (0/0), 1
 packet
```

Examples: Troubleshooting ACLs

If this ACL manager message appears and [chars] is the access-list name,

```
ACLMGR-2-NOVMR: Cannot generate hardware representation of access list [chars]
```

The switch has insufficient resources to create a hardware representation of the ACL. The resources include hardware memory and label space but not CPU memory. A lack of available logical operation units or specialized hardware resources causes this problem. Logical operation units are needed for a TCP flag match or a test other than **eq** (**ne**, **gt**, **lt**, or **range**) on TCP, UDP, or SCTP port numbers.

Use one of these workarounds:

- Modify the ACL configuration to use fewer resources.

- Rename the ACL with a name or number that alphanumerically precedes the ACL names or numbers.

For more information about configuring ACLs with insufficient resources, see CSCsq63926 in the Bug Toolkit.

For example, if you apply this ACL to an interface:

```
permit tcp source source-wildcard destination destination-wildcard range 5 60
permit tcp source source-wildcard destination destination-wildcard range 15 160
permit tcp source source-wildcard destination destination-wildcard range 115 1660
permit tcp source source-wildcard destination destination-wildcard
```

And if this message appears:

```
ACLMGR-2-NOVMR: Cannot generate hardware representation of access list [chars]
```

The flag-related operators are not available. To avoid this issue,

- Move the fourth ACE before the first ACE by using **ip access-list resequence** global configuration command:

  ```
  permit tcp source source-wildcard destination destination-wildcard
  permit tcp source source-wildcard destination destination-wildcard range 5 60
  permit tcp source source-wildcard destination destination-wildcard range 15 160
  permit tcp source source-wildcard destination destination-wildcard range 115 1660
  ```

  or

- Rename the ACL with a name or number that alphanumerically precedes the other ACLs (for example, rename ACL *79* to ACL *1*).

You can now apply the first ACE in the ACL to the interface. The switch allocates the ACE to available mapping bits in the Opselect index and then allocates flag-related operators to use the same bits in the hardware memory.

Additional References

Related Documents

MIBs

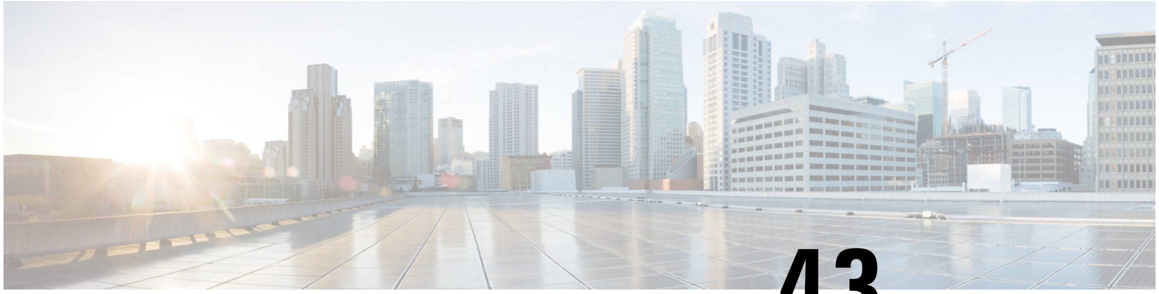
MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for IPv4 Access Control Lists

Release	Feature Information
Cisco IOS Release 15.2(5)E	IPv4 Access Control Lists perform packet filtering to control which packets move through the network and where. Such control provides security by helping to limit network traffic, restrict the access of users and devices to the network, and prevent traffic from leaving a network. This feature was introduced.
Cisco IOS 15.2(2)E	The Named ACL Support for Noncontiguous Ports on an Access Control Entry feature allows you to specify noncontiguous ports in a single access control entry, which greatly reduces the number of entries required in an access control list when several entries have the same source address, destination address, and protocol, but differ only in the ports.
Cisco IOS 15.2(2)E	The IP Access List Entry Sequence Numbering feature helps users to apply sequence numbers to permit or deny statements and also reorder, add, or remove such statements from a named IP access list. This feature makes revising IP access lists much easier. Prior to this feature, users could add access list entries to the end of an access list only; therefore needing to add statements anywhere except the end required reconfiguring the access list entirely. The following commands were introduced or modified: **deny (IP)**, **ip access-list resequence deny (IP)**, **permit (IP)**.



CHAPTER 43

IPv6 Access Control Lists

Access lists determine what traffic is blocked and what traffic is forwarded at device interfaces and allow filtering of traffic based on source and destination addresses, and inbound and outbound traffic to a specific interface. Standard IPv6 ACL functionality was extended to support traffic filtering based on IPv6 option headers and optional, upper-layer protocol type information for finer granularity of control. Standard IPv6 ACL functionality was extended to support traffic filtering based on IPv6 option headers and optional, upper-layer protocol type information for finer granularity of control.

This module describes how to configure IPv6 traffic filtering and to control access to virtual terminal lines.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for IPv6 ACLs

With IPv4, you can configure standard and extended numbered IP ACLs, named IP ACLs, and MAC ACLs. IPv6 supports only named ACLs.

The switch supports most Cisco IOS-supported IPv6 ACLs with some exceptions:

- The switch does not support matching on these keywords: **routing header**, and **undetermined-transport**.

- The switch does not support reflexive ACLs (the **reflect** keyword).
-
- This release does not support router ACL and VLAN ACLs (VLAN maps) for IPv6.
- This release supports port ACLs, router ACLs and VLAN ACLs (VLAN maps) for IPv6.
-
- The switch does not apply MAC-based ACLs on IPv6 frames.
- When configuring an ACL, there is no restriction on keywords entered in the ACL, regardless of whether or not they are supported on the platform. When you apply the ACL to an interface that requires hardware forwarding (physical ports), the switch checks to determine whether or not the ACL can be supported on the interface. If not, attaching the ACL is rejected.
- If an ACL is applied to an interface and you attempt to add an access control entry (ACE) with an unsupported keyword, the switch does not allow the ACE to be added to the ACL that is currently attached to the interface.

IPv6 ACLs on the switch have these characteristics:

- Fragmented frames (the **fragments** keyword as in IPv6) are not supported.
- The same statistics supported in IPv4 are supported for IPv6 ACLs.
- If the switch runs out of hardware space, the packets associated with the ACL are processed to the CPU, and the ACLs are applied in software.
- The switch supports IPv6 address-matching for a full range of prefix-lengths.

Information About Configuring IPv6 ACLs

You can filter IP version 6 (IPv6) traffic by creating IPv6 access control lists (ACLs) and applying them to interfaces similarly to the way that you create and apply IP version 4(IPv4) named ACLs.

ACL Overview

Packet filtering can help limit network traffic and restrict network use by certain users or devices. ACLs filter traffic as it passes through a router or switch and permit or deny packets crossing specified interfaces or VLANs. An ACL is a sequential collection of permit and deny conditions that apply to packets. When a packet is received on an interface, the switch compares the fields in the packet against any applied ACLs to verify that the packet has the required permissions to be forwarded, based on the criteria specified in the access lists. One by one, it tests packets against the conditions in an access list. The first match decides whether the switch accepts or rejects the packets. Because the switch stops testing after the first match, the order of conditions in the list is critical. If no conditions match, the switch rejects the packet. If there are no restrictions, the switch forwards the packet; otherwise, the switch drops the packet. The switch can use ACLs on all packets it forwards, including packets bridged within a VLAN.

You configure access lists on a router to provide basic security for your network. If you do not configure ACLs, all packets passing through the switch could be allowed onto all parts of the network. You can use ACLs to control which hosts can access different parts of a network or to decide which types of traffic are forwarded or blocked at router interfaces. For example, you can allow e-mail traffic to be forwarded but not Telnet traffic. ACLs can be configured to block inbound traffic, outbound traffic, or both.

IPv6 ACLs Overview

You can filter IP Version 6 (IPv6) traffic by creating IPv6 access control lists (ACLs) and applying them to interfaces similar to how you create and apply IP Version 4 (IPv4) named ACLs.

A switch supports three types of IPv6 ACLs:

- IPv6 router ACLs are supported on outbound or inbound traffic on Layer 3 interfaces, which can be routed ports, switch virtual interfaces (SVIs), or Layer 3 EtherChannels. IPv6 router ACLs apply only to IPv6 packets that are routed.
- IPv6 port ACLs are supported on outbound and inbound Layer 2 interfaces. IPv6 port ACLs are applied to all IPv6 packets entering the interface.
- VLAN ACLs or VLAN maps access-control all packets in a VLAN. You can use VLAN maps to filter traffic between devices in the same VLAN. ACL VLAN maps are applied on L2 VLANs. VLAN maps are configured to provide access control based on Layer 3 addresses for IPv6. Unsupported protocols are access-controlled through MAC addresses using Ethernet ACEs. After a VLAN map is applied to a VLAN, all packets entering the VLAN are checked against the VLAN map.

The switch supports VLAN ACLs (VLAN maps) for IPv6 traffic.

You can apply both IPv4 and IPv6 ACLs to an interface.

The switch does not support VLAN ACLs (VLAN maps) for IPv6 traffic.

Interactions with Other Features and Switches

- If a bridged frame is to be dropped due to a port ACL, the frame is not bridged.
- You can create both IPv4 and IPv6 ACLs on a switch, and you can apply both IPv4 and IPv6 ACLs to the same interface. Each ACL must have a unique name; an error message appears if you try to use a name that is already configured.

  You use different commands to create IPv4 and IPv6 ACLs and to attach IPv4 or IPv6 ACLs to the same Layer 2 interface. If you use the wrong command to attach an ACL (for example, an IPv4 command to attach an IPv6 ACL), you receive an error message.
- You cannot use MAC ACLs to filter IPv6 frames. MAC ACLs can only filter non-IP frames.
- If the hardware memory is full, the packets associated with the ACL are processed to the CPU, and the ACLs are applied in software.

Default Configuration for IPv6 ACLs

The default IPv6 ACL configuration is as follows:

```
Switch# show access-lists preauth_ipv6_acl
IPv6 access list preauth_ipv6_acl (per-user)
permit udp any any eq domain sequence 10
permit tcp any any eq domain sequence 20
permit icmp any any nd-ns sequence 30
permit icmp any any nd-na sequence 40
permit icmp any any router-solicitation sequence 50
permit icmp any any router-advertisement sequence 60
permit icmp any any redirect sequence 70
permit udp any eq 547 any eq 546 sequence 80
permit udp any eq 546 any eq 547 sequence 90
deny ipv6 any any sequence 100
```

Supported ACL Features

IPv6 ACLs on the switch have these characteristics:

- Fragmented frames (the fragments keyword as in IPv4) are supported.
- The same statistics supported in IPv4 are supported for IPv6 ACLs.
- If the switch runs out of TCAM space, packets associated with the ACL label are forwarded to the CPU, and the ACLs are applied in software.

IPv6 Port-Based Access Control List Support

The IPv6 PACL feature provides the ability to provide access control (permit or deny) on Layer 2 switch ports for IPv6 traffic. IPv6 PACLs are similar to IPv4 PACLs, which provide access control on Layer 2 switch ports for IPv4 traffic. They are supported only in the ingress direction and in hardware.

ACLs and Traffic Forwarding

The IPv6 ACL Extensions for Hop by Hop Filtering feature allows you to control IPv6 traffic that might contain hop-by-hop extension headers. You can configure an access control list (ACL) to deny all hop-by-hop traffic or to selectively permit traffic based on protocol.

IPv6 access control lists (ACLs) determine what traffic is blocked and what traffic is forwarded at device interfaces. ACLs allow filtering based on source and destination addresses, inbound and outbound to a specific interface. Use the **ipv6 access-list** command to define an IPv6 ACL, and the **deny** and **permit** commands to configure its conditions.

The IPv6 ACL Extensions for Hop by Hop Filtering feature implements RFC 2460 to support traffic filtering in any upper-layer protocol type.

How to Configure IPv6 ACLs

Configuring IPv6 ACLs

To filter IPv6 traffic, you perform these steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. {**ipv6 access-list** *list-name*

4. {**deny** | **permit**} protocol {*source-ipv6-prefix/*|*prefix-length*|**any**| **host** *source-ipv6-address*} [operator [*port-number*]] { *destination-ipv6-prefix/ prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]][**dscp** *value*] [**fragments**] [**log**] [**log-input**][**sequence** *value*] [**time-range** *name*]
5. {**deny** | **permit**} **tcp** {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [**operator** [**port-number**]] {*destination-ipv6- prefix/prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]] [**ack**] [**dscp** *value*] [**fin**] [**log**] [**log-input**] [**neq** {**port** | protocol}] [**psh**] [**range** {**port** | protocol}] [**rst**] [**sequence** *value*] [**syn**] [**time-range** *name*] [**urg**]
6. {**deny** | **permit**} **udp** {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [operator [*port-number*]] {*destination-ipv6-prefix/prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]] [**dscp** *value*] [**log**] [**log-input**] [**neq** {*port* | *protocol*}] [**range** {*port* | *protocol*}] [**sequence** *value*] [**time-range** *name*]]
7. {**deny** | **permit**} **icmp** {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [operator [*port-number*]] {*destination-ipv6-prefix/prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]] [*icmp-type* [*icmp-code*] | icmp-message] [**dscp** *value*] [**log**] [**log-input**] [**sequence** *value*] [**time-range** *name*]
8. **end**
9. **show ipv6 access-list**
10. **show running-config**
11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	{**ipv6 access-list** *list-name* **Example:** `Switch(config)# ipv6 access-list example_acl_list`	Defines an IPv6 ACL name, and enters IPv6 access list configuration mode.
Step 4	{**deny** | **permit**} protocol {*source-ipv6-prefix/*|*prefix-length*|**any**| **host** *source-ipv6-address*} [operator [*port-number*]] { *destination-ipv6-prefix/ prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]][**dscp** *value*] [**fragments**] [**log**] [**log-input**][**sequence** *value*] [**time-range** *name*]	Enter deny or permit to specify whether to deny or permit the packet if conditions are matched. These are the conditions: • For protocol, enter the name or number of an Internet protocol: **ahp**, **esp**, **icmp**, **ipv6**, **pcp**, **stcp**, **tcp**, or **udp**, or an integer in the range 0 to 255 representing an IPv6 protocol number. • The *source-ipv6-prefix/prefix-length* or *destination-ipv6-prefix/ prefix-length* is the source or

	Command or Action	Purpose
		destination IPv6 network or class of networks for which to set deny or permit conditions, specified in hexadecimal and using 16-bit values between colons (see RFC 2373). • Enter any as an abbreviation for the IPv6 prefix ::/0. • For **host** *source-ipv6-address* or *destination-ipv6-address*, enter the source or destination IPv6 host address for which to set deny or permit conditions, specified in hexadecimal using 16-bit values between colons. • (Optional) For operator, specify an operand that compares the source or destination ports of the specified protocol. Operands are **lt** (less than), **gt** (greater than), **eq** (equal), **neq** (not equal), and **range.** If the operator follows the *source-ipv6-prefix/prefix-length* argument, it must match the source port. If the operator follows the *destination-ipv6- prefix/prefix-length* argument, it must match the destination port. • (Optional) The **port-number** is a decimal number from 0 to 65535 or the name of a TCP or UDP port. You can use TCP port names only when filtering TCP. You can use UDP port names only when filtering UDP. • (Optional) Enter **dscp** value to match a differentiated services code point value against the traffic class value in the Traffic Class field of each IPv6 packet header. The acceptable range is from 0 to 63. • (Optional) Enter **fragments** to check noninitial fragments. This keyword is visible only if the protocol is ipv6. • (Optional) Enter **log** to cause an logging message to be sent to the console about the packet that matches the entry. Enter **log-input** to include the input interface in the log entry. • (Optional) Enter **sequence** *value* to specify the sequence number for the access list statement. The acceptable range is from 1 to 4,294,967,295. • (Optional) Enter **time-range** name to specify the time range that applies to the deny or permit statement.
Step 5	{**deny** | **permit**} **tcp** {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [**operator**	(Optional) Define a TCP access list and the access conditions.

	Command or Action	Purpose
	[**port-number**]] {*destination-ipv6- prefix/prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]] [**ack**] [**dscp** *value*] [**fin**] [**log**] [**log-input**] [**neq** {**port** | protocol}] [**psh**] [**range** {**port** | protocol}] [**rst**] [**sequence** *value*] [**syn**] [**time-range** *name*] [**urg**]	Enter **tcp** for Transmission Control Protocol. The parameters are the same as those described in Step 3a, with these additional optional parameters: • **ack**—Acknowledgment bit set. • **fin**—Finished bit set; no more data from sender. • **neq** {*port* | protocol}—Matches only packets that are not on a given port number. • **psh**—Push function bit set. • **range** {*port* | protocol}—Matches only packets in the port number range. • **rst**—Reset bit set. • **syn**—Synchronize bit set. • **urg**—Urgent pointer bit set.
Step 6	{**deny** | **permit**} **udp** {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [operator [*port-number*]] {*destination-ipv6-prefix/prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]] [**dscp** *value*] [**log**] [**log-input**] [**neq** {*port* | *protocol*}] [**range** {*port* | *protocol*}] [**sequence** *value*] [**time-range** *name*]]	(Optional) Define a UDP access list and the access conditions. Enter **udp** for the User Datagram Protocol. The UDP parameters are the same as those described for TCP, except that the [operator [*port*]] port number or name must be a UDP port number or name.
Step 7	{**deny** | **permit**} **icmp** {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [operator [*port-number*]] {*destination-ipv6-prefix/prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]] [*icmp-type* [*icmp-code*] | icmp-message] [**dscp** *value*] [**log**] [**log-input**] [**sequence** *value*] [**time-range** *name*]	(Optional) Define an ICMP access list and the access conditions. Enter **icmp** for Internet Control Message Protocol. The ICMP parameters are the same as those described for most IP protocols in Step 1, with the addition of the ICMP message type and code parameters. These optional keywords have these meanings: • *icmp-type*—Enter to filter by ICMP message type, a number from 0 to 255. • *icmp-code*—Enter to filter ICMP packets that are filtered by the ICMP message code type, a number from 0 to 255. • *icmp-message*—Enter to filter ICMP packets by the ICMP message type name or the ICMP message type and code name. To see a list of ICMP message type names and code names, use the ? key or see command reference for this release.
Step 8	**end**	Return to privileged EXEC mode.
Step 9	**show ipv6 access-list**	Verify the access list configuration.

	Command or Action	Purpose
Step 10	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

Attach the IPv6 ACL to an Interface

Attaching an IPv6 ACL to an Interface

You can apply an ACL to inbound traffic on Layer 2 interfaces.

Follow these steps to control access to an interface:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **ipv6 address** *ipv6-address*
5. **ipv6 traffic-filter** *access-list-name* **in**
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface** *interface-id*	Identify a Layer 2 interface on which to apply an access list, and enter interface configuration mode.
Step 4	**ipv6 address** *ipv6-address*	This command is not required on Layer 2 interfaces or if the interface has already been configured with an explicit IPv6 address.
Step 5	**ipv6 traffic-filter** *access-list-name* **in**	Apply the access list to incoming traffic on the interface. **Note** The out keyword is not supported for Layer 2 interfaces (port ACLs).

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring IPv6 ACLs

You can display information about all configured access lists, all IPv6 access lists, or a specific access list by using one or more of the privileged EXEC commands shown in the table below:

Command	Purpose
show access-lists	Displays all access lists configured on the switch.
show ipv6 access-list [*access-list-name*]	Displays all configured IPv6 access lists or the access list specified by name.

This is an example of the output from the show access-lists privileged EXEC command. The output shows all access lists that are configured on the switch.

```
Switch # show access-lists
Extended IP access list hello
    10 permit ip any any
IPv6 access list ipv6
    permit ipv6 any any sequence 10
```

This is an example of the output from the **show ipv6 access-list** privileged EXEC command. The output shows only IPv6 access lists configured on the switch.

```
Switch# show ipv6 access-list
IPv6 access list inbound
    permit tcp any any eq bgp (8 matches) sequence 10
    permit tcp any any eq telnet (15 matches) sequence 20
    permit udp any any sequence 30
IPv6 access list outbound
    deny udp any any sequence 10
    deny tcp any any eq telnet sequence 20
```

Configuring PACL Mode and Applying IPv6 PACL on an Interface

Before you begin

Before you configure the IPv6 PACL feature, you must configure an IPv6 access list. Once you have configured the IPv6 access list, you must configure the port-based access control list (PACL) mode on the specified IPv6 Layer 2 interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 access-list** *access-list-name*
4. **exit**
5. **interface** *type number*
6. **ipv6 traffic-filter** *access-list-name* **in**
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 access-list** *access-list-name* **Example:** `Device(config)# ipv6 access-list list1`	Defines an IPv6 ACL and enters IPv6 access list configuration mode.
Step 4	**exit** **Example:** `Device(config-ipv6-acl)# exit`	Exits IPv6 access list configuration mode and enters global configuration mode.

	Command or Action	Purpose
Step 5	**interface** *type number* **Example:** `Device(config)# interface Gigabitethernet 0/1`	Specifies an interface type and number and enters interface configuration mode.
Step 6	**ipv6 traffic-filter** *access-list-name* **in** **Example:** `Device(config-if)# ipv6 traffic-filter list1 in`	Filters incoming IPv6 traffic on an interface.

Step 7	**end**
	Example:
	`Device(config-if)# end`
		Exits interface configuration mode and enters privileged EXEC mode.

Configuring IPv6 ACL Extensions for Hop by Hop Filtering

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 access-list** *access-list-name*
4. **permit** *protocol* {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address* } [*operator* [*port-number*]] {*destination-ipv6-prefix/prefix-length* | **any** | **host** *destination-ipv6-address* } [*operator* [*port-number*]] [**dscp** *value*] [**hbh**] [**log**] [**log-input**] [**reflect** *name* [**timeout** *value*]] [**sequence** *value*] [**time-range** *name*]
5.
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 access-list** *access-list-name* **Example:** `Device(config)# ipv6 access-list hbh-acl`	Defines an IPv6 ACL and enters IPv6 access list configuration mode.
Step 4	**permit** *protocol* {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address* } [*operator* [*port-number*]] {*destination-ipv6-prefix/prefix-length* | **any** | **host**	Sets permit conditions for the IPv6 ACL.

	Command or Action	Purpose
	destination-ipv6-address } [*operator* [*port-number*]] [**dscp** *value*] [**hbh**] [**log**] [**log-input**] [**reflect** *name* [**timeout** *value*]] [**sequence** *value*] [**time-range** *name*] **Example:** `Device(config-ipv6-acl)# permit icmp any any dest-option-type`	
Step 5	**Example:** `Device(config-ipv6-acl)# deny icmp any any dest-option-type`	Sets deny conditions for the IPv6 ACL.

Step 6	**end**
	Example:
	`Device (config-ipv6-acl)# end`
		Returns to privileged EXEC configuration mode.

Configuration Examples for IPv6 ACLs

Example: Configuring IPv6 ACLs

This example configures the IPv6 access list named CISCO. The first deny entry in the list denies all packets that have a destination TCP port number greater than 5000. The second deny entry denies packets that have a source UDP port number less than 5000. The second deny also logs all matches to the console. The first permit entry in the list permits all ICMP packets. The second permit entry in the list permits all other traffic. The second permit entry is necessary because an implicit deny -all condition is at the end of each IPv6 access list.

```
Switch(config)# ipv6 access-list CISCO
Switch(config-ipv6-acl)# deny tcp any any gt 5000
Switch config-ipv6-acl)# deny ::/0 lt 5000 ::/0 log
Switch(config-ipv6-acl)# permit icmp any any
Switch(config-ipv6-acl)# permit any any
```

Example: Configuring PACL Mode and Applying IPv6 PACL on an Interface

```
Device# configure terminal

Device(config)# ipv6 access-list list1

Device(config-ipv6-acl)# exit

Device(config-if)# ipv6 traffic-filter list1 in
```

Example: IPv6 ACL Extensions for Hop by Hop Filtering

```
Device(config)# ipv6 access-list hbh_acl
Device(config-ipv6-acl)# permit tcp any any hbh
Device(config-ipv6-acl)# permit tcp any any
Device(config-ipv6-acl)# permit udp any any
Device(config-ipv6-acl)# permit udp any any hbh
Device(config-ipv6-acl)# permit hbh any any
Device(config-ipv6-acl)# permit any any
Device(config-ipv6-acl)# exit

! Assign an IP address and add the ACL on the interface.

Device(config)# interface gigabitethernet0/1
Device(config-if)# ipv6 address 1001::1/64
Device(config-if)# ipv6 traffic-filter hbh_acl in
Device(config-if)# exit
Device(config)# exit
Device# clear counters
Clear "show interface" counters on all interfaces [confirm]
Device#

! Verify the configurations.

Device# show running-config interface gigabitethernet0/1

Building configuration...

Current configuration : 114 bytes
!
interface gigabitethernet0/1
no switchport
ipv6 address 1001::1/64
ipv6 traffic-filter hbh_acl
end
```

Additional References

Related Documents

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for IPv6 Access Control Lists

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 87: Feature Information for IPv6 Access Control Lists

Feature Name	Releases	Feature Information
IPv6 ACL Extensions for Hop-by-Hop Filtering	Cisco IOS Release 15.2(5)E	Allows you to control IPv6 traffic that might contain hop-by-hop extension headers. The following commands were introduced or modified: **deny (IPv6)**, **permit (IPv6)**.
IPv6 PACL Support	Cisco IOS Release 15.2(5)E	The IPv6 PACL feature permits or denies the movement of traffic between port-based interface, Layer 3 subnets, wireless or wired clients, and VLANs, or within a VLAN. The following command was introduced or modified: **ipv6 traffic-filter**.
IPv6 Services: Extended Access Control Lists	Cisco IOS Release 15.2(5)E	Standard IPv6 ACL functionality was extended to support traffic filtering based on IPv6 option headers and optional, upper-layer protocol type information for finer granularity of control.

Feature Name	Releases	Feature Information
IPv6 Services: Standard Access Control Lists	Cisco IOS Release 15.2(5)E	Access lists determine what traffic is blocked and what traffic is forwarded at router interfaces and allow filtering based on source and destination addresses, inbound and outbound to a specific interface.

CHAPTER 44

Configuring DHCP

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for DHCP

The following scenario is not supported:

A non-DHCP snooping VLAN, and the SVI of the non-DHCP snooping VLAN is configured on a device. The SVI of the non-DHCP snooping VLAN is configured with the status of *no shutdown*. In this scenario, the DHCP packets in the non-DHCP snooping VLAN are not forwarded to the trusted ports.

If the SVI of the non-DHCP snooping VLAN is not configured or is configured with the *shutdown* status, DHCP packets are forwarded to the trusted ports, and DHCP clients can obtain IP address from the DHCP server.

Information About DHCP

DHCP Server

The DHCP server assigns IP addresses from specified address pools on a switch or router to DHCP clients and manages them. If the DHCP server cannot give the DHCP client the requested configuration parameters from its database, it forwards the request to one or more secondary DHCP servers defined by the network administrator. The switch can act as a DHCP server.

DHCP Relay Agent

A DHCP relay agent is a Layer 3 device that forwards DHCP packets between clients and servers. Relay agents forward requests and replies between clients and servers when they are not on the same physical subnet. Relay agent forwarding is different from the normal Layer 2 forwarding, in which IP datagrams are switched transparently between networks. Relay agents receive DHCP messages and generate new DHCP messages to send on output interfaces.

DHCP Snooping

DHCP snooping is a DHCP security feature that provides network security by filtering untrusted DHCP messages and by building and maintaining a DHCP snooping binding database, also referred to as a DHCP snooping binding table.

DHCP snooping acts like a firewall between untrusted hosts and DHCP servers. You use DHCP snooping to differentiate between untrusted interfaces connected to the end user and trusted interfaces connected to the DHCP server or another switch.

Note For DHCP snooping to function properly, all DHCP servers must be connected to the switch through trusted interfaces.

An untrusted DHCP message is a message that is received through an untrusted interface. By default, the switch considers all interfaces untrusted. So, the switch must be configured to trust some interfaces to use DHCP Snooping. When you use DHCP snooping in a service-provider environment, an untrusted message is sent from a device that is not in the service-provider network, such as a customer’s switch. Messages from unknown devices are untrusted because they can be sources of traffic attacks.

The DHCP snooping binding database has the MAC address, the IP address, the lease time, the binding type, the VLAN number, and the interface information that corresponds to the local untrusted interfaces of a switch. It does not have information regarding hosts interconnected with a trusted interface.

Note When configuring DHCP snooping to block unauthorized IP address using the **ip verify source prot-security** command on an interface, the **switchport port-security** command should also be configured.

In a service-provider network, an example of an interface you might configure as trusted is one connected to a port on a device in the same network. An example of an untrusted interface is one that is connected to an untrusted interface in the network or to an interface on a device that is not in the network.

When a switch receives a packet on an untrusted interface and the interface belongs to a VLAN in which DHCP snooping is enabled, the switch compares the source MAC address and the DHCP client hardware address. If the addresses match (the default), the switch forwards the packet. If the addresses do not match, the switch drops the packet.

The switch drops a DHCP packet when one of these situations occurs:

- A packet from a DHCP server, such as a DHCPOFFER, DHCPACK, DHCPNAK, or DHCPLEASEQUERY packet, is received from outside the network or firewall.
- A packet is received on an untrusted interface, and the source MAC address and the DHCP client hardware address do not match.
- The switch receives a DHCPRELEASE or DHCPDECLINE broadcast message that has a MAC address in the DHCP snooping binding database, but the interface information in the binding database does not match the interface on which the message was received.
- A DHCP relay agent forwards a DHCP packet that includes a relay-agent IP address that is not 0.0.0.0, or the relay agent forwards a packet that includes option-82 information to an untrusted port.

If the switch is an aggregation switch supporting DHCP snooping and is connected to an edge switch that is inserting DHCP option-82 information, the switch drops packets with option-82 information when packets are received on an untrusted interface. If DHCP snooping is enabled and packets are received on a trusted port, the aggregation switch does not learn the DHCP snooping bindings for connected devices and cannot build a complete DHCP snooping binding database.

When an aggregation switch can be connected to an edge switch through an untrusted interface and you enter the **ip dhcp snooping information option allow-untrusted** global configuration command, the aggregation switch accepts packets with option-82 information from the edge switch. The aggregation switch learns the bindings for hosts connected through an untrusted switch interface. The DHCP security features, such as dynamic ARP inspection or IP source guard, can still be enabled on the aggregation switch while the switch receives packets with option-82 information on untrusted input interfaces to which hosts are connected. The port on the edge switch that connects to the aggregation switch must be configured as a trusted interface.

Normally, it is not desirable to broadcast packets to wireless clients. So, DHCP snooping replaces destination broadcast MAC address (ffff.ffff.ffff) with unicast MAC address for DHCP packets that are going from server to wireless clients. The unicast MAC address is retrieved from CHADDR field in the DHCP payload. This processing is applied for server to client packets such as DHCP OFFER, DHCP ACK, and DHCP NACK messages. The **ip dhcp snooping wireless bootp-broadcast enable** can be used to revert this behavior. When the wireless BOOTP broadcast is enabled, the broadcast DHCP packets from server are forwarded to wireless clients without changing the destination MAC address.

Related Topics

Prerequisites for Configuring DHCP Snooping and Option 82, on page 790

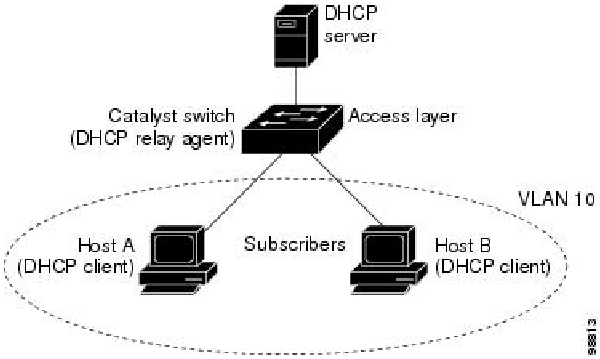
Option-82 Data Insertion

In residential, metropolitan Ethernet-access environments, DHCP can centrally manage the IP address assignments for a large number of subscribers. When the DHCP option-82 feature is enabled on the switch, a subscriber device is identified by the switch port through which it connects to the network (in addition to its MAC address). Multiple hosts on the subscriber LAN can be connected to the same port on the access switch and are uniquely identified.

Note The DHCP option-82 feature is supported only when DHCP snooping is globally enabled on the VLANs to which subscriber devices using option-82 are assigned.

The following illustration shows a metropolitan Ethernet network in which a centralized DHCP server assigns IP addresses to subscribers connected to the switch at the access layer. Because the DHCP clients and their associated DHCP server do not reside on the same IP network or subnet, a DHCP relay agent (the Catalyst switch) is configured with a helper address to enable broadcast forwarding and to transfer DHCP messages between the clients and the server.

Figure 58: DHCP Relay Agent in a Metropolitan Ethernet Network



When you enable the DHCP snooping information option 82 on the switch, the following sequence of events occurs:

- The host (DHCP client) generates a DHCP request and broadcasts it on the network.
- When the switch receives the DHCP request, it adds the option-82 information in the packet. By default, the remote-ID suboption is the switch MAC address, and the circuit-ID suboption is the port identifier, **vlan-mod-port**, from which the packet is received.You can configure the remote ID and circuit ID.
- If the IP address of the relay agent is configured, the switch adds this IP address in the DHCP packet.
- The switch forwards the DHCP request that includes the option-82 field to the DHCP server.
- The DHCP server receives the packet. If the server is option-82-capable, it can use the remote ID, the circuit ID, or both to assign IP addresses and implement policies, such as restricting the number of IP addresses that can be assigned to a single remote ID or circuit ID. Then the DHCP server echoes the option-82 field in the DHCP reply.
- The DHCP server unicasts the reply to the switch if the request was relayed to the server by the switch. The switch verifies that it originally inserted the option-82 data by inspecting the remote ID and possibly the circuit ID fields. The switch removes the option-82 field and forwards the packet to the switch port that connects to the DHCP client that sent the DHCP request.

In the default suboption configuration, when the described sequence of events occurs, the values in these fields do not change (see the illustration,*Suboption Packet Formats*):

- Circuit-ID suboption fields

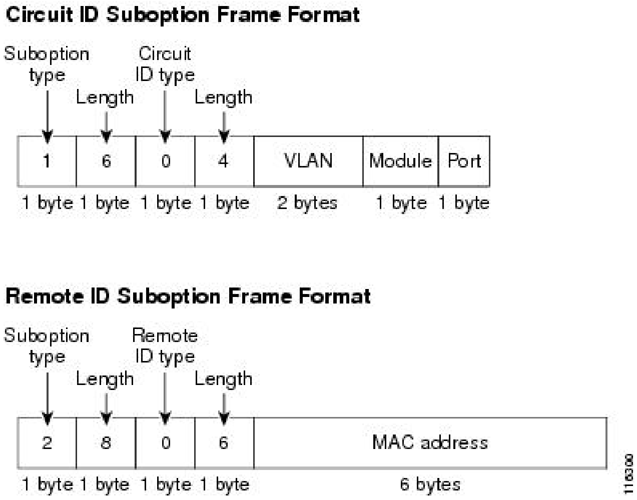
    - Suboption type
    - Length of the suboption type
    - Circuit-ID type
    - Length of the circuit-ID type

- Remote-ID suboption fields
    - Suboption type
    - Length of the suboption type
    - Remote-ID type
    - Length of the remote-ID type

In the port field of the circuit ID suboption, the port numbers start at 3. For example, on a switch with 24 10/100/1000 ports and four small form-factor pluggable (SFP) module slots, port 3 is the Gigabit Ethernet 1/0/1 port, port 4 is the Gigabit Ethernet 1/0/2 port, and so forth. Port 27 is the SFP module slot Gigabit Ethernet1/0/25, and so forth.

The illustration, *Suboption Packet Formats*. shows the packet formats for the remote-ID suboption and the circuit-ID suboption when the default suboption configuration is used. The switch uses the packet formats when you globally enable DHCP snooping and enter the ip dhcp snooping information option global configuration command.

Figure 59: Suboption Packet Formats

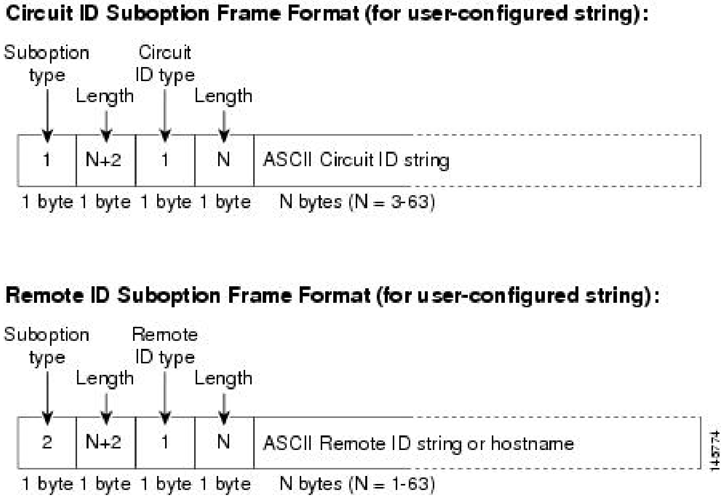


The illustration, *User-Configured Suboption Packet Formats,* shows the packet formats for user-configured remote-ID and circuit-ID suboptions The switch uses these packet formats when DHCP snooping is globally enabled and when the **ip dhcp snooping information option format remote-id** global configuration command and the**ip dhcp snooping vlan information option format-type circuit-id string** interface configuration command are entered.

The values for these fields in the packets change from the default values when you configure the remote-ID and circuit-ID suboptions:

- Circuit-ID suboption fields
    - The circuit-ID type is 1.
    - The length values are variable, depending on the length of the string that you configure.
- Remote-ID suboption fields
    - The remote-ID type is 1.
    - The length values are variable, depending on the length of the string that you configure.

Figure 60: User-Configured Suboption Packet Formats


Circuit ID Suboption Frame Format (for user-configured string):
Suboption type
Length
Circuit ID type
Length
1
N+2
1
N
ASCII Circuit ID string
1 byte 1 byte 1 byte 1 byte
N bytes (N = 3-63)
Remote ID Suboption Frame Format (for user-configured string):
Suboption type
Length
Remote ID type
Length
2
N+2
1
N
ASCII Remote ID string or hostname
1 byte 1 byte 1 byte 1 byte
N bytes (N = 1-63)
145774

Cisco IOS DHCP Server Database

During the DHCP-based autoconfiguration process, the designated DHCP server uses the Cisco IOS DHCP server database. It has IP addresses, address bindings, and configuration parameters, such as the boot file.

An address binding is a mapping between an IP address and a MAC address of a host in the Cisco IOS DHCP server database. You can manually assign the client IP address, or the DHCP server can allocate an IP address from a DHCP address pool. For more information about manual and automatic address bindings, see the “Configuring DHCP” chapter of the *Cisco IOS IP Configuration Guide, Release 12.4*.

For procedures to enable and configure the Cisco IOS DHCP server database, see the “DHCP Configuration Task List” section in the “Configuring DHCP” chapter of the *Cisco IOS IP Configuration Guide, Release 12.4*.

DHCP Snooping Binding Database

When DHCP snooping is enabled, the switch uses the DHCP snooping binding database to store information about untrusted interfaces. The database can have up to 64,000 bindings.

Each database entry (binding) has an IP address, an associated MAC address, the lease time (in hexadecimal format), the interface to which the binding applies, and the VLAN to which the interface belongs. The database agent stores the bindings in a file at a configured location. At the end of each entry is a checksum that accounts for all the bytes from the start of the file through all the bytes associated with the entry. Each entry is 72 bytes, followed by a space and then the checksum value.

To keep the bindings when the switch reloads, you must use the DHCP snooping database agent. If the agent is disabled, dynamic ARP inspection or IP source guard is enabled, and the DHCP snooping binding database has dynamic bindings, the switch loses its connectivity. If the agent is disabled and only DHCP snooping is enabled, the switch does not lose its connectivity, but DHCP snooping might not prevent DHCP spoofing attacks.

When reloading, the switch reads the binding file to build the DHCP snooping binding database. The switch updates the file when the database changes.

When a switch learns of new bindings or when it loses bindings, the switch immediately updates the entries in the database. The switch also updates the entries in the binding file. The frequency at which the file is updated is based on a configurable delay, and the updates are batched. If the file is not updated in a specified time (set by the write-delay and cancel-timeout values), the update stops.

This is the format of the file with bindings:

```
<initial-checksum>
TYPE DHCP-SNOOPING
VERSION 1
BEGIN
<entry-1> <checksum-1>
<entry-2> <checksum-1-2>
...
...
<entry-n> <checksum-1-2-..-n>
END
```

Each entry in the file is tagged with a checksum value that the switch uses to verify the entries when it reads the file. The initial-checksum entry on the first line distinguishes entries associated with the latest file update from entries associated with a previous file update.

This is an example of a binding file:

```
2bb4c2a1
TYPE DHCP-SNOOPING
VERSION 1
BEGIN
192.1.168.1 3 0003.47d8.c91f 2BB6488E Gi1/0/4 21ae5fbb
192.1.168.3 3 0003.44d6.c52f 2BB648EB Gi1/0/4 1bdb223f
192.1.168.2 3 0003.47d9.c8f1 2BB648AB Gi1/0/4 584a38f0
END
```

When the switch starts and the calculated checksum value equals the stored checksum value, the switch reads entries from the binding file and adds the bindings to its DHCP snooping binding database. The switch ignores an entry when one of these situations occurs:

- The switch reads the entry and the calculated checksum value does not equal the stored checksum value. The entry and the ones following it are ignored.
- An entry has an expired lease time (the switch might not remove a binding entry when the lease time expires).
- The interface in the entry no longer exists on the system.
- The interface is a routed interface or a DHCP snooping-trusted interface.

How to Configure DHCP Features

Default DHCP Snooping Configuration

Table 88: Default DHCP Configuration

Feature	Default Setting
DHCP server	Enabled in Cisco IOS software, requires configuration[8]
DHCP relay agent	Enabled[9]
DHCP packet forwarding address	None configured
Checking the relay agent information	Enabled (invalid messages are dropped)
DHCP relay agent forwarding policy	Replace the existing relay agent information
DHCP snooping enabled globally	Disabled
DHCP snooping information option	Enabled
DHCP snooping option to accept packets on untrusted input interfaces[10]	Disabled
DHCP snooping limit rate	None configured
DHCP snooping trust	Untrusted
DHCP snooping VLAN	Disabled
DHCP snooping MAC address verification	Enabled
Cisco IOS DHCP server binding database	Enabled in Cisco IOS software, requires configuration. **Note** The switch gets network addresses and configuration parameters only from a device configured as a DHCP server.
DHCP snooping binding database agent	Enabled in Cisco IOS software, requires configuration. This feature is operational only when a destination is configured.

[8] The switch responds to DHCP requests only if it is configured as a DHCP server.

[9] The switch relays DHCP packets only if the IP address of the DHCP server is configured on the SVI of the DHCP client.

[10] Use this feature when the switch is an aggregation switch that receives packets with option-82 information from an edge switch.

DHCP Snooping Configuration Guidelines

- If a switch port is connected to a DHCP server, configure a port as trusted by entering the **ip dhcp snooping trust interface** configuration command.
- If a switch port is connected to a DHCP client, configure a port as untrusted by entering the **no ip dhcp snooping trust** interface configuration command.
- You can display DHCP snooping statistics by entering the **show ip dhcp snooping statistics** user EXEC command, and you can clear the snooping statistics counters by entering the **clear ip dhcp snooping statistics** privileged EXEC command.

Configuring the DHCP Server

The switch can act as a DHCP server.

For procedures to configure the switch as a DHCP server, see the "Configuring DHCP" section of the "IP addressing and Services" section of the *Cisco IOS IP Configuration Guide, Release 12.4*.

Configuring the DHCP Relay Agent

Follow these steps to enable the DHCP relay agent on the switch:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **service dhcp**
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**service dhcp** **Example:**	Enables the DHCP server and relay agent on your switch. By default, this feature is enabled.

	Command or Action	Purpose
	`Switch(config)# service dhcp`	

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

- Checking (validating) the relay agent information
- Configuring the relay agent forwarding policy

Specifying the Packet Forwarding Address

If the DHCP server and the DHCP clients are on different networks or subnets, you must configure the switch with the **ip helper-address** *address* interface configuration command. The general rule is to configure the command on the Layer 3 interface closest to the client. The address used in the **ip helper-address** command can be a specific DHCP server IP address, or it can be the network address if other DHCP servers are on the destination network segment. Using the network address enables any DHCP server to respond to requests.

Beginning in privileged EXEC mode, follow these steps to specify the packet forwarding address:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface vlan** *vlan-id*
4. **ip address** *ip-address subnet-mask*
5. **ip helper-address** *address*
6. **end**
7. Use one of the following:
    - **interface range** *port-range*
    - **interface** *interface-id*

8. **switchport mode access**
9. **switchport access vlan** *vlan-id*
10. **end**
11. **show running-config**
12. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface vlan** *vlan-id* **Example:** `Switch(config)# interface vlan 1`	Creates a switch virtual interface by entering a VLAN ID, and enter interface configuration mode.
Step 4	**ip address** *ip-address subnet-mask* **Example:** `Switch(config-if)# ip address 192.108.1.27 255.255.255.0`	Configures the interface with an IP address and an IP subnet.
Step 5	**ip helper-address** *address* **Example:** `Switch(config-if)# ip helper-address 172.16.1.2`	Specifies the DHCP packet forwarding address. The helper address can be a specific DHCP server address, or it can be the network address if other DHCP servers are on the destination network segment. Using the network address enables other servers to respond to DHCP requests. If you have multiple servers, you can configure one helper address for each server.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to global configuration mode.

Step 7	Use one of the following: • **interface range** *port-range* • **interface** *interface-id*	Configures multiple physical ports that are connected to the DHCP clients, and enter interface range configuration mode.

	Command or Action	Purpose
	Example: `Switch(config)# interface gigabitethernet0/2`	or Configures a single physical port that is connected to the DHCP client, and enter interface configuration mode.
Step 8	**switchport mode access** **Example:** `Switch(config-if)# switchport mode access`	Defines the VLAN membership mode for the port.
Step 9	**switchport access vlan** *vlan-id* **Example:** `Switch(config-if)# switchport access vlan 1`	Assigns the ports to the same VLAN as configured in Step 2.

Step 10	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 11	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 12	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Prerequisites for Configuring DHCP Snooping and Option 82

The prerequisites for DHCP Snooping and Option 82 are as follows:

- You must globally enable DHCP snooping on the switch.
- Before globally enabling DHCP snooping on the switch, make sure that the devices acting as the DHCP server and the DHCP relay agent are configured and enabled.
- If you want the switch to respond to DHCP requests, it must be configured as a DHCP server.
- Before configuring the DHCP snooping information option on your switch, be sure to configure the device that is acting as the DHCP server. You must specify the IP addresses that the DHCP server can assign or exclude, or you must configure DHCP options for these devices.
- For DHCP snooping to function properly, all DHCP servers must be connected to the switch through trusted interfaces. In a service-provider network, a trusted interface is connected to a port on a device in the same network.

- You must configure the switch to use the Cisco IOS DHCP server binding database to use it for DHCP snooping.
- To use the DHCP snooping option of accepting packets on untrusted inputs, the switch must be an aggregation switch that receives packets with option-82 information from an edge switch.
- The following prerequisites apply to DHCP snooping binding database configuration:
  - You must configure a destination on the DHCP snooping binding database to use the switch for DHCP snooping.
  - Because both NVRAM and the flash memory have limited storage capacity, we recommend that you store the binding file on a TFTP server.
  - For network-based URLs (such as TFTP and FTP), you must create an empty file at the configured URL before the switch can write bindings to the binding file at that URL. See the documentation for your TFTP server to determine whether you must first create an empty file on the server; some TFTP servers cannot be configured this way.
  - To ensure that the lease time in the database is accurate, we recommend that you enable and configure Network Time Protocol (NTP).
  - If NTP is configured, the switch writes binding changes to the binding file only when the switch system clock is synchronized with NTP.
- Before configuring the DHCP relay agent on your switch, make sure to configure the device that is acting as the DHCP server. You must specify the IP addresses that the DHCP server can assign or exclude, configure DHCP options for devices, or set up the DHCP database agent.
- If you want the switch to relay DHCP packets, the IP address of the DHCP server must be configured on the switch virtual interface (SVI) of the DHCP client.
- If a switch port is connected to a DHCP server, configure a port as trusted by entering the **ip dhcp snooping trust interface** configuration command.
- If a switch port is connected to a DHCP client, configure a port as untrusted by entering the **no ip dhcp snooping trust** interface configuration command.

Related Topics

DHCP Snooping, on page 780

Enabling DHCP Snooping and Option 82

Follow these steps to enable DHCP snooping on the switch:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip dhcp snooping**
4. **ip dhcp snooping vlan** *vlan-range*
5. **ip dhcp snooping information option**
6. **ip dhcp snooping information option format remote-id** [**string** *ASCII-string* | **hostname**]
7. **ip dhcp snooping information option allow-untrusted**

8. **interface** *interface-id*
9. **ip dhcp snooping vlan** *vlan* **information option format-type circuit-id** [**override**] **string** *ASCII-string*
10. **ip dhcp snooping trust**
11. **ip dhcp snooping limit rate** *rate*
12. **exit**
13. **ip dhcp snooping verify mac-address**
14. **end**
15. **show running-config**
16. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip dhcp snooping** **Example:** `Switch(config)# ip dhcp snooping`	Enables DHCP snooping globally.
Step 4	**ip dhcp snooping vlan** *vlan-range* **Example:** `Switch(config)# ip dhcp snooping vlan 10`	Enables DHCP snooping on a VLAN or range of VLANs. The range is 1 to 4094. You can enter a single VLAN ID identified by VLAN ID number, a series of VLAN IDs separated by commas, a range of VLAN IDs separated by hyphens, or a range of VLAN IDs separated by entering the starting and ending VLAN IDs separated by a space. • You can enter a single VLAN ID identified by VLAN ID number, a series of VLAN IDs separated by commas, a range of VLAN IDs separated by hyphens, or a range of VLAN IDs separated by entering the starting and ending VLAN IDs separated by a space.
Step 5	**ip dhcp snooping information option** **Example:** `Switch(config)# ip dhcp snooping information option`	Enables the switch to insert and remove DHCP relay information (option-82 field) in forwarded DHCP request messages to the DHCP server. This is the default setting.

	Command or Action	Purpose
Step 6	**ip dhcp snooping information option format remote-id** [**string** *ASCII-string* | **hostname**] **Example:** `Switch(config)# ip dhcp snooping information option format remote-id string acsiistring2`	(Optional) Configures the remote-ID suboption. You can configure the remote ID as: • String of up to 63 ASCII characters (no spaces) • Configured hostname for the switch **Note** If the hostname is longer than 63 characters, it is truncated to 63 characters in the remote-ID configuration. The default remote ID is the switch MAC address.
Step 7	**ip dhcp snooping information option allow-untrusted** **Example:** `Switch(config)# ip dhcp snooping information option allow-untrusted`	(Optional) If the switch is an aggregation switch connected to an edge switch, this command enables the switch to accept incoming DHCP snooping packets with option-82 information from the edge switch. The default setting is disabled. **Note** Enter this command only on aggregation switches that are connected to trusted devices.
Step 8	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the interface to be configured, and enter interface configuration mode.
Step 9	**ip dhcp snooping vlan** *vlan* **information option format-type circuit-id** [**override**] **string** *ASCII-string* **Example:** `Switch(config-if)# ip dhcp snooping vlan 1 information option format-type curcuit-id override string ovrride2`	(Optional) Configures the circuit-ID suboption for the specified interface. Specify the VLAN and port identifier, using a VLAN ID in the range of 1 to 4094. The default circuit ID is the port identifier, in the format **vlan-mod-port**. You can configure the circuit ID to be a string of 3 to 63 ASCII characters (no spaces). (Optional) Use the **override** keyword when you do not want the circuit-ID suboption inserted in TLV format to define subscriber information.
Step 10	**ip dhcp snooping trust** **Example:** `Switch(config-if)# ip dhcp snooping trust`	(Optional) Configures the interface as trusted or untrusted. Use the **no** keyword to configure an interface to receive messages from an untrusted client. The default setting is untrusted.
Step 11	**ip dhcp snooping limit rate** *rate* **Example:** `Switch(config-if)# ip dhcp snooping limit rate 100`	(Optional) Configures the number of DHCP packets per second that an interface can receive. The range is 1 to 2048. By default, no rate limit is configured.

	Command or Action	Purpose
		Note We recommend an untrusted rate limit of not more than 100 packets per second. If you configure rate limiting for trusted interfaces, you might need to increase the rate limit if the port is a trunk port assigned to more than one VLAN with DHCP snooping.
Step 12	**exit** **Example:** `Switch(config-if)# exit`	Returns to global configuration mode.
Step 13	**ip dhcp snooping verify mac-address** **Example:** `Switch(config)# ip dhcp snooping verify mac-address`	(Optional) Configures the switch to verify that the source MAC address in a DHCP packet received on untrusted ports matches the client hardware address in the packet. The default is to verify that the source MAC address matches the client hardware address in the packet.

Step 14	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 15	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 16	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Enabling the Cisco IOS DHCP Server Database

For procedures to enable and configure the Cisco IOS DHCP server database, see the “DHCP Configuration Task List” section in the “Configuring DHCP” chapter of the Cisco IOS IP Configuration Guide, Release 12.4

Monitoring DHCP Snooping Information

Table 89: Commands for Displaying DHCP Information

show ip dhcp snooping	Displays the DHCP snooping configuration for a switch
show ip dhcp snooping binding	Displays only the dynamically configured bindings in the DHCP snooping binding database, also referred to as a binding table.
show ip dhcp snooping database	Displays the DHCP snooping binding database status and statistics.
show ip dhcp snooping statistics	Displays the DHCP snooping statistics in summary or detail form.
show ip source binding	Display the dynamically and statically configured bindings.

Note If DHCP snooping is enabled and an interface changes to the down state, the switch does not delete the statically configured bindings.

Configuring DHCP Server Port-Based Address Allocation

DHCP Server Port-Based Address Allocation

DHCP server port-based address allocation is a feature that enables DHCP to maintain the same IP address on an Ethernet switch port regardless of the attached device client identifier or client hardware address.

When Ethernet switches are deployed in the network, they offer connectivity to the directly connected devices. In some environments, such as on a factory floor, if a device fails, the replacement device must be working immediately in the existing network. With the current DHCP implementation, there is no guarantee that DHCP would offer the same IP address to the replacement device. Control, monitoring, and other software expect a stable IP address associated with each device. If a device is replaced, the address assignment should remain stable even though the DHCP client has changed.

When configured, the DHCP server port-based address allocation feature ensures that the same IP address is always offered to the same connected port even as the client identifier or client hardware address changes in the DHCP messages received on that port. The DHCP protocol recognizes DHCP clients by the client identifier option in the DHCP packet. Clients that do not include the client identifier option are identified by the client hardware address. When you configure this feature, the port name of the interface overrides the client identifier or hardware address and the actual point of connection, the switch port, becomes the client identifier.

In all cases, by connecting the Ethernet cable to the same port, the same IP address is allocated through DHCP to the attached device.

The DHCP server port-based address allocation feature is only supported on a Cisco IOS DHCP server and not a third-party server.

Default Port-Based Address Allocation Configuration

By default, DHCP server port-based address allocation is disabled.

Port-Based Address Allocation Configuration Guidelines

- By default, DHCP server port-based address allocation is disabled.
- To restrict assignments from the DHCP pool to preconfigured reservations (unreserved addresses are not offered to the client and other clients are not served by the pool), you can enter the **reserved-only** DHCP pool configuration command.

Enabling the DHCP Snooping Binding Database Agent

Beginning in privileged EXEC mode, follow these steps to enable and configure the DHCP snooping binding database agent on the switch:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip dhcp snooping database** {**flash**[*number*]**:**/*filename* | **ftp://***user***:***password***@***host*/*filename* | **http://**[[*username***:***password*]**@**]{*hostname* | *host-ip*}[/*directory*] /*image-name***.tar** | **rcp://***user***@***host*/*filename*}| **tftp://***host*/*filename*
4. **ip dhcp snooping database timeout** *seconds*
5. **ip dhcp snooping database write-delay** *seconds*
6. **end**
7. **ip dhcp snooping binding** *mac-address* **vlan** *vlan-id* *ip-address* **interface** *interface-id* **expiry** *seconds*
8. **show ip dhcp snooping database** [**detail**]
9. **show running-config**
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 3	**ip dhcp snooping database** {**flash**[*number*]**:**/*filename* | **ftp:**//*user***:***password***@***host*/*filename* | **http:**//[[*username***:***password*]**@**]{*hostname* | *host-ip*}[/*directory*] /*image-name***.tar** | **rcp:**//*user***@***host*/*filename*}| **tftp:**//*host*/*filename* **Example:** `Switch(config)# ip dhcp snooping database tftp://10.90.90.90/snooping-rp2`	Specifies the URL for the database agent or the binding file by using one of these forms: • **flash**[*number*]**:**/*filename* • **ftp:**//*user***:***password***@***host*/*filename* • **http:**//[[*username***:***password*]**@**]{*hostname* | *host-ip*}[/*directory*] /*image-name***.tar** • **rcp:**//*user***@***host*/*filename* • **tftp:**//*host*/*filename*
Step 4	**ip dhcp snooping database timeout** *seconds* **Example:** `Switch(config)# ip dhcp snooping database timeout 300`	Specifies (in seconds) how long to wait for the database transfer process to finish before stopping the process. The default is 300 seconds. The range is 0 to 86400. Use 0 to define an infinite duration, which means to continue trying the transfer indefinitely.
Step 5	**ip dhcp snooping database write-delay** *seconds* **Example:** `Switch(config)# ip dhcp snooping database write-delay 15`	Specifies the duration for which the transfer should be delayed after the binding database changes. The range is from 15 to 86400 seconds. The default is 300 seconds (5 minutes).

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**ip dhcp snooping binding** *mac-address* **vlan** *vlan-id* *ip-address* **interface** *interface-id* **expiry** *seconds* **Example:** `Switch# ip dhcp snooping binding 0001.1234.1234 vlan 1 172.20.50.5 interface gi1/1 expiry 1000`	(Optional) Adds binding entries to the DHCP snooping binding database. The *vlan-id* range is from 1 to 4904. The *seconds* range is from 1 to 4294967295. Enter this command for each entry that you add. Use this command when you are testing or debugging the switch.
Step 8	**show ip dhcp snooping database** [**detail**] **Example:** `Switch# show ip dhcp snooping database detail`	Displays the status and statistics of the DHCP snooping binding database agent.
Step 9	**show running-config** **Example:**	Verifies your entries.

	Command or Action	Purpose
	`Switch# show running-config`	
Step 10	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Enabling DHCP Server Port-Based Address Allocation

Follow these steps to globally enable port-based address allocation and to automatically generate a subscriber identifier on an interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip dhcp use subscriber-id client-id**
4. **ip dhcp subscriber-id interface-name**
5. **interface** *interface-id*
6. **ip dhcp server use subscriber-id client-id**
7. **end**
8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip dhcp use subscriber-id client-id** **Example:** `Switch(config)# ip dhcp use subscriber-id client-id`	Configures the DHCP server to globally use the subscriber identifier as the client identifier on all incoming DHCP messages.

	Command or Action	Purpose
Step 4	**ip dhcp subscriber-id interface-name** **Example:** `Switch(config)# ip dhcp subscriber-id interface-name`	Automatically generates a subscriber identifier based on the short name of the interface. A subscriber identifier configured on a specific interface takes precedence over this command.
Step 5	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the interface to be configured, and enter interface configuration mode.
Step 6	**ip dhcp server use subscriber-id client-id** **Example:** `Switch(config-if)# ip dhcp server use subscriber-id client-id`	Configures the DHCP server to use the subscriber identifier as the client identifier on all incoming DHCP messages on the interface.

Step 7	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

After enabling DHCP port-based address allocation on the switch, use the **ip dhcp pool** global configuration command to preassign IP addresses and to associate them to clients.

Monitoring DHCP Server Port-Based Address Allocation

Table 90: Commands for Displaying DHCP Port-Based Address Allocation Information

Command	Purpose
show interface *interface id*	Displays the status and configuration of a specific interface.

Command	Purpose
show ip dhcp pool	Displays the DHCP address pools.
show ip dhcp binding	Displays address bindings on the Cisco IOS DHCP server.

Additional References

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for DHCP Snooping and Option 82

Release	Feature Information
Cisco IOS Release 15.2(5)E	This feature was introduced.
	Introduced support for the following commands: • **show ip dhcp snooping statistics** user EXEC command for displaying DHCP snooping statistics. • **clear ip dhcp snooping statistics** privileged EXEC command for clearing the snooping statistics counters.

CHAPTER 45

Configuring IP Source Guard

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About IP Source Guard

IP Source Guard

You can use IP source guard to prevent traffic attacks if a host tries to use the IP address of its neighbor and you can enable IP source guard when DHCP snooping is enabled on an untrusted interface.

After IPSG is enabled on an interface, the switch blocks all IP traffic received on the interface except for DHCP packets allowed by DHCP snooping.

The switch uses a source IP lookup table in hardware to bind IP addresses to ports. For IP and MAC filtering, a combination of source IP and source MAC lookups are used. IP traffic with a source IP address in the binding table is allowed, all other traffic is denied.

The IP source binding table has bindings that are learned by DHCP snooping or are manually configured (static IP source bindings). An entry in this table has an IP address, its associated MAC address, and its associated VLAN number. The switch uses the IP source binding table only when IP source guard is enabled.

IPSG is supported only on Layer 2 ports, including access and trunk ports. You can configure IPSG with source IP address filtering or with source IP and MAC address filtering.

IP Source Guard for Static Hosts

Note Do not use IPSG (IP source guard) for static hosts on uplink ports or trunk ports.

IPSG for static hosts extends the IPSG capability to non-DHCP and static environments. The previous IPSG used the entries created by DHCP snooping to validate the hosts connected to a switch. Any traffic received from a host without a valid DHCP binding entry is dropped. This security feature restricts IP traffic on nonrouted Layer 2 interfaces. It filters traffic based on the DHCP snooping binding database and on manually configured IP source bindings. The previous version of IPSG required a DHCP environment for IPSG to work.

IPSG for static hosts allows IPSG to work without DHCP. IPSG for static hosts relies on IP device tracking-table entries to install port ACLs. The switch creates static entries based on ARP requests or other IP packets to maintain the list of valid hosts for a given port. You can also specify the number of hosts allowed to send traffic to a given port. This is equivalent to port security at Layer 3.

IPSG for static hosts also supports dynamic hosts. If a dynamic host receives a DHCP-assigned IP address that is available in the IP DHCP snooping table, the same entry is learned by the IP device tracking table. When you enter the EXEC command, the IP device tracking table displays the entries as ACTIVE.

Note Some IP hosts with multiple network interfaces can inject some invalid packets into a network interface. The invalid packets contain the IP or MAC address for another network interface of the host as the source address. The invalid packets can cause IPSG for static hosts to connect to the host, to learn the invalid IP or MAC address bindings, and to reject the valid bindings. Consult the vendor of the corresponding operating system and the network interface to prevent the host from injecting invalid packets.

IPSG for static hosts initially learns IP or MAC bindings dynamically through an ACL-based snooping mechanism. IP or MAC bindings are learned from static hosts by ARP and IP packets. They are stored in the device tracking database. When the number of IP addresses that have been dynamically learned or statically configured on a given port reaches a maximum, the hardware drops any packet with a new IP address. To resolve hosts that have moved or gone away for any reason, IPSG for static hosts leverages IP device tracking to age out dynamically learned IP address bindings. This feature can be used with DHCP snooping. Multiple bindings are established on a port that is connected to both DHCP and static hosts. For example, bindings are stored in both the device tracking database as well as in the DHCP snooping binding database.

IP Source Guard Configuration Guidelines

- You can configure static IP bindings only on nonrouted ports. If you enter the **ip source binding** *mac-address* **vlan** *vlan-id ip-address* **interface** *interface-id* global configuration command on a routed interface, this error message appears:

```
Static IP source binding can only be configured on switch port.
```

- When IP source guard with source IP filtering is enabled on an interface, DHCP snooping must be enabled on the access VLAN for that interface.
- If you are enabling IP source guard on a trunk interface with multiple VLANs and DHCP snooping is enabled on all the VLANs, the source IP address filter is applied on all the VLANs.

Note If IP source guard is enabled and you enable or disable DHCP snooping on a VLAN on the trunk interface, the switch might not properly filter traffic.

- You can enable this feature when 802.1x port-based authentication is enabled.

How to Configure IP Source Guard

Enabling IP Source Guard

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **ip verify source** [**port-security**]
5. **exit**
6. **ip source binding** *mac-address* **vlan** *vlan-id ip-address* **interface** *interface-id*
7. **end**
8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:**	Specifies the interface to be configured, and enters interface configuration mode.

	Command or Action	Purpose
	`Switch(config)# interface gigabitethernet 1/0/1`	
Step 4	**ip verify source** [**port-security**] **Example:** `Switch(config-if)# ip verify source`	Enables IP source guard with source IP address filtering. (Optional) **port-security**—Enables IP Source Guard with source IP address and MAC address filtering.
Step 5	**exit** **Example:** `Switch(config-if)# exit`	Returns to global configuration mode.
Step 6	**ip source binding** *mac-address* **vlan** *vlan-id ip-address* **interface** *interface-id* **Example:** `Switch(config)# ip source binding 0100.0230.0002 vlan 11 10.0.0.4 interface gigabitethernet1/0/1`	Adds a static IP source binding. Enter this command for each static binding.

Step 7	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring IP Source Guard for Static Hosts on a Layer 2 Access Port

You must configure the **ip device tracking maximum** *limit-number* interface configuration command globally for IPSG for static hosts to work. If you only configure this command on a port without enabling IP device tracking globally or by setting an IP device tracking maximum on that interface, IPSG with static hosts rejects all the IP traffic from that interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip device tracking**
4. **interface** *interface-id*
5. **switchport mode access**
6. **switchport access vlan** *vlan-id*
7. **ip verify source**[**tracking**] [**port-security**]
8. **ip device tracking maximum** *number*
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip device tracking** **Example:** `Switch(config)# ip device tracking`	Turns on the IP host table, and globally enables IP device tracking.
Step 4	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 1/0/1`	Enters interface configuration mode.
Step 5	**switchport mode access** **Example:** `Switch(config-if)# switchport mode access`	Configures a port as access.
Step 6	**switchport access vlan** *vlan-id* **Example:**	Configures the VLAN for this port.

	Command or Action	Purpose
	`Switch(config-if)# switchport access vlan 10`	
Step 7	**ip verify source**[**tracking**] [**port-security**] **Example:** `Switch(config-if)# ip verify source tracking port-security`	Enables IP source guard with source IP address filtering. (Optional) **tracking**—Enables IP source guard for static hosts. (Optional) **port-security**—Enables MAC address filtering. The command **ip verify source tracking port-security**enables IP source guard for static hosts with MAC address filtering.
Step 8	**ip device tracking maximum** *number* **Example:** `Switch(config-if)# ip device tracking maximum 8`	Establishes a maximum limit for the number of static IPs that the IP device tracking table allows on the port. The range is 1to 10. The maximum number is 10. **Note** You must configure the **ip device tracking maximum** *limit-number* interface configuration command.

Step 9	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Monitoring IP Source Guard

Table 91: Privileged EXEC show Commands

Command	Purpose
show ip verify source [**interface** *interface-id*]	Displays the IP source guard configuration on the switch or on a specific interface.
show ip device tracking { **all** | **interface** *interface-id* | **ip** *ip-address* | **mac** *mac-address*}	Displays information about the entries in the IP device tracking table.

Table 92: Interface Configuration Commands

Command	Purpose
ip verify source tracking	Verifies the data source.

For detailed information about the fields in these displays, see the command reference for this release.

Additional References

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

CHAPTER 46

Configuring IEEE 802.1x Port-Based Authentication

This chapter describes how to configure IEEE 802.1x port-based authentication. IEEE 802.1x authentication prevents unauthorized devices (clients) from gaining access to the network. Unless otherwise noted, the term *switch* refers to a standalone switch.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About 802.1x Port-Based Authentication

The 802.1x standard defines a client-server-based access control and authentication protocol that prevents unauthorized clients from connecting to a LAN through publicly accessible ports unless they are properly authenticated. The authentication server authenticates each client connected to a switch port before making available any services offered by the switch or the LAN.

Note TACACS is not supported with 802.1x authentication.

Until the client is authenticated, 802.1x access control allows only Extensible Authentication Protocol over LAN (EAPOL), Cisco Discovery Protocol (CDP), and Spanning Tree Protocol (STP) traffic through the port to which the client is connected. After authentication is successful, normal traffic can pass through the port.

Client session	Maximum sessions supported
Maximum dot1x or MAB client sessions	2000
Maximum web-based authentication sessions	2000
Maximum dot1x sessions with critical-auth VLAN enabled and server re-initialized	2000
Maximum MAB sessions with various session features applied	2000
Maximum dot1x sessions with service templates or session features applied	2000

Port-Based Authentication Process

To configure IEEE 802.1X port-based authentication, you must enable authentication, authorization, and accounting (AAA) and specify the authentication method list. A method list describes the sequence and authentication method to be queried to authenticate a user.

The AAA process begins with authentication. When 802.1x port-based authentication is enabled and the client supports 802.1x-compliant client software, these events occur:

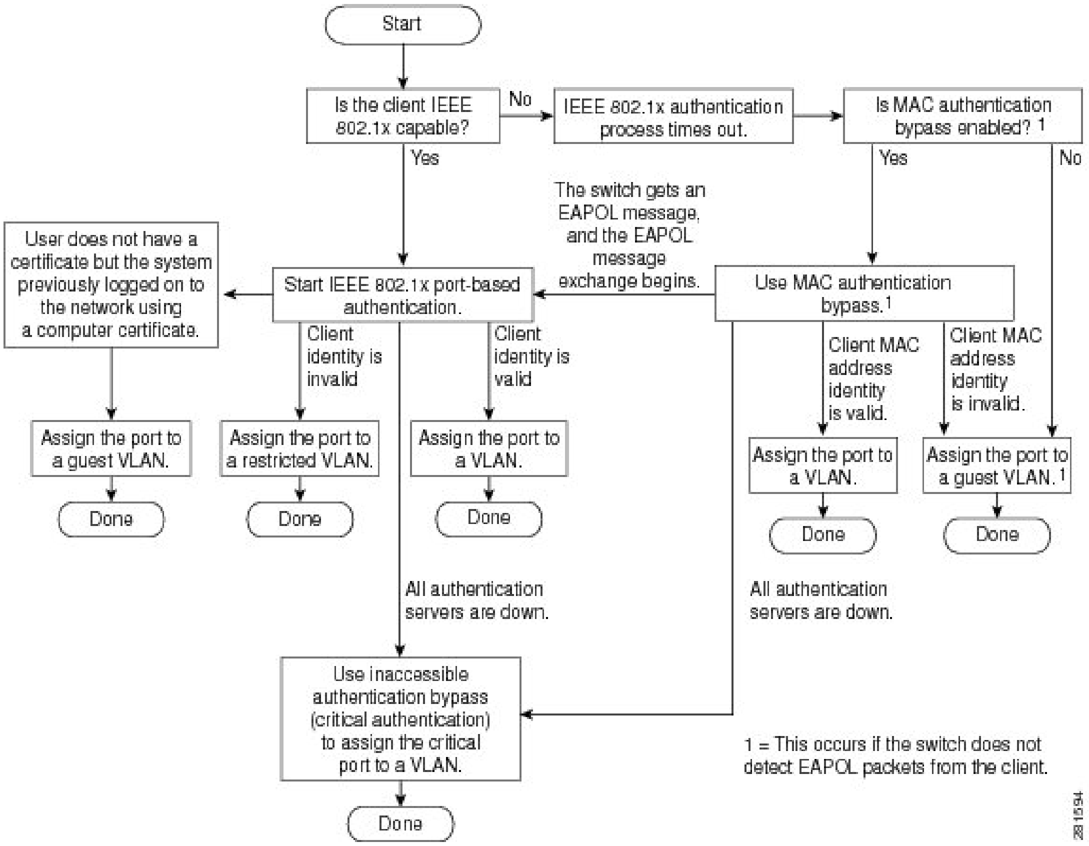
- If the client identity is valid and the 802.1x authentication succeeds, the switch grants the client access to the network.
- If 802.1x authentication times out while waiting for an EAPOL message exchange and MAC authentication bypass is enabled, the switch can use the client MAC address for authorization. If the client MAC address is valid and the authorization succeeds, the switch grants the client access to the network. If the client MAC address is invalid and the authorization fails, the switch assigns the client to a guest VLAN that provides limited services if a guest VLAN is configured.
- If the switch gets an invalid identity from an 802.1x-capable client and a restricted VLAN is specified, the switch can assign the client to a restricted VLAN that provides limited services.
- If the RADIUS authentication server is unavailable (down) and inaccessible authentication bypass is enabled, the switch grants the client access to the network by putting the port in the critical-authentication state in the RADIUS-configured or the user-specified access VLAN.

Note Inaccessible authentication bypass is also referred to as critical authentication or the AAA fail policy.

If Multi Domain Authentication (MDA) is enabled on a port, this flow can be used with some exceptions that are applicable to voice authorization.

Figure 61: Authentication Flowchart

This figure shows the authentication process.


Start
Is the client IEEE 802.1x capable?
No
IEEE 802.1x authentication process times out.
Is MAC authentication bypass enabled? 1
Yes
No
Yes
The switch gets an EAPOL message, and the EAPOL message exchange begins.
User does not have a certificate but the system previously logged on to the network using a computer certificate.
Start IEEE 802.1x port-based authentication.
Use MAC authentication bypass.1
Client identity is invalid
Client identity is valid
Client MAC address identity is valid.
Client MAC address identity is invalid.
Assign the port to a guest VLAN.
Assign the port to a restricted VLAN.
Assign the port to a VLAN.
Assign the port to a VLAN.
Assign the port to a guest VLAN. 1
Done
Done
Done
Done
Done
All authentication servers are down.
All authentication servers are down.
Use inaccessible authentication bypass (critical authentication) to assign the critical port to a VLAN.
Done
1 = This occurs if the switch does not detect EAPOL packets from the client.
281594

The switch re-authenticates a client when one of these situations occurs:

- Periodic re-authentication is enabled, and the re-authentication timer expires.

  You can configure the re-authentication timer to use a switch-specific value or to be based on values from the RADIUS server.

  After 802.1x authentication using a RADIUS server is configured, the switch uses timers based on the Session-Timeout RADIUS attribute (Attribute[27]) and the Termination-Action RADIUS attribute (Attribute [29]).

  The Session-Timeout RADIUS attribute (Attribute[27]) specifies the time after which re-authentication occurs.

  The Termination-Action RADIUS attribute (Attribute [29]) specifies the action to take during re-authentication. The actions are *Initialize* and *ReAuthenticate*. When the *Initialize* action is set (the attribute value is *DEFAULT*), the 802.1x session ends, and connectivity is lost during re-authentication. When the *ReAuthenticate* action is set (the attribute value is RADIUS-Request), the session is not affected during re-authentication.

- You manually re-authenticate the client by entering the **dot1x re-authenticate interface** *interface-id* privileged EXEC command.

Port-Based Authentication Initiation and Message Exchange

During 802.1x authentication, the switch or the client can initiate authentication. If you enable authentication on a port by using the **authentication port-control auto** interface configuration command, the switch initiates authentication when the link state changes from down to up or periodically as long as the port remains up and unauthenticated. The switch sends an EAP-request/identity frame to the client to request its identity. Upon receipt of the frame, the client responds with an EAP-response/identity frame.

However, if during bootup, the client does not receive an EAP-request/identity frame from the switch, the client can initiate authentication by sending an EAPOL-start frame, which prompts the switch to request the client's identity.

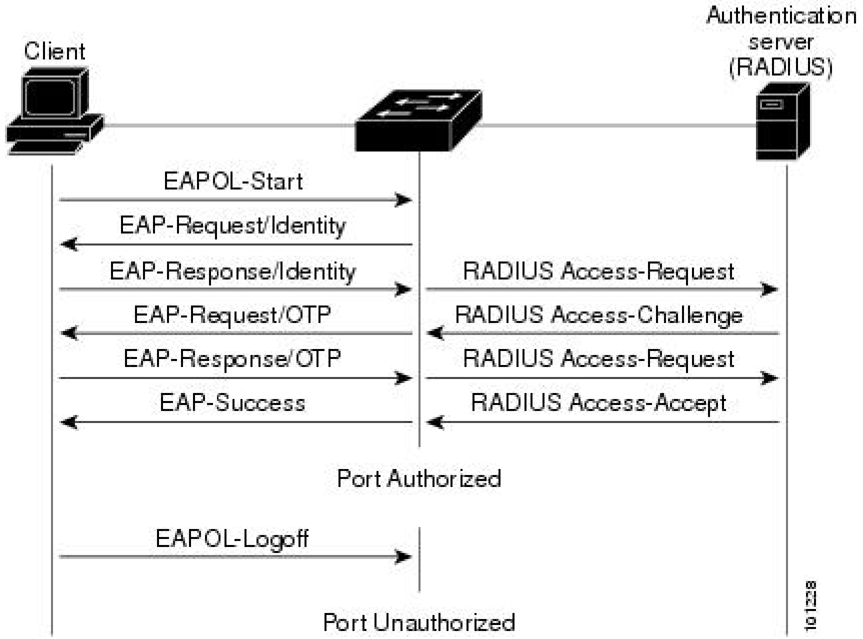
Note If 802.1x authentication is not enabled or supported on the network access device, any EAPOL frames from the client are dropped. If the client does not receive an EAP-request/identity frame after three attempts to start authentication, the client sends frames as if the port is in the authorized state. A port in the authorized state effectively means that the client has been successfully authenticated.

When the client supplies its identity, the switch begins its role as the intermediary, passing EAP frames between the client and the authentication server until authentication succeeds or fails. If the authentication succeeds, the switch port becomes authorized. If the authentication fails, authentication can be retried, the port might be assigned to a VLAN that provides limited services, or network access is not granted.

The specific exchange of EAP frames depends on the authentication method being used.

Figure 62: Message Exchange

This figure shows a message exchange initiated by the client when the client uses the One-Time-Password (OTP) authentication method with a RADIUS server.

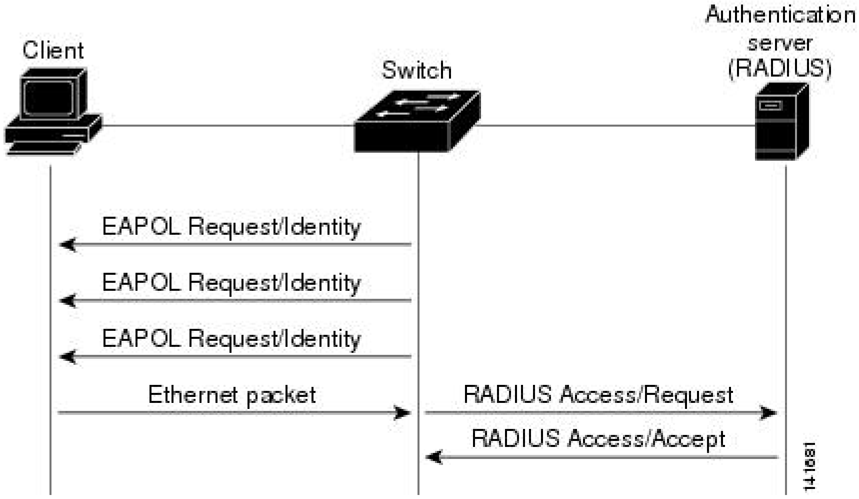


If 802.1x authentication times out while waiting for an EAPOL message exchange and MAC authentication bypass is enabled, the switch can authorize the client when the switch detects an Ethernet packet from the

client. The switch uses the MAC address of the client as its identity and includes this information in the RADIUS-access/request frame that is sent to the RADIUS server. After the server sends the switch the RADIUS-access/accept frame (authorization is successful), the port becomes authorized. If authorization fails and a guest VLAN is specified, the switch assigns the port to the guest VLAN. If the switch detects an EAPOL packet while waiting for an Ethernet packet, the switch stops the MAC authentication bypass process and starts 802.1x authentication.

Figure 63: Message Exchange During MAC Authentication Bypass

This figure shows the message exchange during MAC authentication bypass.



Authentication Manager for Port-Based Authentication

Port-Based Authentication Methods

Table 93: 802.1x Features

Authentication method	Mode			
	Single host	Multiple host	MDA	Multiple Authentication
802.1x	VLAN assignment Per-user ACL Filter-ID attribute Downloadable ACL Redirect URL	VLAN assignment	VLAN assignment Per-user ACL Filter-Id attribute Downloadable ACL Redirect URL	VLAN assignment Per-user ACL Filter-Id attribute Downloadable ACL Redirect URL

Authentication method	Mode			
	Single host	**Multiple host**	**MDA**	**Multiple Authentication**
MAC authentication bypass	VLAN assignment Per-user ACL Filter-ID attribute Downloadable ACL Redirect URL	VLAN assignment	VLAN assignment Per-user ACL Filter-Id attribute Downloadable ACL Redirect URL	VLAN assignment Per-user ACL Filter-Id attribute Downloadable ACL Redirect URL
Standalone web authentication	Proxy ACL, Filter-Id attribute, downloadable ACL			
NAC Layer 2 IP validation	Filter-Id attribute Downloadable ACL Redirect URL	Filter-Id attribute Downloadable ACL Redirect URL	Filter-Id attribute Downloadable ACL Redirect URL	Filter-Id attribute Downloadable ACL Redirect URL
Web authentication as fallback method	Proxy ACL Filter-Id attribute Downloadable ACL	Proxy ACL Filter-Id attribute Downloadable ACL	Proxy ACL Filter-Id attribute Downloadable ACL	Proxy ACL Filter-Id attribute Downloadable ACL

[11] Supported in Cisco IOS Release 12.2(50)SE and later.
[12] For clients that do not support 802.1x authentication.

Per-User ACLs and Filter-Ids

Note You can only set **any** as the source in the ACL.

Note For any ACL configured for multiple-host mode, the source portion of statement must be *any*. (For example, **permit icmp** *any* **host 10.10.1.1**.)

You must specify **any** in the source ports of any defined ACL. Otherwise, the ACL cannot be applied and authorization fails. Single host is the only exception to support backward compatibility.

More than one host can be authenticated on MDA-enabled and multiauth ports. The ACL policy applied for one host does not effect the traffic of another host. If only one host is authenticated on a multi-host port, and the other hosts gain network access without authentication, the ACL policy for the first host can be applied to the other connected hosts by specifying any in the source address.

Port-Based Authentication Manager CLI Commands

The authentication-manager interface-configuration commands control all the authentication methods, such as 802.1x, MAC authentication bypass, and web authentication. The authentication manager commands determine the priority and order of authentication methods applied to a connected host.

The authentication manager commands control generic authentication features, such as host-mode, violation mode, and the authentication timer. Generic authentication commands include the **authentication host-mode**, **authentication violation**, and **authentication timer** interface configuration commands.

802.1x-specific commands begin with the **dot1x** keyword. For example, the **authentication port-control auto** interface configuration command enables authentication on an interface.

To disable dot1x on a switch, remove the configuration globally by using the no dot1x system-auth-control , and also remove it from all configured interfaces.

Note If 802.1x authentication is globally disabled, other authentication methods are still enabled on that port, such as web authentication.

The **authentication manager** commands provide the same functionality as earlier 802.1x commands.

When filtering out verbose system messages generated by the authentication manager, the filtered content typically relates to authentication success. You can also filter verbose messages for 802.1x authentication and MAB authentication. There is a separate command for each authentication method:

- The **no authentication logging verbose** global configuration command filters verbose messages from the authentication manager.
- The **no dot1x logging verbose** global configuration command filters 802.1x authentication verbose messages.
- The **no mab logging verbose** global configuration command filters MAC authentication bypass (MAB) verbose messages

Table 94: Authentication Manager Commands and Earlier 802.1x Commands

The authentication manager commands in Cisco IOS Release 12.2(50)SE or later	The equivalent 802.1x commands in Cisco IOS Release 12.2(46)SE and earlier	Description
authentication control-direction {**both** | **in**}	**dot1x control-direction** {**both** | **in**}	Enable 802.1x authentication with the wake-on-LAN (WoL) feature, and configure the port control as unidirectional or bidirectional.
authentication event	**dot1x auth-fail vlan** **dot1x critical (interface configuration)** **dot1x guest-vlan6**	Enable the restricted VLAN on a port. Enable the inaccessible-authentication-bypass feature. Specify an active VLAN as an 802.1x guest VLAN.

The authentication manager commands in Cisco IOS Release 12.2(50)SE or later	The equivalent 802.1x commands in Cisco IOS Release 12.2(46)SE and earlier	Description
authentication fallback *fallback-profile*	**dot1x fallback** *fallback-profile*	Configure a port to use web authentication as a fallback method for clients that do not support 802.1x authentication.
authentication host-mode [**multi-auth** | **multi-domain** | **multi-host** | **single-host**]	**dot1x host-mode** {**single-host** | **multi-host** | **multi-domain**}	Allow a single host (client) or multiple hosts on an 802.1x-authorized port.
authentication order	**mab**	Provides the flexibility to define the order of authentication methods to be used.
authentication periodic	**dot1x reauthentication**	Enable periodic re-authentication of the client.
authentication port-control {**auto** | **force-authorized** | **force-un authorized**}	**dot1x port-control** {**auto** | **force-authorized** | **force-unauthorized**}	Enable manual control of the authorization state of the port.
authentication timer	**dot1x timeout**	Set the 802.1x timers.
authentication violation {**protect** | **restrict** | **shutdown**}	**dot1x violation-mode** {**shutdown** | **restrict** | **protect**}	Configure the violation modes that occur when a new device connects to a port or when a new device connects to a port after the maximum number of devices are connected to that port.

Ports in Authorized and Unauthorized States

During 802.1x authentication, depending on the switch port state, the switch can grant a client access to the network. The port starts in the *unauthorized* state. While in this state, the port that is not configured as a voice VLAN port disallows all ingress and egress traffic except for 802.1x authentication, CDP, and STP packets. When a client is successfully authenticated, the port changes to the *authorized* state, allowing all traffic for the client to flow normally. If the port is configured as a voice VLAN port, the port allows VoIP traffic and 802.1x protocol packets before the client is successfully authenticated.

Note CDP bypass is not supported and may cause a port to go into err-disabled state.

If a client that does not support 802.1x authentication connects to an unauthorized 802.1x port, the switch requests the client's identity. In this situation, the client does not respond to the request, the port remains in the unauthorized state, and the client is not granted access to the network.

In contrast, when an 802.1x-enabled client connects to a port that is not running the 802.1x standard, the client initiates the authentication process by sending the EAPOL-start frame. When no response is received, the client sends the request for a fixed number of times. Because no response is received, the client begins sending frames as if the port is in the authorized state.

You control the port authorization state by using the **authentication port-control** interface configuration command and these keywords:

- **force-authorized**—disables 802.1x authentication and causes the port to change to the authorized state without any authentication exchange required. The port sends and receives normal traffic without 802.1x-based authentication of the client. This is the default setting.
- **force-unauthorized**—causes the port to remain in the unauthorized state, ignoring all attempts by the client to authenticate. The switch cannot provide authentication services to the client through the port.
- **auto**—enables 802.1x authentication and causes the port to begin in the unauthorized state, allowing only EAPOL frames to be sent and received through the port. The authentication process begins when the link state of the port changes from down to up or when an EAPOL-start frame is received. The switch requests the identity of the client and begins relaying authentication messages between the client and the authentication server. Each client attempting to access the network is uniquely identified by the switch by using the client MAC address.

If the client is successfully authenticated (receives an Accept frame from the authentication server), the port state changes to authorized, and all frames from the authenticated client are allowed through the port. If the authentication fails, the port remains in the unauthorized state, but authentication can be retried. If the authentication server cannot be reached, the switch can resend the request. If no response is received from the server after the specified number of attempts, authentication fails, and network access is not granted.

When a client logs off, it sends an EAPOL-logoff message, causing the switch port to change to the unauthorized state.

If the link state of a port changes from up to down, or if an EAPOL-logoff frame is received, the port returns to the unauthorized state.

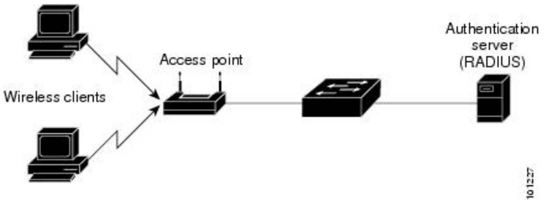
802.1x Host Mode

You can configure an 802.1x port for single-host or for multiple-hosts mode. In single-host mode, only one client can be connected to the 802.1x-enabled switch port. The switch detects the client by sending an EAPOL frame when the port link state changes to the up state. If a client leaves or is replaced with another client, the switch changes the port link state to down, and the port returns to the unauthorized state.

In multiple-hosts mode, you can attach multiple hosts to a single 802.1x-enabled port. In this mode, only one of the attached clients must be authorized for all clients to be granted network access. If the port becomes unauthorized (re-authentication fails or an EAPOL-logoff message is received), the switch denies network access to all of the attached clients.

In this topology, the wireless access point is responsible for authenticating the clients attached to it, and it also acts as a client to the switch.

Figure 64: Multiple Host Mode Example



Note For all host modes, the line protocol stays up before authorization when port-based authentication is configured.

The switch supports multidomain authentication (MDA), which allows both a data device and a voice device, such as an IP Phone (Cisco or non-Cisco), to connect to the same switch port.

802.1x Multiple Authentication Mode

Multiple-authentication (multiauth) mode allows multiple authenticated clients on the data VLAN and voice VLAN. Each host is individually authenticated. There is no limit to the number of data or voice device that can be authenticated on a multiauthport.

If a hub or access point is connected to an 802.1x-enabled port, each connected client must be authenticated. For non-802.1x devices, you can use MAC authentication bypass or web authentication as the per-host authentication fallback method to authenticate different hosts with different methods on a single port.

Note When a port is in multiple-authentication mode, the authentication-failed VLAN features do not activate.

You can assign a RADIUS-server-supplied VLAN in multi-auth mode, under the following conditions:

- The host is the first host authorized on the port, and the RADIUS server supplies VLAN information
- Subsequent hosts are authorized with a VLAN that matches the operational VLAN.
- A host is authorized on the port with no VLAN assignment, and subsequent hosts either have no VLAN assignment, or their VLAN information matches the operational VLAN.
- The first host authorized on the port has a group VLAN assignment, and subsequent hosts either have no VLAN assignment, or their group VLAN matches the group VLAN on the port. Subsequent hosts must use the same VLAN from the VLAN group as the first host. If a VLAN list is used, all hosts are subject to the conditions specified in the VLAN list.
- After a VLAN is assigned to a host on the port, subsequent hosts must have matching VLAN information or be denied access to the port.
- You cannot configure a guest VLAN or an auth-fail VLAN in multi-auth mode.
- The behavior of the critical-auth VLAN is not changed for multi-auth mode. When a host tries to authenticate and the server is not reachable, all authorized hosts are reinitialized in the configured VLAN.

MAC Move

When a MAC address is authenticated on one switch port, that address is not allowed on another authentication manager-enabled port of the switch. If the switch detects that same MAC address on another authentication manager-enabled port, the address is not allowed.

There are situations where a MAC address might need to move from one port to another on the same switch. For example, when there is another device (for example a hub or an IP phone) between an authenticated host and a switch port, you might want to disconnect the host from the device and connect it directly to another port on the same switch.

You can globally enable MAC move so the device is reauthenticated on the new port. When a host moves to a second port, the session on the first port is deleted, and the host is reauthenticated on the new port. MAC move is supported on all host modes. (The authenticated host can move to any port on the switch, no matter which host mode is enabled on the that port.) When a MAC address moves from one port to another, the switch terminates the authenticated session on the original port and initiates a new authentication sequence on the new port. The MAC move feature applies to both voice and data hosts.

Note In open authentication mode, a MAC address is immediately moved from the original port to the new port, with no requirement for authorization on the new port.

MAC Replace

The MAC replace feature can be configured to address the violation that occurs when a host attempts to connect to a port where another host was previously authenticated.

Note This feature does not apply to ports in multi-auth mode, because violations are not triggered in that mode. It does not apply to ports in multiple host mode, because in that mode, only the first host requires authentication.

If you configure the **authentication violation** interface configuration command with the **replace** keyword, the authentication process on a port in multi-domain mode is:

- A new MAC address is received on a port with an existing authenticated MAC address.
- The authentication manager replaces the MAC address of the current data host on the port with the new MAC address.
- The authentication manager initiates the authentication process for the new MAC address.
- If the authentication manager determines that the new host is a voice host, the original voice host is removed.

If a port is in open authentication mode, any new MAC address is immediately added to the MAC address table.

802.1x Accounting

The 802.1x standard defines how users are authorized and authenticated for network access but does not keep track of network usage. 802.1x accounting is disabled by default. You can enable 802.1x accounting to monitor this activity on 802.1x-enabled ports:

- User successfully authenticates.
- User logs off.
- Link-down occurs.
- Re-authentication successfully occurs.
- Re-authentication fails.

The switch does not log 802.1x accounting information. Instead, it sends this information to the RADIUS server, which must be configured to log accounting messages.

802.1x Accounting Attribute-Value Pairs

The information sent to the RADIUS server is represented in the form of Attribute-Value (AV) pairs. These AV pairs provide data for different applications. (For example, a billing application might require information that is in the Acct-Input-Octets or the Acct-Output-Octets attributes of a RADIUS packet.)

AV pairs are automatically sent by a switch that is configured for 802.1x accounting. Three types of RADIUS accounting packets are sent by a switch:

- START–sent when a new user session starts
- INTERIM–sent during an existing session for updates
- STOP–sent when a session terminates

You can view the AV pairs that are being sent by the switch by entering the **debug radius accounting** privileged EXEC command. For more information about this command, see the *Cisco IOS Debug Command Reference, Release 12.4.*

This table lists the AV pairs and when they are sent are sent by the switch.

Table 95: Accounting AV Pairs

Attribute Number	AV Pair Name	START	INTERIM	STOP
Attribute[1]	User-Name	Always	Always	Always
Attribute[4]	NAS-IP-Address	Always	Always	Always
Attribute[5]	NAS-Port	Always	Always	Always
Attribute[8]	Framed-IP-Address	Never	Sometimes[13]	Sometimes
Attribute[25]	Class	Always	Always	Always
Attribute[30]	Called-Station-ID	Always	Always	Always
Attribute[31]	Calling-Station-ID	Always	Always	Always
Attribute[40]	Acct-Status-Type	Always	Always	Always
Attribute[41]	Acct-Delay-Time	Always	Always	Always
Attribute[42]	Acct-Input-Octets	Never	Always	Always
Attribute[43]	Acct-Output-Octets	Never	Always	Always
Attribute[47]	Acct-Input-Packets	Never	Always	Always
Attribute[48]	Acct-Output-Packets	Never	Always	Always
Attribute[44]	Acct-Session-ID	Always	Always	Always

Attribute Number	AV Pair Name	START	INTERIM	STOP
Attribute[45]	Acct-Authentic	Always	Always	Always
Attribute[46]	Acct-Session-Time	Never	Always	Always
Attribute[49]	Acct-Terminate-Cause	Never	Never	Always
Attribute[61]	NAS-Port-Type	Always	Always	Always

[13] The Framed-IP-Address AV pair is sent when a valid static IP address is configured or w when a Dynamic Host Control Protocol (DHCP) binding exists for the host in the DHCP snooping bindings table.

Switch-to-RADIUS-Server Communication

RADIUS security servers are identified by their hostname or IP address, hostname and specific UDP port numbers, or IP address and specific UDP port numbers. The combination of the IP address and UDP port number creates a unique identifier, which enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, authentication—the second host entry configured acts as the fail-over backup to the first one. The RADIUS host entries are tried in the order that they were configured.

802.1x Authentication with VLAN Assignment

The switch supports 802.1x authentication with VLAN assignment. After successful 802.1x authentication of a port, the RADIUS server sends the VLAN assignment to configure the switch port. The RADIUS server database maintains the username-to-VLAN mappings, assigning the VLAN based on the username of the client connected to the switch port. You can use this feature to limit network access for certain users.

Voice device authentication is supported with multidomain host mode in Cisco IOS Release 12.2(37)SE. In Cisco IOS Release 12.2(40)SE and later, when a voice device is authorized and the RADIUS server returned an authorized VLAN, the voice VLAN on the port is configured to send and receive packets on the assigned voice VLAN. Voice VLAN assignment behaves the same as data VLAN assignment on multidomain authentication (MDA)-enabled ports.

When configured on the switch and the RADIUS server, 802.1x authentication with VLAN assignment has these characteristics:

- If no VLAN is supplied by the RADIUS server or if 802.1x authentication is disabled, the port is configured in its access VLAN after successful authentication. Recall that an access VLAN is a VLAN assigned to an access port. All packets sent from or received on this port belong to this VLAN.
- If 802.1x authentication is enabled but the VLAN information from the RADIUS server is not valid, authorization fails and configured VLAN remains in use. This prevents ports from appearing unexpectedly in an inappropriate VLAN because of a configuration error.

  Configuration errors could include specifying a VLAN for a routed port, a malformed VLAN ID, a nonexistent or internal (routed port) VLAN ID, an RSPAN VLAN, a shut down or suspended VLAN. In the case of a multidomain host port, configuration errors can also be due to an attempted assignment of a data VLAN that matches the configured or assigned voice VLAN ID (or the reverse).
- If 802.1x authentication is enabled and all information from the RADIUS server is valid, the authorized device is placed in the specified VLAN after authentication.

- If the multiple-hosts mode is enabled on an 802.1x port, all hosts are placed in the same VLAN (specified by the RADIUS server) as the first authenticated host.
- Enabling port security does not impact the RADIUS server-assigned VLAN behavior.
- If 802.1x authentication is disabled on the port, it is returned to the configured access VLAN and configured voice VLAN.
- If an 802.1x port is authenticated and put in the RADIUS server-assigned VLAN, any change to the port access VLAN configuration does not take effect. In the case of a multidomain host, the same applies to voice devices when the port is fully authorized with these exceptions:
    - If the VLAN configuration change of one device results in matching the other device configured or assigned VLAN, then authorization of all devices on the port is terminated and multidomain host mode is disabled until a valid configuration is restored where data and voice device configured VLANs no longer match.
    - If a voice device is authorized and is using a downloaded voice VLAN, the removal of the voice VLAN configuration, or modifying the configuration value to *dot1p* or *untagged* results in voice device un-authorization and the disablement of multi-domain host mode.

When the port is in the force authorized, force unauthorized, unauthorized, or shutdown state, it is put into the configured access VLAN.

To configure VLAN assignment you need to perform these tasks:

- Enable AAA authorization by using the **network** keyword to allow interface configuration from the RADIUS server.
- Enable 802.1x authentication. (The VLAN assignment feature is automatically enabled when you configure 802.1x authentication on an access port).
- Assign vendor-specific tunnel attributes in the RADIUS server. The RADIUS server must return these attributes to the switch:
    - [64] Tunnel-Type = VLAN
    - [65] Tunnel-Medium-Type = 802
    - [81] Tunnel-Private-Group-ID = VLAN name or VLAN ID
    - [83] Tunnel-Preference

  Attribute [64] must contain the value *VLAN* (type 13). Attribute [65] must contain the value *802* (type 6). Attribute [81] specifies the *VLAN name* or *VLAN ID* assigned to the IEEE 802.1x-authenticated user.

802.1x Authentication with Guest VLAN

You can configure a guest VLAN for each 802.1x port on the switch to provide limited services to clients, such as downloading the 802.1x client. These clients might be upgrading their system for 802.1x authentication, and some hosts, such as Windows 98 systems, might not be IEEE 802.1x-capable.

When you enable a guest VLAN on an 802.1x port, the switch assigns clients to a guest VLAN when the switch does not receive a response to its EAP request/identity frame or when EAPOL packets are not sent by the client.

The switch maintains the EAPOL packet history. If an EAPOL packet is detected on the interface during the lifetime of the link, the switch determines that the device connected to that interface is an IEEE 802.1x-capable supplicant, and the interface does not change to the guest VLAN state. EAPOL history is cleared if the interface link status goes down. If no EAPOL packet is detected on the interface, the interface changes to the guest VLAN state.

If the switch is trying to authorize an 802.1x-capable voice device and the AAA server is unavailable, the authorization attempt fails, but the detection of the EAPOL packet is saved in the EAPOL history. When the AAA server becomes available, the switch authorizes the voice device. However, the switch no longer allows other devices access to the guest VLAN. To prevent this situation, use one of these command sequences:

- Enter the **authentication event no-response action authorize vlan** *vlan-id* interface configuration command to allow access to the guest VLAN.
- Enter the **shutdown** interface configuration command followed by the **no shutdown** interface configuration command to restart the port.

If devices send EAPOL packets to the switch during the lifetime of the link, the switch no longer allows clients that fail authentication access to the guest VLAN.

Note If an EAPOL packet is detected after the interface has changed to the guest VLAN, the interface reverts to an unauthorized state, and 802.1x authentication restarts.

Any number of 802.1x-incapable clients are allowed access when the switch port is moved to the guest VLAN. If an 802.1x-capable client joins the same port on which the guest VLAN is configured, the port is put into the unauthorized state in the user-configured access VLAN, and authentication is restarted.

Guest VLANs are supported on 802.1x ports in single host, multiple host, multi-auth and multi-domain modes.

The switch supports *MAC authentication bypass*. When MAC authentication bypass is enabled on an 802.1x port, the switch can authorize clients based on the client MAC address when IEEE 802.1x authentication times out while waiting for an EAPOL message exchange. After detecting a client on an 802.1x port, the switch waits for an Ethernet packet from the client. The switch sends the authentication server a RADIUS-access/request frame with a username and password based on the MAC address. If authorization succeeds, the switch grants the client access to the network. If authorization fails, the switch assigns the port to the guest VLAN if one is specified.

802.1x Authentication with Restricted VLAN

You can configure a restricted VLAN (also referred to as an *authentication failed VLAN*) for each IEEE 802.1x port on a switch to provide limited services to clients that cannot access the guest VLAN. These clients are 802.1x-compliant and cannot access another VLAN because they fail the authentication process. A restricted VLAN allows users without valid credentials in an authentication server (typically, visitors to an enterprise) to access a limited set of services. The administrator can control the services available to the restricted VLAN.

Note You can configure a VLAN to be both the guest VLAN and the restricted VLAN if you want to provide the same services to both types of users.

Without this feature, the client attempts and fails authentication indefinitely, and the switch port remains in the spanning-tree blocking state. With this feature, you can configure the switch port to be in the restricted VLAN after a specified number of authentication attempts (the default value is 3 attempts).

The authenticator counts the failed authentication attempts for the client. When this count exceeds the configured maximum number of authentication attempts, the port moves to the restricted VLAN. The failed attempt count increments when the RADIUS server replies with either an *EAP failure* or an empty response without an EAP packet. When the port moves into the restricted VLAN, the failed attempt counter resets.

Users who fail authentication remain in the restricted VLAN until the next re-authentication attempt. A port in the restricted VLAN tries to re-authenticate at configured intervals (the default is 60 seconds). If re-authentication fails, the port remains in the restricted VLAN. If re-authentication is successful, the port moves either to the configured VLAN or to a VLAN sent by the RADIUS server. You can disable re-authentication. If you do this, the only way to restart the authentication process is for the port to receive a *link down* or *EAP logoff* event. We recommend that you keep re-authentication enabled if a client might connect through a hub. When a client disconnects from the hub, the port might not receive the *link down* or *EAP logoff* event.

After a port moves to the restricted VLAN, a simulated EAP success message is sent to the client. This prevents clients from indefinitely attempting authentication. Some clients (for example, devices running Windows XP) cannot implement DHCP without EAP success.

Restricted VLANs are supported on 802.1x ports in all host modes and on Layer 2 ports.

Other security port features such as dynamic ARP Inspection, DHCP snooping, and IP source guard can be configured independently on a restricted VLAN.

802.1X Auth Fail VLAN

You can configure an auth fail VLAN for each 802.1X port on a switch to provide limited services to clients that cannot access the guest VLAN. These clients are 802.1X-compliant and cannot access another VLAN because they fail the authentication process. An auth fail VLAN allows users without valid credentials in an authentication server (typically, visitors to an enterprise) to access a limited set of services. The administrator can control the services available to the auth fail VLAN.

Note You can configure a VLAN to be both the guest VLAN and the auth fail VLAN if you want to provide the same services to both types of users.

Without this feature, the client attempts and fails authentication indefinitely, and the switch port remains in the spanning-tree blocking state. With this feature, you can configure the switch port to be in the auth fail VLAN after a specified number of authentication attempts (the default value is 3 attempts).

The authenticator counts the failed authentication attempts for the client. When this count exceeds the configured maximum number of authentication attempts, the port moves to the auth fail VLAN. The failed attempt count increments when the RADIUS server replies with either an EAP failure or an empty response without an EAP packet. When the port moves into the auth fail VLAN, the failed attempt counter resets.

Users who fail authentication remain in the auth fail VLAN until the next reauthentication attempt. A port in the auth fail VLAN tries to reauthenticate at configured intervals (the default is 60 seconds). If reauthentication fails, the port remains in the auth fail VLAN. If reauthentication is successful, the port moves either to the configured VLAN or to a VLAN sent by the RADIUS server. You can disable reauthentication. If you do this, the only way to restart the authentication process is for the port to receive a link down or EAP logoff event. It is recommended that you keep reauthentication enabled if a client might connect through a hub. When a client disconnects from the hub, the port might not receive the link down or EAP logoff event.

After a port moves to the auth fail VLAN, a simulated EAP success message is sent to the client. This prevents clients from indefinitely attempting authentication.

As a prerequisite, the switch must be connected to a Cisco secure Access Control System (ACS) and RADIUS authentication, authorization, and accounting (AAA) must be configured for Web authentication. If appropriate, you must enable ACL download.

802.1x Authentication with Inaccessible Authentication Bypass

Use the inaccessible authentication bypass feature, also referred to as *critical authentication* or the *AAA fail policy*, when the switch cannot reach the configured RADIUS servers and new hosts cannot be authenticated. You can configure the switch to connect those hosts to *critical ports.*

When a new host tries to connect to the critical port, that host is moved to a user-specified access VLAN, the *critical VLAN*. The administrator gives limited authentication to the hosts.

When the switch tries to authenticate a host connected to a critical port, the switch checks the status of the configured RADIUS server. If a server is available, the switch can authenticate the host. However, if all the RADIUS servers are unavailable, the switch grants network access to the host and puts the port in the *critical-authentication* state, which is a special case of the authentication state.

Note If *critical authentication* is configured on interface, then vlan used for critical authorization (*critical vlan*) should be active on the switch. If the *critical vlan* is inactive (or) down, *critical authentication* session will keep trying to enable inactive vlan and fail repeatedly. This can lead to large amount of memory holding.

Inaccessible Authentication Bypass Support on Multiple-Authentication Ports

When a port is configured on any host mode and the AAA server is unavailable, the port is then configured to multi-host mode and moved to the critical VLAN. To support this inaccessible bypass on multiple-authentication (multiauth) ports, use the **authentication event server dead action reinitialize vlan** *vlan-id* command. When a new host tries to connect to the critical port, that port is reinitialized and all the connected hosts are moved to the user-specified access VLAN.

This command is supported on all host modes.

Inaccessible Authentication Bypass Authentication Results

The behavior of the inaccessible authentication bypass feature depends on the authorization state of the port:

- If the port is unauthorized when a host connected to a critical port tries to authenticate and all servers are unavailable, the switch puts the port in the critical-authentication state in the RADIUS-configured or user-specified access VLAN.

- If the port is already authorized and reauthentication occurs, the switch puts the critical port in the critical-authentication state in the current VLAN, which might be the one previously assigned by the RADIUS server.

- If the RADIUS server becomes unavailable during an authentication exchange, the current exchange times out, and the switch puts the critical port in the critical-authentication state during the next authentication attempt.

You can configure the critical port to reinitialize hosts and move them out of the critical VLAN when the RADIUS server is again available. When this is configured, all critical ports in the critical-authentication state are automatically re-authenticated.

Inaccessible Authentication Bypass Feature Interactions

Inaccessible authentication bypass interacts with these features:

- Guest VLAN—Inaccessible authentication bypass is compatible with guest VLAN. When a guest VLAN is enabled on 8021.x port, the features interact as follows:
  - If at least one RADIUS server is available, the switch assigns a client to a guest VLAN when the switch does not receive a response to its EAP request/identity frame or when EAPOL packets are not sent by the client.
  - If all the RADIUS servers are not available and the client is connected to a critical port, the switch authenticates the client and puts the critical port in the critical-authentication state in the RADIUS-configured or user-specified access VLAN.
  - If all the RADIUS servers are not available and the client is not connected to a critical port, the switch might not assign clients to the guest VLAN if one is configured.
  - If all the RADIUS servers are not available and if a client is connected to a critical port and was previously assigned to a guest VLAN, the switch keeps the port in the guest VLAN.
- Restricted VLAN—If the port is already authorized in a restricted VLAN and the RADIUS servers are unavailable, the switch puts the critical port in the critical-authentication state in the restricted VLAN.
- 802.1x accounting—Accounting is not affected if the RADIUS servers are unavailable.
- Voice VLAN—Inaccessible authentication bypass is compatible with voice VLAN, but the RADIUS-configured or user-specified access VLAN and the voice VLAN must be different.
- Remote Switched Port Analyzer (RSPAN)—Do not configure an RSPAN VLAN as the RADIUS-configured or user-specified access VLAN for inaccessible authentication bypass.

802.1x Critical Voice VLAN

When an IP phone connected to a port is authenticated by the Cisco Identity Services Engine (ISE), the phone is put into the voice domain. If the ISE is not reachable, the switch cannot determine if the device is a voice device. If the server is unavailable, the phone cannot access the voice network and therefore cannot operate.

For data traffic, you can configure inaccessible authentication bypass, or critical authentication, to allow traffic to pass through on the native VLAN when the server is not available. If the RADIUS authentication server is unavailable (down) and inaccessible authentication bypass is enabled, the switch grants the client access to the network and puts the port in the critical-authentication state in the RADIUS-configured or the user-specified access VLAN. When the switch cannot reach the configured RADIUS servers and new hosts cannot be authenticated, the switch connects those hosts to critical ports. A new host trying to connect to the critical port is moved to a user-specified access VLAN, the critical VLAN, and granted limited authentication.

You can enter the **authentication event server dead action authorize voice** interface configuration command to configure the critical voice VLAN feature. When the ISE does not respond, the port goes into critical authentication mode. When traffic coming from the host is tagged with the voice VLAN, the connected device (the phone) is put in the configured voice VLAN for the port. The IP phones learn the voice VLAN identification through Cisco Discovery Protocol (Cisco devices) or through LLDP or DHCP.

You can configure the voice VLAN for a port by entering the **switchport voice vlan** *vlan-id* interface configuration command.

This feature is supported in multidomain and multi-auth host modes. Although you can enter the command when the switch in single-host or multi-host mode, the command has no effect unless the device changes to multidomain or multi-auth host mode.

802.1x User Distribution

You can configure 802.1x user distribution to load-balance users with the same group name across multiple different VLANs.

The VLANs are either supplied by the RADIUS server or configured through the switch CLI under a VLAN group name.

- Configure the RADIUS server to send more than one VLAN name for a user. The multiple VLAN names can be sent as part of the response to the user. The 802.1x user distribution tracks all the users in a particular VLAN and achieves load balancing by moving the authorized user to the least populated VLAN.

- Configure the RADIUS server to send a VLAN group name for a user. The VLAN group name can be sent as part of the response to the user. You can search for the selected VLAN group name among the VLAN group names that you configured by using the switch CLI. If the VLAN group name is found, the corresponding VLANs under this VLAN group name are searched to find the least populated VLAN. Load balancing is achieved by moving the corresponding authorized user to that VLAN.

Note The RADIUS server can send the VLAN information in any combination of VLAN-IDs, VLAN names, or VLAN groups.

802.1x User Distribution Configuration Guidelines

- Confirm that at least one VLAN is mapped to the VLAN group.

- You can map more than one VLAN to a VLAN group.

- You can modify the VLAN group by adding or deleting a VLAN.

- When you clear an existing VLAN from the VLAN group name, none of the authenticated ports in the VLAN are cleared, but the mappings are removed from the existing VLAN group.

- If you clear the last VLAN from the VLAN group name, the VLAN group is cleared.

- You can clear a VLAN group even when the active VLANs are mapped to the group. When you clear a VLAN group, none of the ports or users that are in the authenticated state in any VLAN within the group are cleared, but the VLAN mappings to the VLAN group are cleared.

IEEE 802.1x Authentication with Voice VLAN Ports

A voice VLAN port is a special access port associated with two VLAN identifiers:

- VVID to carry voice traffic to and from the IP phone. The VVID is used to configure the IP phone connected to the port.
- PVID to carry the data traffic to and from the workstation connected to the switch through the IP phone. The PVID is the native VLAN of the port.

The IP phone uses the VVID for its voice traffic, regardless of the authorization state of the port. This allows the phone to work independently of IEEE 802.1x authentication.

In single-host mode, only the IP phone is allowed on the voice VLAN. In multiple-hosts mode, additional clients can send traffic on the voice VLAN after a supplicant is authenticated on the PVID. When multiple-hosts mode is enabled, the supplicant authentication affects both the PVID and the VVID.

A voice VLAN port becomes active when there is a link, and the device MAC address appears after the first CDP message from the IP phone. Cisco IP phones do not relay CDP messages from other devices. As a result, if several IP phones are connected in series, the switch recognizes only the one directly connected to it. When IEEE 802.1x authentication is enabled on a voice VLAN port, the switch drops packets from unrecognized IP phones more than one hop away.

When IEEE 802.1x authentication is enabled on a switch port, you can configure an access port VLAN that is also a voice VLAN.

When IP phones are connected to an 802.1x-enabled switch port that is in single host mode, the switch grants the phones network access without authenticating them. We recommend that you use multidomain authentication (MDA) on the port to authenticate both a data device and a voice device, such as an IP phone

Note If you enable IEEE 802.1x authentication on an access port on which a voice VLAN is configured and to which a Cisco IP Phone is connected, the Cisco IP phone loses connectivity to the switch for up to 30 seconds.

IEEE 802.1x Authentication with Port Security

In general, Cisco does not recommend enabling port security when IEEE 802.1x is enabled. Since IEEE 802.1x enforces a single MAC address per port (or per VLAN when MDA is configured for IP telephony), port security is redundant and in some cases may interfere with expected IEEE 802.1x operations.

IEEE 802.1x Authentication with MAC Authentication Bypass

You can configure the switch to authorize clients based on the client MAC address by using the MAC authentication bypass feature. For example, you can enable this feature on IEEE 802.1x ports connected to devices such as printers.

If IEEE 802.1x authentication times out while waiting for an EAPOL response from the client, the switch tries to authorize the client by using MAC authentication bypass.

When the MAC authentication bypass feature is enabled on an IEEE 802.1x port, the switch uses the MAC address as the client identity. The authentication server has a database of client MAC addresses that are allowed network access. After detecting a client on an IEEE 802.1x port, the switch waits for an Ethernet packet from the client. The switch sends the authentication server a RADIUS-access/request frame with a username and password based on the MAC address. If authorization succeeds, the switch grants the client access to the network. If authorization fails, the switch assigns the port to the guest VLAN if one is configured. This process works for most client devices; however, it does not work for clients that use an alternate MAC address format. You can configure how MAB authentication is performed for clients with MAC addresses that deviate from the standard format or where the RADIUS configuration requires the user name and password to differ.

If an EAPOL packet is detected on the interface during the lifetime of the link, the switch determines that the device connected to that interface is an 802.1x-capable supplicant and uses 802.1x authentication (not MAC authentication bypass) to authorize the interface. EAPOL history is cleared if the interface link status goes down.

If the switch already authorized a port by using MAC authentication bypass and detects an IEEE 802.1x supplicant, the switch does not unauthorize the client connected to the port. When re-authentication occurs, the switch uses the authentication or re-authentication methods configured on the port, if the previous session ended because the Termination-Action RADIUS attribute value is DEFAULT.

Clients that were authorized with MAC authentication bypass can be re-authenticated. The re-authentication process is the same as that for clients that were authenticated with IEEE 802.1x. During re-authentication, the port remains in the previously assigned VLAN. If re-authentication is successful, the switch keeps the port in the same VLAN. If re-authentication fails, the switch assigns the port to the guest VLAN, if one is configured.

If re-authentication is based on the Session-Timeout RADIUS attribute (Attribute[27]) and the Termination-Action RADIUS attribute (Attribute [29]) and if the Termination-Action RADIUS attribute (Attribute [29]) action is *Initialize* (the attribute value is *DEFAULT*), the MAC authentication bypass session ends, and connectivity is lost during re-authentication. If MAC authentication bypass is enabled and the IEEE 802.1x authentication times out, the switch uses the MAC authentication bypass feature to initiate re-authorization. For more information about these AV pairs, see RFC 3580, “IEEE 802.1X Remote Authentication Dial In User Service (RADIUS) Usage Guidelines.”

MAC authentication bypass interacts with the features:

- IEEE 802.1x authentication—You can enable MAC authentication bypass only if 802.1x authentication is enabled on the port .
- Guest VLAN—If a client has an invalid MAC address identity, the switch assigns the client to a guest VLAN if one is configured.
- Restricted VLAN—This feature is not supported when the client connected to an IEEE 802.lx port is authenticated with MAC authentication bypass.
- Port security
- Voice VLAN

Per-User ACLs Authentication through 802.1x/MAB/WebAuth Users

You can enable per-user access control lists (ACLs) to provide different levels of network access and service to an 802.1x-authenticated user. When the RADIUS server authenticates a user connected to an 802.1x port, it retrieves the ACL attributes based on the user identity and sends them to the switch. The switch applies the attributes to the 802.1x port for the duration of the user session. The switch removes the per-user ACL configuration when the session is over, if authentication fails, or if a link-down condition occurs. The switch does not save RADIUS-specified ACLs in the running configuration. When the port is unauthorized, the switch removes the ACL from the port.

RADIUS supports per-user attributes, including vendor-specific attributes. These vendor-specific attributes (VSAs) are in octet-string format and are passed to the switch during the authentication process. The VSAs used for per-user ACLs are inacl#<*n*> for the ingress direction and outacl#<*n*> for the egress direction. MAC ACLs are supported only in the ingress direction. The switch supports VSAs only in the ingress direction. It does not support port ACLs in the egress direction on Layer 2 ports.

Use only the extended ACL syntax style to define the per-user configuration stored on the RADIUS server. When the definitions are passed from the RADIUS server, they are created by using the extended naming convention. However, if you use the Filter-Id attribute, it can point to a standard ACL.

You can use the Filter-Id attribute to specify an inbound or outbound ACL that is already configured on the switch. The attribute contains the ACL number followed by *.in* for ingress filtering or *.out* for egress filtering. If the RADIUS server does not allow the *.in* or *.out* syntax, the access list is applied to the outbound ACL by default. The user is marked unauthorized if the Filter-Id sent from the RADIUS server is not configured on the device. Because of limited support of Cisco IOS access lists on the switch, the Filter-Id attribute is supported only for IP ACLs numbered in the range of 1 to 199 (IP standard ACLs) and 1300 to 2699 (IP extended ACLs).

The maximum size of the per-user ACL is 4000 ASCII characters but is limited by the maximum size of RADIUS-server per-user ACLs.

You must meet the following prerequisites to configure per-user ACLs:

- Enable AAA authentication.
- Enable AAA authorization by using the **network** keyword to allow interface configuration from the RADIUS server.
- Enable 802.1x authentication.
- Configure the user profile and VSAs on the RADIUS server.

Flexible Authentication Ordering

You can use flexible authentication ordering to configure the order of methods that a port uses to authenticate a new host. The IEEE 802.1X Flexible Authentication feature supports three authentication methods:

- dot1X—IEEE 802.1X authentication is a Layer 2 authentication method.
- mab—MAC-Authentication Bypass is a Layer 2 authentication method.
- webauth—Web authentication is a Layer 3 authentication method.

Using this feature, you can control which ports use which authentication methods, and you can control the failover sequencing of methods on those ports. For example, MAC authentication bypass and 802.1x can be the primary or secondary authentication methods, and web authentication can be the fallback method if either or both of those authentication attempts fail.

The IEEE 802.1X Flexible Authentication feature supports the following host modes:

- multi-auth—Multiauthentication allows one authentication on a voice VLAN and multiple authentications on the data VLAN.
- multi-domain—Multidomain authentication allows two authentications: one on the voice VLAN and one on the data VLAN.

Open1x Authentication

Open1x authentication allows a device access to a port before that device is authenticated. When open authentication is configured, a new host can pass traffic according to the access control list (ACL) defined on the port. After the host is authenticated, the policies configured on the RADIUS server are applied to that host.

You can configure open authentication with these scenarios:

- Single-host mode with open authentication–Only one user is allowed network access before and after authentication.
- MDA mode with open authentication–Only one user in the voice domain and one user in the data domain are allowed.
- Multiple-hosts mode with open authentication–Any host can access the network.
- Multiple-authentication mode with open authentication–Similar to MDA, except multiple hosts can be authenticated.

Note If open authentication is configured, it takes precedence over other authentication controls. This means that if you use the **authentication open** interface configuration command, the port will grant access to the host irrespective of the **authentication port-control** interface configuration command.

Multidomain Authentication

The switch supports multidomain authentication (MDA), which allows both a data device and voice device, such as an IP phone (Cisco or non-Cisco), to authenticate on the same switch port. The port is divided into a data domain and a voice domain.

Note For all host modes, the line protocol stays up before authorization when port-based authentication is configured.

MDA does not enforce the order of device authentication. However, for best results, we recommend that a voice device is authenticated before a data device on an MDA-enabled port.

Follow these guidelines for configuring MDA:

- You must configure a switch port for MDA.
- You must configure the voice VLAN for the IP phone when the host mode is set to multidomain.
- Voice VLAN assignment on an MDA-enabled port is supported Cisco IOS Release 12.2(40)SE and later.
- To authorize a voice device, the AAA server must be configured to send a Cisco Attribute-Value (AV) pair attribute with a value of *device-traffic-class=voice*. Without this value, the switch treats the voice device as a data device.
- The guest VLAN and restricted VLAN features only apply to the data devices on an MDA-enabled port. The switch treats a voice device that fails authorization as a data device.

- If more than one device attempts authorization on either the voice or the data domain of a port, it is error disabled.
- Until a device is authorized, the port drops its traffic. Non-Cisco IP phones or voice devices are allowed into both the data and voice VLANs. The data VLAN allows the voice device to contact a DHCP server to obtain an IP address and acquire the voice VLAN information. After the voice device starts sending on the voice VLAN, its access to the data VLAN is blocked.
- A voice device MAC address that is binding on the data VLAN is not counted towards the port security MAC address limit.
- MDA can use MAC authentication bypass as a fallback mechanism to allow the switch port to connect to devices that do not support IEEE 802.1x authentication.
- When a *data* or a *voice* device is detected on a port, its MAC address is blocked until authorization succeeds. If the authorization fails, the MAC address remains blocked for 5 minutes.
- If more than five devices are detected on the *data* VLAN or more than one voice device is detected on the *voice* VLAN while a port is unauthorized, the port is error disabled.
- When a port host mode is changed from single- or multihost to multidomain mode, an authorized data device remains authorized on the port. However, a Cisco IP phone that has been allowed on the port voice VLAN is automatically removed and must be reauthenticated on that port.
- Active fallback mechanisms such as guest VLAN and restricted VLAN remain configured after a port changes from single- or multihost mode to multidomain mode.
- Switching a port host mode from multidomain to single- or multihost mode removes all authorized devices from the port.
- If a data domain is authorized first and placed in the guest VLAN, non-IEEE 802.1x-capable voice devices need to tag their packets on the voice VLAN to trigger authentication.
- We do not recommend per-user ACLs with an MDA-enabled port. An authorized device with a per-user ACL policy might impact traffic on both the voice and data VLANs of the port. If used, only one device on the port should enforce per-user ACLs.

Limiting Login for Users

The Limiting Login feature helps Network administrators to limit the login attempt of users to a network. When a user fails to successfully login to a network within a configurable number of attempts within a configurable time limit, the user can be blocked. This feature is enabled only for local users and not for remote users. You need to configure the **aaa authentication rejected** command in global configuration mode to enable this feature.

Voice Aware 802.1x Security

Note To use voice aware IEEE 802.1x authentication, the switch must be running the LAN base image.

You use the voice aware 802.1x security feature to configure the switch to disable only the VLAN on which a security violation occurs, whether it is a data or voice VLAN. In previous releases, when an attempt to authenticate the data client caused a security violation, the entire port shut down, resulting in a complete loss of connectivity.

You can use this feature in IP phone deployments where a PC is connected to the IP phone. A security violation found on the data VLAN results in the shutdown of only the data VLAN. The traffic on the voice VLAN flows through the switch without interruption.

How to Configure 802.1x Port-Based Authentication

Default 802.1x Authentication Configuration

Table 96: Default 802.1x Authentication Configuration

Feature	Default Setting
Switch 802.1x enable state	Disabled.
Per-port 802.1x enable state	Disabled (force-authorized). The port sends and receives normal traffic without 802.1x-based authentication of the client.
AAA	Disabled.
RADIUS server • IP address • UDP authentication port • Default accounting port • Key	• None specified. • 1645. • 1646. • None specified.
Host mode	Single-host mode.
Control direction	Bidirectional control.
Periodic re-authentication	Disabled.
Number of seconds between re-authentication attempts	3600 seconds.
Re-authentication number	2 times (number of times that the switch restarts the authentication process before the port changes to the unauthorized state).
Quiet period	60 seconds (number of seconds that the switch remains in the quiet state following a failed authentication exchange with the client).
Retransmission time	30 seconds (number of seconds that the switch should wait for a response to an EAP request/identity frame from the client before resending the request).

Feature	Default Setting
Maximum retransmission number	2 times (number of times that the switch will send an EAP-request/identity frame before restarting the authentication process).
Client timeout period	30 seconds (when relaying a request from the authentication server to the client, the amount of time the switch waits for a response before resending the request to the client.)
Authentication server timeout period	30 seconds (when relaying a response from the client to the authentication server, the amount of time the switch waits for a reply before resending the response to the server.) You can change this timeout period by using the dot1x timeout server-timeout interface configuration command.
Inactivity timeout	Disabled.
Guest VLAN	None specified.
Inaccessible authentication bypass	Disabled.
Restricted VLAN	None specified.
Authenticator (switch) mode	None specified.
MAC authentication bypass	Disabled.
Voice-aware security	Disabled.

802.1x Authentication Configuration Guidelines

802.1x Authentication

These are the 802.1x authentication configuration guidelines:

- When 802.1x authentication is enabled, ports are authenticated before any other Layer 2 or Layer 3 features are enabled.
- If the VLAN to which an 802.1x-enabled port is assigned changes, this change is transparent and does not affect the switch. For example, this change occurs if a port is assigned to a RADIUS server-assigned VLAN and is then assigned to a different VLAN after re-authentication.

  If the VLAN to which an 802.1x port is assigned to shut down, disabled, or removed, the port becomes unauthorized. For example, the port is unauthorized after the access VLAN to which a port is assigned shuts down or is removed.
- The 802.1x protocol is supported on Layer 2 static-access ports, voice VLAN ports, and Layer 3 routed ports, but it is not supported on these port types:

  - Dynamic ports—A port in dynamic mode can negotiate with its neighbor to become a trunk port. If you try to enable 802.1x authentication on a dynamic port, an error message appears, and 802.1x authentication is not enabled. If you try to change the mode of an 802.1x-enabled port to dynamic, an error message appears, and the port mode is not changed.

  - EtherChannel port—Do not configure a port that is an active or a not-yet-active member of an EtherChannel as an 802.1x port. If you try to enable 802.1x authentication on an EtherChannel port, an error message appears, and 802.1x authentication is not enabled.

  - Switched Port Analyzer (SPAN) destination ports—You can enable 802.1x authentication on a port that is a SPAN destination port. However, 802.1x authentication is disabled until the port is removed as a SPAN destination port. You can enable 802.1x authentication on a SPAN source port.

- Before globally enabling 802.1x authentication on a switch by entering the **dot1x system-auth-control** global configuration command, remove the EtherChannel configuration from the interfaces on which 802.1x authentication and EtherChannel are configured.

VLAN Assignment, Guest VLAN, Restricted VLAN, and Inaccessible Authentication Bypass

These are the configuration guidelines for VLAN assignment, guest VLAN, restricted VLAN, and inaccessible authentication bypass:

- When 802.1x authentication is enabled on a port, you cannot configure a port VLAN that is equal to a voice VLAN.

- The 802.1x authentication with VLAN assignment feature is not supported on trunk ports, or dynamic ports.

- You can configure any VLAN except a voice VLAN as an 802.1x guest VLAN. The guest VLAN feature is not supported on internal VLANs (routed ports) or trunk ports; it is supported only on access ports.

- After you configure a guest VLAN for an 802.1x port to which a DHCP client is connected, you might need to get a host IP address from a DHCP server. You can change the settings for restarting the 802.1x authentication process on the switch before the DHCP process on the client times out and tries to get a host IP address from the DHCP server. Decrease the settings for the 802.1x authentication process (**authentication timer inactivity** and **authentication timer reauthentication** interface configuration commands). The amount to decrease the settings depends on the connected 802.1x client type.

- When configuring the inaccessible authentication bypass feature, follow these guidelines:

  - The feature is supported on 802.1x port in single-host mode and multihosts mode.

  - You can configure the inaccessible authentication bypass feature and the restricted VLAN on an 802.1x port. If the switch tries to re-authenticate a critical port in a restricted VLAN and all the RADIUS servers are unavailable, switch changes the port state to the critical authentication state and remains in the restricted VLAN.

- You can configure any VLAN except a voice VLAN as an 802.1x restricted VLAN. The restricted VLAN feature is not supported on internal VLANs (routed ports) or trunk ports; it is supported only on access ports.

MAC Authentication Bypass

These are the MAC authentication bypass configuration guidelines:

- Unless otherwise stated, the MAC authentication bypass guidelines are the same as the 802.1x authentication guidelines.
- If you disable MAC authentication bypass from a port after the port has been authorized with its MAC address, the port state is not affected.
- If the port is in the unauthorized state and the client MAC address is not the authentication-server database, the port remains in the unauthorized state. However, if the client MAC address is added to the database, the switch can use MAC authentication bypass to re-authorize the port.
- If the port is in the authorized state, the port remains in this state until re-authorization occurs.
- You can configure a timeout period for hosts that are connected by MAC authentication bypass but are inactive. The range is 1to 65535 seconds.

Maximum Number of Allowed Devices Per Port

This is the maximum number of devices allowed on an 802.1x-enabled port:

- In single-host mode, only one device is allowed on the access VLAN. If the port is also configured with a voice VLAN, an unlimited number of Cisco IP phones can send and receive traffic through the voice VLAN.
- In multidomain authentication (MDA) mode, one device is allowed for the access VLAN, and one IP phone is allowed for the voice VLAN.
- In multihost mode, only one 802.1x supplicant is allowed on the port, but an unlimited number of non-802.1x hosts are allowed on the access VLAN. An unlimited number of devices are allowed on the voice VLAN.

Configuring Voice Aware 802.1x Security

Note To use voice aware IEEE 802.1x authentication, the switch must be running the LAN base image.

You use the voice aware 802.1x security feature on the switch to disable only the VLAN on which a security violation occurs, whether it is a data or voice VLAN. You can use this feature in IP phone deployments where a PC is connected to the IP phone. A security violation found on the data VLAN results in the shutdown of only the data VLAN. The traffic on the voice VLAN flows through the switch without interruption.

Follow these guidelines to configure voice aware 802.1x voice security on the switch:

- You enable voice aware 802.1x security by entering the **errdisable detect cause security-violation shutdown vlan** global configuration command. You disable voice aware 802.1x security by entering the **no** version of this command. This command applies to all 802.1x-configured ports in the switch.

  Note If you do not include the **shutdown vlan** keywords, the entire port is shut down when it enters the error-disabled state.

- If you use the **errdisable recovery cause security-violation** global configuration command to configure error-disabled recovery, the port is automatically re-enabled. If error-disabled recovery is not configured for the port, you re-enable it by using the **shutdown** and **no shutdown** interface configuration commands.
- You can re-enable individual VLANs by using the **clear errdisable interface** *interface-id* **vlan** [*vlan-list*] privileged EXEC command. If you do not specify a range, all VLANs on the port are enabled.

Beginning in privileged EXEC mode, follow these steps to enable voice aware 802.1x security:

SUMMARY STEPS

1. **configure terminal**
2. **errdisable detect cause security-violation shutdown vlan**
3. **errdisable recovery cause security-violation**
4. **clear errdisable interface***interface-id* **vlan** *[vlan-list]*
5. Enter the following:
   - **shutdown**
   - **no shutdown**
6. **end**
7. **show errdisable detect**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**errdisable detect cause security-violation shutdown vlan**	Shut down any VLAN on which a security violation error occurs. **Note** If the **shutdown vlan** keywords are not included, the entire port enters the error-disabled state and shuts down.
Step 3	**errdisable recovery cause security-violation**	Enter global configuration mode.
Step 4	**clear errdisable interface***interface-id* **vlan** *[vlan-list]*	(Optional) Reenable individual VLANs that have been error disabled. • For interface-id specify the port on which to reenable individual VLANs. • (Optional) For vlan-list specify a list of VLANs to be re-enabled. If vlan-list is not specified, all VLANs are re-enabled.
Step 5	Enter the following: • **shutdown** • **no shutdown**	(Optional) Re-enable an error-disabled VLAN, and clear all error-disable indications.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show errdisable detect**	Verify your entries.

Example

This example shows how to configure the switch to shut down any VLAN on which a security violation error occurs:

```
Switch(config)# errdisable detect cause security-violation shutdown vlan
```

This example shows how to re-enable all VLANs that were error disabled on port Gigabit Ethernet 40/2.

```
Switch# clear errdisable interface gigabitethernet40/2
vlan
```

You can verify your settings by entering the **show errdisable detect** privileged EXEC command.

Configuring 802.1x Violation Modes

You can configure an 802.1x port so that it shuts down, generates a syslog error, or discards packets from a new device when:

- a device connects to an 802.1x-enabled port
- the maximum number of allowed about devices have been authenticated on the port

Beginning in privileged EXEC mode, follow these steps to configure the security violation actions on the switch:

SUMMARY STEPS

1. **configure terminal**
2. **aaa new-model**
3. **aaa authentication dot1x** {**default**} *method1*
4. **interface** *interface-id*
5. **switchport mode access**
6. **authentication violation** {**shutdown** | **restrict** | **protect** | **replace**}
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA.

	Command or Action	Purpose
Step 3	**aaa authentication dot1x** {**default**} *method1* **Example:** `Switch(config)# aaa authentication dot1x default group radius`	Creates an 802.1x authentication method list. To create a default list that is used when a named list is *not* specified in the **authentication** command, use the **default** keyword followed by the method that is to be used in default situations. The default method list is automatically applied to all ports. For *method1*, enter the **group radius** keywords to use the list of all RADIUS servers for authentication.
Step 4	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/4`	Specifies the port connected to the client that is to be enabled for IEEE 802.1x authentication, and enter interface configuration mode.
Step 5	**switchport mode access** **Example:** `Switch(config-if)# switchport mode access`	Sets the port to access mode.

Step 6	**authentication violation** {**shutdown** | **restrict** | **protect** | **replace**}
	Example:
	`Switch(config-if)# authentication violation restrict`
		Configures the violation mode. The keywords have these meanings:
		• **shutdown**–Error disable the port.
		• **restrict**–Generate a syslog error.
		• **protect**–Drop packets from any new device that sends traffic to the port.
		• **replace**–Removes the current session and authenticates with the new host.

Step 7	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring 802.1x Authentication

To allow per-user ACLs or VLAN assignment, you must enable AAA authorization to configure the switch for all network-related service requests.

This is the 802.1x AAA process:

Before you begin

To configure 802.1x port-based authentication, you must enable authentication, authorization, and accounting (AAA) and specify the authentication method list. A method list describes the sequence and authentication method to be queried to authenticate a user.

SUMMARY STEPS

1. A user connects to a port on the switch.
2. Authentication is performed.
3. VLAN assignment is enabled, as appropriate, based on the RADIUS server configuration.
4. The switch sends a start message to an accounting server.
5. Re-authentication is performed, as necessary.
6. The switch sends an interim accounting update to the accounting server that is based on the result of re-authentication.
7. The user disconnects from the port.
8. The switch sends a stop message to the accounting server.

DETAILED STEPS

	Command or Action	Purpose
Step 1	A user connects to a port on the switch.	
Step 2	Authentication is performed.	
Step 3	VLAN assignment is enabled, as appropriate, based on the RADIUS server configuration.	
Step 4	The switch sends a start message to an accounting server.	
Step 5	Re-authentication is performed, as necessary.	
Step 6	The switch sends an interim accounting update to the accounting server that is based on the result of re-authentication.	
Step 7	The user disconnects from the port.	
Step 8	The switch sends a stop message to the accounting server.	

Configuring 802.1x Port-Based Authentication

Beginning in privileged EXEC mode, follow these steps to configure 802.1x port-based authentication:

SUMMARY STEPS

1. **configure terminal**
2. **aaa new-model**
3. **aaa authentication dot1x** {**default**} *method1*
4. **dot1x system-auth-control**
5. **aaa authorization network** {**default**} **group radius**
6. **radius-server host** *ip-address*

7. **radius-server key** *string*
8. **interface** *interface-id*
9. **switchport mode access**
10. **authentication port-control auto**
11. **dot1x pae authenticator**
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA.
Step 3	**aaa authentication dot1x** {**default**} *method1* **Example:** `Switch(config)# aaa authentication dot1x default group radius`	Creates an 802.1x authentication method list. To create a default list that is used when a named list is *not* specified in the **authentication** command, use the **default** keyword followed by the method that is to be used in default situations. The default method list is automatically applied to all ports. For *method1*, enter the **group radius** keywords to use the list of all RADIUS servers for authentication. **Note** Though other keywords are visible in the command-line help string, only the **group radius** keywords are supported.
Step 4	**dot1x system-auth-control** **Example:** `Switch(config)# dot1x system-auth-control`	Enables 802.1x authentication globally on the switch.
Step 5	**aaa authorization network** {**default**} **group radius** **Example:** `Switch(config)# aaa authorization network default group radius`	(Optional) Configures the switch to use user-RADIUS authorization for all network-related service requests, such as per-user ACLs or VLAN assignment.

	Command or Action	Purpose
Step 6	**radius-server host** *ip-address* **Example:** `Switch(config)# radius-server host 124.2.2.12`	(Optional) Specifies the IP address of the RADIUS server.
Step 7	**radius-server key** *string* **Example:** `Switch(config)# radius-server key abc1234`	(Optional) Specifies the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server.
Step 8	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the port connected to the client that is to be enabled for IEEE 802.1x authentication, and enter interface configuration mode.
Step 9	**switchport mode access** **Example:** `Switch(config-if)# switchport mode access`	(Optional) Sets the port to access mode only if you configured the RADIUS server in Step 6 and Step 7.
Step 10	**authentication port-control auto** **Example:** `Switch(config-if)# authentication port-control auto`	Enables 802.1x authentication on the port.
Step 11	**dot1x pae authenticator** **Example:** `Switch(config-if)# dot1x pae authenticator`	Sets the interface Port Access Entity to act only as an authenticator and ignore messages meant for a supplicant.

Step 12	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring the Switch-to-RADIUS-Server Communication

You can globally configure the timeout, retransmission, and encryption key values for all RADIUS servers by using the **radius-server host** global configuration command. If you want to configure these options on a per-server basis, use the **radius-server timeout**, the **radius-server retransmit**, and the **radius-server key** global configuration commands.

You also need to configure some settings on the RADIUS server. These settings include the IP address of the switch and the key string to be shared by both the server and the switch. For more information, see the RADIUS server documentation.

Follow these steps to configure the RADIUS server parameters on the switch. This procedure is required.

Before you begin

You must enable authentication, authorization, and accounting (AAA) and specify the authentication method list. A method list describes the sequence and authentication method to be queried to authenticate a user.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius-server host** {*hostname* | *ip-address*} **auth-port** *port-number* **key** *string*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**radius-server host** {*hostname* | *ip-address*} **auth-port** *port-number* **key** *string* **Example:** `Switch(config)# radius-server host 125.5.5.43 auth-port 1645 key rad123`	Configures the RADIUS server parameters. For *hostname* | *ip-address*, specify the server name or IP address of the remote RADIUS server. For **auth-port** *port-number*, specify the UDP destination port for authentication requests. The default is 1645. The range is 0 to 65536. For **key** *string*, specify the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server. The key is a text string that must match the encryption key used on the RADIUS server.

	Command or Action	Purpose
		Note Always configure the key as the last item in the **radius-server host** command syntax because leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in the key, do not enclose the key in quotation marks unless the quotation marks are part of the key. This key must match the encryption used on the RADIUS daemon. If you want to use multiple RADIUS servers, re-enter this command.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Configuring the Host Mode

Beginning in privileged EXEC mode, follow these steps to allow multiple hosts (clients) on an IEEE 802.1x-authorized port that has the **authentication port-control** interface configuration command set to **auto**. Use the **multi-domain** keyword to configure and enable multidomain authentication (MDA), which allows both a host and a voice device, such as an IP phone (Cisco or non-Cisco), on the same switch port. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **authentication host-mode** [**multi-auth** | **multi-domain** | **multi-host** | **single-host**]
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to which multiple hosts are indirectly attached, and enter interface configuration mode.

	Command or Action	Purpose
Step 3	**authentication host-mode** [**multi-auth** | **multi-domain** | **multi-host** | **single-host**] **Example:** `Switch(config-if)# authentication host-mode multi-host`	Allows multiple hosts (clients) on an 802.1x-authorized port. The keywords have these meanings: • **multi-auth**–Allow multiple authenticated clients on both the voice VLAN and data VLAN. **Note** The **multi-auth** keyword is only available with the **authentication host-mode** command. • **multi-host**–Allow multiple hosts on an 802.1x-authorized port after a single host has been authenticated. • **multi-domain**–Allow both a host and a voice device, such as an IP phone (Cisco or non-Cisco), to be authenticated on an IEEE 802.1x-authorized port. **Note** You must configure the voice VLAN for the IP phone when the host mode is set to **multi-domain**. Make sure that the **authentication port-control** interface configuration command is set to **auto** for the specified interface.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring Periodic Re-Authentication

You can enable periodic 802.1x client re-authentication and specify how often it occurs. If you do not specify a time period before enabling re-authentication, the number of seconds between attempts is 3600.

Beginning in privileged EXEC mode, follow these steps to enable periodic re-authentication of the client and to configure the number of seconds between re-authentication attempts. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **authentication periodic**
4. **authentication timer** {{[**inactivity** | **reauthenticate** | **restart** | **unauthorized**]} {*value*}}
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**authentication periodic** **Example:** `Switch(config-if)# authentication periodic`	Enables periodic re-authentication of the client, which is disabled by default. **Note** The default value is 3600 seconds. To change the value of the reauthentication timer or to have the switch use a RADIUS-provided session timeout, enter the **authentication timer reauthenticate** command.

Step 4	**authentication timer** {{[**inactivity** | **reauthenticate** | **restart** | **unauthorized**]} {*value*}}
	Example:
	`Switch(config-if)# authentication timer reauthenticate 180`
		Sets the number of seconds between re-authentication attempts.
		The **authentication timer** keywords have these meanings:
		• **inactivity**—Interval in seconds after which if there is no activity from the client then it is unauthorized
		• **reauthenticate**—Time in seconds after which an automatic re-authentication attempt is initiated
		• **restart** *value*—Interval in seconds after which an attempt is made to authenticate an unauthorized port
		• **unauthorized** *value*—Interval in seconds after which an unauthorized session will get deleted
		This command affects the behavior of the switch only if periodic re-authentication is enabled.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Changing the Quiet Period

When the switch cannot authenticate the client, the switch remains idle for a set period of time and then tries again. The **authentication timer restart** interface configuration command controls the idle period. A failed authentication of the client might occur because the client provided an invalid password. You can provide a faster response time to the user by entering a number smaller than the default.

Beginning in privileged EXEC mode, follow these steps to change the quiet period. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **authentication timer restart** *seconds*
4. **end**
5. **show authentication sessions interface** *interface-id*
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**authentication timer restart** *seconds* **Example:** `Switch(config-if)# authentication timer restart 30`	Sets the number of seconds that the switch remains in the quiet state following a failed authentication exchange with the client. The range is 1 to 65535 seconds; the default is 60.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 5	**show authentication sessions interface** *interface-id* **Example:** `Switch# show authentication sessions interface`	Verifies your entries.

	Command or Action	Purpose
	`gigabitethernet 0/1`	
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Changing the Switch-to-Client Retransmission Time

The client responds to the EAP-request/identity frame from the switch with an EAP-response/identity frame. If the switch does not receive this response, it waits a set period of time (known as the retransmission time) and then resends the frame.

Note You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Beginning in privileged EXEC mode, follow these steps to change the amount of time that the switch waits for client notification. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **authentication timer reauthenticate** *seconds*
4. **end**
5. **show authentication sessions interface** *interface-id*
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be configured, and enter interface configuration mode.

	Command or Action	Purpose
Step 3	**authentication timer reauthenticate** *seconds* **Example:** `Switch(config-if)# authentication timer reauthenticate 60`	Sets the number of seconds that the switch waits for a response to an EAP-request/identity frame from the client before resending the request. The range is 1 to 65535 seconds; the default is 5.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 5	**show authentication sessions interface** *interface-id* **Example:** `Switch# show authentication sessions interface gigabitethernet 0/1`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Setting the Switch-to-Client Frame-Retransmission Number

In addition to changing the switch-to-client retransmission time, you can change the number of times that the switch sends an EAP-request/identity frame (assuming no response is received) to the client before restarting the authentication process.

Note You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Beginning in privileged EXEC mode, follow these steps to set the switch-to-client frame-retransmission number. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **dot1x max-reauth-req** *count*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**dot1x max-reauth-req** *count* **Example:** `Switch(config-if)# dot1x max-reauth-req 5`	Sets the number of times that the switch sends an EAP-request/identity frame to the client before restarting the authentication process. The range is 1 to 10; the default is 2.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Setting the Re-Authentication Number

You can also change the number of times that the switch restarts the authentication process before the port changes to the unauthorized state.

Note You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Beginning in privileged EXEC mode, follow these steps to set the re-authentication number. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **switchport mode access**
4. **dot1x max-req** *count*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch# interface gigabitethernet 0/1`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**switchport mode access** **Example:** `Switch(config-if)# switchport mode access`	Sets the port to access mode only if you previously configured the RADIUS server.
Step 4	**dot1x max-req** *count* **Example:** `Switch(config-if)# dot1x max-req 4`	Sets the number of times that the switch restarts the authentication process before the port changes to the unauthorized state. The range is 0 to 10; the default is 2.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Enabling MAC Move

MAC move allows an authenticated host to move from one port on the switch to another.

Beginning in privileged EXEC mode, follow these steps to globally enable MAC move on the switch. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **authentication mac-move permit**
3. **end**
4. **show running-config**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**authentication mac-move permit** **Example:** `Switch(config)# authentication mac-move permit`	Enables MAC move on the switch. Default is deny. In Session Aware Networking mode, the default CLI is **access-session mac-move deny**. To enable Mac Move in Session Aware Networking, use the **no access-session mac-move** global configuration command. In legacy mode (IBNS 1.0), default value for **mac-move** is **deny** and in C3PL mode (IBNS 2.0) default value is **permit**.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 4	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Enabling MAC Replace

MAC replace allows a host to replace an authenticated host on a port.

Beginning in privileged EXEC mode, follow these steps to enable MAC replace on an interface. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **authentication violation** {**protect** | **replace** | **restrict** | **shutdown**}
4. **end**
5. **show running-config**

6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the port to be configured, and enter interface configuration mode.

Step 3	**authentication violation** {**protect** | **replace** | **restrict** | **shutdown**}
	Example:
	`Switch(config-if)# authentication violation replace`
		Use the **replace** keyword to enable MAC replace on the interface. The port removes the current session and initiates authentication with the new host.
		The other keywords have these effects:
		• **protect**: the port drops packets with unexpected MAC addresses without generating a system message.
		• **restrict**: violating packets are dropped by the CPU and a system message is generated.
		• **shutdown**: the port is error disabled when it receives an unexpected MAC address.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring 802.1x Accounting

Enabling AAA system accounting with 802.1x accounting allows system reload events to be sent to the accounting RADIUS server for logging. The server can then infer that all active 802.1x sessions are closed.

Because RADIUS uses the unreliable UDP transport protocol, accounting messages might be lost due to poor network conditions. If the switch does not receive the accounting response message from the RADIUS server after a configurable number of retransmissions of an accounting request, this system message appears:

```
Accounting message %s for session %s failed to receive Accounting Response.
```

When the stop message is not sent successfully, this message appears:

```
00:09:55: %RADIUS-4-RADIUS_DEAD: RADIUS server 172.20.246.201:1645,1646 is not responding.
```

Note You must configure the RADIUS server to perform accounting tasks, such as logging start, stop, and interim-update messages and time stamps. To turn on these functions, enable logging of "Update/Watchdog packets from this AAA client" in your RADIUS server Network Configuration tab. Next, enable "CVS RADIUS Accounting" in your RADIUS server System Configuration tab.

Beginning in privileged EXEC mode, follow these steps to configure 802.1x accounting after AAA is enabled on your switch. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **aaa accounting dot1x default start-stop group radius**
4. **aaa accounting system default start-stop group radius**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/3`	Specifies the port to be configured, and enter interface configuration mode.

	Command or Action	Purpose
Step 3	**aaa accounting dot1x default start-stop group radius** **Example:** `Switch(config-if)# aaa accounting dot1x default start-stop group radius`	Enables 802.1x accounting using the list of all RADIUS servers.
Step 4	**aaa accounting system default start-stop group radius** **Example:** `Switch(config-if)# aaa accounting system default start-stop group radius`	(Optional) Enables system accounting (using the list of all RADIUS servers) and generates system accounting reload event messages when the switch reloads.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEc mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a Guest VLAN

When you configure a guest VLAN, clients that are not 802.1x-capable are put into the guest VLAN when the server does not receive a response to its EAP request/identity frame. Clients that are 802.1x-capable but that fail authentication are not granted network access. The switch supports guest VLANs in single-host or multiple-hosts mode.

Beginning in privileged EXEC mode, follow these steps to configure a guest VLAN. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **authentication event no-response action authorize vlan** *vlan-id*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**authentication event no-response action authorize vlan** *vlan-id* **Example:** `Switch(config-if)# authentication event no-response action authorize vlan 2`	Specifies an active VLAN as an 802.1x guest VLAN. The range is 1 to 4094. You can configure any active VLAN except an internal VLAN (routed port), an RSPAN VLAN or a voice VLAN as an 802.1x guest VLAN.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring a Restricted VLAN

When you configure a restricted VLAN on a switch stack, clients that are IEEE 802.1x-compliant are moved into the restricted VLAN when the authentication server does not receive a valid username and password. The switch supports restricted VLANs only in single-host mode.

Beginning in privileged EXEC mode, follow these steps to configure a restricted VLAN. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **authentication port-control auto**
4. **authentication event fail action authorize vlan** *vlan-id*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**authentication port-control auto** **Example:** `Switch(config-if)# authentication port-control auto`	Enables 802.1x authentication on the port.
Step 4	**authentication event fail action authorize vlan** *vlan-id* **Example:** `Switch(config-if)# authentication event fail action authorize vlan 2`	Specifies an active VLAN as an 802.1x restricted VLAN. The range is 1 to 4094. You can configure any active VLAN except an internal VLAN (routed port), an RSPAN VLAN or a voice VLAN as an 802.1x restricted VLAN.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring Number of Authentication Attempts on a Restricted VLAN

You can configure the maximum number of authentication attempts allowed before a user is assigned to the restricted VLAN by using the **authentication event retry** *retry count* interface configuration command. The range of allowable authentication attempts is 1 to 3. The default is 3 attempts.

Beginning in privileged EXEC mode, follow these steps to configure the maximum number of allowed authentication attempts. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **authentication port-control auto**
4. **authentication event fail action authorize vlan** *vlan-id*
5. **authentication event retry** *retry count*

6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/3`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**authentication port-control auto** **Example:** `Switch(config-if)# authentication port-control auto`	Enables 802.1x authentication on the port.
Step 4	**authentication event fail action authorize vlan** *vlan-id* **Example:** `Switch(config-if)# authentication event fail action authorize vlan 8`	Specifies an active VLAN as an 802.1x restricted VLAN. The range is 1 to 4094. You can configure any active VLAN except an internal VLAN (routed port), an RSPAN VLAN or a voice VLAN as an 802.1x restricted VLAN.
Step 5	**authentication event retry** *retry count* **Example:** `Switch(config-if)# authentication event retry 2`	Specifies a number of authentication attempts to allow before a port moves to the restricted VLAN. The range is 1 to 3, and the default is 3.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring 802.1x Inaccessible Authentication Bypass with Critical Voice VLAN

Beginning in privileged EXEC mode, follow these steps to configure critical voice VLAN on a port and enable the inaccessible authentication bypass feature.

SUMMARY STEPS

1. **configure terminal**
2. **aaa new-model**
3. **radius-server dead-criteria**{**time** *seconds* } [**tries** *number*]
4. **radius-serverdeadtime***minutes*
5. **radius-server host ip-address** *address*[**acct-port** *udp-port*][**auth-port** *udp-port*] [**testusername** *name*[**idle-time** *time*] [**ignore-acct-port**][**ignore auth-port**]] [**key** *string*]
6. **dot1x critical** {**eapol** | **recovery delay** *milliseconds*}
7. **interface** *interface-id*
8. **authentication event server dead action** {**authorize** | **reinitialize**} **vlan** *vlan-id*]
9. **switchport voice vlan** *vlan-id*
10. **authentication event server dead action authorize voice**
11. **show authentication interface** *interface-id*
12. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA.
Step 3	**radius-server dead-criteria**{**time** *seconds* } [**tries** *number*] **Example:** `Switch(config)# radius-server dead-criteria time 20 tries 10`	Sets the conditions that determine when a RADIUS server is considered un-available or down (dead). • **time**— 1 to 120 seconds. The switch dynamically determines a default *seconds* value between 10 and 60. • **number**—1 to 100 tries. The switch dynamically determines a default **tries***number* between 10 and 100.
Step 4	**radius-serverdeadtime***minutes* **Example:** `Switch(config)# radius-server deadtime 60`	(Optional) Sets the number of minutes during which a RADIUS server is not sent requests. The range is from 0 to 1440 minutes (24 hours). The default is 0 minutes.
Step 5	**radius-server host ip-address** *address*[**acct-port** *udp-port*][**auth-port** *udp-port*] [**testusername**	(Optional) Configure the RADIUS server parameters by using these keywords:

	Command or Action	Purpose

	name[**idle-time** *time*] [**ignore-acct-port**][**ignore auth-port**]] [**key** *string*]
	Example:
	`Switch(config)# radius-server host 10.0.0.10`
	`acct-port 1550 auth-port`
	`1560 test username user1 idle-time 30 key abc1234`
		- **acct-port***udp-port*—Specify the UDP port for the RADIUS accounting server. The range for the UDP port number is from 0 to 65536. The default is 1646.
		- **auth-port***udp-port*—Specify the UDP port for the RADIUS authentication server. The range for the UDP port number is from 0 to 65536. The default is 1645.
		Note You should configure the UDP port for the RADIUS accounting server and the UDP port for the RADIUS authentication server to nondefault values.
		- **test username***name*—Enable automated testing of the RADIUS server status, and specify the username to be used.
		- **idle-time** *time*—Set the interval of time in minutes after which the switch sends test packets to the server. The range is from 1 to 35791 minutes. The default is 60 minutes (1 hour).
		- **ignore-acct-port**—Disable testing on the RADIUS-server accounting port.
		- **ignore-auth-port**—Disable testing on the RADIUS-server authentication port.
		- For **key***string*, specify the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server. The key is a text string that must match the encryption key used on the RADIUS server.
		Note Always configure the key as the last item in the **radius-server host** command syntax because leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in the key, do not enclose the key in quotation marks unless the quotation marks are part of the key. This key must match the encryption used on the RADIUS daemon.
		You can also configure the authentication and encryption key by using the**radius-server key** {**0**string | **7***string* | *string*} global configuration command.

Step 6	**dot1x critical** {**eapol** | **recovery delay** *milliseconds*} **Example:**	(Optional) Configure the parameters for inaccessible authentication bypass:

	Command or Action	Purpose

	`Switch(config)# dot1x critical eapol`
	`(config)# dot1x critical recovery delay 2000`
		• **eapol**—Specify that the switch sends an EAPOL-Success message when the switch successfully authenticates the critical port.
		• **recovery delay***milliseconds*—Set the recovery delay period during which the switch waits to re-initialize a critical port when a RADIUS server that was unavailable becomes available. The range is from 1 to 10000 milliseconds. The default is 1000 milliseconds (a port can be re-initialized every second).

Step 7	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specify the port to be configured, and enter interface configuration mode.

Step 8	**authentication event server dead action** {**authorize** | **reinitialize**} **vlan** *vlan-id*]
	Example:
	`Switch(config-if)# authentication event server dead action`
	`reinitialicze vlan 20`
		Use these keywords to move hosts on the port if the RADIUS server is unreachable:
		• **authorize**—Move any new hosts trying to authenticate to the user-specified critical VLAN.
		• **reinitialize**—Move all authorized hosts on the port to the user-specified critical VLAN.

Step 9	**switchport voice vlan** *vlan-id* **Example:** `Switch(config-if)# switchport voice vlan`	Specifies the voice VLAN for the port. The voice VLAN cannot be the same as the critical data VLAN configured in Step 6.

Step 10	**authentication event server dead action authorize voice**
	Example:
	`Switch(config-if)#  authentication event server dead action`
	`authorize voice`
		Configures critical voice VLAN to move data traffic on the port to the voice VLAN if the RADIUS server is unreachable.

Step 11	**show authentication interface** *interface-id* **Example:** `Switch(config-if)#  do show authentication interface gigabit 1/0/1`	(Optional) Verify your entries.
Step 12	**copy running-config startup-config** **Example:**	(Optional) Verify your entries.

	Command or Action	Purpose
	`Switch(config-if)# do copy running-config startup-config`	

Example

To return to the RADIUS server default settings, use the **no radius-server dead-criteria**, the **no radius-server deadtime**, and the **no radius-server host** global configuration commands. To disable inaccessible authentication bypass, use the **no authentication event server dead action** interface configuration command. To disable critical voice VLAN, use the no **authentication event server dead action authorize voice** interface configuration command.

Example of Configuring Inaccessible Authentication Bypass

This example shows how to configure the inaccessible authentication bypass feature:

```
Switch(config)# radius-server dead-criteria time 30 tries 20
Switch(config)# radius-server deadtime 60
Switch(config)# radius-server host 10.0.0.10 acct-port 1550 auth-port 1560 test username
user1 idle-time 30 key abc1234
Switch(config)# dot1x critical eapol
Switch(config)# dot1x critical recovery delay 2000
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# dot1x critical
Switch(config-if)# dot1x critical recovery action reinitialize
Switch(config-if)# dot1x critical vlan 20
Switch(config-if)# end
```

Configuring MAC Authentication Bypass

Beginning in privileged EXEC mode, follow these steps to enable MAC authentication bypass. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **authentication port-control auto**
4. **mab** [**eap**]
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**authentication port-control auto** **Example:** `Switch(config-if)# authentication port-control auto`	Enables 802.1x authentication on the port.
Step 4	**mab** [**eap**] **Example:** `Switch(config-if)# mab`	Enables MAC authentication bypass. (Optional) Use the **eap** keyword to configure the switch to use EAP for authorization.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Formatting a MAC Authentication Bypass Username and Password

Use the optional **mab request format** command to format the MAB username and password in a style accepted by the authentication server. The username and password are usually the MAC address of the client. Some authentication server configurations require the password to be different from the username.

Beginning in privileged EXEC mode, follow these steps to format MAC authentication bypass username and passwords.

SUMMARY STEPS

1. **configure terminal**
2. **mab request format attribute 1 groupsize** {**1** | **2** | **4** |**12**} [**separator** {**-** | **:** | **.**} {**lowercase** | **uppercase**}]
3. **mab request format attribute2** {**0** | **7**} *text*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 2	**mab request format attribute 1 groupsize** {**1** | **2** | **4** |**12**} [**separator** {**-** | **:** | **.**} {**lowercase** | **uppercase**}] **Example:** `Switch(config)# mab request format attribute 1 groupsize 12`	Specifies the format of the MAC address in the User-Name attribute of MAB-generated Access-Request packets. 1—Sets the username format of the 12 hex digits of the MAC address. group size—The number of hex nibbles to concatenate before insertion of a separator. A valid groupsize must be either 1, 2, 4, or 12. separator—The character that separates the hex nibbles according to group size. A valid separator must be either a hyphen, colon, or period. No separator is used for a group size of 12. {lowercase | uppercase}—Specifies if nonnumeric hex nibbles should be in lowercase or uppercase.
Step 3	**mab request format attribute2** {**0** | **7**} *text* **Example:** `Switch(config)# mab request format attribute 2 7 A02f44E18B12`	**2**—Specifies a custom (nondefault) value for the User-Password attribute in MAB-generated Access-Request packets. **0**—Specifies a cleartext password to follow. **7**—Specifies an encrypted password to follow. *text*—Specifies the password to be used in the User-Password attribute. **Note** When you send configuration information in e-mail, remove type 7 password information. The **show tech-support** command removes this information from its output by default.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Configuring Per-User ACLs Authentication through 802.1x/MAB/WebAuth Users

To configure a switch to accept downloadable ACLs or redirect URLs from the RADIUS server during authentication of an attached host, perform this task.

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **ip device tracking**
4. **aaa new-model**
5. **aaa authorization network default group radius**
6. **radius-server vsa send authentication**
7. **interface** *interface-id*
8. **ip access-group** *acl-id* **in**
9. end
10. **show running-config interface***interface-id*
11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted .
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip device tracking** **Example:** `Switch(config)# ip device tracking`	Enables the IP device tracking table.
Step 4	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA.
Step 5	**aaa authorization network default group radius** **Example:** `Switch(config)# aaa authorization network default group radius`	Sets the authorization method. To remove the authorization method, use the **no aaa authorization network default group radius** command.
Step 6	**radius-server vsa send authentication** **Example:** `Switch(config)# radius-server vsa send autentication`	Configures the network access server.
Step 7	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/1`	Specifies the port to be configured, and enters interface configuration mode.

	Command or Action	Purpose
Step 8	**ip access-group** *acl-id* **in** **Example:** `Switch(config-if)# ip access-group 99 in`	Configures the default ACL on the port in the input direction. Applicable only for WebAuth Users; dynamically available for 8.2.1x and MAB authentication. **Note** The ACL ID is an access list name or number.
Step 9	end	`Switch(config-if)# end` Returns to Privileged EXEC mode.
Step 10	**show running-config interface***interface-id* **Example:** `Switch# show running-config interface interface-id`	Displays the specific interface configuration for verification.
Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Save entries in the configuration file.

Example: Per-User ACLs Authentication through 802.1x/MAB/WebAuth Users

The following example shows how to configure a switch for a downloadable policy:

```
Switch# configure terminal
Switch(config)# aaa new-model
Switch(config)# aaa authorization network default local group radius
Switch(config)# ip device tracking
Switch(config)# ip access-list extended default_acl
Switch(config-ext-nacl)# permit ip any any
Switch(config-ext-nacl)# exit
Switch(config)# radius-server vsa send authentication
Switch(config)# interface fastEthernet 2/13
Switch(config-if)# ip access-group default_acl in
Switch(config-if)# exit
```

Configuring Limiting Login for Users

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa authentication login default local**
5. **aaa authentication rejected** *n* **in** *m* **ban** *x*
6. **end**
7. **show aaa local user blocked**
8. **clear aaa local user blocked username** *username*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Device(config)# aaa new-model`	Enables the authentication, authorization, and accounting (AAA) access control model.
Step 4	**aaa authentication login default local** **Example:** `Device(config)# aaa authentication login default local`	Sets the authentication, authorization, and accounting (AAA) authentication by using the default authentication methods.
Step 5	**aaa authentication rejected** *n* **in** *m* **ban** *x* **Example:** `Device(config)# aaa authentication rejected 3 in 20 ban 300`	Configures the time period for which an user is blocked, if the user fails to successfully login within the specified time and login attempts. • *n*—Specifies the number of times a user can try to login. • *m*—Specifies the number of seconds within which an user can try to login. • *x*—Specifies the time period an user is banned if the user fails to successfully login.

Step 6	**end**
	Example:
	`Device(config)# end`
		Exits global configuration mode and returns to privileged EXEC mode.

Step 7	**show aaa local user blocked** **Example:** `Device# show aaa local user blocked`	Displays the list of local users who were blocked.
Step 8	**clear aaa local user blocked username** *username* **Example:** `Device# clear aaa local user blocked username user1`	Clears the information about the blocked local user.

Example

The following is sample output from the **show aaa local user blocked** command:

```
Device# show aaa local user blocked

       Local-user                  State

       user1                       Watched (till 11:34:42 IST Feb 5 2015)
```

Configuring 802.1X Auth Fail VLAN

Perform this optional task to configure an auth fail VLAN.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *type slot/port*
3. **access-session port-control auto**
4. **authentication event fail action authorize vlan** *vlan-id*
5. **end**
6. **show access-session interface** *interface-id*
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *type slot/port* **Example:** `Switch(config)# interface gigabitethernet0/1`	Specifies the port to be configured, and enters interface configuration mode.
Step 3	**access-session port-control auto** **Example:** `Switch(config-if)# access-session port-control auto`	Enables 802.1X authentication on the port.
Step 4	**authentication event fail action authorize vlan** *vlan-id* **Example:** `Switch(config-if)# authentication event fail action authorize vlan 40`	Specifies an active VLAN as an 802.1X auth fail VLAN. The range is 1 to 4094.
Step 5	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config-if)# end`	
Step 6	**show access-session interface** *interface-id* **Example:** `Switch# show access-session interface gigabitethernet0/1`	(Optional) Verify your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

To disable and remove the auth fail VLAN, use the **no authentication event fail** interface configuration command. The port returns to the default state.

Configuring the Number of Authentication Retries

You can configure the maximum number of authentication attempts allowed before a user is assigned to the restricted VLAN by using the **authentication event retry** *retry count* interface configuration command. The range of allowable authentication attempts is 1 to 3. The default is 3 attempts.

Perform this optional task to configure the maximum number of allowed authentication attempts.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **access-session port-control auto**
4. **authentication event fail action authorize vlan** *vlan-id*
5. **authentication event failretry** *retry-count*
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/1`	Specifies the port to be configured, and enters interface configuration mode.

	Command or Action	Purpose
Step 3	**access-session port-control auto** **Example:** `Switch(config-if)# access-session port-control auto`	Enables 802.1X authentication on the port.
Step 4	**authentication event fail action authorize vlan** *vlan-id* **Example:** `Switch(config-if)# authentication event fail action authorize vlan 40`	Specifies an active VLAN as an 802.1X auth fail VLAN. The range is 1 to 4094.
Step 5	**authentication event failretry** *retry-count* **Example:** `Switch(config-if)# authentication event fail retry 4`	Specifies a number of authentication attempts before a port moves to the auth fail VLAN. The range is 0 to 5, and the default is 2 attempts after the initial failed event.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Example

The following example shows how to set 2 as the number of authentication attempts allowed before the port moves to the auth fail VLAN:

```
Switch(config-if)# authentication event retry 2
```

Configuring Flexible Authentication Ordering

The examples used in the instructions below changes the order of Flexible Authentication Ordering so that MAB is attempted before IEEE 802.1X authentication (dot1x). MAB is configured as the first authentication method, so MAB will have priority over all other authentication methods.

Beginning in privileged EXEC mode, follow these steps:

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **switchport mode access**
4. **authentication order** [**dot1x** | **mab**] | {**webauth**}
5. **authentication priority** [**dot1x** | **mab**] | {**webauth**}
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**switchport mode access** **Example:** `Switch(config-if)# switchport mode access`	Sets the port to access mode only if you previously configured the RADIUS server.

Step 4	**authentication order** [**dot1x** | **mab**] | {**webauth**}
	Example:
	`Switch(config-if)# authentication order mab dot1x`
		(Optional) Sets the order of authentication methods used on a port.

Step 5	**authentication priority** [**dot1x** | **mab**] | {**webauth**}
	Example:
	`Switch(config-if)# authentication priority mab dot1x`
		(Optional) Adds an authentication method to the port-priority list.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring Open1x

Beginning in privileged EXEC mode, follow these steps to enable manual control of the port authorization state:

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*

3. **switchport mode access**
4. **authentication control-direction** {**both** | **in**}
5. **authentication fallback** *name*
6. **authentication host-mode** [**multi-auth** | **multi-domain** | **multi-host** | **single-host**]
7. **authentication open**
8. **authentication order** [**dot1x** | **mab**] | {**webauth**}
9. **authentication periodic**
10. **authentication port-control** {**auto** | **force-authorized** | **force-un authorized**}
11. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**switchport mode access** **Example:** `Switch(config-if)# switchport mode access`	Sets the port to access mode only if you configured the RADIUS server.

Step 4	**authentication control-direction** {**both** | **in**}
	Example:
	`Switch(config-if)# authentication control-direction both`
		(Optional) Configures the port control as unidirectional or bidirectional.

Step 5	**authentication fallback** *name* **Example:** `Switch(config-if)# authentication fallback profile1`	(Optional) Configures a port to use web authentication as a fallback method for clients that do not support 802.1x authentication.
Step 6	**authentication host-mode** [**multi-auth** | **multi-domain** | **multi-host** | **single-host**] **Example:**	(Optional) Sets the authorization manager mode on a port.

	Command or Action	Purpose
	`Switch(config-if)# authentication host-mode multi-auth`	
Step 7	**authentication open** **Example:** `Switch(config-if)# authentication open`	(Optional) Enables or disable open access on a port.

Step 8	**authentication order** [**dot1x** | **mab**] | {**webauth**}
	Example:
	`Switch(config-if)# authentication order dot1x webauth`
		(Optional) Sets the order of authentication methods used on a port.

Step 9	**authentication periodic** **Example:** `Switch(config-if)# authentication periodic`	(Optional) Enables or disable reauthentication on a port.

Step 10	**authentication port-control** {**auto** | **force-authorized** | **force-un authorized**}
	Example:
	`Switch(config-if)# authentication port-control auto`
		(Optional) Enables manual control of the port authorization state.

Step 11	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Disabling 802.1x Authentication on the Port

You can disable 802.1x authentication on the port by using the **no dot1x pae** interface configuration command.

Beginning in privileged EXEC mode, follow these steps to disable 802.1x authentication on the port. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **switchport mode access**

4. **no dot1x pae authenticator**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be configured, and enter interface configuration mode.
Step 3	**switchport mode access** **Example:** `Switch(config-if)# switchport mode access`	(Optional) Sets the port to access mode only if you configured the RADIUS server.
Step 4	**no dot1x pae authenticator** **Example:** `Switch(config-if)# no dot1x pae authenticator`	Disables 802.1x authentication on the port.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Resetting the 802.1x Authentication Configuration to the Default Values

Beginning in privileged EXEC mode, follow these steps to reset the 802.1x authentication configuration to the default values. This procedure is optional.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **dot1x default**
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Enters interface configuration mode, and specify the port to be configured.
Step 3	**dot1x default** **Example:** `Switch(config-if)# dot1x default`	Resets the 802.1x parameters to the default values.

Step 4	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Monitoring 802.1x Statistics and Status

Table 97: Privileged EXEC show Commands

Command	Purpose
show dot1x all statistics	Displays 802.1x statistics for all ports
show dot1x interface *interface-id* **statistics**	Displays 802.1x statistics for a specific port
show dot1x all [**count** | **details** | **statistics** | **summary**]	Displays the 802.1x administrative and operational status for a switch
show dot1x interface *interface-id*	Displays the 802.1x administrative and operational status for a specific port

Table 98: Global Configuration Commands

Command	Purpose
no dot1x logging verbose	Filters verbose 802.1x authentication messages (beginning with Cisco IOS Release 12.2(55)SE)

For detailed information about the fields in these displays, see the command reference for this release.

Additional References for IEEE 802.1x Port-Based Authentication

Related Documents

Related Topic	Document Title
Configuring Identity Control policies and Identity Service templates for Session Aware networking.	Session Aware Networking Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches) http://www.cisco.com/en/US/docs/ios-xml/ios/san/configuration/xe-3se/3850/san-xe-3se-3850-book.html
Configuring RADIUS, TACACS+, Secure Shell, 802.1X and AAA.	Securing User Services Configuration Guide Library, Cisco IOS XE Release 3SE (Catalyst 3850 Switches) http://www.cisco.com/en/US/docs/ios-xml/ios/security/config_library/xe-3se/3850/secuser-xe-3se-3850-libra

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for 802.1x Port-Based Authentication

Release	Feature Information
	Supports the use of same authorization methods on all the Catalyst switches in a network.
	Supports filtering verbose system messages from the authentication manager.

CHAPTER 47

Configuring IPv6 First Hop Security

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for First Hop Security in IPv6

- You have configured the necessary IPv6 enabled SDM template.
- QoS should be enabled on the switch before configuring CoPP policies using **mls qos** command.

Restrictions for First Hop Security in IPv6

- The following restrictions apply when applying FHS policies to EtherChannel interfaces (Port Channels):
    - A physical port with an FHS policy attached cannot join an EtherChannel group.
    - An FHS policy cannot be attached to an physical port when it is a member of an EtherChannel group.
- By default, a snooping policy has a security-level of guard. When such a snooping policy is configured on an access switch, external IPv6 Router Advertisement (RA) or Dynamic Host Configuration Protocol for IPv6 (DHCPv6) server packets are blocked, even though the uplink port facing the router or DHCP server/relay is configured as a trusted port. To allow IPv6 RA or DHCPv6 server messages, do the following:
    - Apply an IPv6 RA-guard policy (for RA) or IPv6 DHCP-guard policy (for DHCP server messages) on the uplink port.
    - Configure a snooping policy with a lower security-level, for example glean or inspect. However; configuring a lower security level is not recommended with such a snooping policy, because benefits of First Hop security features are not effective.
- The following restrictions apply for CoPP policies with IPv6 SISF-based device tracking policies due to limitation reported in CSCvk32439:
    - CoPP policies are required to limit IPv6 NDP traffic when IPv6 SISF policies are configured on the switch.
    - After NDP CoPP policies are configured, limited traffic hits CPU. To accommodate the total end points connected, the number of NDP CoPP policies should be slightly more than the number of users connected to each switch in a stack. If you configure NDP CoPP policies less than the number of end points connected to the switch, the IP allocation to the end point is delayed but is not ignored completely.

    Note For example, if a stack of 5 switches has approximately 300 users, the NDP CoPP policies should be more than 300.

    - The DHCPv6 (server-to-client and client-to-server) CoPP policies are required only if Lightweight DHCPv6 Relay Agent (LDRA) is configured under IPv6 SISF-based device tracking policies on the switch.

Information about First Hop Security in IPv6

First Hop Security in IPv6 (FHS IPv6) is a set of IPv6 security features, the policies of which can be attached to a physical interface, an EtherChannel interface, or a VLAN. An IPv6 software policy database service stores and accesses these policies. When a policy is configured or modified, the attributes of the policy are stored or updated in the software policy database, then applied as was specified. The following IPv6 policies are currently supported:

- IPv6 Snooping Policy—IPv6 Snooping Policy acts as a container policy that enables most of the features available with FHS in IPv6.
- IPv6 FHS Binding Table Content—A database table of IPv6 neighbors connected to the switch is created from information sources such as Neighbor Discovery (ND) protocol snooping. This database, or binding, table is used by various IPv6 guard features (such as IPv6 ND Inspection) to validate the link-layer address (LLA), the IPv4 or IPv6 address, and prefix binding of the neighbors to prevent spoofing and redirect attacks.
- IPv6 Neighbor Discovery Inspection—IPv6 ND inspection learns and secures bindings for stateless autoconfiguration addresses in Layer 2 neighbor tables. IPv6 ND inspection analyzes neighbor discovery messages in order to build a trusted binding table database and IPv6 neighbor discovery messages that do not conform are dropped. An ND message is considered trustworthy if its IPv6-to-Media Access Control (MAC) mapping is verifiable.

  This feature mitigates some of the inherent vulnerabilities of the ND mechanism, such as attacks on DAD, address resolution, router discovery, and the neighbor cache.
- IPv6 Router Advertisement Guard—The IPv6 Router Advertisement (RA) guard feature enables the network administrator to block or reject unwanted or rogue RA guard messages that arrive at the network switch platform. RAs are used by routers to announce themselves on the link. The RA Guard feature analyzes the RAs and filters out bogus RAs sent by unauthorized routers. In host mode, all router advertisement and router redirect messages are disallowed on the port. The RA guard feature compares configuration information on the Layer 2 device with the information found in the received RA frame. Once the Layer 2 device has validated the content of the RA frame and router redirect frame against the configuration, it forwards the RA to its unicast or multicast destination. If the RA frame content is not validated, the RA is dropped.
- IPv6 DHCP Guard—The IPv6 DHCP Guard feature blocks reply and advertisement messages that come from unauthorized DHCPv6 servers and relay agents. IPv6 DHCP guard can prevent forged messages from being entered in the binding table and block DHCPv6 server messages when they are received on ports that are not explicitly configured as facing a DHCPv6 server or DHCP relay. To use this feature, configure a policy and attach it to an interface or a VLAN. To debug DHCP guard packets, use the **debug ipv6 snooping dhcp-guard** privileged EXEC command.

How to Configure an IPv6 Snooping Policy

Beginning in privileged EXEC mode, follow these steps to configure IPv6 Snooping Policy :

SUMMARY STEPS

1. **configure terminal**
2. **ipv6 snooping policy** *policy-name*
3. {[**default**] | [**device-role** {**node** | **switch**}] | [**limit address-count** *value*] | [**no**] | [**protocol** {**dhcp** | **ndp**}] | [**security-level** {**glean** | **guard** | **inspect**}] | [**tracking** {**disable** [**stale-lifetime** [*seconds* | **infinite**] | **enable** [**reachable-lifetime** [*seconds* | **infinite**] }] | [**trusted-port**] }
4. **end**
5. **show ipv6 snooping policy** *policy-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**ipv6 snooping policy** *policy-name* **Example:** `Switch(config)# ipv6 snooping policy example_policy`	Creates a snooping policy and enters IPv6 Snooping Policy Configuration mode.
Step 3	{[**default**] | [**device-role** {**node** | **switch**}] | [**limit address-count** *value*] | [**no**] | [**protocol** {**dhcp** | **ndp**}] | [**security-level** {**glean** | **guard** | **inspect**}] | [**tracking** {**disable** [**stale-lifetime** [*seconds* | **infinite**] | **enable** [**reachable-lifetime** [*seconds* | **infinite**] }] | [**trusted-port**] } **Example:** Switch `(config-ipv6-snooping)# security-level inspect` **Example:** Switch `(config-ipv6-snooping)# trusted-port`	Enables data address gleaning, validates messages against various criteria, specifies the security level for messages. • (Optional) **default**—Sets all to default options. • (Optional) **device-role**{**node**] | **switch**}—Specifies the role of the device attached to the port. Default is **node**. • (Optional) **limit address-count** *value*—Limits the number of addresses allowed per target. • (Optional) **no**—Negates a command or sets it to defaults. • (Optional) **protocol**{**dhcp** | **ndp**}—Specifies which protocol should be redirected to the snooping feature for analysis. The default, is **dhcp** and **ndp**. To change the default, use the **no protocol** command. • (Optional) **security-level**{**glean**|**guard**|**inspect**}—Specifies the level of security enforced by the feature. Default is **guard.** **glean**—Gleans addresses from messages and populates the binding table without any verification. **guard**—Gleans addresses and inspects messages. In addition, it rejects RA and DHCP server messages. This is the default option. **inspect**—Gleans addresses, validates messages for consistency and conformance, and enforces address ownership. • (Optional) **tracking** {**disable** | **enable**}—Overrides the default tracking behavior and specifies a tracking option. • (Optional) **trusted-port**—Sets up a trusted port. It disables the guard on applicable targets. Bindings learned through a trusted port have preference over

	Command or Action	Purpose
		bindings learned through any other port. A trusted port is given preference in case of a collision while making an entry in the table.

Step 4	**end**
	Example:
	`Switch(config-ipv6-snooping)# exit`
		Exits configuration modes to Privileged EXEC mode.

Step 5	**show ipv6 snooping policy** *policy-name* **Example:** `Switch#show ipv6 snooping policy example_policy`	Displays the snooping policy configuration.

What to do next

Attach an IPv6 Snooping policy to interfaces or VLANs.

How to Attach an IPv6 Snooping Policy to an Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Snooping policy on an interface or VLAN:

SUMMARY STEPS

1. **configure terminal**
2. **interface** Interface_type *stack/module/port*
3. **switchport**
4. **ipv6 snooping** [**attach-policy** *policy_name* [**vlan** {*vlan_id* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids*}] | **vlan** {*vlan_id* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
5. **do show running-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface** Interface_type *stack/module/port* **Example:** `Switch(config)#  interface gigabitethernet 1/1/4`	Specifies an interface type and identifier; enters the interface configuration mode.
Step 3	**switchport** **Example:**	Enters the Switchport mode.

	Command or Action	Purpose
	`Switch(config-if)# switchport`	**Note** To configure Layer 2 parameters, if the interface is in Layer 3 mode, you must enter the switchport interface configuration command without any parameters to put the interface into Layer 2 mode. This shuts down the interface and then re-enables it, which might generate messages on the device to which the interface is connected. When you put an interface that is in Layer 3 mode into Layer 2 mode, the previous configuration information related to the affected interface might be lost, and the interface is returned to its default configuration. The command prompt displays as (config-if)# in Switchport configuration mode.

Step 4	**ipv6 snooping** [**attach-policy** *policy_name* [**vlan** {*vlan_id* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids*}] | **vlan** {*vlan_id* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
	Example:
	`Switch(config-if)# ipv6 snooping`
	`or`
	`Switch(config-if)# ipv6 snooping attach-policy example_policy`
	`or`
	`Switch(config-if)# ipv6 snooping vlan 111,112`
	`or`
	`Switch(config-if)# ipv6 snooping attach-policy example_policy vlan 111,112`
		Attaches a custom ipv6 snooping policy to the interface or the specified VLANs on the interface. To attach the default policy to the interface, use the **ipv6 snooping** command without the **attach-policy** keyword. To attach the default policy to VLANs on the interface, use the **ipv6 snooping vlan** command. The default policy is, security-level **guard**, device-role **node**, protocol **ndp** and **dhcp.**

Step 5	**do show running-config**
	Example:
	`Switch#(config-if)#  do show running-config`
		Verifies that the policy is attached to the specified interface without exiting the interface configuration mode.

How to Attach an IPv6 Snooping Policy to a Layer 2 EtherChannel Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Snooping policy on an EtherChannel interface or VLAN:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface range** *Interface_name* **Example:** `Switch(config)#  interface range Po11`	Specify the port-channel interface name assigned when the EtherChannel was created. Enters the interface range configuration mode. **Tip** Enter the **do show interfaces summary** command for quick reference to interface names and types.

Step 3	**ipv6 snooping** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_ids* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
	Example:
	`Switch(config-if-range)# ipv6 snooping attach-policy example_policy`
	`or`
	`Switch(config-if-range)# ipv6 snooping attach-policy example_policy vlan 222,223,224`
	`or`
	`Switch(config-if-range)#ipv6 snooping vlan 222, 223,224`
		Attaches the IPv6 Snooping policy to the interface or the specified VLANs on that interface. The default policy is attached if the **attach-policy** option is not used.

Step 4	**do show running-config interface***portchannel_interface_name*
	Example:
	`Switch#(config-if-range)#  do show running-config int po11`
		Confirms that the policy is attached to the specified interface without exiting the configuration mode.

How to Configure the IPv6 Binding Table Content

Beginning in privileged EXEC mode, follow these steps to configure IPv6 Binding Table Content :

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **ipv6 neighbor binding** [**vlan** *vlan-id* {*ipv6-address* **interface** interface_type *stack/module/port hw_address* [**reachable-lifetimevalue** [*seconds* | **default** | **infinite**] | [**tracking**{ [default | disable] [

reachable-lifetimevalue [*seconds* | **default** | **infinite**] | [**enable** [**reachable-lifetimevalue** [*seconds* | **default** | **infinite**] | [**retry-interval** {*seconds*| **default** [**reachable-lifetimevalue** [*seconds* | **default** | **infinite**] }]

3. [**no**] **ipv6 neighbor binding max-entries** *number* [**mac-limit** *number* | **port-limit** *number* [**mac-limit** *number*] | **vlan-limit** *number* [[**mac-limit** *number*] | [**port-limit** *number* [**mac-limit***number*]]]]
4. **ipv6 neighbor binding logging**
5. **exit**
6. **show ipv6 neighbor binding**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	[**no**] **ipv6 neighbor binding** [**vlan** *vlan-id* {*ipv6-address* **interface** interface_type *stack/module/port hw_address* [**reachable-lifetimevalue** [*seconds* | **default** | **infinite**] | [**tracking**{ [default | disable] [**reachable-lifetimevalue** [*seconds* | **default** | **infinite**] | [**enable** [**reachable-lifetimevalue** [*seconds* | **default** | **infinite**] | [**retry-interval** {*seconds*| **default** [**reachable-lifetimevalue** [*seconds* | **default** | **infinite**] }] **Example:** `Switch(config)#  ipv6 neighbor binding`	Adds a static entry to the binding table database.
Step 3	[**no**] **ipv6 neighbor binding max-entries** *number* [**mac-limit** *number* | **port-limit** *number* [**mac-limit** *number*] | **vlan-limit** *number* [[**mac-limit** *number*] | [**port-limit** *number* [**mac-limit***number*]]]] **Example:** `Switch(config)#  ipv6 neighbor binding max-entries 30000`	Specifies the maximum number of entries that are allowed to be inserted in the binding table cache.
Step 4	**ipv6 neighbor binding logging** **Example:** `Switch(config)# ipv6 neighbor binding logging`	Enables the logging of binding table main events.
Step 5	**exit** **Example:** `Switch(config)# exit`	Exits global configuration mode, and places the router in privileged EXEC mode.
Step 6	**show ipv6 neighbor binding** **Example:** `Switch#  show ipv6 neighbor binding`	Displays contents of a binding table.

How to Configure an IPv6 Neighbor Discovery Inspection Policy

Beginning in privileged EXEC mode, follow these steps to configure an IPv6 ND Inspection Policy:

SUMMARY STEPS

1. **configure terminal**
2. [**no**]**ipv6 nd inspection policy** *policy-name*
3. **device-role** {**host** | **monitor** | **router** | **switch**}
4. **drop-unsecure**
5. **limit address-count** *value*
6. **sec-level minimum** *value*
7. **tracking** {**enable** [**reachable-lifetime** {*value* | **infinite**}] | **disable** [**stale-lifetime** {*value* | **infinite**}]}
8. **trusted-port**
9. **validate source-mac**
10. **no** {**device-role** | **drop-unsecure** | **limit address-count** | **sec-level minimum** | **tracking** | **trusted-port** | **validate source-mac**}
11. **default** {**device-role** | **drop-unsecure** | **limit address-count** | **sec-level minimum** | **tracking** | **trusted-port** | **validate source-mac**}
12. **do show ipv6 nd inspection policy** *policy_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	[**no**]**ipv6 nd inspection policy** *policy-name* **Example:** `Switch(config)# ipv6 nd inspection policy example_policy`	Specifies the ND inspection policy name and enters ND Inspection Policy configuration mode.

Step 3	**device-role** {**host** | **monitor** | **router** | **switch**}
	Example:
	`Switch(config-nd-inspection)# device-role switch`
		Specifies the role of the device attached to the port. The default is **host**.

Step 4	**drop-unsecure** **Example:** `Switch(config-nd-inspection)# drop-unsecure`	Drops messages with no or invalid options or an invalid signature.
Step 5	**limit address-count** *value* **Example:** `Switch(config-nd-inspection)# limit address-count 1000`	Enter 1–10,000.

	Command or Action	Purpose
Step 6	**sec-level minimum** *value* **Example:** `Switch(config-nd-inspection)# limit address-count 1000`	Specifies the minimum security level parameter value when Cryptographically Generated Address (CGA) options are used.

Step 7	**tracking** {**enable** [**reachable-lifetime** {*value* | **infinite**}] | **disable** [**stale-lifetime** {*value* | **infinite**}]}
	Example:
	`Switch(config-nd-inspection)# tracking disable stale-lifetime infinite`
		Overrides the default tracking policy on a port.

Step 8	**trusted-port** **Example:** `Switch(config-nd-inspection)# trusted-port`	Configures a port to become a trusted port.
Step 9	**validate source-mac** **Example:** `Switch(config-nd-inspection)# validate source-mac`	Checks the source media access control (MAC) address against the link-layer address.

Step 10	**no** {**device-role** | **drop-unsecure** | **limit address-count** | **sec-level minimum** | **tracking** | **trusted-port** | **validate source-mac**}
	Example:
	`Switch(config-nd-inspection)# no validate source-mac`
		Remove the current configuration of a parameter with the **no** form of the command.

Step 11	**default** {**device-role** | **drop-unsecure** | **limit address-count** | **sec-level minimum** | **tracking** | **trusted-port** | **validate source-mac**}
	Example:
	`Switch(config-nd-inspection)# default limit address-count`
		Restores configuration to the default values.

Step 12	**do show ipv6 nd inspection policy** *policy_name*
	Example:
	`Switch(config-nd-inspection)# do show ipv6 nd inspection policy example_policy`
		Verifies the ND Inspection Configuration without exiting ND inspection configuration mode.

How to Attach an IPv6 Neighbor Discovery Inspection Policy to an Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 ND Inspection policy to an interface or VLANs on an interface :

SUMMARY STEPS

1. **configure terminal**

2. **interface** Interface_type *stack/module/port*
3. **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_ids* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
4. **do show running-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface** Interface_type *stack/module/port* **Example:** `Switch(config)#  interface gigabitethernet 1/1/4`	Specifies an interface type and identifier; enters the interface configuration mode.
Step 3	**ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** {*vlan_ids*	**add** *vlan_ids*	**except** *vlan_ids*	**none**	**remove** *vlan_ids*	**all**}]	**vlan** [{*vlan_ids*	**add** *vlan_ids*	**except***vlan_ids*	**none**	**remove** *vlan_ids*	**all**}] **Example:** `Switch(config-if)# ipv6 nd inspection attach-policy example_policy` `or` `Switch(config-if)# ipv6 nd inspection attach-policy example_policy vlan 222,223,224` `or` `Switch(config-if)# ipv6 nd inspection vlan 222, 223,224`	Attaches the Neighbor Discovery Inspection policy to the interface or the specified VLANs on that interface. The default policy is attached if the **attach-policy** option is not used.

Step 4	**do show running-config**
	Example:
	`Switch#(config-if)#  do show running-config`
		Verifies that the policy is attached to the specified interface without exiting the interface configuration mode.

How to Attach an IPv6 Neighbor Discovery Inspection Policy to a Layer 2 EtherChannel Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Neighbor Discovery Inspection policy on an EtherChannel interface or VLAN:

SUMMARY STEPS

1. **configure terminal**
2. **interface range** *Interface_name*
3. **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_ids* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
4. **do show running-config interface***portchannel_interface_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface range** *Interface_name* **Example:** `Switch(config)#  interface Po11`	Specify the port-channel interface name assigned when the EtherChannel was created. Enters the interface range configuration mode. **Tip** Enter the **do show interfaces summary** command for quick reference to interface names and types.
Step 3	**ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** {*vlan_ids*	**add** *vlan_ids*	**except** *vlan_ids*	**none**	**remove** *vlan_ids*	**all**}]	**vlan** [{*vlan_ids*	**add** *vlan_ids*	**except***vlan_ids*	**none**	**remove** *vlan_ids*	**all**}] **Example:** `Switch(config-if-range)# ipv6 nd inspection attach-policy example_policy` `or` `Switch(config-if-range)# ipv6 nd inspection attach-policy example_policy vlan 222,223,224` `or` `Switch(config-if-range)#ipv6 nd inspection vlan 222, 223,224`	Attaches the ND Inspection policy to the interface or the specified VLANs on that interface. The default policy is attached if the **attach-policy** option is not used.

Step 4	**do show running-config interface***portchannel_interface_name*
	Example:
	`Switch#(config-if-range)#  do show running-config int po11`
		Confirms that the policy is attached to the specified interface without exiting the configuration mode.

How to Attach an IPv6 Neighbor Discovery Multicast Suppress Policy on a Device

To attach an IPV6 Neighbor Discovery Multicast Suppress policy on a device, complete the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 nd suppress policy** *policy-name*
4. **mode dad-proxy**
5. **mode full-proxy**
6. **mode mc-proxy**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal**	Enters the global configuration mode.
Step 3	**ipv6 nd suppress policy** *policy-name*	Defines the Neighbor Discovery suppress policy name and enters Neighbor Discovery suppress policy configuration mode.
Step 4	**mode dad-proxy**	Enables Neighbor Discovery suppress in IPv6 DAD proxy mode.
Step 5	**mode full-proxy**	Enables Neighbor Discovery suppress to proxy multicast and unicast Neighbor Solicitation messages.
Step 6	**mode mc-proxy**	Enables Neighbor Discovery suppress to proxy multicast Neighbor Solicitation messages.

How to Attach an IPv6 Neighbor Discovery Multicast Suppress Policy on an Interface

To attach an IPv6 Neighbor Discovery Multicast Suppress policy on an interface, complete the following steps:

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. Perform one of the following tasks:
   - **interface** *type number*
   - **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** { **add** | **except** | **none** | **remove** | **all**} *vlan* [*vlan1, vlan2, vlan3...*]]]

     OR

   - **vlan configuration** *vlan-id*
   - **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** { **add** | **except** | **none** | **remove** | **all**} *vlan* [*vlan1, vlan2, vlan3...*]]]
4. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal**	Enters the global configuration mode.
Step 3	Perform one of the following tasks: • **interface** *type number* • **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** { **add** | **except** | **none** | **remove** | **all**} *vlan* [*vlan1, vlan2, vlan3...*]]] OR • **vlan configuration** *vlan-id* • **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** { **add** | **except** | **none** | **remove** | **all**} *vlan* [*vlan1, vlan2, vlan3...*]]]	Specifies an interface type and number, and places the device in interface configuration mode. Attaches the IPv6 Neighbor Discovery Multicast Policy to an interface or a VLAN.
Step 4	**exit**	Exists the interface configuration mode.

How to Attach an IPv6 Neighbor Discovery Multicast Suppress Policy to a Layer 2 EtherChannel Interface

To attach an IPv6 Neighbor Discovery Multicast Suppress policy on an EtherChannel interface, complete the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. Perform one of the following tasks:
   - **interface port-channel** *port-channel-number*
   - **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** { **add** | **except** | **none** | **remove** | **all**} *vlan* [*vlan1, vlan2, vlan3*...]]]

     OR

   - **vlan configuration** *vlan-id*
   - **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** { **add** | **except** | **none** | **remove** | **all**} *vlan* [*vlan1, vlan2, vlan3*...]]]
4. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal**	Enters the global configuration mode.
Step 3	Perform one of the following tasks: • **interface port-channel** *port-channel-number* • **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** { **add** | **except** | **none** | **remove** | **all**} *vlan* [*vlan1, vlan2, vlan3*...]]] OR • **vlan configuration** *vlan-id* • **ipv6 nd inspection** [**attach-policy** *policy_name* [**vlan** { **add** | **except** | **none** | **remove** | **all**} *vlan* [*vlan1, vlan2, vlan3*...]]]	Specifies an interface type and port number and places the switch in the port channel configuration mode. Attaches the IPv6 Neighbor Discovery Multicast Policy to an interface or a VLAN.
Step 4	**exit**	Exists the interface configuration mode.

How to Configure an IPv6 Router Advertisement Guard Policy

Beginning in privileged EXEC mode, follow these steps to configure an IPv6 Router Advertisement policy :

SUMMARY STEPS

1. **configure terminal**
2. [**no**]**ipv6 nd raguard policy** *policy-name*
3. [**no**]**device-role** {**host** | **monitor** | **router** | **switch**}
4. [**no**]**hop-limit** {**maximum** | **minimum**} *value*
5. [**no**]**managed-config-flag** {**off** | **on**}
6. [**no**]**match** {**ipv6 access-list** *list* | **ra prefix-list** *list*}
7. [**no**]**other-config-flag** {**on** | **off**}
8. [**no**]**router-preference maximum** {**high** | **medium** | **low**}
9. [**no**]**trusted-port**
10. **default** {**device-role** | **hop-limit** {**maximum** | **minimum**} | **managed-config-flag** | **match** {**ipv6 access-list** | **ra prefix-list** } | **other-config-flag** | **router-preference maximum**| **trusted-port**}
11. **do show ipv6 nd raguard policy** *policy_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	[**no**]**ipv6 nd raguard policy** *policy-name* **Example:** `Switch(config)# ipv6 nd raguard policy example_policy`	Specifies the RA Guard policy name and enters RA Guard Policy configuration mode.

Step 3	[**no**]**device-role** {**host** | **monitor** | **router** | **switch**}
	Example:
	`Switch(config-nd-raguard)# device-role switch`
		Specifies the role of the device attached to the port. The default is **host**.

Step 4	[**no**]**hop-limit** {**maximum** | **minimum**} *value* **Example:** `Switch(config-nd-raguard)# hop-limit maximum 33`	(1–255) Range for Maximum and Minimum Hop Limit values. Enables filtering of Router Advertisement messages by the Hop Limit value. A rogue RA message may have a low Hop Limit value (equivalent to the IPv4 Time to Live) that when accepted by the host, prevents the host from generating traffic to destinations beyond the rogue RA message generator. An RA message with an unspecified Hop Limit value is blocked. If not configured, this filter is disabled. Configure **minimum** to block RA messages with Hop Limit values lower than the value you specify. Configure **maximum**to block RA messages with Hop Limit values greater than the value you specify.

	Command or Action	Purpose

Step 5	[**no**]**managed-config-flag** {**off** | **on**}
	Example:
	`Switch(config-nd-raguard)# managed-config-flag on`
		Enables filtering of Router Advertisement messages by the Managed Address Configuration, or "M" flag field. A rouge RA message with an M field of 1 can cause a host to use a rogue DHCPv6 server. If not configured, this filter is disabled.
		On—Accepts and forwards RA messages with an M value of 1, blocks those with 0.
		Off—Accepts and forwards RA messages with an M value of 0, blocks those with 1.

Step 6	[**no**]**match** {**ipv6 access-list** *list* | **ra prefix-list** *list*}
	Example:
	`Switch(config-nd-raguard)# match ipv6 access-list example_list`
		Matches a specified prefix list or access list.

Step 7	[**no**]**other-config-flag** {**on** | **off**}
	Example:
	`Switch(config-nd-raguard)# other-config-flag on`
		Enables filtering of Router Advertisement messages by the Other Configuration, or "O" flag field. A rouge RA message with an O field of 1 can cause a host to use a rogue DHCPv6 server. If not configured, this filter is disabled.
		On—Accepts and forwards RA messages with an O value of 1, blocks those with 0.
		Off—Accepts and forwards RA messages with an O value of 0, blocks those with 1.

Step 8	[**no**]**router-preference maximum** {**high** | **medium** | **low**}
	Example:
	`Switch(config-nd-raguard)# router-preference maximum high`
		Enables filtering of Router Advertisement messages by the Router Preference flag. If not configured, this filter is disabled.
		• **high**—Accepts RA messages with the Router Preference set to high, medium, or low.
		• **medium**—Blocks RA messages with the Router Preference set to high.
		• **low**—Blocks RA messages with the Router Preference set to medium and high.

Step 9	[**no**]**trusted-port** **Example:** `Switch(config-nd-raguard)# trusted-port`	When configured as a trusted port, all attached devices are trusted, and no further message verification is performed.
Step 10	**default** {**device-role** | **hop-limit** {**maximum** | **minimum**} | **managed-config-flag** | **match** {**ipv6 access-list** | **ra prefix-list** } | **other-config-flag** | **router-preference maximum**| **trusted-port**} **Example:**	Restores a command to its default value.

	Command or Action	Purpose
	`Switch(config-nd-raguard)# default hop-limit`	

Step 11	**do show ipv6 nd raguard policy** *policy_name*
	Example:
	`Switch(config-nd-raguard)# do show ipv6 nd raguard policy example_policy`
		(Optional)—Displays the ND Guard Policy configuration without exiting the RA Guard policy configuration mode.

How to Attach an IPv6 Router Advertisement Guard Policy to an Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Router Advertisement policy to an interface or to VLANs on the interface :

SUMMARY STEPS

1. **configure terminal**
2. **interface** Interface_type *stack/module/port*
3. **ipv6 nd raguard** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_ids* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
4. **do show running-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface** Interface_type *stack/module/port* **Example:** `Switch(config)#  interface gigabitethernet 1/1/4`	Specifies an interface type and identifier; enters the interface configuration mode.

Step 3	**ipv6 nd raguard** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_ids* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
	Example:
	`Switch(config-if)# ipv6 nd raguard attach-policy example_policy`
	`or`
	`Switch(config-if)# ipv6 nd raguard attach-policy example_policy vlan 222,223,224`
	`or`
		Attaches the Neighbor Discovery Inspection policy to the interface or the specified VLANs on that interface. The default policy is attached if the **attach-policy** option is not used.

	Command or Action	Purpose
	`Switch(config-if)# ipv6 nd raguard vlan 222, 223,224`	

Step 4	**do show running-config**
	Example:
	`Switch#(config-if)#  do show running-config`
		Confirms that the policy is attached to the specified interface without exiting the configuration mode.

How to Attach an IPv6 Router Advertisement Guard Policy to a Layer 2 EtherChannel Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 Router Advertisement Guard Policy on an EtherChannel interface or VLAN:

SUMMARY STEPS

1. **configure terminal**
2. **interface range** *Interface_name*
3. **ipv6 nd raguard** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_ids* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
4. **do show running-config interface***portchannel_interface_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface range** *Interface_name* **Example:** `Switch(config)#  interface Po11`	Specify the port-channel interface name assigned when the EtherChannel was created. Enters the interface range configuration mode. **Tip** Enter the **do show interfaces summary** command for quick reference to interface names and types.
Step 3	**ipv6 nd raguard** [**attach-policy** *policy_name* [**vlan** {*vlan_ids*	**add** *vlan_ids*	**except** *vlan_ids*	**none**	**remove** *vlan_ids*	**all**}]	**vlan** [{*vlan_ids*	**add** *vlan_ids*	**except***vlan_ids*	**none**	**remove** *vlan_ids*	**all**}] **Example:** `Switch(config-if-range)# ipv6 nd raguard attach-policy example_policy`	Attaches the RA Guard policy to the interface or the specified VLANs on that interface. The default policy is attached if the **attach-policy** option is not used.

	Command or Action	Purpose

	or
	`Switch(config-if-range)#` **`ipv6 nd raguard attach-policy example_policy vlan 222,223,224`**
	`or`
	`Switch(config-if-range)#`**`ipv6 nd raguard vlan 222, 223,224`**	

Step 4	**do show running-config interface***portchannel_interface_name*
	Example:
	`Switch#(config-if-range)#` **`do show running-config int po11`**
		Confirms that the policy is attached to the specified interface without exiting the configuration mode.

How to Configure an IPv6 DHCP Guard Policy

Beginning in privileged EXEC mode, follow these steps to configure an IPv6 DHCP (DHCPv6) Guard policy:

SUMMARY STEPS

1. **configure terminal**
2. [**no**]**ipv6 dhcp guard policy** *policy-name*
3. [**no**]**device-role** {**client** | **server**}
4. [**no**] **match server access-list** *ipv6-access-list-name*
5. [**no**] **match reply prefix-list** *ipv6-prefix-list-name*
6. [**no**]**preference**{ **max** *limit* | **min** *limit* }
7. [**no**] **trusted-port**
8. **default** {**device-role** | **trusted-port**}
9. **do show ipv6 dhcp guard policy** *policy_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch#` **`configure terminal`**	Enters the global configuration mode.
Step 2	[**no**]**ipv6 dhcp guard policy** *policy-name* **Example:** `Switch(config)#` **`ipv6 dhcp guard policy example_policy`**	Specifies the DHCPv6 Guard policy name and enters DHCPv6 Guard Policy configuration mode.

	Command or Action	Purpose

Step 3	[**no**]**device-role** {**client** | **server**}
	Example:
	`Switch(config-dhcp-guard)# device-role server`
		(Optional) Filters out DHCPv6 replies and DHCPv6 advertisements on the port that are not from a device of the specified role. Default is **client**.
		• **client**—Default value, specifies that the attached device is a client. Server messages are dropped on this port.
		• **server**—Specifies that the attached device is a DHCPv6 server. Server messages are allowed on this port.

Step 4	[**no**] **match server access-list** *ipv6-access-list-name*
	Example:
	`;;Assume a preconfigured IPv6 Access List as follows:`
	`Switch(config)# ipv6 access-list my_acls`
	`Switch(config-ipv6-acl)# permit host FE80::A8BB:CCFF:FE01:F700 any`
	`;;configure DCHPv6 Guard to match approved access list.`
	`Switch(config-dhcp-guard)#  match server access-list my_acls`
		(Optional). Enables verification that the advertised DHCPv6 server or relay address is from an authorized server access list (The destination address in the access list is 'any'). If not configured, this check will be bypassed. An empty access list is treated as a permit all.

Step 5	[**no**] **match reply prefix-list** *ipv6-prefix-list-name*
	Example:
	`;;Assume a preconfigured IPv6 prefix list as follows:`
	`Switch(config)# ipv6 prefix-list my_prefix permit 2001:0DB8::/64 le 128`
	`;; Configure DCHPv6 Guard to match prefix`
	`Switch(config-dhcp-guard)#  match reply prefix-list my_prefix`
		(Optional) Enables verification of the advertised prefixes in DHCPv6 reply messages from the configured authorized prefix list. If not configured, this check will be bypassed. An empty prefix list is treated as a permit.

Step 6	[**no**]**preference**{ **max** *limit* | **min** *limit* }
	Example:
	`Switch(config-dhcp-guard)# preference max 250`
	`Switch(config-dhcp-guard)#preference min 150`
		Configure **max** and **min** when **device-role** is **server**to filter DCHPv6 server advertisements by the server preference value. The defaults permit all advertisements.
		max *limit*—(0 to 255) (Optional) Enables verification that the advertised preference (in preference option) is less than the specified limit. Default is 255. If not specified, this check will be bypassed.
		min *limit*—(0 to 255) (Optional) Enables verification that the advertised preference (in preference option) is greater than the specified limit. Default is 0. If not specified, this check will be bypassed.

	Command or Action	Purpose
Step 7	[**no**] **trusted-port** **Example:** `Switch(config-dhcp-guard)# trusted-port`	(Optional) **trusted-port**—Sets the port to a trusted mode. No further policing takes place on the port. **Note** If you configure a trusted port then the device-role option is not available.

Step 8	**default** {**device-role** | **trusted-port**}
	Example:
	`Switch(config-dhcp-guard)# default device-role`
		(Optional) **default**—Sets a command to its defaults.

Step 9	**do show ipv6 dhcp guard policy** *policy_name*
	Example:
	`Switch(config-dhcp-guard)# do show ipv6 dhcp guard policy example_policy`
		(Optional) Displays the configuration of the IPv6 DHCP guard policy without leaving the configuration submode. Omitting the *policy_name* variable displays all DHCPv6 policies.

Example of DHCPv6 Guard Configuration

```
enable
configure terminal
ipv6 access-list acl1
 permit host FE80::A8BB:CCFF:FE01:F700 any
ipv6 prefix-list abc permit 2001:0DB8::/64 le 128
ipv6 dhcp guard policy pol1
 device-role server
 match server access-list acl1
 match reply prefix-list abc
 preference min 0
 preference max 255
 trusted-port
interface GigabitEthernet 0/2/0
 switchport
 ipv6 dhcp guard attach-policy pol1 vlan add 1
 vlan 1
  ipv6 dhcp guard attach-policy pol1
show ipv6 dhcp guard policy pol1
```

How to Attach an IPv6 DHCP Guard Policy to an Interface or a VLAN on an Interface

Beginning in privileged EXEC mode, follow these steps to configure IPv6 Binding Table Content :

SUMMARY STEPS

1. **configure terminal**
2. **interface** Interface_type *stack/module/port*
3. **ipv6 dhcp guard** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_id*s | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
4. **do show running-config interface** Interface_type *stack/module/port*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface** Interface_type *stack/module/port* **Example:** `Switch(config)#  interface gigabitethernet 1/1/4`	Specifies an interface type and identifier; enters the interface configuration mode.

Step 3	**ipv6 dhcp guard** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_ids* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
	Example:
	`Switch(config-if)# ipv6 dhcp guard attach-policy example_policy`
	`or`
	`Switch(config-if)# ipv6 dhcp guard attach-policy example_policy vlan 222,223,224`
	`or`
	`Switch(config-if)# ipv6 dhcp guard vlan 222, 223,224`
		Attaches the DHCP Guard policy to the interface or the specified VLANs on that interface. The default policy is attached if the **attach-policy** option is not used.

Step 4	**do show running-config interface** Interface_type *stack/module/port*
	Example:
	`Switch#(config-if)#  do show running-config gig 1/1/4`
		Confirms that the policy is attached to the specified interface without exiting the configuration mode.

How to Attach an IPv6 DHCP Guard Policy to a Layer 2 EtherChannel Interface

Beginning in privileged EXEC mode, follow these steps to attach an IPv6 DHCP Guard policy on an EtherChannel interface or VLAN:

SUMMARY STEPS

1. **configure terminal**
2. **interface range** *Interface_name*
3. **ipv6 dhcp guard** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_ids* | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]

4. **do show running-config interface***portchannel_interface_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 2	**interface range** *Interface_name* **Example:** `Switch(config)#  interface Po11`	Specify the port-channel interface name assigned when the EtherChannel was created. Enters the interface range configuration mode. **Tip** Enter the **do show interfaces summary** command for quick reference to interface names and types.

Step 3	**ipv6 dhcp guard** [**attach-policy** *policy_name* [**vlan** {*vlan_ids* | **add** *vlan_ids* | **except** *vlan_ids* | **none** | **remove** *vlan_ids* | **all**}] | **vlan** [{*vlan_id*s | **add** *vlan_ids* | **except***vlan_ids* | **none** | **remove** *vlan_ids* | **all**}]
	Example:
	`Switch(config-if-range)# ipv6 dhcp guard attach-policy example_policy`
	`or`
	`Switch(config-if-range)# ipv6 dhcp guard attach-policy example_policy vlan 222,223,224`
	`or`
	`Switch(config-if-range)#ipv6 dhcp guard vlan 222, 223,224`
		Attaches the DHCP Guard policy to the interface or the specified VLANs on that interface. The default policy is attached if the **attach-policy** option is not used.

Step 4	**do show running-config interface***portchannel_interface_name*
	Example:
	`Switch#(config-if-range)#  do show running-config int po11`
		Confirms that the policy is attached to the specified interface without exiting the configuration mode.

How to Configure IPv6 Source Guard

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. [**no**] **ipv6 source-guard policy** *policy_name*
4. [**deny global-autoconf**] [**permit link-local**] [**default**{. . . }] [**exit**] [**no**{. . . }]
5. **end**
6. **show ipv6 source-guard policy** *policy_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 3	[**no**] **ipv6 source-guard policy** *policy_name* **Example:** `Switch(config)#  ipv6 source-guard policy example_policy`	Specifies the IPv6 Source Guard policy name and enters IPv6 Source Guard policy configuration mode.
Step 4	[**deny global-autoconf**] [**permit link-local**] [**default**{. . . }] [**exit**] [**no**{. . . }] **Example:** `Switch(config-sisf-sourceguard)#  deny global-autoconf`	(Optional) Defines the IPv6 Source Guard policy. • **deny global-autoconf**—Denies data traffic from auto-configured global addresses. This is useful when all global addresses on a link are DHCP-assigned and the administrator wants to block hosts with self-configured addresses to send traffic. • **permit link-local**—Allows all data traffic that is sourced by a link-local address. **Note** Trusted option under source guard policy is not supported.

Step 5	**end**
	Example:
	`Switch(config-sisf-sourceguard)# end`
		Exits out of IPv6 Source Guard policy configuration mode.

Step 6	**show ipv6 source-guard policy** *policy_name* **Example:** `Switch# show ipv6 source-guard policy example_policy`	Shows the policy configuration and all the interfaces where the policy is applied.

What to do next

Apply the IPv6 Source Guard policy to an interface.

How to Attach an IPv6 Source Guard Policy to an Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** Interface_type *stack/module/port*
4. **ipv6 source-guard** [**attach-policy** <*policy_name*>]
5. **show ipv6 source-guard policy** *policy_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 3	**interface** Interface_type *stack/module/port* **Example:** `Switch(config)#  interface gigabitethernet 1/1/4`	Specifies an interface type and identifier; enters the interface configuration mode.
Step 4	**ipv6 source-guard** [**attach-policy** <*policy_name*>] **Example:** `Switch(config-if)# ipv6 source-guard attach-policy example_policy`	Attaches the IPv6 Source Guard policy to the interface. The default policy is attached if the **attach-policy** option is not used.
Step 5	**show ipv6 source-guard policy** *policy_name* **Example:** `Switch#(config-if)# show ipv6 source-guard policy example_policy`	Shows the policy configuration and all the interfaces where the policy is applied.

How to attach an IPv6 Source Guard Policy to a Layer 2 EtherChannel Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface port-channel** *port-channel-number*

4. **ipv6 source-guard** [**attach-policy** <*policy_name*>]
5. **show ipv6 source-guard policy** *policy_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters the global configuration mode.
Step 3	**interface port-channel** *port-channel-number* **Example:** `Device (config)# interface Po4`	Specifies an interface type and port number and places the switch in the port channel configuration mode.
Step 4	**ipv6 source-guard** [**attach-policy** <*policy_name*>] **Example:** `Device(config-if) # ipv6 source-guard attach-policy example_policy`	Attaches the IPv6 Source Guard policy to the interface. The default policy is attached if the **attach-policy** option is not used.
Step 5	**show ipv6 source-guard policy** *policy_name* **Example:** `Device(config-if) #show ipv6 source-guard policy example_policy`	Shows the policy configuration and all the interfaces where the policy is applied.

How to Configure IPv6 Prefix Guard

Note To allow routing protocol control packets sourced by a link-local address when prefix guard is applied, enable the permit link-local command in the source-guard policy configuration mode.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. [**no**] **ipv6 source-guard policy** *source-guard-policy*
4. [**no**] **validate address**
5. **validate prefix**
6. **exit**

7. **show ipv6 source-guard policy** [*source-guard-policy*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	[**no**] **ipv6 source-guard policy** *source-guard-policy* **Example:** `Device(config)# ipv6 source-guard policy my_snooping_policy`	Defines an IPv6 source-guard policy name and enters switch integrated security features source-guard policy configuration mode.
Step 4	[**no**] **validate address** **Example:** `Device(config-sisf-sourceguard)# no validate address`	Disables the validate address feature and enables the IPv6 prefix guard feature to be configured.
Step 5	**validate prefix** **Example:** `Device(config-sisf-sourceguard)# validate prefix`	Enables IPv6 source guard to perform the IPv6 prefix-guard operation.
Step 6	**exit** **Example:** `Device(config-sisf-sourceguard)# exit`	Exits switch integrated security features source-guard policy configuration mode and returns to privileged EXEC mode.
Step 7	**show ipv6 source-guard policy** [*source-guard-policy*] **Example:** `Device# show ipv6 source-guard policy policy1`	Displays the IPv6 source-guard policy configuration.

How to Attach an IPv6 Prefix Guard Policy to an Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** Interface_type *stack/module/port*
4. **ipv6 source-guard attach-policy** *policy_name*

5. **show ipv6 source-guard policy** *policy_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters the global configuration mode.
Step 3	**interface** Interface_type *stack/module/port* **Example:** `Switch(config)#  interface gigabitethernet 1/1/4`	Specifies an interface type and identifier; enters the interface configuration mode.
Step 4	**ipv6 source-guard attach-policy** *policy_name* **Example:** `Switch(config-if)# ipv6 source-guard attach-policy example_policy`	Attaches the IPv6 Source Guard policy to the interface. The default policy is attached if the **attach-policy** option is not used.
Step 5	**show ipv6 source-guard policy** *policy_name* **Example:** `Switch(config-if)# show ipv6 source-guard policy example_policy`	Shows the policy configuration and all the interfaces where the policy is applied.

How to attach an IPv6 Prefix Guard Policy to a Layer 2 EtherChannel Interface

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface port-channel** *port-channel-number*
4. **ipv6 source-guard** [**attach-policy** <*policy_name*>]
5. **show ipv6 source-guard policy** *policy_name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
	`Device> enable`	
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters the global configuration mode.
Step 3	**interface port-channel** *port-channel-number* **Example:** `Device (config)# interface Po4`	Specifies an interface type and port number and places the switch in the port channel configuration mode.
Step 4	**ipv6 source-guard** [**attach-policy** <*policy_name*>] **Example:** `Device(config-if)# ipv6 source-guard attach-policy example_policy`	Attaches the IPv6 Source Guard policy to the interface. The default policy is attached if the **attach-policy** option is not used.
Step 5	**show ipv6 source-guard policy** *policy_name* **Example:** `Device(config-if)# show ipv6 source-guard policy example_policy`	Shows the policy configuration and all the interfaces where the policy is applied.

Configuration Examples for IPv6 First Hop Security

Examples: How to attach an IPv6 Source Guard Policy to a Layer 2 EtherChannel Interface

The following example shows how to attach an IPv6 Source Guard Policy to a Layer 2 EtherChannel Interface:

```
Switch# configure terminal
Switch(config)# ipv6 source-guard policy POL
Switch(config-sisf-sourceguard) # validate address
switch(config-sisf-sourceguard)# exit
Switch(config)# interface Po4
Switch(config)# ipv6 snooping
Switch(config-if)# ipv6 source-guard attach-policy POL
Switch(config-if)# exit
switch(config)#
```

Examples: How to attach an IPv6 Prefix Guard Policy to a Layer 2 EtherChannel Interface

The following example shows how to attach an IPv6 Prefix Guard Policy to a Layer 2 EtherChannel Interface:

```
Switch# configure terminal
Switch(config)# ipv6 source-guard policy POL
Switch (config-sisf-sourceguard)# no validate address
```

```
Switch((config-sisf-sourceguard)# validate prefix
Switch(config)# interface Po4
Switch(config-if)# ipv6 snooping
Switch(config-if)# ipv6 source-guard attach-policy POL
```

Additional References

Related Documents

Related Topic	Document Title
Implementing IPv6 Addressing and Basic Connectivity	[illegible]
IPv6 network management and security topics	IPv6 Configuration Library, Cisco IOS XE Release 3SE (Catalyst 3850 Switches) [illegible]
IPv6 Command Reference	IPv6 Command Reference, Cisco IOS XE Release 3SE (Catalyst 3850 Switches) [illegible]

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

CHAPTER 48

Per-User ACL Support for 802.1X/MAB/Webauth Users

This feature allows per-user ACLs to be downloaded from the Cisco Access Control Server (ACS) as policy enforcement after authentication using IEEE 802.1X, MAB authentication bypass, or web authentication.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

PrerequisitesforPer-UserACLSupportfor802.1X/MAB/Webauth Users

- AAA authentication must be enabled.
- AAA authorization must be enabled by using the **network** keyword to allow interface configuration from the RADIUS server.
- 802.1X authentication must be enabled.
- The user profile and VSAs must be configured on the RADIUS server.

Restrictions for Per-User ACL Support for 802.1X/MAB/Webauth Users

- Per-user Access Control Lists (ACLs) are supported only in single-host mode.
- This feature does not support standard ACLs on the switch port.
- Only one 802.1X-authenticated user is supported on a port. If the multiple-hosts mode is enabled on the port, the per-user ACL attribute is disabled for the associated port.
- The maximum size of the per-user ACL is 4000 ASCII characters but is limited by the maximum size of RADIUS-server per-user ACLs.

Information About Per-User ACL Support for 802.1X/MAB/Webauth Users

802.1X Authentication with Per-User ACLs

Per-user access control lists (ACLs) can be configured to provide different levels of network access and service to an 802.1X-authenticated user. When the RADIUS server authenticates a user that is connected to an 802.1X port, it retrieves the ACL attributes based on the user identity and sends them to the switch. The switch applies the attributes to the 802.1X port for the duration of the user session. The switch removes the per-user ACL configuration when the session is over, if authentication fails, or if a link-down condition occurs. The switch does not save RADIUS-specified ACLs in the running configuration. When the port is unauthorized, the switch removes the ACL from the port.

RADIUS supports per-user attributes, including vendor-specific attributes. These vendor-specific attributes (VSAs) are in octet-string format and are passed to the switch during the authentication process. The VSAs used for per-user ACLs are inacl#<n > for the ingress direction and outacl#<n > for the egress direction. MAB ACLs are supported only in the ingress direction. The switch supports VSAs only in the ingress direction. It does not support port ACLs in the egress direction on Layer 2 ports. For more information, see the “Configuring Network Security with ACLs|” module.

The extended ACL syntax style should be used to define the per-user configuration that is stored on the RADIUS server. When the definitions are passed from the RADIUS server, they are created by using the extended naming convention. However, if the Filter-Id attribute is used, it can point to a standard ACL.

The Filter-Id attribute can be used to specify an inbound or outbound ACL that is already configured on the switch. The attribute contains the ACL number followed by *.in* for ingress filtering or *.out* for egress filtering. If the RADIUS server does not allow the *.in* or *.out* syntax, the access list is applied to the outbound ACL by default. Because of limited support of Cisco IOS access lists on the switch, the Filter-Id attribute is supported only for IP ACLs numbered 1 to 199 and 1300 to 2699 (IP standard and IP extended ACLs).

Only one 802.1X-authenticated user is supported on a port. If the multiple-hosts mode is enabled on the port, the per-user ACL attribute is disabled for the associated port.

The maximum size of the per-user ACL is 4000 ASCII characters but is limited by the maximum size of RADIUS-server per-user ACLs.

How to Configure Per-User ACL Support for 802.1X/MAB/Webauth Users

Configuring Downloadable ACLs

To configure a switch to accept downloadable ACLs or redirect URLs from the RADIUS server during authentication of an attached host, perform this task.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip device tracking**
4. **aaa new-model**
5. **aaa authorization network default group radius**
6. **radius-server vsa send authentication**
7. **interface** *interface-id*
8. **ip access-group** *acl-id* **in**
9. end
10. **show running-config interface***interface-id*
11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted .
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip device tracking** **Example:** `Switch(config)# ip device tracking`	Enables the IP device tracking table.
Step 4	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA.

	Command or Action	Purpose
Step 5	**aaa authorization network default group radius** **Example:** `Switch(config)# aaa authorization network default group radius`	Sets the authorization method. To remove the authorization method, use the **no aaa authorization network default group radius** command.
Step 6	**radius-server vsa send authentication** **Example:** `Switch(config)# radius-server vsa send autentication`	Configures the network access server.
Step 7	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/1`	Specifies the port to be configured, and enters interface configuration mode.
Step 8	**ip access-group** *acl-id* **in** **Example:** `Switch(config-if)# ip access-group 99 in`	Configures the default ACL on the port in the input direction. **Note** The ACL ID is an access list name or number.
Step 9	end	`Switch(config-if)# end` Returns to Privileged EXEC mode.
Step 10	**show running-config interface***interface-id* **Example:** `Switch# show running-config interface interface-id`	Displays the specific interface configuration for verification.
Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Save entries in the configuration file.

Configuration Examples for Per-User ACL Support for 802.1X/MAB/Webauth Users

Example: Configuring a Switch for a Downloadable Policy

The following example shows how to configure a switch for a downloadable policy:

```
Switch# configure terminal
Switch(config)# aaa new-model
Switch(config)# aaa authorization network default local group radius
Switch(config)# ip device tracking
Switch(config)# ip access-list extended default_acl
Switch(config-ext-nacl)# permit ip any any
Switch(config-ext-nacl)# exit
Switch(config)# radius-server vsa send authentication
Switch(config)# interface fastEthernet 2/13
Switch(config-if)# ip access-group default_acl in
Switch(config-if)# exit
```

Additional References

Related Documents

Related Topic	Document Title
Authentication commands	*Cisco IOS Security Command Reference Commands A to C*
IPsec	*Cisco IOS Security Configuration Guide: Secure Connectivity, Release 15.0.*
RADIUS	"Configuring RADIUS" module.
Standalone MAB Support	*Standalone MAB Support*
Layer 2 ports	Configuring Network Security with ACLs

Standards and RFCs

Standard/RFC	Title
IEEE 802.1X protocol	—
RFC 3580	*IEEE 802.1x Remote Authentication Dial In User Service (RADIUS)*

MIBs

MIB	MIBs Link
• CISCO–AUTH–FRAMEWORK–MIB • CISCO–MAB–AUTH–BYPASS–MIB • CISCO–PAE–MIB • IEEE8021–PAE–MIB	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

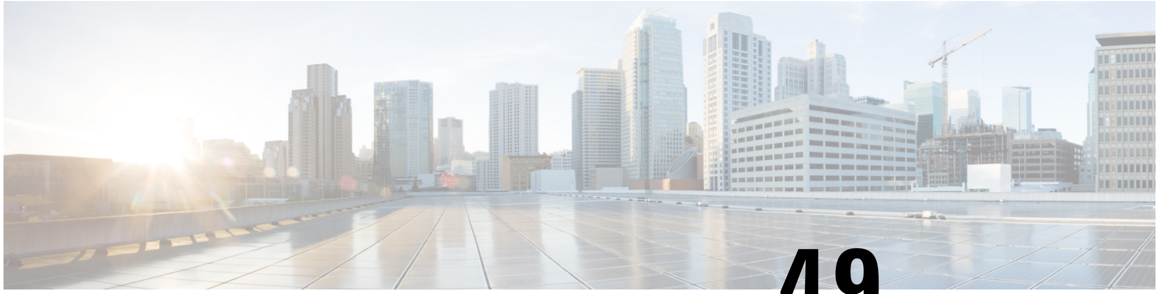
Feature Information for Per-User ACL Support for 802.1X/MAB/Webauth Users

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 99: Feature Information for Per-User ACL Support for 802.1X/MAB/Webauth Users

Feature Name	Releases	Feature Information
Per-User ACL Support for 802.1X/MAB/Webauth Users		This feature allows per-user ACLs to be downloaded from the Cisco Access Control Server (ACS) as policy enforcement after authentication using IEEE 802.1X, MAB authentication bypass, or web authentication.



CHAPTER 49

Web Authentication Redirection to Original URL

The Web Authentication Redirection to Original URL feature enables networks to redirect guest users to the URL that they had originally requested. This feature is enabled by default and requires no configuration. This module provides information about this feature.

Web Authentication Redirection to Original URL Overview

The Web Authentication Redirection to Original URL feature enables networks to redirect guest users to the URL that they had originally requested. This feature is enabled by default and requires no configuration.

Guest networks are network connections provided by an enterprise to allow their guests to gain access to the Internet and to their own enterprise networks without compromising the security of the host enterprise. Guest users of an enterprise network can connect to the guest access network through either a wired Ethernet connection or a wireless connection.

Guest access uses a captive portal to gather all web requests made by guests and redirect these requests to one of the guest on-boarding web pages. When guests successfully complete the guest workflow, they are redirected to the page that they had originally requested.

The originally requested URL is passed as metadata along with the Cisco Identity Services Engine (ISE) guest access redirect URL. The Cisco ISE is a security policy management and control platform. It automates and simplifies access control and security compliance for wired, wireless, and VPN connectivity. The requested URL is added at the end of the Cisco ISE guest URL so that the device can send the redirect URL to the guest client. The Cisco ISE parses the URL and redirects the guest to the original URL after completing the on-boarding.

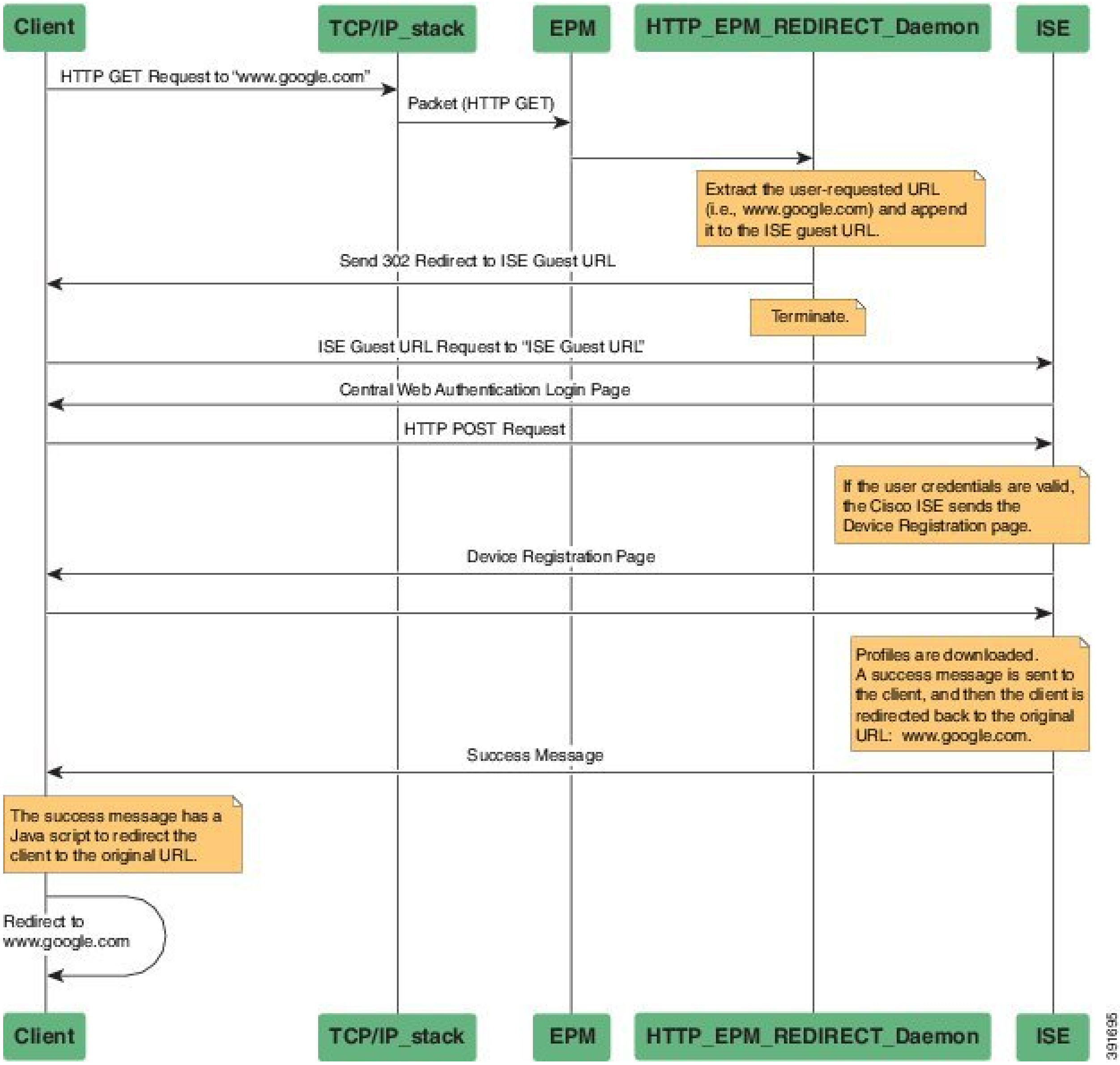
The following is an example of a redirect URL along with the original requested URL:

```
https://10.64.67.92:8443/guestportal/gateway?sessionId=0920269E0000000B0002426B&action=cwa&redirect_
url=http://www.cisco.com/
```

In this example, the URL, https://10.64.67.92:8443/guestportal/gateway?sessionId= 0920269E0000000B0002426B&action=cwa is the URL for the guest portal, “&” tells the browser that what follows is a list of name value pairs, and redirect_url=http://www.cisco.com identifies the URL that the user originally requested and to which the user is redirected after completing the guest workflow.

This illustration displays the packet flow that redirects a user to the originally requested URL:

Figure 65: Original URL Redirection Packet Flow


Client
TCP/IP_stack
EPM
HTTP_EPM_REDIRECT_Daemon
ISE
HTTP GET Request to "www.google.com"
Packet (HTTP GET)
Extract the user-requested URL (i.e., www.google.com) and append it to the ISE guest URL.
Send 302 Redirect to ISE Guest URL
Terminate.
ISE Guest URL Request to "ISE Guest URL"
Central Web Authentication Login Page
HTTP POST Request
If the user credentials are valid, the Cisco ISE sends the Device Registration page.
Device Registration Page
Profiles are downloaded. A success message is sent to the client, and then the client is redirected back to the original URL: www.google.com.
Success Message
The success message has a Java script to redirect the client to the original URL.
Redirect to www.google.com
391695

1. A user accesses a network for the first time and sends an HTTP request to access www.google.com. When the user first accesses the network, a MAC authentication bypass (MAB) is triggered and the MAC address is sent to the Cisco ISE.

2. The Cisco ISE returns a RADIUS access-accept message (even if the MAC address is not received) along with the redirect access control list (ACL), the ACL-WEBAUTH-REDIRECT message, and the guest web portal URL to the device.

   The RADIUS message instructs the device to open a port that is restricted based on the configured port and the redirect ACLs, for regular network traffic.

3. When the user launches a web browser, the device intercepts the HTTP traffic and redirects the browser to the Cisco ISE central web authentication (CWA) guest web portal URL; the user-requested URL is extracted and appended to the Cisco ISE guest URL.
4. When the user is authenticated, the Cisco ISE sends the Device Registration page to the user. The user enters the required information, and the page is returned to the Cisco ISE. The Cisco ISE downloads user profiles and redirects the user to the originally requested URL: www.google.com.

Additional References for Web Authentication Redirection to Original URL

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
IBNS commands	Cisco IOS Identity-Based Networking Services Command Reference
Wired guest access	"Wired Guest Access" module of the *Identity-Based Networking Services Configuration Guide*

Technical Assistance

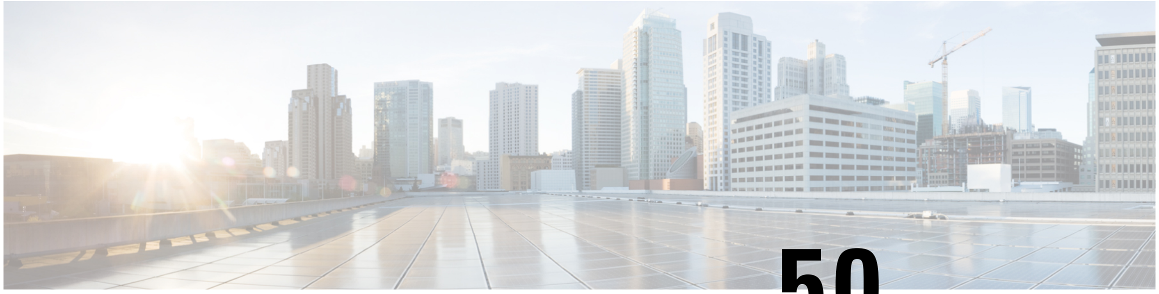
Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for Web Authentication Redirection to Originial URL

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Feature Name	Releases	Feature Information
Web Authentication Redirection to Original URL	Cisco IOS Release 15.2(6)E	The Web Authentication Redirection to Original URL feature enables networks to redirect guest users to the original URL that they had request. This feature is enabled by default and requires no configuration. In



CHAPTER 50

Configuring Web-Based Authentication

The Web-Based Authentication feature, also known as web authentication proxy, authenticates end users on host systems that do not run the IEEE 802.1x supplicant.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for Web-Based Authentication

- Web-based authentication and url-redirect are not supported on the same port at the same time.

Information About Web-Based Authentication

Web-Based Authentication Overview

Use the web-based authentication feature, known as web authentication proxy, to authenticate end users on host systems that do not run the IEEE 802.1x supplicant.

Note You can configure web-based authentication on Layer 2 interfaces only.

When you initiate an HTTP session, web-based authentication intercepts ingress HTTP packets from the host and sends an HTML login page to the users. The users enter their credentials, which the web-based authentication feature sends to the authentication, authorization, and accounting (AAA) server for authentication.

If authentication succeeds, web-based authentication sends a Login-Successful HTML page to the host and applies the access policies returned by the AAA server.

If authentication fails, web-based authentication forwards a Login-Fail HTML page to the user, prompting the user to retry the login. If the user exceeds the maximum number of attempts, web-based authentication forwards a Login-Expired HTML page to the host, and the user is placed on a watch list for a waiting period.

Note HTTPS traffic interception for central web authentication redirect is not supported.

Note You should use global parameter-map (for method-type, custom, and redirect) only for using the same web authentication methods like consent, web consent, and webauth, for all the clients and SSIDs. This ensures that all the clients have the same web-authentication method.

If the requirement is to use Consent for one SSID and Web-authentication for another SSID, then you should use two named parameter-maps. You should configure Consent in first parameter-map and configure webauth in second parameter-map.

Based on where the web pages are hosted, the local web authention can be categorozied as follows:

- *Internal*—The internal default HTML pages (Login, Success, Fail, and Expire) in the controller are used during the local web authentication.
- *Customized*—The customized web pages (Login, Success, Fail, and Expire) are downloaded onto the controller and used during the local web authentication.
- *External*—The customized web pages are hosted on the external web server instead of using the in-built or custom web pages.

Based on the various web authentication pages, the types of web authentication are as follows:

- *Webauth*—This is a basic web authentication. Herein, the controller presents a policy page with the user name and password. You need to enter the correct credentials to access the network.
- *Consent or web-passthrough*—Herein, the controller presents a policy page with the Accept or Deny buttons. You need to click the Accept button to access the network.
- *Webconsent*—This is a combination of webauth and consent web authentication types. Herein, the controller presents a policy page with Accept or Deny buttons along with user name or password. You need to enter the correct credentials and click the Accept button to access the network.

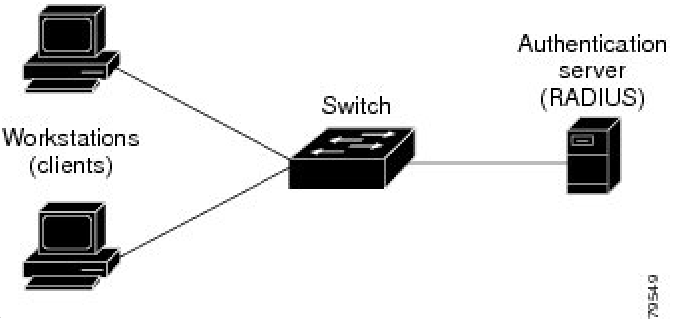
Device Roles

With web-based authentication, the devices in the network have these specific roles:

- *Client*—The device (workstation) that requests access to the LAN and the services and responds to requests from the switch. The workstation must be running an HTML browser with Java Script enabled.
- *Authentication server*—Authenticates the client. The authentication server validates the identity of the client and notifies the switch that the client is authorized to access the LAN and the switch services or that the client is denied.
- *Switch*—Controls the physical access to the network based on the authentication status of the client. The switch acts as an intermediary (proxy) between the client and the authentication server, requesting identity information from the client, verifying that information with the authentication server, and relaying a response to the client.

Figure 66: Web-Based Authentication Device Roles

This figure shows the roles of these devices in a network.



Host Detection

The switch maintains an IP device tracking table to store information about detected hosts.

For Layer 2 interfaces, web-based authentication detects IP hosts by using these mechanisms:

- ARP based trigger—ARP redirect ACL allows web-based authentication to detect hosts with a static IP address or a dynamic IP address.
- Dynamic ARP inspection
- DHCP snooping—Web-based authentication is notified when the switch creates a DHCP-binding entry for the host.

Session Creation

When web-based authentication detects a new host, it creates a session as follows:

- Reviews the exception list.

  If the host IP is included in the exception list, the policy from the exception list entry is applied, and the session is established.
- Reviews for authorization bypass

If the host IP is not on the exception list, web-based authentication sends a nonresponsive-host (NRH) request to the server.

If the server response is access accepted, authorization is bypassed for this host. The session is established.

- Sets up the HTTP intercept ACL

  If the server response to the NRH request is access rejected, the HTTP intercept ACL is activated, and the session waits for HTTP traffic from the host.

Authentication Process

When you enable web-based authentication, these events occur:

- The user initiates an HTTP session.
- The HTTP traffic is intercepted, and authorization is initiated. The switch sends the login page to the user. The user enters a username and password, and the switch sends the entries to the authentication server.
- If the authentication succeeds, the switch downloads and activates the user's access policy from the authentication server. The login success page is sent to the user.
- If the authentication fails, the switch sends the login fail page. The user retries the login. If the maximum number of attempts fails, the switch sends the login expired page, and the host is placed in a watch list. After the watch list times out, the user can retry the authentication process.
- If the authentication server does not respond to the switch, and if an AAA fail policy is configured, the switch applies the failure access policy to the host. The login success page is sent to the user.
- The switch reauthenticates a client when the host does not respond to an ARP probe on a Layer 2 interface.
- The feature applies the downloaded timeout or the locally configured session timeout.
- If the terminate action is RADIUS, the feature sends a nonresponsive host (NRH) request to the server. The terminate action is included in the response from the server.
- If the terminate action is default, the session is dismantled, and the applied policy is removed.

Using Authentication Proxy

The authentication proxy feature requires some user interaction on the client host. The table below describes the interaction of the authentication proxy with the client host.

Table 100: Authentication Proxy Interaction with the Client Host

Authentication Proxy Action with Client	Description
Triggering on HTTP connections	If a user is not currently authenticated at the firewall router, any HTTP connection initiated by the user triggers the authentication proxy. If the user is already authenticated, the authentication proxy is transparent to the user.

Authentication Proxy Action with Client	Description
Logging in using the login page	Triggering the authentication proxy generates an HTML-based login page. The user must enter a username and password to be authenticated with the AAA server. The Authentication Proxy Login Page figure, in the How the Authentication Proxy Works module, illustrates the authentication proxy login page.
Authenticating the user at the client	Following the login attempt, the authentication proxy action can vary depending on whether JavaScript is enabled in the browser. If JavaScript is enabled, and authentication is successful, the authentication proxy displays a message indicating the status of the authentication as shown in the Authentication Proxy Login Status Message figure, in the How the Authentication Proxy Works module. After the authentication status is displayed, the proxy automatically completes the HTTP connection. If JavaScript is disabled, and authentication is successful, the authentication proxy generates a popup window with additional instructions for completing the connection. See the Authentication Proxy Login Status Message with JavaScript Disabled figure, in the Secure Authentication module. If authentication is unsuccessful in any case, the user must log in again from the login page.

When to Use the Authentication Proxy

The following are some situations in which you can use the authentication proxy:

- You want to manage access privileges on an individual (per-user) basis using the services provided by the authentication servers instead of configuring access control based on host IP address or global access policies. Authenticating and authorizing users from any host IP address also allows network administrators to configure host IP addresses using DHCP.
- You want to authenticate and authorize local users before permitting access to intranet or Internet services.
- You want to authenticate and authorize remote users before permitting access to local services.
- You want to control access for specific extranet users. For example, you might want to authenticate and authorize the financial officer of a corporate partner with one set of access privileges while authorizing the technology officer for that same partner to use another set of access privileges.
- You want to use the authentication proxy in conjunction with VPN client software to validate users and to assign specific access privileges.
- You want to use the authentication proxy in conjunction with AAA accounting to generate “start” and “stop” accounting records that can be used for billing, security, or resource allocation purposes, thereby allowing users to track traffic from the authenticated hosts.

Applying Authentication Proxy

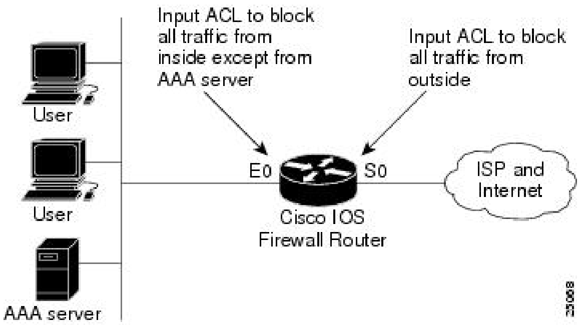
Apply the authentication proxy in the inbound direction at any interface on the router where you want per-user authentication and authorization. Applying the authentication proxy inbound at an interface causes it to intercept the initial connection request from an user, before that request is subjected to any other processing. If the user fails to gain authentication with the AAA server, the connection request is dropped.

How you apply the authentication proxy depends on your security policy. For example, you can block all traffic through an interface and enable the authentication proxy feature to require authentication and authorization for all user-initiated HTTP connections. Users are authorized for services only after successful authentication with the AAA server.

The authentication proxy feature also allows you to use standard access lists to specify a host or group of hosts whose initial HTTP traffic triggers the proxy.

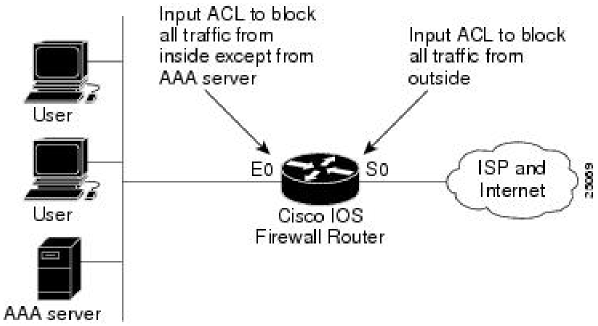
The figure below shows the authentication proxy applied at the LAN interface with all network users required to be authenticated upon the initial connection (all traffic is blocked at each interface).

Figure 67: Applying the Authentication Proxy at the Local Interface


Input ACL to block all traffic from inside except from AAA server
Input ACL to block all traffic from outside
User
User
AAA server
E0
S0
Cisco IOS Firewall Router
ISP and Internet
25068

The figure below shows the authentication proxy applied at the dial-in interface with all network traffic blocked at each interface.

Figure 68: Applying the Authentication Proxy at an Outside Interface


Input ACL to block all traffic from inside except from AAA server
Input ACL to block all traffic from outside
User
User
AAA server
E0
S0
Cisco IOS Firewall Router
ISP and Internet
25069

Local Web Authentication Banner

With Web Authentication, you can create a default and customized web-browser banners that appears when you log in to a switch.

The banner appears on both the login page and the authentication-result pop-up pages. The default banner messages are as follows:

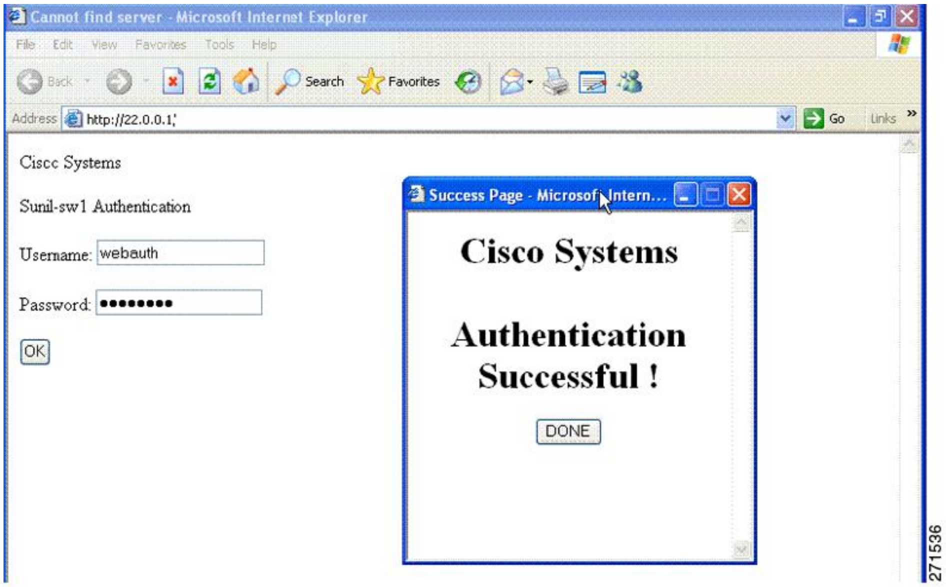
- *Authentication Successful*
- *Authentication Failed*
- *Authentication Expired*

The Local Web Authentication Banner can be configured in legacy and new-style (Session-aware) CLIs as follows:

- Legacy mode—Use the **ip admission auth-proxy-banner http** global configuration command.
- New-style mode—Use the **parameter-map type webauth global banner** global configuration command.

The default banner *Cisco Systems* and *Switch host-name Authentication* appear on the Login Page. *Cisco Systems* appears on the authentication result pop-up page.

Figure 69: Authentication Successful Banner


Cannot find server - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Address
Go
Links
OK
Success Page - Microsoft Intern...
DONE
271536

http://22.0.0.1/

Cisco Systems

Sunil-sw1 Authentication

Username: webauth

Password: •••••••••

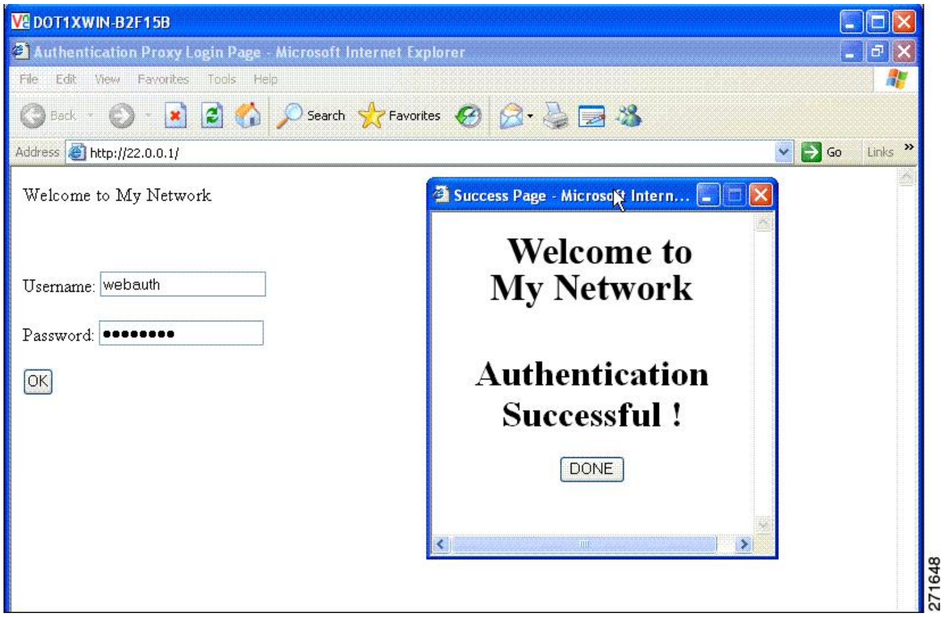
Cisco Systems

Authentication Successful !

The banner can be customized as follows:

- Add a message, such as switch, router, or company name to the banner:
  - Legacy mode—Use the **ip admission auth-proxy-banner http** *banner-text*global configuration command.
  - New-style mode—Use the **parameter-map type webauth global banner** global configuration command.
- Add a logo or text file to the banner:
  - Legacy mode—Use the **ip admission auth-proxy-banner http** *file-path* global configuration command.
  - New-style mode—Use the **parameter-map type webauth global banner** global configuration command.

Figure 70: Customized Web Banner


DOT1XWIN-B2F15B
Authentication Proxy Login Page - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://22.0.0.1/
Go Links
Success Page - Microsoft Intern...
OK
DONE
271648

Welcome to My Network

Username: webauth

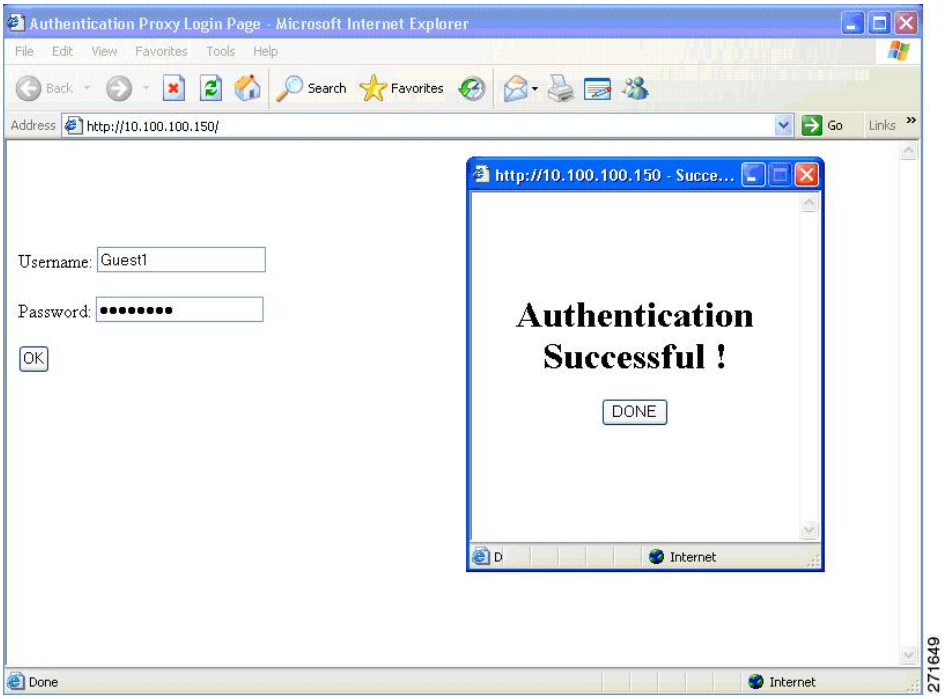
Password: ●●●●●●●●●

Welcome to My Network

Authentication Successful !

If you do not enable a banner, only the username and password dialog boxes appear in the web authentication login screen, and no banner appears when you log into the switch.

Figure 71: Login Screen With No Banner


Authentication Proxy Login Page - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://10.100.100.150/
Go Links
http://10.100.100.150 - Succe...
OK
DONE
D
Internet
Done
Internet
271649

Username: Guest1

Password: ●●●●●●●●●

Authentication Successful !

Web Authentication Customizable Web Pages

During the web-based authentication process, the switch internal HTTP server hosts four HTML pages to deliver to an authenticating client. The server uses these pages to notify you of these four-authentication process states:

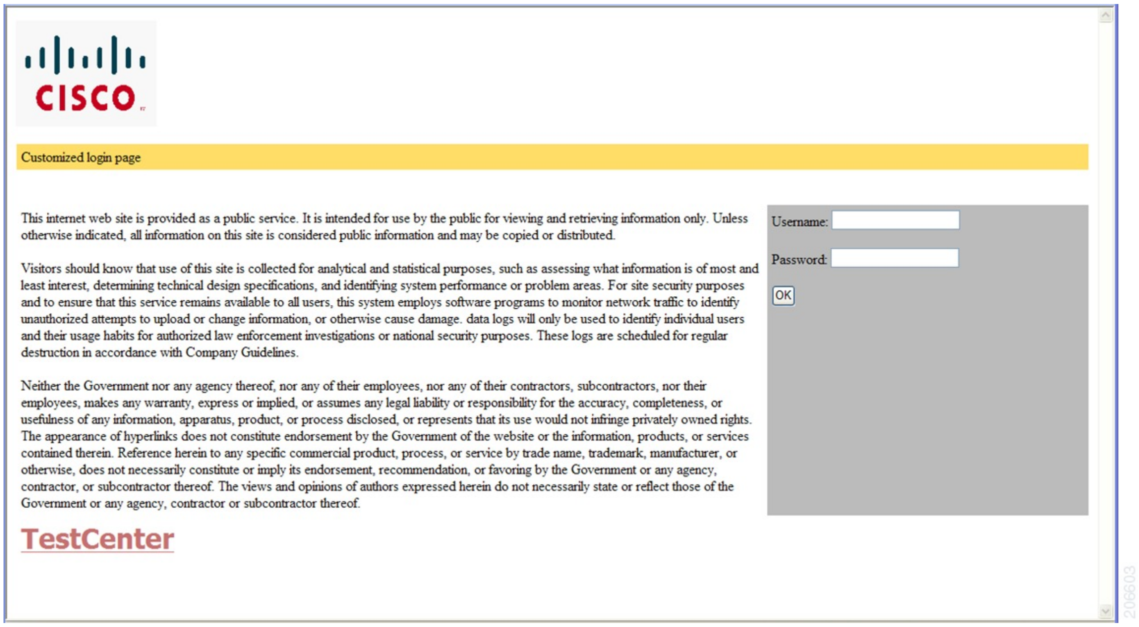
- Login—Your credentials are requested.
- Success—The login was successful.
- Fail—The login failed.
- Expire—The login session has expired because of excessive login failures.

Guidelines

- You can substitute your own HTML pages for the default internal HTML pages.
- You can use a logo or specify text in the *login*, *success*, *failure*, and *expire* web pages.
- On the banner page, you can specify text in the login page.
- The pages are in HTML.
- You must include an HTML redirect command in the success page to access a specific URL.
- The URL string must be a valid URL (for example, http://www.cisco.com). An incomplete URL might cause *page not found* or similar errors on a web browser.
- If you configure web pages for HTTP authentication, they must include the appropriate HTML commands (for example, to set the page time out, to set a hidden password, or to confirm that the same page is not submitted twice).
- The CLI command to redirect users to a specific URL is not available when the configured login form is enabled. The administrator should ensure that the redirection is configured in the web page.
- If the CLI command redirecting users to specific URL after authentication occurs is entered and then the command configuring web pages is entered, the CLI command redirecting users to a specific URL does not take effect.
- Configured web pages can be copied to the switch boot flash or flash.
- The login page can be on one flash, and the success and failure pages can be another flash.
- You must configure all four pages.
- The banner page has no effect if it is configured with the web page.
- All of the logo files (image, flash, audio, video, and so on) that are stored in the system directory (for example, flash, disk0, or disk) and that must be displayed on the login page must use *web_auth_<filename>* as the file name.
- The configured authentication proxy feature supports both HTTP and SSL.

You can substitute your HTML pages for the default internal HTML pages. You can also specify a URL to which users are redirected after authentication occurs, which replaces the internal Success page.

Figure 72: Customizable Authentication Page



Customized login page

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Visitors should know that use of this site is collected for analytical and statistical purposes, such as assessing what information is of most and least interest, determining technical design specifications, and identifying system performance or problem areas. For site security purposes and to ensure that this service remains available to all users, this system employs software programs to monitor network traffic to identify unauthorized attempts to upload or change information, or otherwise cause damage. data logs will only be used to identify individual users and their usage habits for authorized law enforcement investigations or national security purposes. These logs are scheduled for regular destruction in accordance with Company Guidelines.

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Authentication Proxy Web Page Guidelines

When configuring customized authentication proxy web pages, follow these guidelines:

- To enable the custom web pages feature, specify all four custom HTML files. If you specify fewer than four files, the internal default HTML pages are used.
- The four custom HTML files must be present on the flash memory of the switch. The maximum size of each HTML file is 8 KB.
- Any images on the custom pages must be on an accessible HTTP server. Configure an intercept ACL within the admission rule.
- Any external link from a custom page requires configuration of an intercept ACL within the admission rule.
- To access a valid DNS server, any name resolution required for external links or images requires configuration of an intercept ACL within the admission rule.
- If the custom web pages feature is enabled, a configured auth-proxy-banner is not used.
- If the custom web pages feature is enabled, the redirection URL for successful login feature is not available.
- To remove the specification of a custom file, use the **no** form of the command.

Because the custom login page is a public web form, consider these guidelines for the page:

- The login form must accept user entries for the username and password and must show them as **uname** and **pwd**.
- The custom login page should follow best practices for a web form, such as page timeout, hidden password, and prevention of redundant submissions.

Web-based Authentication Interactions with Other Features

802.1x Authentication

These are the 802.1x authentication configuration guidelines:

- When 802.1x authentication is enabled, ports are authenticated before any other Layer 2 or Layer 3 features are enabled.
- If the VLAN to which an 802.1x-enabled port is assigned changes, this change is transparent and does not affect the switch. For example, this change occurs if a port is assigned to a RADIUS server-assigned VLAN and is then assigned to a different VLAN after re-authentication.

  If the VLAN to which an 802.1x port is assigned to shut down, disabled, or removed, the port becomes unauthorized. For example, the port is unauthorized after the access VLAN to which a port is assigned shuts down or is removed.
- The 802.1x protocol is supported on Layer 2 static-access ports, voice VLAN ports, and Layer 3 routed ports, but it is not supported on these port types:
  - Dynamic ports—A port in dynamic mode can negotiate with its neighbor to become a trunk port. If you try to enable 802.1x authentication on a dynamic port, an error message appears, and 802.1x authentication is not enabled. If you try to change the mode of an 802.1x-enabled port to dynamic, an error message appears, and the port mode is not changed.
  - EtherChannel port—Do not configure a port that is an active or a not-yet-active member of an EtherChannel as an 802.1x port. If you try to enable 802.1x authentication on an EtherChannel port, an error message appears, and 802.1x authentication is not enabled.
  - Switched Port Analyzer (SPAN) and Remote SPAN (RSPAN) destination ports—You can enable 802.1x authentication on a port that is a SPAN or RSPAN destination port. However, 802.1x authentication is disabled until the port is removed as a SPAN or RSPAN destination port. You can enable 802.1x authentication on a SPAN or RSPAN source port.
- Before globally enabling 802.1x authentication on a switch by entering the **dot1x system-auth-control** global configuration command, remove the EtherChannel configuration from the interfaces on which 802.1x authentication and EtherChannel are configured.
- Cisco IOS Release 12.2(55)SE and later supports filtering of system messages related to 802.1x authentication.

AAA Accounting with Authentication Proxy

Using the authentication proxy, you can generate “start” and “stop” accounting records with enough information to be used for billing and security auditing purposes. Thus, you can monitor the actions of authenticated hosts that use the authentication proxy service.

When an authentication proxy cache expires and is deleted, additional data, such as elapsed time, is added to the accounting information and a “stop” record is sent to the server. At this point, the information is deleted from the data structure.

The accounting records for the authentication proxy user session are related to the cache and the dynamic ACL usage.

ACLs

You must configure port ACLs on interfaces for web-based authentication.

Ensure that sufficient TCAM space is available to enable web-based authentication.

If you configure a VLAN ACL or a Cisco IOS ACL on an interface, the ACL is applied to the host traffic only after the web-based authentication host policy is applied.

For Layer 2 web-based authentication, it is more secure, though not required, to configure a port ACL (PACL) as the default access policy for ingress traffic from hosts connected to the port. After authentication, the web-based authentication host policy overrides the PACL. The Policy ACL is applied to the session even if there is no ACL configured on the port.

You cannot configure a MAC ACL and web-based authentication on the same interface.

You cannot configure web-based authentication on a port whose access VLAN is configured for VACL capture.

Context-Based Access Control

Web-based authentication cannot be configured on a Layer 2 port if context-based access control (CBAC) is configured on the Layer 3 VLAN interface of the port VLAN.

Gateway IP

You cannot configure Gateway IP (GWIP) on a Layer 3 VLAN interface if web-based authentication is configured on any of the switch ports in the VLAN.

You can configure web-based authentication on the same Layer 3 interface as Gateway IP. The host policies for both features are applied in software. The GWIP policy overrides the web-based authentication host policy.

LAN Port IP

You can configure LAN port IP (LPIP) and Layer 2 web-based authentication on the same port. The host is authenticated by using web-based authentication first, followed by LPIP posture validation. The LPIP host policy overrides the web-based authentication host policy.

If the web-based authentication idle timer expires, the NAC policy is removed. The host is authenticated, and posture is validated again.

Port Security

You can configure web-based authentication and port security on the same port. Web-based authentication authenticates the port, and port security manages network access for all MAC addresses, including that of the client. You can then limit the number or group of clients that can access the network through the port.

Default Web-Based Authentication Configuration

The following table shows the default web-based authentication configuration.

Table 101: Default Web-based Authentication Configuration

Feature	Default Setting
AAA	Disabled

Feature	Default Setting
RADIUS server • IP address • UDP authentication port • Key	• None specified • 1645 • None specified
Default value of inactivity timeout	3600 seconds
Inactivity timeout	Enabled

Web-Based Authentication Configuration Guidelines and Restrictions

- Web-based authentication is an ingress-only feature.
- You can configure web-based authentication only on access ports. Web-based authentication is not supported on trunk ports, EtherChannel member ports, or dynamic trunk ports.
- Port ACLs must be present in the port configuration. If they are not present, adding intercept ACL will fail.
- Port ACLs should be configured sufficiently to allow the necessary traffic after authentication.
- The switch supports one web authentication client per port on all host modes. Having multiple clients may lead to unexpected results and is not recommended.
- Configuring port ACLs in the authentication rule for web authentication is not allowed because DACL is not supported.
- You cannot authenticate hosts on Layer 2 interfaces with static ARP cache assignment. These hosts are not detected by the web-based authentication feature because they do not send ARP messages.
- By default, the IP device tracking feature is disabled on a switch. You must enable the IP device tracking feature to use web-based authentication.
- You must configure at least one IP address to run the switch HTTP server. You must also configure routes to reach each host IP address. The HTTP server sends the HTTP login page to the host.
- Hosts that are more than one hop away might experience traffic disruption if an STP topology change results in the host traffic arriving on a different port. This occurs because the ARP and DHCP updates might not be sent after a Layer 2 (STP) topology change.
- Web-based authentication does not support VLAN assignment as a downloadable-host policy.
- Web-based authentication and Network Edge Access Topology (NEAT) are mutually exclusive. You cannot use web-based authentication when NEAT is enabled on an interface, and you cannot use NEAT when web-based authentication is running on an interface.
- Web-based authentication NRH (Non-Responsive Host) is not supported for voice devices.
- Only the Password Authentication Protocol (PAP) is supported for web-based RADIUS authentication on controllers. The Challenge Handshake Authentication Protocol (CHAP) is not supported for web-based RADIUS authentication on controllers.

- Identify the following RADIUS security server settings that will be used while configuring switch-to-RADIUS-server communication:
  - Host name
  - Host IP address
  - Host name and specific UDP port numbers
  - IP address and specific UDP port numbers

  The combination of the IP address and UDP port number creates a unique identifier, that enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service (for example, authentication) the second host entry that is configured functions as the failover backup to the first one. The RADIUS host entries are chosen in the order that they were configured.

- When you configure the RADIUS server parameters:
  - Specify the **key** *string* on a separate command line.
  - For **key** *string*, specify the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server. The key is a text string that must match the encryption key used on the RADIUS server.
  - When you specify the **key** *string*, use spaces within and at the end of the key. If you use spaces in the key, do not enclose the key in quotation marks unless the quotation marks are part of the key. This key must match the encryption used on the RADIUS daemon.
  - You can globally configure the timeout, retransmission, and encryption key values for all RADIUS servers by using with the **radius-server host** global configuration command. If you want to configure these options on a per-server basis, use the **radius-server timeout**, radius-server transmit, and the radius-server key global configuration commands.

Note You need to configure some settings on the RADIUS server, including: the switch IP address, the key string to be shared by both the server and the switch, and the downloadable ACL (DACL). For more information, see the RADIUS server documentation.

- You cannot start a web-based authentication session from a PC connected to an IP phone in MDA/MA mode (because downloadable ACLs are not supported.
- The switch cannot be configured as gateway for web-based authentication clients (because there is no Layer 3 lookup happening on the switch). Instead, configure an uplink device switch virtual interface (SVI) as gateway.
- The total TCAM space according to the ASIC is limited to 384. So if port ACLs and Web-based authentication is configured across all the ports, the total number of sessions will depend on the access control entries (ACE) that have been configured on the switch. (Ports configured with web-based authentication will not share ACLs in the TCAM. Once the TCAM space is full with port ACLs, web-based authentication sessions will not start.)

How to Configure Web-Based Authentication

Configuring the Authentication Rule and Interfaces

Follow these steps to configure the authentication rule and interfaces:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip admission name** *name* **proxy http**
4. **interface** *type slot/port*
5. **ip access-group** *name*
6. **ip admission name**
7. **exit**
8. **ip device tracking**
9. **end**
10. **show ip admission**
11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip admission name** *name* **proxy http** **Example:** `Switch(config)# ip admission name webauth1 proxy http`	Configures an authentication rule for web-based authorization.

	Command or Action	Purpose
Step 4	**interface** *type slot/port* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Enters interface configuration mode and specifies the ingress Layer 2 or Layer 3 interface to be enabled for web-based authentication. *type* can be fastethernet, gigabit ethernet, or tengigabitethernet.
Step 5	**ip access-group** *name* **Example:** `Switch(config-if)# ip access-group webauthag`	Applies the default ACL.
Step 6	**ip admission name** **Example:** `Switch(config)# ip admission name`	Configures an authentication rule for web-based authorization for the interface.
Step 7	**exit** **Example:** `Switch(config-if)# exit`	Returns to configuration mode.
Step 8	**ip device tracking** **Example:** `Switch(config)# ip device tracking`	Enables the IP device tracking table.

Step 9	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 10	**show ip admission** **Example:** `Switch# show ip admission`	Displays the configuration.
Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring AAA Authentication

SUMMARY STEPS

1. **aaa new-model**
2. **aaa authentication login default group** {**tacacs+** | **radius**}
3. **aaa authorization auth-proxy default group** {**tacacs+** | **radius**}
4. **tacacs-server host** {*hostname* | *ip_address*}
5. **tacacs-server key** {*key-data*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**aaa new-model** **Example:** `Switch(config)# aaa new-model`	Enables AAA functionality.
Step 2	**aaa authentication login default group** {**tacacs+** | **radius**} **Example:** `Switch(config)# aaa authentication login default group tacacs+`	Defines the list of authentication methods at login. **named_authentication_list** refers to any name that is not greater than 31 characters. **AAA_group_name** refers to the server group name. You need to define the server-group **server_name** at the beginning itself.

Step 3	**aaa authorization auth-proxy default group** {**tacacs+** | **radius**}
	Example:
	`Switch(config)# aaa authorization auth-proxy default group tacacs+`
		Creates an authorization method list for web-based authorization.

Step 4	**tacacs-server host** {*hostname* | *ip_address*}
	Example:
	`Switch(config)# tacacs-server host 10.1.1.1`
		Specifies an AAA server.

Step 5	**tacacs-server key** {*key-data*}
	Example:
	`Switch(config)# tacacs-server key`
		Configures the authorization and encryption key used between the switch and the TACACS server.

Configuring Switch-to-RADIUS-Server Communication

Follow these steps to configure the RADIUS server parameters:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip radius source-interface**
4. **radius-server host** {*hostname* | *ip-address*} **test username** *username*
5. **radius-server key** *string*
6. **radius-server dead-criteria tries** *num-tries*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip radius source-interface** **Example:** `Switch(config)# ip radius source-interface vlan 80`	Specifies that the RADIUS packets have the IP address of the indicated interface.
Step 4	**radius-server host** {*hostname* | *ip-address*} **test username** *username* **Example:** `Switch(config)# radius-server host 172.120.39.46 test username user1`	Specifies the host name or IP address of the remote RADIUS server. The **test username** *username* option enables automated testing of the RADIUS server connection. The specified *username* does not need to be a valid user name. The **key** option specifies an authentication and encryption key to use between the switch and the RADIUS server. To use multiple RADIUS servers, reenter this command for each server.

	Command or Action	Purpose
Step 5	**radius-server key** *string* **Example:** `Switch(config)# radius-server key rad123`	Configures the authorization and encryption key used between the switch and the RADIUS daemon running on the RADIUS server.
Step 6	**radius-server dead-criteria tries** *num-tries* **Example:** `Switch(config)# radius-server dead-criteria tries 30`	Specifies the number of unanswered sent messages to a RADIUS server before considering the server to be inactive. The range of *num-tries* is 1 to 100.

Step 7	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Configuring the HTTP Server

To use web-based authentication, you must enable the HTTP server within the Switch. You can enable the server for either HTTP or HTTPS.

Note The Apple psuedo-browser will not open if you configure only the **ip http secure-server** command. You should also configure the **ip http server** command.

Follow these steps to enable the server for either HTTP or HTTPS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip http server**
4. **ip http secure-server**
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip http server** **Example:** `Switch(config)# ip http server`	Enables the HTTP server. The web-based authentication feature uses the HTTP server to communicate with the hosts for user authentication.
Step 4	**ip http secure-server** **Example:** `Switch(config)# ip http secure-server`	Enables HTTPS. You can configure custom authentication proxy web pages or specify a redirection URL for successful login. **Note** To ensure secure authentication when you enter the **ip http secure-server** command, the login page is always in HTTPS (secure HTTP) even if the user sends an HTTP request.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Customizing the Authentication Proxy Web Pages

You can configure web authentication to display four substitute HTML pages to the user in place of the Switch default HTML pages during web-based authentication.

Follow these steps to specify the use of your custom authentication proxy web pages:

Before you begin

Store your custom HTML files on the Switch flash memory.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip admission proxy http login page file** *device:login-filename*
4. **ip admission proxy http success page file** *device:success-filename*
5. **ip admission proxy http failure page file** *device:fail-filename*
6. **ip admission proxy http login expired page file** *device:expired-filename*
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip admission proxy http login page file** *device:login-filename* **Example:** `Switch(config)# ip admission proxy http login page file disk1:login.htm`	Specifies the location in the Switch memory file system of the custom HTML file to use in place of the default login page. The *device:* is flash memory.
Step 4	**ip admission proxy http success page file** *device:success-filename* **Example:** `Switch(config)# ip admission proxy http success page file disk1:success.htm`	Specifies the location of the custom HTML file to use in place of the default login success page.
Step 5	**ip admission proxy http failure page file** *device:fail-filename* **Example:** `Switch(config)# ip admission proxy http fail page file disk1:fail.htm`	Specifies the location of the custom HTML file to use in place of the default login failure page.
Step 6	**ip admission proxy http login expired page file** *device:expired-filename* **Example:** `Switch(config)# ip admission proxy http login expired page file disk1:expired.htm`	Specifies the location of the custom HTML file to use in place of the default login expired page.
Step 7	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	

Configuring the Web-Based Authentication Parameters

Follow these steps to configure the maximum number of failed login attempts before the client is placed in a watch list for a waiting period:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip admission max-login-attempts** *number*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip admission max-login-attempts** *number* **Example:** `Switch(config)# ip admission max-login-attempts 10`	Sets the maximum number of failed login attempts. The range is 1 to 2147483647 attempts. The default is 5.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a Web Authentication Local Banner

For the equivalent Session Aware Networking configuration example for this feature, see the section "Configuring a Parameter Map for Web-Based Authentication" in the chapter, "Configuring Identity Control Policies" of the book,"*Session Aware Networking Configuration Guide, Cisco IOS XE Release 3SE (Catalyst 3850 Switches)*."

Beginning in privileged EXEC mode, follow these steps to configure a local banner on a switch that has web authentication configured.

SUMMARY STEPS

1. **configure terminal**
2. **ip auth-proxy auth-proxy-banner http** [*banner-text* | *file-path*]
3. **end**
4. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 2	**ip auth-proxy auth-proxy-banner http** [*banner-text* | *file-path*]
	Example:
	`Switch(config)# aaa ip auth-proxy auth-proxy-banner`
	` C My Switch C`
		Enables the local banner.
		(Optional) Create a custom banner by entering *C banner-text C*, where *C* is a delimiting character or a file-path indicates a file (for example, a logo or text file) that appears in the banner.

Step 3	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 4	**copy running-config startup-config** **Example:** `Switch(config)# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Central Web Authentication

Central Web Authentication (CWA) is a process where a policy server, like Cisco Identity Services Engine (ISE), is used to centrally authenticate users via Web Authentication. Having a central policy server for Web Authentication makes it easier to implement operationally. CWA supports both ACL and VLAN-based enforcement. Additionally, RADIUS CoA is also supported. This allows for posture assessment and enforcement based on profiling.

Note CWA is introduced for the Catalyst 2960-L switch from Cisco IOS Release 15.2(5)E1.

For details on how to configure Central Web Authentication for all Catalyst switches, refer to the Central Web Authentication with a Switch and Identity Services Engine Configuration Example document.

Removing Web-Based Authentication Cache Entries

Follow these steps to remove web-based authentication cache entries:

SUMMARY STEPS

1. **enable**
2. **clear ip admission cache** {* | *host ip address*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**clear ip admission cache** {* | *host ip address*} **Example:** `Switch# clear ip admission cache 192.168.4.5`	Delete authentication proxy entries. Use an asterisk to delete all cache entries. Enter a specific IP address to delete the entry for a single host.

Monitoring Web-Based Authentication Status

Use the commands in this topic to display the web-based authentication settings for all interfaces or for specific ports.

Table 102: Privileged EXEC show Commands

Command	Purpose
show authentication sessions method webauth	Displays the web-based authentication settings for all interfaces for fastethernet, gigabitethernet, or tengigabitethernet
show wireless client mac-address *a.a.a* **detail**	Displays the session specific wireless information and wireless states.
show authentication sessions interface *type slot/port*[**details**]	Displays the web-based authentication settings for the specified interface for fastethernet, gigabitethernet, or tengigabitethernet. In Session Aware Networking mode, use the **show access-session interface** command.

Displaying Web-Based Authentication Status

Perform this task to display the web-based authentication settings for all interfaces or for specific ports:

SUMMARY STEPS

1. **show authentication sessions** {**interface***type/ slot*}

DETAILED STEPS

	Command or Action	Purpose

Step 1	**show authentication sessions** {**interface***type/ slot*}
	Example:
	This example shows how to view only the global web-based authentication status:
	`Switch# show authentication sessions`
	Example:
	This example shows how to view the web-based authentication settings for gigabit interface 3/27:
	`Switch# show authentication sessions interface gigabitethernet 3/27`
		Displays the web-based authentication settings.
		type = fastethernet, gigabitethernet, or tengigabitethernet
		(Optional) Use the interface keyword to display the web-based authentication settings for a specific interface

Monitoring HTTP Authentication Proxy

Perform the following task to troubleshoot your HTTP authentication proxy configuration:

SUMMARY STEPS

1. **enable**
2. **debug ip admission all**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**debug ip admission all** **Example:** `Device# debug ip admission all`	Displays all IP admission debugging information for web-based authentication.

Verifying HTTPS Authentication Proxy

To verify your HTTPS authentication proxy configuration, perform the following optional steps:

SUMMARY STEPS

1. **enable**
2. **show ip admission { status | cache }**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

Step 2	**show ip admission { status | cache }**
	Example:
	`Device# show ip admission cache`
		Display the network admission configuration status and cache entries for web authentication sessions.

Configuration Examples for Web-Based Authentication

Example: Configuring the Authentication Rule and Interfaces

This example shows how to enable web-based authentication on Fast Ethernet port 5/1 :

```
Switch(config)# ip admission name webauth1 proxy http
Switch(config)# interface fastethernet 5/1
Switch(config-if)# ip admission webauth1
Switch(config-if)# exit
Switch(config)# ip device tracking
```

This example shows how to verify the configuration:

```
Switch# show ip admission
IP admission status:
  Enabled interfaces           0
  Total sessions               0
  Init sessions                0     Max init sessions allowed     100
    Limit reached              0     Hi watermark                  0
  TCP half-open connections    0     Hi watermark                  0
  TCP new connections          0     Hi watermark                  0
  TCP half-open + new          0     Hi watermark                  0
  HTTPD1 Contexts              0     Hi watermark                  0

  Parameter Map: Global
    Custom Pages
      Custom pages not configured
    Banner
      Banner not configured
```

Example: AAA Configuration

```
aaa new-model
aaa authentication login default group tacacs group radius
! Set up the aaa new model to use the authentication proxy.
aaa authorization auth-proxy default group tacacs group radius
! Define the AAA servers used by the router.
aaa accounting auth-proxy default start-stop group tacacs+
! Set up authentication proxy with accounting.
tacacs-server host 172.31.54.143
tacacs-server key cisco
radius-server host 172.31.54.143
radius-server key cisco
```

Example: HTTP Server Configuration

```
! Enable the HTTP server on the router.
ip http server
! Set the HTTP server authentication method to AAA.
ip http authentication aaa
! Define standard access list 61 to deny any host.
access-list 61 deny any
! Use ACL 61 to deny connections from any host to the HTTP server.
ip http access-class 61
```

Example: Customizing the Authentication Proxy Web Pages

This example shows how to configure custom authentication proxy web pages:

```
Switch(config)# ip admission proxy http login page file flash:login.htm
Switch(config)# ip admission proxy http success page file flash:success.htm
Switch(config)# ip admission proxy http fail page file flash:fail.htm
Switch(config)# ip admission proxy http login expired page flash flash:expired.htm
```

The following output displays the host IP addresses, the session timeout, and the posture states. If the posture statue is POSTURE ESTAB, the host validation was successful.

```
Switch# show ip admission cache eapoudp
Posture Validation Proxy Cache
Total Sessions: 3 Init Sessions: 1
 Client IP 10.0.0.112, timeout 60, posture state POSTURE ESTAB
 Client IP 10.0.0.142, timeout 60, posture state POSTURE INIT
 Client IP 10.0.0.205, timeout 60, posture state POSTURE ESTAB
```

Example: Specifying a Redirection URL for Successful Login

Configuring redirection URL for successful login

```
Switch(config)# ip admission proxy http success redirect www.cisco.com
```

Verifying redirection URL for Successful Login

This example shows how to configure a redirection URL for successful login:

Additional References for Web-Based Authentication

Related Documents

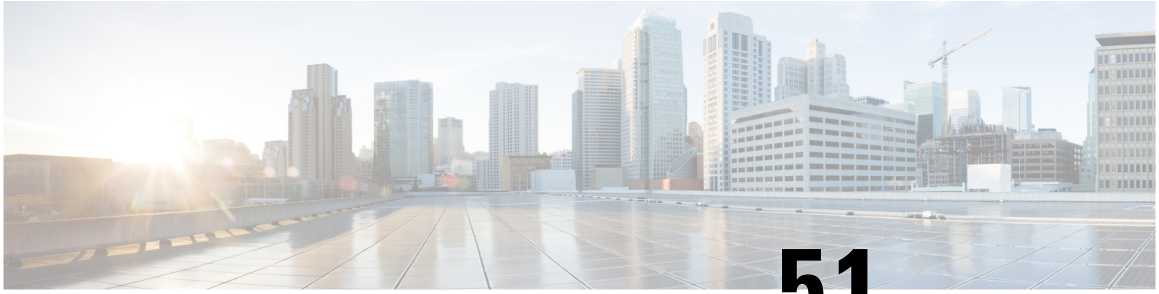
Related Topic	Document Title
IBNS commands	Cisco IOS Identity-Based Networking Services Command Reference

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information for Web-Based Authentication

Release	Feature Information
Cisco IOS Release 15.2(5)E	This feature is introduced.



CHAPTER 51

Configuring Port-Based Traffic Control

Overview of Port-Based Traffic Control

Port-based traffic control is a set of Layer 2 features on the Cisco Catalyst switches used to filter or block packets at the port level in response to specific traffic conditions. The following port-based traffic control features are supported in the Cisco IOS Release for which this guide is written:

- Storm Control
- Protected Ports
- Port Blocking
- Port Security
- Protocol Storm Protection

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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Information About Storm Control

Storm Control

Storm control prevents traffic on a LAN from being disrupted by a broadcast, multicast, or unicast storm on one of the physical interfaces. A LAN storm occurs when packets flood the LAN, creating excessive traffic and degrading network performance. Errors in the protocol-stack implementation, mistakes in network configurations, or users issuing a denial-of-service attack can cause a storm.

Storm control (or traffic suppression) monitors packets passing from an interface to the switching bus and determines if the packet is unicast, multicast, or broadcast. The switch counts the number of packets of a specified type received within the 1-second time interval and compares the measurement with a predefined suppression-level threshold.

How Traffic Activity is Measured

Storm control uses one of these methods to measure traffic activity:

- Bandwidth as a percentage of the total available bandwidth of the port that can be used by the broadcast, multicast, or unicast traffic

- Traffic rate in packets per second at which broadcast, multicast, or unicast packets are received
- Traffic rate in bits per second at which broadcast, multicast, or unicast packets are received
- Traffic rate in packets per second and for small frames. This feature is enabled globally. The threshold for small frames is configured for each interface.

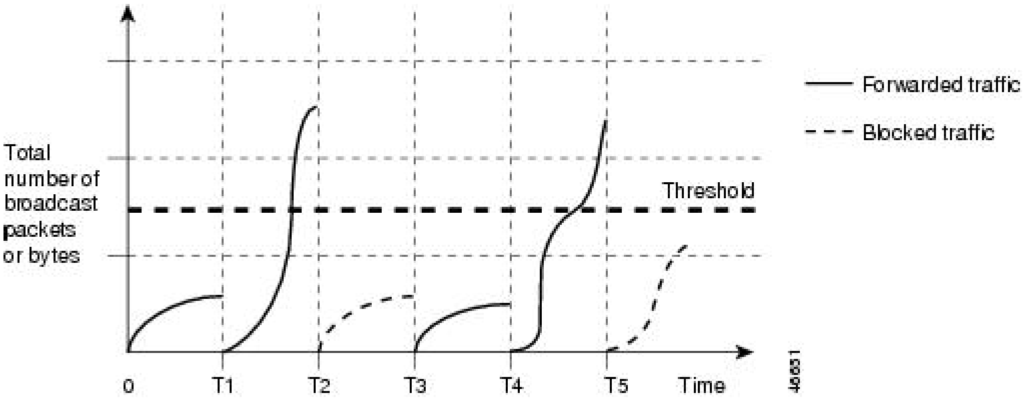
With each method, the port blocks traffic when the rising threshold is reached. The port remains blocked until the traffic rate drops below the falling threshold (if one is specified) and then resumes normal forwarding. If the falling suppression level is not specified, the switch blocks all traffic until the traffic rate drops below the rising suppression level. In general, the higher the level, the less effective the protection against broadcast storms.

Note When the storm control threshold for multicast traffic is reached, all multicast traffic except control traffic, such as bridge protocol data unit (BDPU) and Cisco Discovery Protocol (CDP) frames, are blocked. However, the switch does not differentiate between routing updates, such as OSPF, and regular multicast data traffic, so both types of traffic are blocked.

Traffic Patterns

Figure 73: Broadcast Storm Control Example

This example shows broadcast traffic patterns on an interface over a given period of time.



Broadcast traffic being forwarded exceeded the configured threshold between time intervals T1 and T2 and between T4 and T5. When the amount of specified traffic exceeds the threshold, all traffic of that kind is dropped for the next time period. Therefore, broadcast traffic is blocked during the intervals following T2 and T5. At the next time interval (for example, T3), if broadcast traffic does not exceed the threshold, it is again forwarded.

The combination of the storm-control suppression level and the 1-second time interval controls the way the storm control algorithm works. A higher threshold allows more packets to pass through. A threshold value of 100 percent means that no limit is placed on the traffic. A value of 0.0 means that all broadcast, multicast, or unicast traffic on that port is blocked.

Note Because packets do not arrive at uniform intervals, the 1-second time interval during which traffic activity is measured can affect the behavior of storm control.

You use the **storm-control** interface configuration commands to set the threshold value for each traffic type.

How to Configure Storm Control

Configuring Storm Control and Threshold Levels

You configure storm control on a port and enter the threshold level that you want to be used for a particular type of traffic.

However, because of hardware limitations and the way in which packets of different sizes are counted, threshold percentages are approximations. Depending on the sizes of the packets making up the incoming traffic, the actual enforced threshold might differ from the configured level by several percentage points.

Note Storm control is supported on physical interfaces. You can also configure storm control on an EtherChannel. When storm control is configured on an EtherChannel, the storm control settings propagate to the EtherChannel physical interfaces.

Follow these steps to storm control and threshold levels:

Before you begin

Storm control is supported on physical interfaces. You can also configure storm control on an EtherChannel. When storm control is configured on an EtherChannel, the storm control settings propagate to the EtherChannel physical interfaces.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **storm-control action** {**shutdown** | **trap**}
5. **storm-control** {**broadcast** | **multicast** | **unicast**} **level** {*level* [*level-low*] | **bps** *bps* [*bps-low*] | **pps** *pps* [*pps-low*]}
6. **end**
7. **show storm-control** [*interface-id*] [**broadcast** | **multicast** | **unicast**]
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Switch> enable`	- Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the interface to be configured, and enter interface configuration mode.

Step 4	**storm-control action** {**shutdown** | **trap**}
	Example:
	`Switch(config-if)# storm-control action trap`
		Specifies the action to be taken when a storm is detected. The default is to filter out the traffic and not to send traps.
		- Select the **shutdown** keyword to error-disable the port during a storm.
		- Select the **trap** keyword to generate an SNMP trap when a storm is detected.

Step 5	**storm-control** {**broadcast** | **multicast** | **unicast**} **level** {*level* [*level-low*] | **bps** *bps* [*bps-low*] | **pps** *pps* [*pps-low*]}
	Example:
	`Switch(config-if)# storm-control unicast level 87 65`
		Configures broadcast, multicast, or unicast storm control. By default, storm control is disabled.
		The keywords have these meanings:
		- For *level*, specifies the rising threshold level for broadcast, multicast, or unicast traffic as a percentage (up to two decimal places) of the bandwidth. The port blocks traffic when the rising threshold is reached. The range is 0.00 to 100.00.
		- (Optional) For *level-low*, specifies the falling threshold level as a percentage (up to two decimal places) of the bandwidth. This value must be less than or equal to the rising suppression value. The port forwards traffic when traffic drops below this level. If you do not configure a falling suppression level, it is set to the rising suppression level. The range is 0.00 to 100.00.
		If you set the threshold to the maximum value (100 percent), no limit is placed on the traffic. If you set the threshold to 0.0, all broadcast, multicast, and unicast traffic on that port is blocked.
		- For **bps** *bps*, specifies the rising threshold level for broadcast, multicast, or unicast traffic in bits per second (up to one decimal place). The port blocks

	Command or Action	Purpose
		traffic when the rising threshold is reached. The range is 0.0 to 10000000000.0. • (Optional) For *bps-low*, specifies the falling threshold level in bits per second (up to one decimal place). It can be less than or equal to the rising threshold level. The port forwards traffic when traffic drops below this level. The range is 0.0 to 10000000000.0. • For **pps** *pps*, specifies the rising threshold level for broadcast, multicast, or unicast traffic in packets per second (up to one decimal place). The port blocks traffic when the rising threshold is reached. The range is 0.0 to 10000000000.0. • (Optional) For *pps-low*, specifies the falling threshold level in packets per second (up to one decimal place). It can be less than or equal to the rising threshold level. The port forwards traffic when traffic drops below this level. The range is **0.0 to** 10000000000.0. For BPS and PPS settings, you can use metric suffixes such as k, m, and g for large number thresholds.

Step 6	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 7	**show storm-control** [*interface-id*] [**broadcast** | **multicast** | **unicast**] **Example:** `Switch# show storm-control gigabitethernet 0/1 unicast`	Verifies the storm control suppression levels set on the interface for the specified traffic type. If you do not enter a traffic type, details for all traffic types (broadcast, multicast and unicast) are displayed.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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Information About Protected Ports

Protected Ports

Some applications require that no traffic be forwarded at Layer 2 between ports on the same switch so that one neighbor does not see the traffic generated by another neighbor. In such an environment, the use of protected ports ensures that there is no exchange of unicast, broadcast, or multicast traffic between these ports on the switch.

Protected ports have these features:

- A protected port does not forward any traffic (unicast, multicast, or broadcast) to any other port that is also a protected port. Data traffic cannot be forwarded between protected ports at Layer 2; only control traffic, such as PIM packets, is forwarded because these packets are processed by the CPU and forwarded in software. All data traffic passing between protected ports must be forwarded through a Layer 3 device.
- Forwarding behavior between a protected port and a nonprotected port proceeds as usual.

Default Protected Port Configuration

The default is to have no protected ports defined.

Protected Ports Guidelines

You can configure protected ports on a physical interface (for example, Gigabit Ethernet port 1) or an EtherChannel group (for example, port-channel 5). When you enable protected ports for a port channel, it is enabled for all ports in the port-channel group.

How to Configure Protected Ports

Configuring a Protected Port

Before you begin

Protected ports are not pre-defined. This is the task to configure one.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*

4. **switchport protected**
5. **end**
6. **show interfaces** *interface-id* **switchport**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the interface to be configured, and enter interface configuration mode.
Step 4	**switchport protected** **Example:** `Switch(config-if)# switchport protected`	Configures the interface to be a protected port.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show interfaces** *interface-id* **switchport** **Example:** `Switch# show interfaces gigabitethernet 0/1 switchport`	Verifies your entries.
Step 7	**show running-config** **Example:**	Verifies your entries.

	Command or Action	Purpose
	`Switch# show running-config`	
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring Protected Ports

Table 103: Commands for Displaying Protected Port Settings

Command	Purpose
show interfaces [*interface-id*] **switchport**	Displays the administrative and operational status of all switching (nonrouting) ports or the specified port, including port blocking and port protection settings.

Where to Go Next

-

Additional References

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature Information

Release	Feature Information
Cisco IOS Release 15.2(5)E	This feature was introduced.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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Information About Port Blocking

Port Blocking

By default, the switch floods packets with unknown destination MAC addresses out of all ports. If unknown unicast and multicast traffic is forwarded to a protected port, there could be security issues. To prevent unknown unicast or multicast traffic from being forwarded from one port to another, you can block a port (protected or nonprotected) from flooding unknown unicast or multicast packets to other ports.

How to Configure Port Blocking

Blocking Flooded Traffic on an Interface

Before you begin

The interface can be a physical interface or an EtherChannel group. When you block multicast or unicast traffic for a port channel, it is blocked on all ports in the port-channel group.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport block multicast**
5. **switchport block unicast**
6. **end**
7. **show interfaces** *interface-id* **switchport**
8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the interface to be configured, and enter interface configuration mode.
Step 4	**switchport block multicast** **Example:**	Blocks unknown multicast forwarding out of the port. **Note** Pure Layer 2 multicast traffic as well as multicast packets that contain IPv6 information in the header are blocked.

	Command or Action	Purpose
	`Switch(config-if)# switchport block multicast`	
Step 5	**switchport block unicast** **Example:** `Switch(config-if)# switchport block unicast`	Blocks unknown unicast forwarding out of the port.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show interfaces** *interface-id* **switchport** **Example:** `Switch# show interfaces gigabitethernet 0/1 switchport`	Verifies your entries.
Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring Port Blocking

Table 104: Commands for Displaying Port Blocking Settings

Command	Purpose
show interfaces [*interface-id*] **switchport**	Displays the administrative and operational status of all switching (nonrouting) ports or the specified port, including port blocking and port protection settings.

Where to Go Next

-

Additional References

Related Documents

Related Topic	Document Title

Error Message Decoder

Description	Link
To help you research and resolve system error messages in this release, use the Error Message Decoder tool.	https://www.cisco.com/cgi-bin/Support/Errordecoder/index.cgi

Standards and RFCs

Standard/RFC	Title

MIBs

MIB	MIBs Link
	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
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Feature Information

Release	Feature Information
Cisco IOS Release 15.2(5)E	This feature was introduced.

Prerequisites for Port Security

Note If you try to set the maximum value to a number less than the number of secure addresses already configured on an interface, the command is rejected.

Restrictions for Port Security

The maximum number of secure MAC addresses that you can configure on a switch is set by the maximum number of available MAC addresses allowed in the system. This number is the total of available MAC addresses, including those used for other Layer 2 functions and any other secure MAC addresses configured on interfaces.

Information About Port Security

Port Security

You can use the port security feature to restrict input to an interface by limiting and identifying MAC addresses of the stations allowed to access the port. When you assign secure MAC addresses to a secure port, the port does not forward packets with source addresses outside the group of defined addresses. If you limit the number of secure MAC addresses to one and assign a single secure MAC address, the workstation attached to that port is assured the full bandwidth of the port.

If a port is configured as a secure port and the maximum number of secure MAC addresses is reached, when the MAC address of a station attempting to access the port is different from any of the identified secure MAC addresses, a security violation occurs. Also, if a station with a secure MAC address configured or learned on one secure port attempts to access another secure port, a violation is flagged.

Related Topics

Enabling and Configuring Port Security
Configuration Examples for Port Security, on page 975

Types of Secure MAC Addresses

The switch supports these types of secure MAC addresses:

- Static secure MAC addresses—These are manually configured by using the **switchport port-security mac-address** *mac-address* interface configuration command, stored in the address table, and added to the switch running configuration.
- Dynamic secure MAC addresses—These are dynamically configured, stored only in the address table, and removed when the switch restarts.
- Sticky secure MAC addresses—These can be dynamically learned or manually configured, stored in the address table, and added to the running configuration. If these addresses are saved in the configuration file, when the switch restarts, the interface does not need to dynamically reconfigure them.

Sticky Secure MAC Addresses

You can configure an interface to convert the dynamic MAC addresses to sticky secure MAC addresses and to add them to the running configuration by enabling sticky learning. The interface converts all the dynamic secure MAC addresses, including those that were dynamically learned before sticky learning was enabled, to sticky secure MAC addresses. All sticky secure MAC addresses are added to the running configuration.

The sticky secure MAC addresses do not automatically become part of the configuration file, which is the startup configuration used each time the switch restarts. If you save the sticky secure MAC addresses in the configuration file, when the switch restarts, the interface does not need to relearn these addresses. If you do not save the sticky secure addresses, they are lost.

If sticky learning is disabled, the sticky secure MAC addresses are converted to dynamic secure addresses and are removed from the running configuration.

Security Violations

It is a security violation when one of these situations occurs:

- The maximum number of secure MAC addresses have been added to the address table, and a station whose MAC address is not in the address table attempts to access the interface.
- An address learned or configured on one secure interface is seen on another secure interface in the same VLAN.
- Running diagnostic tests with port security enabled.

You can configure the interface for one of three violation modes, based on the action to be taken if a violation occurs:

- protect—when the number of secure MAC addresses reaches the maximum limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses to drop below the maximum value or increase the number of maximum allowable addresses. You are not notified that a security violation has occurred.

Note We do not recommend configuring the protect violation mode on a trunk port. The protect mode disables learning when any VLAN reaches its maximum limit, even if the port has not reached its maximum limit.

- restrict—when the number of secure MAC addresses reaches the maximum limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses to drop below the maximum value or increase the number of maximum allowable addresses. In this mode, you are notified that a security violation has occurred. An SNMP trap is sent, a syslog message is logged, and the violation counter increments.
- shutdown—a port security violation causes the interface to become error-disabled and to shut down immediately, and the port LED turns off. When a secure port is in the error-disabled state, you can bring it out of this state by entering the **errdisable recovery cause** *psecure-violation* global configuration command, or you can manually re-enable it by entering the **shutdown** and **no shut down** interface configuration commands. This is the default mode.
- shutdown vlan—Use to set the security violation mode per-VLAN. In this mode, the VLAN is error disabled instead of the entire port when a violation occurs

This table shows the violation mode and the actions taken when you configure an interface for port security.

Table 105: Security Violation Mode Actions

Violation Mode	Traffic is forwarded [14]	Sends SNMP trap	Sends syslog message	Displays error message [15]	Violation counter increments	Shuts down port
protect	No	No	No	No	No	No
restrict	No	Yes	Yes	No	Yes	No
shutdown	No	No	No	No	Yes	Yes
shutdown vlan	No	No	Yes	No	Yes	No [16]

[14] Packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses.
[15] The switch returns an error message if you manually configure an address that would cause a security violation.
[16] Shuts down only the VLAN on which the violation occurred.

Port Security Aging

You can use port security aging to set the aging time for all secure addresses on a port. Two types of aging are supported per port:

- Absolute—The secure addresses on the port are deleted after the specified aging time.
- Inactivity—The secure addresses on the port are deleted only if the secure addresses are inactive for the specified aging time.

Related Topics

Enabling and Configuring Port Security Aging, on page 974

Default Port Security Configuration

Table 106: Default Port Security Configuration

Feature	Default Setting
Port security	Disabled on a port.
Sticky address learning	Disabled.
Maximum number of secure MAC addresses per port	1.
Violation mode	Shutdown. The port shuts down when the maximum number of secure MAC addresses is exceeded.
Port security aging	Disabled. Aging time is 0. Static aging is disabled. Type is absolute.

Port Security Configuration Guidelines

- Port security can only be configured on static access ports or trunk ports. A secure port cannot be a dynamic access port.
- A secure port cannot be a destination port for Switched Port Analyzer (SPAN).
- **Note** Voice VLAN is only supported on access ports and not on trunk ports, even though the configuration is allowed.
- When you enable port security on an interface that is also configured with a voice VLAN, set the maximum allowed secure addresses on the port to two. When the port is connected to a Cisco IP phone, the IP phone requires one MAC address. The Cisco IP phone address is learned on the voice VLAN, but is not learned on the access VLAN. If you connect a single PC to the Cisco IP phone, no additional MAC addresses are required. If you connect more than one PC to the Cisco IP phone, you must configure enough secure addresses to allow one for each PC and one for the phone.
- When a trunk port configured with port security and assigned to an access VLAN for data traffic and to a voice VLAN for voice traffic, entering the **switchport voice** and **switchport priority extend** interface configuration commands has no effect.

  When a connected device uses the same MAC address to request an IP address for the access VLAN and then an IP address for the voice VLAN, only the access VLAN is assigned an IP address.
- When you enter a maximum secure address value for an interface, and the new value is greater than the previous value, the new value overwrites the previously configured value. If the new value is less than the previous value and the number of configured secure addresses on the interface exceeds the new value, the command is rejected.
- The switch does not support port security aging of sticky secure MAC addresses.

This table summarizes port security compatibility with other port-based features.

Table 107: Port Security Compatibility with Other Switch Features

Type of Port or Feature on Port	Compatible with Port Security
DTP [17] port [18]	No
Trunk port	Yes
Dynamic-access port [19]	No
Routed port	No
SPAN source port	Yes
SPAN destination port	No
EtherChannel	Yes
Tunneling port	Yes
Protected port	Yes
IEEE 802.1x port	Yes
Voice VLAN port [20]	Yes
IP source guard	Yes
Dynamic Address Resolution Protocol (ARP) inspection	Yes
Flex Links	Yes

[17] DTP=Dynamic Trunking Protocol

[18] A port configured with the **switchport mode dynamic** interface configuration command.

[19] A VLAN Query Protocol (VQP) port configured with the **switchport access vlan dynamic** interface configuration command.

[20] You must set the maximum allowed secure addresses on the port to two plus the maximum number of secure addresses allowed on the access VLAN.

How to Configure Port Security

Enabling and Configuring Port Security

Before you begin

This task restricts input to an interface by limiting and identifying MAC addresses of the stations allowed to access the port:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **port-security mac-address forbidden** *mac address*
4. **interface** *interface-id*
5. **switchport mode** {**access** | **trunk**}
6. **switchport voice vlan** *vlan-id*
7. **switchport port-security**
8. **switchport port-security [maximum** *value* [**vlan** {*vlan-list* | {**access** | **voice**}}]]
9. **switchport port-security violation** {**protect** | **restrict** | **shutdown** | **shutdown vlan**}
10. **switchport port-security [mac-address** *mac-address* [**vlan** {*vlan-id* | {**access** | **voice**}}]
11. **switchport port-security mac-address sticky**
12. **switchport port-security mac-address sticky** [*mac-address* | **vlan** {*vlan-id* | {**access** | **voice**}}]
13. **switchport port-security mac-address forbidden** *mac address*
14. **end**
15. **show port-security**
16. **show running-config**
17. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**port-security mac-address forbidden** *mac address* **Example:** `Switch(config)# port-security mac-address forbidden 2.2.2`	Specifies a MAC address that should be forbidden by port-security on all the interfaces.
Step 4	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the interface to be configured, and enter interface configuration mode.

	Command or Action	Purpose

Step 5	**switchport mode** {**access** | **trunk**}
	Example:
	`Switch(config-if)# switchport mode access`
		Sets the interface switchport mode as access or trunk; an interface in the default mode (dynamic auto) cannot be configured as a secure port.

Step 6	**switchport voice vlan** *vlan-id* **Example:** `Switch(config-if)# switchport voice vlan 22`	Enables voice VLAN on a port. vlan-id—Specifies the VLAN to be used for voice traffic.
Step 7	**switchport port-security** **Example:** `Switch(config-if)# switchport port-security`	Enable port security on the interface.
Step 8	**switchport port-security [maximum** *value* [**vlan** {*vlan-list* | {**access** | **voice**}}]] **Example:** `Switch(config-if)# switchport port-security maximum 20`	(Optional) Sets the maximum number of secure MAC addresses for the interface. The maximum number of secure MAC addresses that you can configure on a switch is set by the maximum number of available MAC addresses allowed in the system. This number is the total of available MAC addresses, including those used for other Layer 2 functions and any other secure MAC addresses configured on interfaces. (Optional) **vlan**—sets a per-VLAN maximum value Enter one of these options after you enter the **vlan** keyword: • *vlan-list*—On a trunk port, you can set a per-VLAN maximum value on a range of VLANs separated by a hyphen or a series of VLANs separated by commas. For nonspecified VLANs, the per-VLAN maximum value is used. • **access**—On an access port, specifies the VLAN as an access VLAN. • **voice**—On an access port, specifies the VLAN as a voice VLAN. **Note** The **voice** keyword is available only if a voice VLAN is configured on a port and if that port is not the access VLAN. If an interface is configured for voice VLAN, configure a maximum of two secure MAC addresses.

	Command or Action	Purpose

Step 9	**switchport port-security violation** {**protect** | **restrict** | **shutdown** | **shutdown vlan**}
	Example:
	`Switch(config-if)#` **`switchport port-security violation restrict`**
		(Optional) Sets the violation mode, the action to be taken when a security violation is detected, as one of these:
		• **protect**—When the number of port secure MAC addresses reaches the maximum limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses to drop below the maximum value or increase the number of maximum allowable addresses. You are not notified that a security violation has occurred.
		Note We do not recommend configuring the protect mode on a trunk port. The protect mode disables learning when any VLAN reaches its maximum limit, even if the port has not reached its maximum limit.
		• **restrict**—When the number of secure MAC addresses reaches the limit allowed on the port, packets with unknown source addresses are dropped until you remove a sufficient number of secure MAC addresses or increase the number of maximum allowable addresses. An SNMP trap is sent, a syslog message is logged, and the violation counter increments.
		• **shutdown**—The interface is error-disabled when a violation occurs, and the port LED turns off. An SNMP trap is sent, a syslog message is logged, and the violation counter increments.
		• **shutdown vlan**—Use to set the security violation mode per VLAN. In this mode, the VLAN is error disabled instead of the entire port when a violation occurs.
		Note When a secure port is in the error-disabled state, you can bring it out of this state by entering the **errdisable recovery cause psecure-violation** global configuration command. You can manually re-enable it by entering the **shutdown** and **no shutdown** interface configuration commands or by using the **clear errdisable interface vlan** privileged EXEC command.

Step 10	**switchport port-security [mac-address** *mac-address* [**vlan** {*vlan-id* | {**access** | **voice**}}] **Example:**	(Optional) Enters a secure MAC address for the interface. You can use this command to enter the maximum number of secure MAC addresses. If you configure fewer secure

	Command or Action	Purpose
	`Switch(config-if)# switchport port-security mac-address 00:A0:C7:12:C9:25 vlan 3 voice`	MAC addresses than the maximum, the remaining MAC addresses are dynamically learned. **Note** If you enable sticky learning after you enter this command, the secure addresses that were dynamically learned are converted to sticky secure MAC addresses and are added to the running configuration. (Optional) **vlan**—sets a per-VLAN maximum value. Enter one of these options after you enter the **vlan** keyword: • *vlan-id*—On a trunk port, you can specify the VLAN ID and the MAC address. If you do not specify a VLAN ID, the native VLAN is used. • **access**—On an access port, specifies the VLAN as an access VLAN. • **voice**—On an access port, specifies the VLAN as a voice VLAN. **Note** The **voice** keyword is available only if a voice VLAN is configured on a port and if that port is not the access VLAN. If an interface is configured for voice VLAN, configure a maximum of two secure MAC addresses.
Step 11	**switchport port-security mac-address sticky** **Example:** `Switch(config-if)# switchport port-security mac-address sticky`	(Optional) Enables sticky learning on the interface.
Step 12	**switchport port-security mac-address sticky** [*mac-address* | **vlan** {*vlan-id* | {**access** | **voice**}}] **Example:** `Switch(config-if)# switchport port-security mac-address sticky 00:A0:C7:12:C9:25 vlan voice`	(Optional) Enters a sticky secure MAC address, repeating the command as many times as necessary. If you configure fewer secure MAC addresses than the maximum, the remaining MAC addresses are dynamically learned, are converted to sticky secure MAC addresses, and are added to the running configuration. **Note** If you do not enable sticky learning before this command is entered, an error message appears, and you cannot enter a sticky secure MAC address. (Optional) **vlan**—sets a per-VLAN maximum value. Enter one of these options after you enter the **vlan** keyword:

	Command or Action	Purpose
		• *vlan-id*—On a trunk port, you can specify the VLAN ID and the MAC address. If you do not specify a VLAN ID, the native VLAN is used. • **access**—On an access port, specifies the VLAN as an access VLAN. • **voice**—On an access port, specifies the VLAN as a voice VLAN. **Note** The **voice** keyword is available only if a voice VLAN is configured on a port and if that port is not the access VLAN.
Step 13	**switchport port-security mac-address forbidden** *mac address* **Example:** `Switch(config-if)# switchport port-security mac-address forbidden 2.2.2`	Specifies a MAC address that should be forbidden by port-security on the particular interface.

Step 14	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 15	**show port-security** **Example:** `Switch# show port-security`	Verifies your entries.
Step 16	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 17	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Enabling and Configuring Port Security Aging

Use this feature to remove and add devices on a secure port without manually deleting the existing secure MAC addresses and to still limit the number of secure addresses on a port. You can enable or disable the aging of secure addresses on a per-port basis.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport port-security aging** {**static** | **time** *time* | **type** {**absolute** | **inactivity**}}
5. **end**
6. **show port-security** [**interface** *interface-id*] [**address**]
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the interface to be configured, and enter interface configuration mode.

Step 4	**switchport port-security aging** {**static** | **time** *time* | **type** {**absolute** | **inactivity**}}
	Example:
	`Switch(config-if)# switchport port-security aging time 120`
		Enables or disable static aging for the secure port, or set the aging time or type.
		Note The switch does not support port security aging of sticky secure addresses.
		Enter **static** to enable aging for statically configured secure addresses on this port.
		For *time*, specifies the aging time for this port. The valid range is from 0 to 1440 minutes.
		For **type**, select one of these keywords:

	Command or Action	Purpose
		• **absolute**—Sets the aging type as absolute aging. All the secure addresses on this port age out exactly after the time (minutes) specified lapses and are removed from the secure address list. • **inactivity**—Sets the aging type as inactivity aging. The secure addresses on this port age out only if there is no data traffic from the secure source addresses for the specified time period.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show port-security** [**interface** *interface-id*] [**address**] **Example:** `Switch# show port-security interface gigabitethernet 0/1`	Verifies your entries.
Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

Port Security Aging, on page 966

Configuration Examples for Port Security

This example shows how to enable port security on a port and to set the maximum number of secure addresses to 50. The violation mode is the default, no static secure MAC addresses are configured, and sticky learning is enabled.

```
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# switchport mode access
Switch(config-if)# switchport port-security
Switch(config-if)# switchport port-security maximum 50
Switch(config-if)# switchport port-security mac-address sticky
```

This example shows how to configure a static secure MAC address on VLAN 3 on a port:

```
Switch(config)# interface gigabitethernet 0/2
Switch(config-if)# switchport mode trunk
Switch(config-if)# switchport port-security
Switch(config-if)# switchport port-security mac-address 0000.0200.0004 vlan 3
```

This example shows how to enable sticky port security on a port, to manually configure MAC addresses for data VLAN and voice VLAN, and to set the total maximum number of secure addresses to 20 (10 for data VLAN and 10 for voice VLAN).

```
Switch(config)# interface tengigabitethernet 0/1
Switch(config-if)# switchport access vlan 21
Switch(config-if)# switchport mode access
Switch(config-if)# switchport voice vlan 22
Switch(config-if)# switchport port-security
Switch(config-if)# switchport port-security maximum 20
Switch(config-if)# switchport port-security violation restrict
Switch(config-if)# switchport port-security mac-address sticky
Switch(config-if)# switchport port-security mac-address sticky 0000.0000.0002
Switch(config-if)# switchport port-security mac-address 0000.0000.0003
Switch(config-if)# switchport port-security mac-address sticky 0000.0000.0001 vlan voice
Switch(config-if)# switchport port-security mac-address 0000.0000.0004 vlan voice
Switch(config-if)# switchport port-security maximum 10 vlan access
Switch(config-if)# switchport port-security maximum 10 vlan voice
```

Related Topics

Port Security, on page 964
Enabling and Configuring Port Security

Additional References

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Information About Protocol Storm Protection

Protocol Storm Protection

When a switch is flooded with Address Resolution Protocol (ARP) or control packets, high CPU utilization can cause the CPU to overload. These issues can occur:

- Routing protocol can flap because the protocol control packets are not received, and neighboring adjacencies are dropped.
- Spanning Tree Protocol (STP) reconverges because the STP bridge protocol data unit (BPDU) cannot be sent or received.
- CLI is slow or unresponsive.

Using protocol storm protection, you can control the rate at which control packets are sent to the switch by specifying the upper threshold for the packet flow rate. The supported protocols are ARP, ARP snooping, Dynamic Host Configuration Protocol (DHCP) v4, DHCP snooping, Internet Group Management Protocol (IGMP), and IGMP snooping.

When the packet rate exceeds the defined threshold, the switch drops all traffic arriving on the specified virtual port for 30 seconds. The packet rate is measured again, and protocol storm protection is again applied if necessary.

For further protection, you can manually error disable the virtual port, blocking all incoming traffic on the virtual port. You can manually enable the virtual port or set a time interval for automatic re-enabling of the virtual port.

Note Excess packets are dropped on no more than two virtual ports.

Virtual port error disabling is not supported for EtherChannel and Flexlink interfaces

Default Protocol Storm Protection Configuration

Protocol storm protection is disabled by default. When it is enabled, auto-recovery of the virtual port is disabled by default.

How to Configure Protocol Storm Protection

Enabling Protocol Storm Protection

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **psp** {**arp** | **dhcp** | **igmp**} pps *value*
4. **errdisable detect cause psp**
5. **errdisable recovery interval** *time*
6. **end**
7. **show psp config** {**arp** | **dhcp** | **igmp**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**psp** {**arp** | **dhcp** | **igmp**} pps *value* **Example:**	Configures protocol storm protection for ARP, IGMP, or DHCP.

	Command or Action	Purpose
	`Switch(config)# psp dhcp pps 35`	For *value*, specifies the threshold value for the number of packets per second. If the traffic exceeds this value, protocol storm protection is enforced. The range is from 5 to 50 packets per second.
Step 4	**errdisable detect cause psp** **Example:** `Switch(config)# errdisable detect cause psp`	(Optional) Enables error-disable detection for protocol storm protection. If this feature is enabled, the virtual port is error disabled. If this feature is disabled, the port drops excess packets without error disabling the port.
Step 5	**errdisable recovery interval** *time* **Example:** `Switch`	(Optional) Configures an auto-recovery time (in seconds) for error-disabled virtual ports. When a virtual port is error-disabled, the switch auto-recovers after this time. The range is from 30 to 86400 seconds.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show psp config** {**arp** | **dhcp** | **igmp**}
	Example:
	`Switch# show psp config dhcp`
		Verifies your entries.

Monitoring Protocol Storm Protection

Command	Purpose
show psp config {**arp** | **dhcp** | **igmp**}	Verify your entries.

Additional References

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

PART IX

System Management

CHAPTER 52

Administering the System

Information About Administering the Switch

System Time and Date Management

You can manage the system time and date on your switch using automatic configuration methods (RTC and NTP), or manual configuration methods.

Note For complete syntax and usage information for the commands used in this section, see the *Cisco IOS Configuration Fundamentals Command Reference*on *Cisco.com*.

System Clock

The basis of the time service is the system clock. This clock runs from the moment the system starts up and keeps track of the date and time.

The system clock can then be set from these sources:

- RTC
- NTP
- Manual configuration

The system clock can provide time to these services:

- User **show** commands
- Logging and debugging messages

The system clock keeps track of time internally based on Coordinated Universal Time (UTC), also known as Greenwich Mean Time (GMT). You can configure information about the local time zone and summer time (daylight saving time) so that the time appears correctly for the local time zone.

The system clock keeps track of whether the time is *authoritative* or not (that is, whether it has been set by a time source considered to be authoritative). If it is not authoritative, the time is available only for display purposes and is not redistributed.

Real Time Clock

A real-time clock (RTC) keeps track of the current time on the switch. The switch is shipped to you with RTC set to GMT time until you reconfigure clocking parameters.

The benefits of an RTC are:

- RTC is battery-powered.
- System time is retained during power outage and at system reboot.

The RTC and NTP clocks are integrated on the switch. When NTP is enabled, the RTC time is periodically synchronized to the NTP clock to maintain accuracy.

Network Time Protocol

The NTP is designed to time-synchronize a network of devices. NTP runs over User Datagram Protocol (UDP), which runs over IP. NTP is documented in RFC 1305.

An NTP network usually gets its time from an authoritative time source, such as a radio clock or an atomic clock attached to a time server. NTP then distributes this time across the network. NTP is extremely efficient; no more than one packet per minute is necessary to synchronize two devices to within a millisecond of one another.

NTP uses the concept of a *stratum* to describe how many NTP hops away a device is from an authoritative time source. A stratum 1 time server has a radio or atomic clock directly attached, a stratum 2 time server receives its time through NTP from a stratum 1 time server, and so on. A device running NTP automatically chooses as its time source the device with the lowest stratum number with which it communicates through NTP. This strategy effectively builds a self-organizing tree of NTP speakers.

NTP avoids synchronizing to a device whose time might not be accurate by never synchronizing to a device that is not synchronized. NTP also compares the time reported by several devices and does not synchronize to a device whose time is significantly different than the others, even if its stratum is lower.

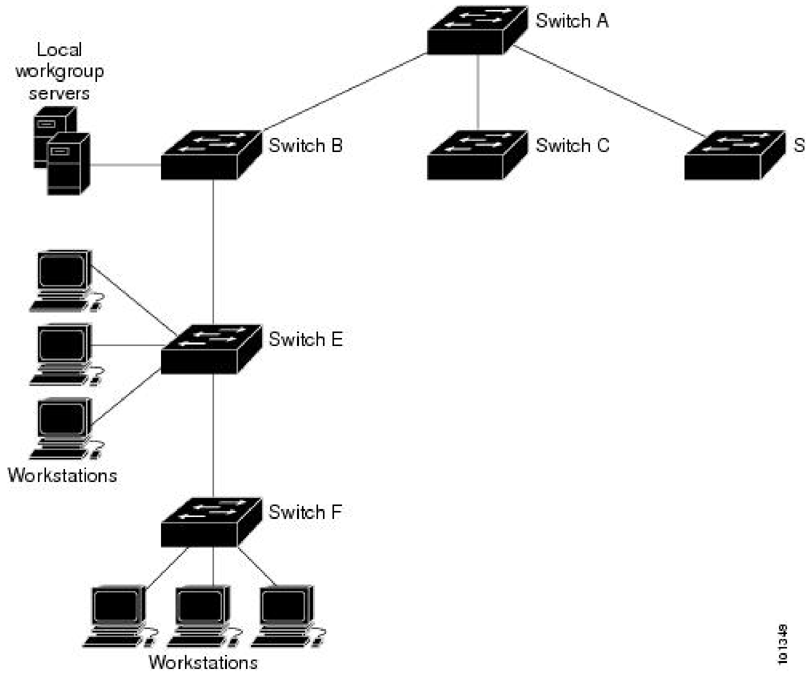
The communications between devices running NTP (known as associations) are usually statically configured; each device is given the IP address of all devices with which it should form associations. Accurate timekeeping is possible by exchanging NTP messages between each pair of devices with an association. However, in a LAN environment, NTP can be configured to use IP broadcast messages instead. This alternative reduces configuration complexity because each device can simply be configured to send or receive broadcast messages. However, in that case, information flow is one-way only.

The time kept on a device is a critical resource; you should use the security features of NTP to avoid the accidental or malicious setting of an incorrect time. Two mechanisms are available: an access list-based restriction scheme and an encrypted authentication mechanism.

Cisco's implementation of NTP does not support stratum 1 service; it is not possible to connect to a radio or atomic clock. We recommend that the time service for your network be derived from the public NTP servers available on the IP Internet.

The figure below shows a typical network example using NTP. Switch A is the NTP primary (formerly known as NTP primary), with the **Switch** B, C, and D configured in NTP server mode, in server association with Switch A. Switch E is configured as an NTP peer to the upstream and downstream Switch, Switch B and Switch F, respectively.

Figure 74: Typical NTP Network Configuration



If the network is isolated from the Internet, Cisco's implementation of NTP allows a device to act as if it is synchronized through NTP, when in fact it has learned the time by using other means. Other devices then synchronize to that device through NTP.

When multiple sources of time are available, NTP is always considered to be more authoritative. NTP time overrides the time set by any other method.

Several manufacturers include NTP software for their host systems, and a publicly available version for systems running UNIX and its various derivatives is also available. This software allows host systems to be time-synchronized as well.

NTP Stratum

NTP uses the concept of a *stratum* to describe how many NTP hops away a device is from an authoritative time source. A stratum 1 time server has a radio or atomic clock directly attached, a stratum 2 time server receives its time through NTP from a stratum 1 time server, and so on. A device running NTP automatically chooses as its time source the device with the lowest stratum number with which it communicates through NTP. This strategy effectively builds a self-organizing tree of NTP speakers.

NTP avoids synchronizing to a device whose time might not be accurate by never synchronizing to a device that is not synchronized. NTP also compares the time reported by several devices and does not synchronize to a device whose time is significantly different than the others, even if its stratum is lower.

NTP Associations

The communications between devices running NTP (known as *associations*) are usually statically configured; each device is given the IP address of all devices with which it should form associations. Accurate timekeeping is possible by exchanging NTP messages between each pair of devices with an association. However, in a LAN environment, NTP can be configured to use IP broadcast messages instead. This alternative reduces configuration complexity because each device can simply be configured to send or receive broadcast messages. However, in that case, information flow is one-way only.

NTP Security

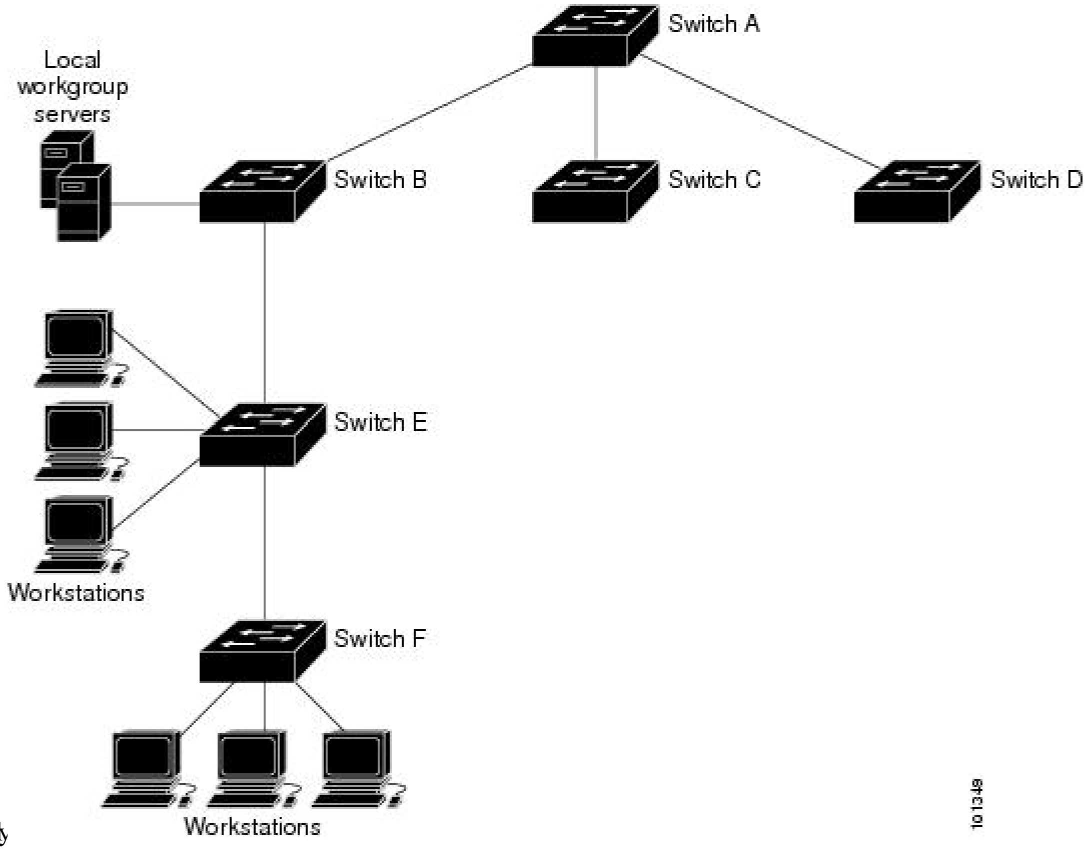
The time kept on a device is a critical resource; you should use the security features of NTP to avoid the accidental or malicious setting of an incorrect time. Two mechanisms are available: an access list-based restriction scheme and an encrypted authentication mechanism.

NTP Implementation

Implementation of NTP does not support stratum 1 service; it is not possible to connect to a radio or atomic clock. We recommend that the time service for your network be derived from the public NTP servers available on the IP Internet.

Figure 75: Typical NTP Network Configuration

The following figure shows a typical network example using NTP. Switch A is the NTP primary, with the Switch B, C, and D configured in NTP server mode, in server association with Switch A. Switch E is configured as an NTP peer to the upstream and downstream switches, Switch B and Switch F,



respectively

If the network is isolated from the Internet, NTP allows a device to act as if it is synchronized through NTP, when in fact it has learned the time by using other means. Other devices then synchronize to that device through NTP.

When multiple sources of time are available, NTP is always considered to be more authoritative. NTP time overrides the time set by any other method.

Several manufacturers include NTP software for their host systems, and a publicly available version for systems running UNIX and its various derivatives is also available. This software allows host systems to be time-synchronized as well.

NTP Version 4

NTP version 4 is implemented on the switch. NTPv4 is an extension of NTP version 3. NTPv4 supports both IPv4 and IPv6 and is backward-compatible with NTPv3.

NTPv4 provides these capabilities:

- Support for IPv6.
- Improved security compared to NTPv3. The NTPv4 protocol provides a security framework based on public key cryptography and standard X509 certificates.
- Automatic calculation of the time-distribution hierarchy for a network. Using specific multicast groups, NTPv4 automatically configures the hierarchy of the servers to achieve the best time accuracy for the lowest bandwidth cost. This feature leverages site-local IPv6 multicast addresses.

For details about configuring NTPv4, see the *Implementing NTPv4 in IPv6* chapter of the *Cisco IOS IPv6 Configuration Guide, Release 12.4T*.

System Name and Prompt

You configure the system name on the Switch to identify it. By default, the system name and prompt are *Switch*.

If you have not configured a system prompt, the first 20 characters of the system name are used as the system prompt. A greater-than symbol [>] is appended. The prompt is updated whenever the system name changes.

For complete syntax and usage information for the commands used in this section, see the *Cisco IOS Configuration Fundamentals Command Reference*, *Release 12.4* and the *Cisco IOS IP Command Reference*, *Volume 2 of 3: Routing Protocols*, *Release 12.4*.

Default System Name and Prompt Configuration

The default switch system name and prompt is *Switch*.

DNS

The DNS protocol controls the Domain Name System (DNS), a distributed database with which you can map hostnames to IP addresses. When you configure DNS on your switch, you can substitute the hostname for the IP address with all IP commands, such as **ping**, **telnet**, **connect**, and related Telnet support operations.

IP defines a hierarchical naming scheme that allows a device to be identified by its location or domain. Domain names are pieced together with periods (.) as the delimiting characters. For example, Cisco Systems is a commercial organization that IP identifies by a *com* domain name, so its domain name is *cisco.com*. A specific device in this domain, for example, the File Transfer Protocol (FTP) system is identified as *ftp.cisco.com*.

To keep track of domain names, IP has defined the concept of a domain name server, which holds a cache (or database) of names mapped to IP addresses. To map domain names to IP addresses, you must first identify the hostnames, specify the name server that is present on your network, and enable the DNS.

Default DNS Settings

Table 108: Default DNS Settings

Feature	Default Setting
DNS enable state	Enabled.
DNS default domain name	None configured.
DNS servers	No name server addresses are configured.

Login Banners

You can configure a message-of-the-day (MOTD) and a login banner. The MOTD banner is displayed on all connected terminals at login and is useful for sending messages that affect all network users (such as impending system shutdowns).

The login banner is also displayed on all connected terminals. It appears after the MOTD banner and before the login prompts.

Note For complete syntax and usage information for the commands used in this section, see the *Cisco IOS Configuration Fundamentals Command Reference, Release 12.4*.

Default Banner Configuration

The MOTD and login banners are not configured.

MAC Address Table

The MAC address table contains address information that the switch uses to forward traffic between ports. All MAC addresses in the address table are associated with one or more ports. The address table includes these types of addresses:

- Dynamic address—A source MAC address that the switch learns and then ages when it is not in use.
- Static address—A manually entered unicast address that does not age and that is not lost when the switch resets.

The address table lists the destination MAC address, the associated VLAN ID, and port number associated with the address and the type (static or dynamic).

Note For complete syntax and usage information for the commands used in this section, see the command reference for this release.

MAC Address Table Creation

With multiple MAC addresses supported on all ports, you can connect any port on the switch to other network devices. The switch provides dynamic addressing by learning the source address of packets it receives on each port and adding the address and its associated port number to the address table. As devices are added or removed from the network, the switch updates the address table, adding new dynamic addresses and aging out those that are not in use.

The aging interval is globally configured. However, the switch maintains an address table for each VLAN, and STP can accelerate the aging interval on a per-VLAN basis.

The switch sends packets between any combination of ports, based on the destination address of the received packet. Using the MAC address table, the switch forwards the packet only to the port associated with the destination address. If the destination address is on the port that sent the packet, the packet is filtered and not forwarded. The switch always uses the store-and-forward method: complete packets are stored and checked for errors before transmission.

MAC Addresses and VLANs

All addresses are associated with a VLAN. An address can exist in more than one VLAN and have different destinations in each. Unicast addresses, for example, could be forwarded to port 1 in VLAN 1 and ports 9, 10, and 1 in VLAN 5.

Each VLAN maintains its own logical address table. A known address in one VLAN is unknown in another until it is learned or statically associated with a port in the other VLAN.

Default MAC Address Table Settings

The following table shows the default settings for the MAC address table.

Table 109: Default Settings for the MAC Address

Feature	Default Setting
Aging time	300 seconds
Dynamic addresses	Automatically learned
Static addresses	None configured

ARP Table Management

To communicate with a device (over Ethernet, for example), the software first must learn the 48-bit MAC address or the local data link address of that device. The process of learning the local data link address from an IP address is called *address resolution*.

The Address Resolution Protocol (ARP) associates a host IP address with the corresponding media or MAC addresses and the VLAN ID. Using an IP address, ARP finds the associated MAC address. When a MAC address is found, the IP-MAC address association is stored in an ARP cache for rapid retrieval. Then the IP datagram is encapsulated in a link-layer frame and sent over the network. Encapsulation of IP datagrams and ARP requests and replies on IEEE 802 networks other than Ethernet is specified by the Subnetwork Access Protocol (SNAP). By default, standard Ethernet-style ARP encapsulation (represented by the **arpa** keyword) is enabled on the IP interface.

ARP entries added manually to the table do not age and must be manually removed.

For CLI procedures, see the Cisco IOS Release 12.4 documentation on *Cisco.com*.

How to Administer the Switch

Configuring the Time and Date Manually

System time remains accurate through restarts and reboot, however, you can manually configure the time and date after the system is restarted.

We recommend that you use manual configuration only when necessary. If you have an outside source to which the switch can synchronize, you do not need to manually set the system clock.

Setting the System Clock

If you have an outside source on the network that provides time services, such as an NTP server, you do not need to manually set the system clock.

Follow these steps to set the system clock:

SUMMARY STEPS

1. **enable**
2. Use one of the following:
   - **clock set** *hh:mm:ss day month year*
   - **clock set** *hh:mm:ss month day year*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	Use one of the following: • **clock set** *hh:mm:ss day month year* • **clock set** *hh:mm:ss month day year* **Example:**	Manually set the system clock using one of these formats: • *hh:mm:ss*—Specifies the time in hours (24-hour format), minutes, and seconds. The time specified is relative to the configured time zone. • *day*—Specifies the day by date in the month.

	Command or Action	Purpose
	`Switch# clock set 13:32:00 23 March 2013`	• *month*—Specifies the month by name. • *year*—Specifies the year (no abbreviation).

Configuring the Time Zone

Follow these steps to manually configure the time zone:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **clock timezone** *zone hours-offset* [*minutes-offset*]
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**clock timezone** *zone hours-offset* [*minutes-offset*] **Example:** `Switch(config)# clock timezone AST -3 30`	Sets the time zone. Internal time is kept in Coordinated Universal Time (UTC), so this command is used only for display purposes and when the time is manually set. • *zone*—Enters the name of the time zone to be displayed when standard time is in effect. The default is UTC. • *hours-offset*—Enters the hours offset from UTC. • (Optional) *minutes-offset*—Enters the minutes offset from UTC. This available where the local time zone is a percentage of an hour different from UTC.
Step 4	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Summer Time (Daylight Saving Time)

To configure summer time (daylight saving time) in areas where it starts and ends on a particular day of the week each year, perform this task:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **clock summer-time** *zone* **date** *date month year hh:mm date month year hh:mm* [*offset*]]
4. **clock summer-time** *zone* **recurring** [*week day month hh:mm week day month hh:mm* [*offset*]]
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**clock summer-time** *zone* **date** *date month year hh:mm date month year hh:mm* [*offset*]]	Configures summer time to start and end on specified days every year.

	Command or Action	Purpose
	Example: `Switch(config)# clock summer-time PDT date 10 March 2013 2:00 3 November 2013 2:00`	
Step 4	**clock summer-time** *zone* **recurring** [*week day month hh:mm week day month hh:mm* [*offset*]] **Example:** `Switch(config)# clock summer-time PDT recurring 10 March 2013 2:00 3 November 2013 2:00`	Configures summer time to start and end on the specified days every year. All times are relative to the local time zone. The start time is relative to standard time. The end time is relative to summer time. Summer time is disabled by default. If you specify **clock summer-time** *zone* **recurring** without parameters, the summer time rules default to the United States rules. If the starting month is after the ending month, the system assumes that you are in the southern hemisphere. • *zone*—Specifies the name of the time zone (for example, PDT) to be displayed when summer time is in effect. • (Optional) *week*— Specifies the week of the month (1 to 4, **first**, or **last**). • (Optional) *day*—Specifies the day of the week (Sunday, Monday...). • (Optional) *month*—Specifies the month (January, February...). • (Optional) *hh:mm*—Specifies the time (24-hour format) in hours and minutes. • (Optional) *offset*—Specifies the number of minutes to add during summer time. The default is 60.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:**	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	`Switch# copy running-config startup-config`	

Follow these steps if summer time in your area does not follow a recurring pattern (configure the exact date and time of the next summer time events):

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **clock summer-time** *zone* **date**[*month date year hh:mm month date year hh:mm* [*offset*]]or**clock summer-time** *zone* **date** [*date month year hh:mm date month year hh:mm* [*offset*]]
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**clock summer-time** *zone* **date**[*month date year hh:mm month date year hh:mm* [*offset*]]or**clock summer-time** *zone* **date** [*date month year hh:mm date month year hh:mm* [*offset*]]	Configures summer time to start on the first date and end on the second date. Summer time is disabled by default. • For *zone*, specify the name of the time zone (for example, PDT) to be displayed when summer time is in effect. • (Optional) For *week*, specify the week of the month (1 to 5 or last). • (Optional) For *day*, specify the day of the week (Sunday, Monday...). • (Optional) For *month*, specify the month (January, February...).

	Command or Action	Purpose
		• (Optional) For *hh:mm*, specify the time (24-hour format) in hours and minutes. • (Optional) For *offset*, specify the number of minutes to add during summer time. The default is 60.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a System Name

Follow these steps to manually configure a system name:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **hostname** *name*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch#` **`configure terminal`**	Enters global configuration mode.

Step 3	**hostname** *name*
	Example:
	`Switch(config)#` **`hostname`**
	`remote-users`
		Configures a system name. When you set the system name, it is also used as the system prompt.
		The default setting is Switch.
		The name must follow the rules for ARPANET hostnames. They must start with a letter, end with a letter or digit, and have as interior characters only letters, digits, and hyphens. Names can be up to 63 characters.

Step 4	**end**
	Example:
	`remote-users(config)#`**`end`**
	`remote-users#`
		Returns to priviliged EXEC mode.

Step 5	**show running-config** **Example:** `Switch#` **`show running-config`**	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch#` **`copy running-config startup-config`**	(Optional) Saves your entries in the configuration file.

Setting Up DNS

If you use the switch IP address as its hostname, the IP address is used and no DNS query occurs. If you configure a hostname that contains no periods (.), a period followed by the default domain name is appended to the hostname before the DNS query is made to map the name to an IP address. The default domain name is the value set by the **ip domain-name** global configuration command. If there is a period (.) in the hostname, the Cisco IOS software looks up the IP address without appending any default domain name to the hostname.

Follow these steps to set up your switch to use the DNS:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip domain-name** *name*
4. **ip name-server** *server-address1* [*server-address2* ... *server-address6*]

5. **ip domain-lookup** [**nsap** | **source-interface** *interface*]
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip domain-name** *name* **Example:** `Switch(config)# ip domain-name Cisco.com`	Defines a default domain name that the software uses to complete unqualified hostnames (names without a dotted-decimal domain name). Do not include the initial period that separates an unqualified name from the domain name. At boot time, no domain name is configured; however, if the switch configuration comes from a BOOTP or Dynamic Host Configuration Protocol (DHCP) server, then the default domain name might be set by the BOOTP or DHCP server (if the servers were configured with this information).
Step 4	**ip name-server** *server-address1* [*server-address2 ... server-address6*] **Example:** `Switch(config)# ip name-server 192.168.1.100 192.168.1.200 192.168.1.300`	Specifies the address of one or more name servers to use for name and address resolution. You can specify up to six name servers. Separate each server address with a space. The first server specified is the primary server. The switch sends DNS queries to the primary server first. If that query fails, the backup servers are queried.
Step 5	**ip domain-lookup** [**nsap** | **source-interface** *interface*] **Example:** `Switch(config)# ip domain-lookup`	(Optional) Enables DNS-based hostname-to-address translation on your switch. This feature is enabled by default. If your network devices require connectivity with devices in networks for which you do not control name assignment, you can dynamically assign device names that uniquely identify your devices by using the global Internet naming scheme (DNS).

	Command or Action	Purpose

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a Message-of-the-Day Login Banner

You can create a single or multiline message banner that appears on the screen when someone logs in to the switch

Follow these steps to configure a MOTD login banner:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **banner motd** *c message c*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	

Step 3	**banner motd** *c message c*
	Example:
	`Switch(config)# banner motd #`
	`This is a secure site. Only`
	`authorized users are allowed.`
	`For access, contact technical`
	`support.`
	`#`
		Specifies the message of the day.
		c—Enters the delimiting character of your choice, for example, a pound sign (#), and press the **Return** key. The delimiting character signifies the beginning and end of the banner text. Characters after the ending delimiter are discarded.
		message—Enters a banner message up to 255 characters. You cannot use the delimiting character in the message.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a Login Banner

You can configure a login banner to be displayed on all connected terminals. This banner appears after the MOTD banner and before the login prompt.

Follow these steps to configure a login banner:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **banner login** *c message c*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch>` **`enable`**	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch#` **`configure terminal`**	Enters global configuration mode.

Step 3	**banner login** *c message c*
	Example:
	`Switch(config)#` **`banner login $`**
	`Access for authorized users only.`
	`Please enter your username and`
	`password.`
	`$`
		Specifies the login message.
		c— Enters the delimiting character of your choice, for example, a pound sign (#), and press the **Return** key. The delimiting character signifies the beginning and end of the banner text. Characters after the ending delimiter are discarded.
		message—Enters a login message up to 255 characters. You cannot use the delimiting character in the message.

Step 4	**end**
	Example:
	`Switch(config)#` **`end`**
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch#` **`show running-config`**	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch#` **`copy running-config startup-config`**	(Optional) Saves your entries in the configuration file.

Managing the MAC Address Table

Changing the Address Aging Time

Follow these steps to configure the dynamic address table aging time:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac address-table aging-time** [*0* | *10-1000000*] [**routed-mac** | **vlan** *vlan-id*]
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**mac address-table aging-time** [*0* | *10-1000000*] [**routed-mac** | **vlan** *vlan-id*] **Example:** `Switch(config)# mac address-table aging-time 500 vlan 2`	Sets the length of time that a dynamic entry remains in the MAC address table after the entry is used or updated. The range is 10 to 1000000 seconds. The default is 300. You can also enter 0, which disables aging. Static address entries are never aged or removed from the table. *vlan-id*—Valid IDs are 1 to 4094.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring MAC Address Change Notification Traps

Follow these steps to configure the switch to send MAC address change notification traps to an NMS host:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server host** *host-addr community-string notification-type* { **informs** | **traps** } {**version** {**1** | **2c** | **3**}} {**vrf** *vrf instance name*}
4. **snmp-server enable traps mac-notification change**
5. **mac address-table notification change**
6. **mac address-table notification change** [**interval** *value*] [**history-size** *value*]
7. **interface** *interface-id*
8. **snmp trap mac-notification change** {**added** | **removed**}
9. **end**
10. **show running-config**
11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**snmp-server host** *host-addr community-string notification-type* { **informs** | **traps** } {**version** {**1** | **2c** | **3**}} {**vrf** *vrf instance name*}
	Example:
	`Switch(config)# snmp-server host 172.20.10.10 traps private mac-notification`
		Specifies the recipient of the trap message.
		• *host-addr*—Specifies the name or address of the NMS.
		• **traps** (the default)—Sends SNMP traps to the host.
		• **informs**—Sends SNMP informs to the host.
		• **version**—Specifies the SNMP version to support. Version 1, the default, is not available with informs.
		• *community-string*—Specifies the string to send with the notification operation. Though you can set this string by using the **snmp-server host** command, we recommend that you define this string by using the **snmp-server community** command before using the **snmp-server host** command.

	Command or Action	Purpose
		• *notification-type*—Uses the **mac-notification** keyword. • **vrf** *vrf instance name*—Specifies the VPN routing/forwarding instance for this host.
Step 4	**snmp-server enable traps mac-notification change** **Example:** `Switch(config)# snmp-server enable traps mac-notification change`	Enables the switch to send MAC address change notification traps to the NMS.
Step 5	**mac address-table notification change** **Example:** `Switch(config)# mac address-table notification change`	Enables the MAC address change notification feature.

Step 6	**mac address-table notification change** [**interval** *value*] [**history-size** *value*]
	Example:
	`Switch(config)# mac address-table notification change interval 123`
	`Switch(config)#mac address-table notification change history-size 100`
		Enters the trap interval time and the history table size.
		• (Optional) **interval** *value*—Specifies the notification trap interval in seconds between each set of traps that are generated to the NMS. The range is 0 to 2147483647 seconds; the default is 1 second.
		• (Optional) **history-size** *value*—Specifies the maximum number of entries in the MAC notification history table. The range is 0 to 500; the default is 1.

Step 7	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Enters interface configuration mode, and specifies the Layer 2 interface on which to enable the SNMP MAC address notification trap.

Step 8	**snmp trap mac-notification change** {**added** | **removed**}
	Example:
	`Switch(config-if)# snmp trap mac-notification change added`
		Enables the MAC address change notification trap on the interface.
		• Enables the trap when a MAC address is **added** on this interface.
		• Enables the trap when a MAC address is **removed** from this interface.

Step 9	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 10	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 11	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring MAC Address Move Notification Traps

When you configure MAC-move notification, an SNMP notification is generated and sent to the network management system whenever a MAC address moves from one port to another within the same VLAN.

Follow these steps to configure the switch to send MAC address-move notification traps to an NMS host:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server host** *host-addr* {**traps** | **informs**} {**version** {**1** | **2c** | **3**}} *community-string notification-type*
4. **snmp-server enable traps mac-notification move**
5. **mac address-table notification mac-move**
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**snmp-server host** *host-addr* {**traps** | **informs**} {**version** {**1** | **2c** | **3**}} *community-string notification-type*	Specifies the recipient of the trap message. • *host-addr*—Specifies the name or address of the NMS.

	Command or Action	Purpose
	Example: `Switch(config)# snmp-server host 172.20.10.10 traps private mac-notification`	• **traps** (the default)—Sends SNMP traps to the host. • **informs**—Sends SNMP informs to the host. • **version**—Specifies the SNMP version to support. Version 1, the default, is not available with informs. • *community-string*—Specifies the string to send with the notification operation. Though you can set this string by using the **snmp-server host** command, we recommend that you define this string by using the **snmp-server community** command before using the **snmp-server host** command. • *notification-type*—Uses the **mac-notification** keyword.
Step 4	**snmp-server enable traps mac-notification move** **Example:** `Switch(config)# snmp-server enable traps mac-notification move`	Enables the switch to send MAC address move notification traps to the NMS.
Step 5	**mac address-table notification mac-move** **Example:** `Switch(config)# mac address-table notification mac-move`	Enables the MAC address move notification feature.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

What to do next

To disable MAC address-move notification traps, use the **no snmp-server enable traps mac-notification move** global configuration command. To disable the MAC address-move notification feature, use the **no mac address-table notification mac-move** global configuration command.

You can verify your settings by entering the **show mac address-table notification mac-move** privileged EXEC commands.

Configuring MAC Threshold Notification Traps

When you configure MAC threshold notification, an SNMP notification is generated and sent to the network management system when a MAC address table threshold limit is reached or exceeded.

Follow these steps to configure the switch to send MAC address table threshold notification traps to an NMS host:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server host** *host-addr* {**traps** | **informs**} {**version** {**1** | **2c** | **3**}} *community-string notification-type*
4. **snmp-server enable traps mac-notification threshold**
5. **mac address-table notification threshold**
6. **mac address-table notification threshold** [**limit** *percentage*] | [**interval** *time*]
7. **end**
8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**snmp-server host** *host-addr* {**traps** | **informs**} {**version** {**1** | **2c** | **3**}} *community-string notification-type* **Example:** `Switch(config)# snmp-server host 172.20.10.10 traps private`	Specifies the recipient of the trap message. • *host-addr*—Specifies the name or address of the NMS. • **traps** (the default)—Sends SNMP traps to the host. • **informs**—Sends SNMP informs to the host.

	Command or Action	Purpose
	`mac-notification`	• **version**—Specifies the SNMP version to support. Version 1, the default, is not available with informs. • *community-string*—Specifies the string to send with the notification operation. You can set this string by using the **snmp-server host** command, but we recommend that you define this string by using the **snmp-server community** command before using the **snmp-server host** command. • *notification-type*—Uses the **mac-notification** keyword.
Step 4	**snmp-server enable traps mac-notification threshold** **Example:** `Switch(config)# snmp-server enable traps mac-notification threshold`	Enables MAC threshold notification traps to the NMS.
Step 5	**mac address-table notification threshold** **Example:** `Switch(config)# mac address-table notification threshold`	Enables the MAC address threshold notification feature.

Step 6	**mac address-table notification threshold** [**limit** *percentage*] | [**interval** *time*]
	Example:
	`Switch(config)# mac address-table notification threshold interval 123`
	`Switch(config)# mac address-table notification threshold limit 78`
		Enters the threshold value for the MAC address threshold usage monitoring.
		• (Optional) **limit** *percentage*—Specifies the percentage of the MAC address table use; valid values are from 1 to 100 percent. The default is 50 percent.
		• (Optional) **interval** *time*—Specifies the time between notifications; valid values are greater than or equal to 120 seconds. The default is 120 seconds.

Step 7	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.

	Command or Action	Purpose
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Adding and Removing Static Address Entries

Follow these steps to add a static address:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac address-table static** *mac-addr* **vlan** *vlan-id* **interface** *interface-id*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**mac address-table static** *mac-addr* **vlan** *vlan-id* **interface** *interface-id* **Example:** `Device(config)# mac address-table static c2f3.220a.12f4 vlan 4 interface gigabitethernet 0/1`	Adds a static address to the MAC address table. • *mac-addr*—Specifies the destination MAC unicast address to add to the address table. Packets with this destination address received in the specified VLAN are forwarded to the specified interface. • *vlan-id*—Specifies the VLAN for which the packet with the specified MAC address is received. Valid VLAN IDs are 1 to 4094. • *interface-id*—Specifies the interface to which the received packet is forwarded. Valid interfaces include physical ports or port channels. For static multicast addresses, you can enter multiple interface IDs. For

	Command or Action	Purpose
		static unicast addresses, you can enter only one interface at a time, but you can enter the command multiple times with the same MAC address and VLAN ID.

Step 4	**end**
	Example:
	`Device(config)# end`
		Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Unicast MAC Address Filtering

Follow these steps to configure the Switch to drop a source or destination unicast static address:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac address-table static** *mac-addr* **vlan** *vlan-id* **drop**
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 3	**mac address-table static** *mac-addr* **vlan** *vlan-id* **drop** **Example:** `Switch(config)# mac address-table static c2f3.220a.12f4 vlan 4 drop`	Enables unicast MAC address filtering and configure the switch to drop a packet with the specified source or destination unicast static address. • *mac-addr*—Specifies a source or destination unicast MAC address (48-bit). Packets with this MAC address are dropped. • *vlan-id*—Specifies the VLAN for which the packet with the specified MAC address is received. Valid VLAN IDs are 1 to 4094.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring and Maintaining Administration of the Switch

Command	Purpose
clear mac address-table dynamic	Removes all dynamic entries.
clear mac address-table dynamic address *mac-address*	Removes a specific MAC address.
clear mac address-table dynamic interface *interface-id*	Removes all addresses on the specified physical port or port channel.
clear mac address-table dynamic vlan *vlan-id*	Removes all addresses on a specified VLAN.
show clock [*detail*]	Displays the time and date configuration.

Command	Purpose
show ip igmp snooping groups	Displays the Layer 2 multicast entries for all VLANs or the specified VLAN.
show mac address-table address *mac-address*	Displays MAC address table information for the specified MAC address.
show mac address-table aging-time	Displays the aging time in all VLANs or the specified VLAN.
show mac address-table count	Displays the number of addresses present in all VLANs or the specified VLAN.
show mac address-table dynamic	Displays only dynamic MAC address table entries.
show mac address-table interface *interface-name*	Displays the MAC address table information for the specified interface.
show mac address-table move update	Displays the MAC address table move update information.
show mac address-table multicast	Displays a list of multicast MAC addresses.
show mac address-table notification {change | mac-move | threshold}	Displays the MAC notification parameters and history table.
show mac address-table secure	Displays the secure MAC addresses.
show mac address-table static	Displays only static MAC address table entries.
show mac address-table vlan *vlan-id*	Displays the MAC address table information for the specified VLAN.

Configuration Examples for Switch Administration

Example: Setting the System Clock

This example shows how to manually set the system clock:

```
Switch# clock set 13:32:00 23 July 2013
```

Examples: Configuring Summer Time

This example (for daylight savings time) shows how to specify that summer time starts on March 10 at 02:00 and ends on November 3 at 02:00:

```
Switch(config)# clock summer-time PDT recurring PST date
```

```
10 March 2013 2:00 3 November 2013 2:00
```

This example shows how to set summer time start and end dates:

```
Switch(config)#clock summer-time PST date
20 March 2013 2:00 20 November 2013 2:00
```

Example: Configuring a MOTD Banner

This example shows how to configure a MOTD banner by using the pound sign (#) symbol as the beginning and ending delimiter:

```
Switch(config)# banner motd #

This is a secure site. Only authorized users are allowed.
For access, contact technical support.

#

Switch(config)#
```

This example shows the banner that appears from the previous configuration:

```
Unix> telnet 192.0.2.15

Trying 192.0.2.15...

Connected to 192.0.2.15.

Escape character is '^]'.

This is a secure site. Only authorized users are allowed.

For access, contact technical support.

User Access Verification

Password:
```

Example: Configuring a Login Banner

This example shows how to configure a login banner by using the dollar sign ($) symbol as the beginning and ending delimiter:

```
Switch(config)# banner login $

Access for authorized users only. Please enter your username and password.

$

Switch(config)#
```

Example: Configuring MAC Address Change Notification Traps

This example shows how to specify 172.20.10.10 as the NMS, enable MAC address notification traps to the NMS, enable the MAC address-change notification feature, set the interval time to 123 seconds, set the history-size to 100 entries, and enable traps whenever a MAC address is added on the specified port:

```
Switch(config)# snmp-server host 172.20.10.10 traps private mac-notification
Switch(config)# snmp-server enable traps mac-notification change
Switch(config)# mac address-table notification change
Switch(config)# mac address-table notification change interval 123
Switch(config)# mac address-table notification change history-size 100
Switch(config)# interface gigabitethernet2/1
Switch(config-if)# snmp trap mac-notification change added
```

Example: Configuring MAC Threshold Notification Traps

This example shows how to specify 172.20.10.10 as the NMS, enable the MAC address threshold notification feature, set the interval time to 123 seconds, and set the limit to 78 per cent:

```
Switch(config)# snmp-server host 172.20.10.10 traps private mac-notification
Switch(config)# snmp-server enable traps mac-notification threshold
Switch(config)# mac address-table notification threshold
Switch(config)# mac address-table notification threshold interval 123
Switch(config)# mac address-table notification threshold limit 78
```

Example: Adding the Static Address to the MAC Address Table

This example shows how to add the static address c2f3.220a.12f4 to the MAC address table. When a packet is received in VLAN 4 with this MAC address as its destination address, the packet is forwarded to the specified port:

Note You cannot associate the same static MAC address to multiple interfaces. If the command is executed again with a different interface, the static MAC address is overwritten on the new interface.

```
Switch(config)# mac address-table static c2f3.220a.12f4 vlan 4 interface gigabitethernet1/1
```

Example: Configuring Unicast MAC Address Filtering

This example shows how to enable unicast MAC address filtering and how to configure drop packets that have a source or destination address of c2f3.220a.12f4. When a packet is received in VLAN 4 with this MAC address as its source or destination, the packet is dropped:

```
Switch(config)# mac address-table static c2f3.220a.12f4 vlan 4 drop
```

Feature History and Information for Switch Administration

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 53

Performing Switch Setup Configuration

Information About Performing Switch Setup Configuration

Review the sections in this module before performing your initial switch configuration tasks that include IP address assignments and DHCP autoconfiguration.

Boot Process

To start your switch, you need to follow the procedures in the getting started guide or the hardware installation guide for installing and powering on the switch and setting up the initial switch configuration (IP address, subnet mask, default gateway, secret and Telnet passwords, and so forth).

The boot loader software performs the normal boot process and includes these activities:

- Locates the bootable (base) package in the bundle or installed package set.
- Performs low-level CPU initialization. It initializes the CPU registers, which control where physical memory is mapped, its quantity, its speed, and so forth.
- Performs power-on self-test (POST) for the CPU subsystem and tests the system DRAM.
- Initializes the file systems on the system board.
- Loads a default operating system software image into memory and boots up the switch.

The boot loader provides access to the flash file systems before the operating system is loaded. Normally, the boot loader is used only to load, decompress, and start the operating system. After the boot loader gives the operating system control of the CPU, the boot loader is not active until the next system reset or power-on.

The boot loader also provides trap-door access into the system if the operating system has problems serious enough that it cannot be used. The trap-door operation provides enough access to the system so that if it is necessary, you can format the flash file system, reinstall the operating system software image by using the Xmodem Protocol, recover from a lost or forgotten password, and finally restart the operating system.

Before you can assign switch information, make sure that you have connected a PC or terminal to the console port or a PC to the Ethernet management port, and make sure you have configured the PC or terminal-emulation software baud rate and character format to match that of the switch console port settings:

- Baud rate default is 9600.
- Data bits default is 8.

Note If the data bits option is set to 8, set the parity option to none.

- Stop bits default is 2 (minor).
- Parity settings default is none.

Switches Information Assignment

You can assign IP information through the switch setup program, through a DHCP server, or manually.

Use the switch setup program if you want to be prompted for specific IP information. With this program, you can also configure a hostname and an enable secret password.

It gives you the option of assigning a Telnet password (to provide security during remote management) and configuring your switch as a command or member switch of a cluster or as a standalone switch.

Use a DHCP server for centralized control and automatic assignment of IP information after the server is configured.

Note If you are using DHCP, do not respond to any of the questions in the setup program until the switch receives the dynamically assigned IP address and reads the configuration file.

If you are an experienced user familiar with the switch configuration steps, manually configure the switch. Otherwise, use the setup program described in the *Boot Process* section.

Default Switch Information

Table 110: Default Switch Information

Feature	Default Setting
IP address and subnet mask	No IP address or subnet mask are defined.
Default gateway	No default gateway is defined.
Enable secret password	No password is defined.
Hostname	The factory-assigned default hostname is Switch.
Telnet password	No password is defined.

Feature	Default Setting
Cluster command switch functionality	Disabled.
Cluster name	No cluster name is defined.

DHCP-Based Autoconfiguration Overview

DHCP provides configuration information to Internet hosts and internetworking devices. This protocol consists of two components: one for delivering configuration parameters from a DHCP server to a device and an operation for allocating network addresses to devices. DHCP is built on a client-server model, in which designated DHCP servers allocate network addresses and deliver configuration parameters to dynamically configured devices. The switch can act as both a DHCP client and a DHCP server.

During DHCP-based autoconfiguration, your switch (DHCP client) is automatically configured at startup with IP address information and a configuration file.

With DHCP-based autoconfiguration, no DHCP client-side configuration is needed on your switch. However, you need to configure the DHCP server for various lease options associated with IP addresses.

If you want to use DHCP to relay the configuration file location on the network, you might also need to configure a Trivial File Transfer Protocol (TFTP) server and a Domain Name System (DNS) server.

The DHCP server for your switch can be on the same LAN or on a different LAN than the switch. If the DHCP server is running on a different LAN, you should configure a DHCP relay device between your switch and the DHCP server. A relay device forwards broadcast traffic between two directly connected LANs. A router does not forward broadcast packets, but it forwards packets based on the destination IP address in the received packet.

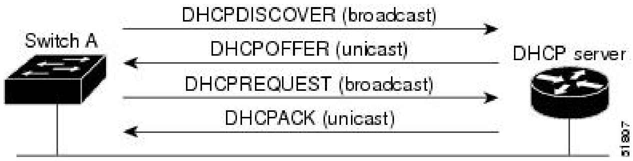
DHCP-based autoconfiguration replaces the BOOTP client functionality on your switch.

DHCP Client Request Process

When you boot up your switch, the DHCP client is invoked and requests configuration information from a DHCP server when the configuration file is not present on the switch. If the configuration file is present and the configuration includes the **ip address dhcp** interface configuration command on specific routed interfaces, the DHCP client is invoked and requests the IP address information for those interfaces.

This is the sequence of messages that are exchanged between the DHCP client and the DHCP server.

Figure 76: DHCP Client and Server Message Exchange



The client, Switch A, broadcasts a DHCPDISCOVER message to locate a DHCP server. The DHCP server offers configuration parameters (such as an IP address, subnet mask, gateway IP address, DNS IP address, a lease for the IP address, and so forth) to the client in a DHCPOFFER unicast message.

In a DHCPREQUEST broadcast message, the client returns a formal request for the offered configuration information to the DHCP server. The formal request is broadcast so that all other DHCP servers that received the DHCPDISCOVER broadcast message from the client can reclaim the IP addresses that they offered to the client.

The DHCP server confirms that the IP address has been allocated to the client by returning a DHCPACK unicast message to the client. With this message, the client and server are bound, and the client uses configuration information received from the server. The amount of information the switch receives depends on how you configure the DHCP server.

If the configuration parameters sent to the client in the DHCPOFFER unicast message are invalid (a configuration error exists), the client returns a DHCPDECLINE broadcast message to the DHCP server.

The DHCP server sends the client a DHCPNAK denial broadcast message, which means that the offered configuration parameters have not been assigned, that an error has occurred during the negotiation of the parameters, or that the client has been slow in responding to the DHCPOFFER message (the DHCP server assigned the parameters to another client).

A DHCP client might receive offers from multiple DHCP or BOOTP servers and can accept any of the offers; however, the client usually accepts the first offer it receives. The offer from the DHCP server is not a guarantee that the IP address is allocated to the client; however, the server usually reserves the address until the client has had a chance to formally request the address. If the switch accepts replies from a BOOTP server and configures itself, the switch broadcasts, instead of unicasts, TFTP requests to obtain the switch configuration file.

The DHCP hostname option allows a group of switches to obtain hostnames and a standard configuration from the central management DHCP server. A client (switch) includes in its DCHPDISCOVER message an option 12 field used to request a hostname and other configuration parameters from the DHCP server. The configuration files on all clients are identical except for their DHCP-obtained hostnames.

If a client has a default hostname (the **hostname** *name* global configuration command is not configured or the **no hostname** global configuration command is entered to remove the hostname), the DHCP hostname option is not included in the packet when you enter the **ip address dhcp** interface configuration command. In this case, if the client receives the DCHP hostname option from the DHCP interaction while acquiring an IP address for an interface, the client accepts the DHCP hostname option and sets the flag to show that the system now has a hostname configured.

DHCP-based Autoconfiguration and Image Update

You can use the DHCP image upgrade features to configure a DHCP server to download both a new image and a new configuration file to one or more switches in a network. Simultaneous image and configuration upgrade for all switches in the network helps ensure that each new switch added to a network receives the same image and configuration.

There are two types of DHCP image upgrades: DHCP autoconfiguration and DHCP auto-image update.

Restrictions for DHCP-based Autoconfiguration

- The DHCP-based autoconfiguration with a saved configuration process stops if there is not at least one Layer 3 interface in an up state without an assigned IP address in the network.
- Unless you configure a timeout, the DHCP-based autoconfiguration with a saved configuration feature tries indefinitely to download an IP address.
- The auto-install process stops if a configuration file cannot be downloaded or if the configuration file is corrupted.

- The configuration file that is downloaded from TFTP is merged with the existing configuration in the running configuration but is not saved in the NVRAM unless you enter the **write memory** or **copy running-configuration startup-configuration** privileged EXEC command. If the downloaded configuration is saved to the startup configuration, the feature is not triggered during subsequent system restarts.

DHCP Autoconfiguration

DHCP autoconfiguration downloads a configuration file to one or more switches in your network from a DHCP server. The downloaded configuration file becomes the running configuration of the switch. It does not over write the bootup configuration saved in the flash, until you reload the switch.

DHCP Auto-Image Update

You can use DHCP auto-image upgrade with DHCP autoconfiguration to download both a configuration and a new image to one or more switches in your network. The switch (or switches) downloading the new configuration and the new image can be blank (or only have a default factory configuration loaded).

If the new configuration is downloaded to a switch that already has a configuration, the downloaded configuration is appended to the configuration file stored on the switch. (Any existing configuration is not overwritten by the downloaded one.)

To enable a DHCP auto-image update on the switch, the TFTP server where the image and configuration files are located must be configured with the correct option 67 (the configuration filename), option 66 (the DHCP server hostname) option 150 (the TFTP server address), and option 125 (description of the Cisco IOS image file) settings.

After you install the switch in your network, the auto-image update feature starts. The downloaded configuration file is saved in the running configuration of the switch, and the new image is downloaded and installed on the switch. When you reboot the switch, the configuration is stored in the saved configuration on the switch.

DHCP Server Configuration Guidelines

Follow these guidelines if you are configuring a device as a DHCP server:

- You should configure the DHCP server with reserved leases that are bound to each switch by the switch hardware address.
- If you want the switch to receive IP address information, you must configure the DHCP server with these lease options:
  - IP address of the client (required)
  - Subnet mask of the client (required)
  - DNS server IP address (optional)
  - Router IP address (default gateway address to be used by the switch) (required)
- If you want the switch to receive the configuration file from a TFTP server, you must configure the DHCP server with these lease options:
  - TFTP server name (required)
  - Boot filename (the name of the configuration file that the client needs) (recommended)

  - Hostname (optional)

- Depending on the settings of the DHCP server, the switch can receive IP address information, the configuration file, or both.

- If you do not configure the DHCP server with the lease options described previously, it replies to client requests with only those parameters that are configured. If the IP address and the subnet mask are not in the reply, the switch is not configured. If the router IP address or the TFTP server name are not found, the switch might send broadcast, instead of unicast, TFTP requests. Unavailability of other lease options does not affect autoconfiguration.

- The switch can act as a DHCP server. By default, the Cisco IOS DHCP server and relay agent features are enabled on your switch but are not configured. (These features are not operational.)

Purpose of the TFTP Server

Based on the DHCP server configuration, the switch attempts to download one or more configuration files from the TFTP server. If you configured the DHCP server to respond to the switch with all the options required for IP connectivity to the TFTP server, and if you configured the DHCP server with a TFTP server name, address, and configuration filename, the switch attempts to download the specified configuration file from the specified TFTP server.

If you did not specify the configuration filename, the TFTP server, or if the configuration file could not be downloaded, the switch attempts to download a configuration file by using various combinations of filenames and TFTP server addresses. The files include the specified configuration filename (if any) and these files: network-config, cisconet.cfg, *hostname*.config, or *hostname*.cfg, where *hostname* is the switch's current hostname. The TFTP server addresses used include the specified TFTP server address (if any) and the broadcast address (255.255.255.255).

For the switch to successfully download a configuration file, the TFTP server must contain one or more configuration files in its base directory. The files can include these files:

- The configuration file named in the DHCP reply (the actual switch configuration file).

- The network-confg or the cisconet.cfg file (known as the default configuration files).

- The router-confg or the ciscortr.cfg file (These files contain commands common to all switches. Normally, if the DHCP and TFTP servers are properly configured, these files are not accessed.)

If you specify the TFTP server name in the DHCP server-lease database, you must also configure the TFTP server name-to-IP-address mapping in the DNS-server database.

If the TFTP server to be used is on a different LAN from the switch, or if it is to be accessed by the switch through the broadcast address (which occurs if the DHCP server response does not contain all the required information described previously), a relay must be configured to forward the TFTP packets to the TFTP server. The preferred solution is to configure the DHCP server with all the required information.

Purpose of the DNS Server

The DHCP server uses the DNS server to resolve the TFTP server name to an IP address. You must configure the TFTP server name-to-IP address map on the DNS server. The TFTP server contains the configuration files for the switch.

You can configure the IP addresses of the DNS servers in the lease database of the DHCP server from where the DHCP replies will retrieve them. You can enter up to two DNS server IP addresses in the lease database.

The DNS server can be on the same LAN or on a different LAN from the switch. If it is on a different LAN, the switch must be able to access it through a router.

How to Obtain Configuration Files

Depending on the availability of the IP address and the configuration filename in the DHCP reserved lease, the switch obtains its configuration information in these ways:

- The IP address and the configuration filename is reserved for the switch and provided in the DHCP reply (one-file read method).

  The switch receives its IP address, subnet mask, TFTP server address, and the configuration filename from the DHCP server. The switch sends a unicast message to the TFTP server to retrieve the named configuration file from the base directory of the server and upon receipt, it completes its boot up process.

- The IP address and the configuration filename is reserved for the switch, but the TFTP server address is not provided in the DHCP reply (one-file read method).

  The switch receives its IP address, subnet mask, and the configuration filename from the DHCP server. The switch sends a broadcast message to a TFTP server to retrieve the named configuration file from the base directory of the server, and upon receipt, it completes its boot-up process.

- Only the IP address is reserved for the switch and provided in the DHCP reply. The configuration filename is not provided (two-file read method).

  The switch receives its IP address, subnet mask, and the TFTP server address from the DHCP server. The switch sends a unicast message to the TFTP server to retrieve the network-confg or cisconet.cfg default configuration file. (If the network-confg file cannot be read, the switch reads the cisconet.cfg file.)

  The default configuration file contains the hostnames-to-IP-address mapping for the switch. The switch fills its host table with the information in the file and obtains its hostname. If the hostname is not found in the file, the switch uses the hostname in the DHCP reply. If the hostname is not specified in the DHCP reply, the switch uses the default *Switch* as its hostname.

  After obtaining its hostname from the default configuration file or the DHCP reply, the switch reads the configuration file that has the same name as its hostname (*hostname*-confg or *hostname*.cfg, depending on whether network-confg or cisconet.cfg was read earlier) from the TFTP server. If the cisconet.cfg file is read, the filename of the host is truncated to eight characters.

  If the switch cannot read the network-confg, cisconet.cfg, or the hostname file, it reads the router-confg file. If the switch cannot read the router-confg file, it reads the ciscortr.cfg file.

Note The switch broadcasts TFTP server requests if the TFTP server is not obtained from the DHCP replies, if all attempts to read the configuration file through unicast transmissions fail, or if the TFTP server name cannot be resolved to an IP address.

How to Control Environment Variables

With a normally operating switch, you enter the boot loader mode only through the console connection. Unplug the switch power cord, then reconnect the power cord. Hold down the **MODE** button until you see the boot loader switch prompt

The switch boot loader software provides support for nonvolatile environment variables, which can be used to control how the boot loader or any other software running on the system, functions. Boot loader environment variables are similar to environment variables that can be set on UNIX or DOS systems.

Environment variables that have values are stored in flash memory outside of the flash file system.

Each line in these files contains an environment variable name and an equal sign followed by the value of the variable. A variable has no value if it is not present; it has a value if it is listed even if the value is a null string. A variable that is set to a null string (for example, “ ”) is a variable with a value. Many environment variables are predefined and have default values.

Environment variables store two kinds of data:

- Data that controls code, which does not read the Cisco IOS configuration file. For example, the name of a boot loader helper file, which extends or patches the functionality of the boot loader can be stored as an environment variable.
- Data that controls code, which is responsible for reading the Cisco IOS configuration file. For example, the name of the Cisco IOS configuration file can be stored as an environment variable.

You can change the settings of the environment variables by accessing the boot loader or by using Cisco IOS commands. Under normal circumstances, it is not necessary to alter the setting of the environment variables.

Common Environment Variables

This table describes the function of the most common environment variables.

Table 111: Common Environment Variables

Variable	Boot Loader Command	Cisco IOS Global Configuration Command
BOOT	**set BOOT** *filesystem* **:/** *file-url* ... A semicolon-separated list of executable files to try to load and execute when automatically booting. If the BOOT environment variable is not set, the system attempts to load and execute the first executable image it can find by using a recursive, depth-first search through the flash file system. If the BOOT variable is set but the specified images cannot be loaded, the system attempts to boot the first bootable file that it can find in the flash file system.	**boot system** {*filesystem* **:** */file-url* ... Specifies the Cisco IOS image to load during the next boot cycle on which the image is loaded. This command changes the setting of the BOOT environment variable.
MANUAL_BOOT	**set MANUAL_BOOT yes** Decides whether the switch automatically or manually boots. Valid values are 1, yes, 0, and no. If it is set to no or 0, the boot loader attempts to automatically boot up the system. If it is set to anything else, you must manually boot up the switch from the boot loader mode.	**boot manual** Enables manually booting the switch during the next boot cycle and changes the setting of the MANUAL_BOOT environment variable. The next time you reboot the system, the switch is in boot loader mode. To boot up the system, use the **boot flash:** *filesystem* **:/** *file-url* boot loader command, and specify the name of the bootable image.

Variable	Boot Loader Command	Cisco IOS Global Configuration Command
CONFIG_FILE	**set CONFIG_FILE flash:/** *file-url* Changes the filename that Cisco IOS uses to read and write a nonvolatile copy of the system configuration.	**boot config-file flash:/** *file-url* Specifies the filename that Cisco IOS uses to read and write a nonvolatile copy of the system configuration. This command changes the CONFIG_FILE environment variable.
BAUD	**set BAUD** *baud-rate*	**line console 0** **speed***speed-value* Configures the baud rate.
ENABLE_BREAK	**set ENABLE_BREAK yes/no**	**boot enable-break switch yes/no** This command can be issued when the flash filesystem is initialized when **ENABLE_BREAK** is set to **yes**.

Scheduled Reload of the Software Image

You can schedule a reload of the software image to occur on the switch at a later time (for example, late at night or during the weekend when the switch is used less), or you can synchronize a reload network-wide (for example, to perform a software upgrade on all switches in the network).

Note A scheduled reload must take place within approximately 24 days.

You have these reload options:

- Reload of the software to take affect in the specified minutes or hours and minutes. The reload must take place within approximately 24 hours. You can specify the reason for the reload in a string up to 255 characters in length.
- Reload of the software to take place at the specified time (using a 24-hour clock). If you specify the month and day, the reload is scheduled to take place at the specified time and date. If you do not specify the month and day, the reload takes place at the specified time on the current day (if the specified time is later than the current time) or on the next day (if the specified time is earlier than the current time). Specifying 00:00 schedules the reload for midnight.

The **reload** command halts the system. If the system is not set to manually boot up, it reboots itself.

If your switch is configured for manual booting, do not reload it from a virtual terminal. This restriction prevents the switch from entering the boot loader mode and then taking it from the remote user's control.

If you modify your configuration file, the switch prompts you to save the configuration before reloading. During the save operation, the system requests whether you want to proceed with the save if the CONFIG_FILE environment variable points to a startup configuration file that no longer exists. If you proceed in this situation, the system enters setup mode upon reload.

To cancel a previously scheduled reload, use the **reload cancel** privileged EXEC command.

How to Perform Switch Setup Configuration

Using DHCP to download a new image and a new configuration to a switch requires that you configure at least two switches. One switch acts as a DHCP and TFTP server and the second switch (client) is configured to download either a new configuration file or a new configuration file and a new image file.

Configuring DHCP Autoconfiguration (Only Configuration File)

This task describes how to configure DHCP autoconfiguration of the TFTP and DHCP settings on an existing switch in the network so that it can support the autoconfiguration of a new switch.

SUMMARY STEPS

1. **configure terminal**
2. **ip dhcp pool** *poolname*
3. **boot** *filename*
4. **network** *network-number mask prefix-length*
5. **default-router** *address*
6. **option 150** *address*
7. **exit**
8. **tftp-server flash**:*filename.text*
9. **interface** *interface-id*
10. **no switchport**
11. **ip address** *address mask*
12. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**ip dhcp pool** *poolname* **Example:** `Switch(config)# ip dhcp pool pool`	Creates a name for the DHCP server address pool, and enters DHCP pool configuration mode.
Step 3	**boot** *filename* **Example:**	Specifies the name of the configuration file that is used as a boot image.

	Command or Action	Purpose
	`Switch(dhcp-config)# boot config-boot.text`	
Step 4	**network** *network-number mask prefix-length* **Example:** `Switch(dhcp-config)# network 10.10.10.0 255.255.255.0`	Specifies the subnet network number and mask of the DHCP address pool. **Note** The prefix length specifies the number of bits that comprise the address prefix. The prefix is an alternative way of specifying the network mask of the client. The prefix length must be preceded by a forward slash (/).
Step 5	**default-router** *address* **Example:** `Switch(dhcp-config)# default-router 10.10.10.1`	Specifies the IP address of the default router for a DHCP client.
Step 6	**option 150** *address* **Example:** `Switch(dhcp-config)# option 150 10.10.10.1`	Specifies the IP address of the TFTP server.
Step 7	**exit** **Example:** `Switch(dhcp-config)# exit`	Returns to global configuration mode.
Step 8	**tftp-server flash**:*filename.text* **Example:** `Switch(config)# tftp-server flash:config-boot.text`	Specifies the configuration file on the TFTP server.
Step 9	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/4`	Specifies the address of the client that will receive the configuration file.
Step 10	**no switchport** **Example:** `Switch(config-if)# no switchport`	Puts the interface into Layer 3 mode.

	Command or Action	Purpose
Step 11	**ip address** *address mask* **Example:** `Switch(config-if)# ip address 10.10.10.1 255.255.255.0`	Specifies the IP address and mask for the interface.

Step 12	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Configuring DHCP Auto-Image Update (Configuration File and Image)

This task describes DHCP autoconfiguration to configure TFTP and DHCP settings on an existing switch to support the installation of a new switch.

Before you begin

You must first create a text file (for example, autoinstall_dhcp) that will be uploaded to the switch. In the text file, put the name of the image that you want to download (forexample, c3750e-ipservices-mz.122-44.3.SE.tarc3750x-ipservices-mz.122-53.3.SE2.tar). This image must be a tar and not a bin file.

SUMMARY STEPS

1. **configure terminal**
2. **ip dhcp pool** *poolname*
3. **boot** *filename*
4. **network** *network-number mask prefix-length*
5. **default-router** *address*
6. **option 150** *address*
7. **option 125** *hex*
8. **copy tftp flash** *filename.txt*
9. **copy tftp flash** *imagename.bin*
10. **exit**
11. **tftp-server flash:** *config.text*
12. **tftp-server flash:** *imagename.bin*
13. **tftp-server flash:** *filename.txt*
14. **interface** *interface-id*
15. **no switchport**
16. **ip address** *address mask*
17. **end**
18. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**ip dhcp pool** *poolname* **Example:** `Switch(config)# ip dhcp pool pool1`	Creates a name for the DHCP server address pool and enter DHCP pool configuration mode.
Step 3	**boot** *filename* **Example:** `Switch(dhcp-config)# boot config-boot.text`	Specifies the name of the file that is used as a boot image.
Step 4	**network** *network-number mask prefix-length* **Example:** `Switch(dhcp-config)# network 10.10.10.0 255.255.255.0`	Specifies the subnet network number and mask of the DHCP address pool. **Note** The prefix length specifies the number of bits that comprise the address prefix. The prefix is an alternative way of specifying the network mask of the client. The prefix length must be preceded by a forward slash (/).
Step 5	**default-router** *address* **Example:** `Switch(dhcp-config)# default-router 10.10.10.1`	Specifies the IP address of the default router for a DHCP client.
Step 6	**option 150** *address* **Example:** `Switch(dhcp-config)# option 150 10.10.10.1`	Specifies the IP address of the TFTP server.
Step 7	**option 125** *hex* **Example:** `Switch(dhcp-config)# option 125 hex 0000.0009.0a05.08661.7574.6f69.6e73.7461.6c6c.5f64.686370`	Specifies the path to the text file that describes the path to the image file.

	Command or Action	Purpose
Step 8	**copy tftp flash** *filename.txt* **Example:** `Switch(config)# copy tftp flash image.bin`	Uploads the text file to the switch.
Step 9	**copy tftp flash** *imagename.bin* **Example:** `Switch(config)# copy tftp flash image.bin`	Uploads the tar file for the new image to the switch.
Step 10	**exit** **Example:** `Switch(dhcp-config)# exit`	Returns to global configuration mode.
Step 11	**tftp-server flash:** *config.text* **Example:** `Switch(config)# tftp-server flash:config-boot.text`	Specifies the Cisco IOS configuration file on the TFTP server.
Step 12	**tftp-server flash:** *imagename.bin* **Example:** `Switch(config)# tftp-server flash:image.bin`	Specifies the image name on the TFTP server.
Step 13	**tftp-server flash:** *filename.txt* **Example:** `Switch(config)# tftp-server flash:boot-config.text`	Specifies the text file that contains the name of the image file to download
Step 14	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/4`	Specifies the address of the client that will receive the configuration file.
Step 15	**no switchport** **Example:** `Switch(config-if)# no switchport`	Puts the interface into Layer 3 mode.

	Command or Action	Purpose
Step 16	**ip address** *address mask* **Example:** `Switch(config-if)# ip address 10.10.10.1 255.255.255.0`	Specifies the IP address and mask for the interface.

Step 17	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 18	**copy running-config startup-config** **Example:** `Switch(config-if)# end`	(Optional) Saves your entries in the configuration file.

Configuring the Client to Download Files from DHCP Server

Note You should only configure and enable the Layer 3 interface. Do not assign an IP address or DHCP-based autoconfiguration with a saved configuration.

SUMMARY STEPS

1. **configure terminal**
2. **boot host dhcp**
3. **boot host retry timeout** *timeout-value*
4. **banner config-save ^C** *warning-message* **^C**
5. **end**
6. **show boot**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**boot host dhcp** **Example:**	Enables autoconfiguration with a saved configuration.

	Command or Action	Purpose
	`Switch(conf)# boot host dhcp`	
Step 3	**boot host retry timeout** *timeout-value* **Example:** `Switch(conf)# boot host retry timeout 300`	(Optional) Sets the amount of time the system tries to download a configuration file. **Note** If you do not set a timeout, the system will try indefinitely to obtain an IP address from the DHCP server.
Step 4	**banner config-save ^C** *warning-message* **^C** **Example:** `Switch(conf)# banner config-save ^C Caution - Saving Configuration File to NVRAM May Cause You to No longer Automatically Download Configuration Files at Reboot^C`	(Optional) Creates warning messages to be displayed when you try to save the configuration file to NVRAM.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**show boot** **Example:** `Switch# show boot`	Verifies the configuration.

Routing Assistance When IP Routing is Disabled

These mechanisms allow the Switch to learn about routes to other networks when it does not have IP routing enabled:

- Default Gateway

Default Gateway

Another method for locating routes is to define a default router or default gateway. All non-local packets are sent to this router, which either routes them appropriately or sends an IP Control Message Protocol (ICMP) redirect message back, defining which local router the host should use. The Switch caches the redirect messages and forwards each packet as efficiently as possible. A limitation of this method is that there is no means of detecting when the default router has gone down or is unavailable.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip default-gateway** *ip-address* **Example:** `Switch(config)# ip default gateway 10.1.5.1`	Sets up a default gateway (router).

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show ip redirects** **Example:** `Switch# show ip redirects`	Displays the address of the default gateway router to verify the setting.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Manually Assigning IP Information to Multiple SVIs

This task describes how to manually assign IP information to multiple switched virtual interfaces (SVIs):

SUMMARY STEPS

1. **configure terminal**
2. **interface vlan** *vlan-id*
3. **ip address** *ip-address subnet-mask*
4. **exit**
5. **ip default-gateway** *ip-address*

6. **end**
7. **show interfaces vlan** *vlan-id*
8. **show ip redirects**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface vlan** *vlan-id* **Example:** `Switch(config)# interface vlan 99`	Enters interface configuration mode, and enter the VLAN to which the IP information is assigned. The range is 1 to 4094.
Step 3	**ip address** *ip-address subnet-mask* **Example:** `Switch(config-vlan)# ip address 10.10.10.2 255.255.255.0`	Enters the IP address and subnet mask.
Step 4	**exit** **Example:** `Switch(config-vlan)# exit`	Returns to global configuration mode.
Step 5	**ip default-gateway** *ip-address* **Example:** `Switch(config)# ip default-gateway 10.10.10.1`	Enters the IP address of the next-hop router interface that is directly connected to the switch where a default gateway is being configured. The default gateway receives IP packets with unresolved destination IP addresses from the switch. Once the default gateway is configured, the switch has connectivity to the remote networks with which a host needs to communicate. **Note** When your switch is configured to route with IP, it does not need to have a default gateway set.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 7	**show interfaces vlan** *vlan-id* **Example:** `Switch# show interfaces vlan 99`	Verifies the configured IP address.
Step 8	**show ip redirects** **Example:** `Switch# show ip redirects`	Verifies the configured default gateway.

Configuring the NVRAM Buffer Size

The default NVRAM buffer size is 512 KB. In some cases, the configuration file might be too large to save to NVRAM. You can configure the size of the NVRAM buffer to support larger configuration files.

Note After you configure the NVRAM buffer size, reload the switch.

SUMMARY STEPS

1. **configure terminal**
2. **boot buffersize** *size*
3. **end**
4. **show boot**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**boot buffersize** *size* **Example:** `Switch(config)# boot buffersize 524288`	Configures the NVRAM buffersize in KB. The valid range for *size* is from 4096 to 1048576.
Step 3	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 4	**show boot** **Example:** `Switch# show boot`	Verifies the configuration.

Modifying the Switch Startup Configuration

Specifying the Filename to Read and Write the System Configuration

By default, the Cisco IOS software uses the config.text file to read and write a nonvolatile copy of the system configuration. However, you can specify a different filename, which will be loaded during the next boot cycle.

Before you begin

Use a standalone switch for this task.

SUMMARY STEPS

1. **configure terminal**
2. **boot flash**:/*file-url*
3. **end**
4. **show boot**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**boot flash**:/*file-url* **Example:** `Switch(config)# boot flash:config.text`	Specifies the configuration file to load during the next boot cycle. *file-url*—The path (directory) and the configuration filename. Filenames and directory names are case-sensitive.
Step 3	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 4	**show boot** **Example:** `Switch# show boot`	Verifies your entries. The **boot** global configuration command changes the setting of the CONFIG_FILE environment variable.
Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Manually Booting the Switch

By default, the switch automatically boots up; however, you can configure it to manually boot up.

Before you begin

Use a standalone switch for this task.

SUMMARY STEPS

1. **configure terminal**
2. **boot manual**
3. **end**
4. **show boot**
5. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**boot manual** **Example:** `Switch(config)# boot manual`	Enables the switch to manually boot up during the next boot cycle.
Step 3	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config)# end`	
Step 4	**show boot** **Example:** `Switch# show boot`	Verifies your entries. The **boot manual** global command changes the setting of the MANUAL_BOOT environment variable. The next time you reboot the system, the switch is in boot loader mode, shown by the *switch:* prompt. To boot up the system, use the **boot** *filesystem:/file-url* boot loader command. • *filesystem*:—Uses flash: for the system board flash device. `Switch: boot flash:` • For *file-url*—Specifies the path (directory) and the name of the bootable image. Filenames and directory names are case-sensitive.
Step 5	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a Scheduled Software Image Reload

This task describes how to configure your switch to reload the software image at a later time.

SUMMARY STEPS

1. **configure terminal**
2. **copy running-config startup-config**
3. **reload in** [*hh*:]*mm* [*text*]
4. **reload at** *hh*: *mm* [*month day* | *day month*] [*text*]
5. **reload cancel**
6. **show reload**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**copy running-config startup-config** **Example:** `copy running-config startup-config`	Saves your switch configuration information to the startup configuration before you use the **reload** command.

Step 3	**reload in** [*hh*:]*mm* [*text*]
	Example:
	`Switch(config)# reload in 12`
	` System configuration has been modified. Save? [yes/no]: y`
		Schedules a reload of the software to take affect in the specified minutes or hours and minutes. The reload must take place within approximately 24 days. You can specify the reason for the reload in a string up to 255 characters in length.

Step 4	**reload at** *hh*: *mm* [*month day* | *day month*] [*text*] **Example:** `Switch(config)# reload at 14:00`	Specifies the time in hours and minutes for the reload to occur. **Note** Use the **at** keyword only if the switch system clock has been set (through Network Time Protocol (NTP), the hardware calendar, or manually). The time is relative to the configured time zone on the switch. To schedule reloads across several switches to occur simultaneously, the time on each switch must be synchronized with NTP.
Step 5	**reload cancel** **Example:** `Switch(config)# reload cancel`	Cancels a previously scheduled reload.
Step 6	**show reload** **Example:** `show reload`	Displays information about a previously scheduled reload or identifies if a reload has been scheduled on the switch.

Configuration Examples for Performing Switch Setup

Example: Configuring a Switch as a DHCP Server

```
Switch# configure terminal
Switch(config)# ip dhcp pool pool1
Switch(dhcp-config)# network 10.10.10.0 255.255.255.0
Switch(dhcp-config)# boot config-boot.text
Switch(dhcp-config)# default-router 10.10.10.1
Switch(dhcp-config)# option 150 10.10.10.1
Switch(dhcp-config)# exit
Switch(config)# tftp-server flash:config-boot.text
Switch(config)# interface gigabitethernet 0/4
Switch(config-if)# no switchport
Switch(config-if)# ip address 10.10.10.1 255.255.255.0
Switch(config-if)# end
```

Example: Configuring DHCP Auto-Image Update

Example: Configuring a Switch to Download Configurations from a DHCP Server

This example uses a Layer 3 SVI interface on VLAN 99 to enable DHCP-based autoconfiguration with a saved configuration:

```
Switch# configure terminal
Switch(config)# boot host dhcp
Switch(config)# boot host retry timeout 300
Switch(config)# banner config-save ^C Caution - Saving Configuration File to NVRAM May Cause
 You to No longer Automatically Download Configuration Files at Reboot^C
Switch(config)# vlan 99
Switch(config-vlan)# interface vlan 99
Switch(config-if)# no shutdown
Switch(config-if)# end
Switch# show boot
BOOT path-list:
Config file:          flash:/config.text
Private Config file:  flash:/private-config.text
Enable Break:         no
Manual Boot:          no
HELPER path-list:
NVRAM/Config file
      buffer size:    32768
Timeout for Config
          Download:    300 seconds
Config Download
       via DHCP:       enabled (next boot: enabled)
Switch#
```

Example: Configuring NVRAM Buffer Size

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# boot buffersize 600000
Switch(config)# end
Switch# show boot
BOOT path-list      :
Config file         : flash:/config.text
Private Config file : flash:/private-config.text
Enable Break        : no
Manual Boot         : no
HELPER path-list    :
Auto upgrade        : yes
Auto upgrade path   :
NVRAM/Config file
```

```
      buffer size:   600000
Timeout for Config
          Download:    300 seconds
Config Download
       via DHCP:       enabled (next boot: enabled)
Switch#
```

CHAPTER 54

Configuring System Message Logs

Restrictions for Configuring System Message Logs

When the **logging discriminator** command is configured, the device may experience memory leak or crash. This usually happens during heavy syslog or debug output. The rate of the memory leak is dependent on the number of logs being produced. In extreme cases, the device may also crash. As a workaround, use the **no logging discriminator** command to disable the logging discriminator.

Information About Configuring System Message Logs

System Messsage Logging

By default, a switch sends the output from system messages and **debug** privileged EXEC commands to a logging process. . The logging process controls the distribution of logging messages to various destinations, such as the logging buffer, terminal lines, or a UNIX syslog server, depending on your configuration. The process also sends messages to the console.

When the logging process is disabled, messages are sent only to the console. The messages are sent as they are generated, so message and debug output are interspersed with prompts or output from other commands. Messages appear on the active consoles after the process that generated them has finished.

You can set the severity level of the messages to control the type of messages displayed on the consoles and each of the destinations. You can time-stamp log messages or set the syslog source address to enhance real-time debugging and management. For information on possible messages, see the system message guide for this release.

You can access logged system messages by using the switch command-line interface (CLI) or by saving them to a properly configured syslog server. The switch software saves syslog messages in an internal buffer on a standalone switch. If a standalone switch , the log is lost unless you had saved it to flash memory.

You can remotely monitor system messages by viewing the logs on a syslog server or by accessing the switch through Telnet, through the console port, or through the Ethernet management port.

Note The syslog format is compatible with 4.3 BSD UNIX.

System Log Message Format

System log messages can contain up to 80 characters and a percent sign (%), which follows the optional sequence number or time-stamp information, if configured. Depending on the switch, messages appear in one of these formats:

- *seq no:timestamp: %facility-severity-MNEMONIC:description (hostname-n)*
- *seq no:timestamp: %facility-severity-MNEMONIC:description*

The part of the message preceding the percent sign depends on the setting of these global configuration commands:

- **service sequence-numbers**
- **service timestamps log datetime**
- **service timestamps log datetime** [**localtime**] [**msec**] [**show-timezone**]
- **service timestamps log uptime**

Table 112: System Log Message Elements

Element	Description
seq no:	Stamps log messages with a sequence number only if the **service sequence-numbers** global configuration command is configured.
timestamp formats: *mm/dd h h:mm:ss* or *hh:mm:ss* (short uptime) or *d h* (long uptime)	Date and time of the message or event. This information appears only if the **service timestamps log** [**datetime** | **log**] global configuration command is configured.
facility	The facility to which the message refers (for example, SNMP, SYS, and so forth).
severity	Single-digit code from 0 to 7 that is the severity of the message.
MNEMONIC	Text string that uniquely describes the message.

Element	Description
description	Text string containing detailed information about the event being reported.

Default System Message Logging Settings

Table 113: Default System Message Logging Settings

Feature	Default Setting
System message logging to the console	Enabled.
Console severity	Debugging.
Logging file configuration	No filename specified.
Logging buffer size	4096 bytes.
Logging history size	1 message.
Time stamps	Disabled.
Synchronous logging	Disabled.
Logging server	Disabled.
Syslog server IP address	None configured.
Server facility	Local7
Server severity	Informational.

Enabling Syslog Trap Messages

You can enable Syslog traps using the **snmp-server enable traps syslog** command.

After enabling Syslog traps, you have to specify the trap message severity. Use the **logging snmp-trap** command to specify the trap level. By default, the command enables severity 0 to 4. To enable all the severity level, configure the **logging snmp-trap 0 7** command.

To enable individual trap levels, configure the following commands:

- **logging snmp-trap emergencies**:Enables only severity 0 traps.
- **logging snmp-trap alert** Enables only severity 1 traps.

Note that, along with the Syslog traps, the Syslog history should also be applied. Without this configuration, Syslog traps are not sent.

Use the **logging history informational** command to enable the Syslog history.

How to Configure System Message Logs

Setting the Message Display Destination Device

If message logging is enabled, you can send messages to specific locations in addition to the console.

This task is optional.

SUMMARY STEPS

1. **configure terminal**
2. **logging buffered** [*size*]
3. **logging** *host*
4. **logging file flash:** *filename* [*max-file-size* [*min-file-size*]] [*severity-level-number* | *type*]
5. **end**
6. **terminal monitor**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**logging buffered** [*size*] **Example:** `Switch(config)# logging buffered 8192`	Logs messages to an internal buffer on the switch. The range is 4096 to 2147483647 bytes. The default buffer size is 4096 bytes. If a standalone switch or the active switch fails, the log file is lost unless you previously saved it to flash memory. See Step 4. **Note** Do not make the buffer size too large because the switch could run out of memory for other tasks. Use the **show memory** privileged EXEC command to view the free processor memory on the switch. However, this value is the maximum available, and the buffer size should *not* be set to this amount.
Step 3	**logging** *host* **Example:** `Switch(config)# logging 125.1.1.100`	Logs messages to a UNIX syslog server host. *host* specifies the name or IP address of the host to be used as the syslog server. To build a list of syslog servers that receive logging messages, enter this command more than once.

	Command or Action	Purpose
Step 4	**logging file flash:** *filename* [*max-file-size* [*min-file-size*]] [*severity-level-number* | *type*] **Example:** `Switch(config)# logging file flash:log_msg.txt 40960 4096 3`	Stores log messages in a file in flash memory on a standalone switch. • *filename*—Enters the log message filename. • (Optional) **max-file-size** —Specifies the maximum logging file size. The range is 4096 to 2147483647. The default is 4096 bytes. • (Optional) *min-file-size*—Specifies the minimum logging file size. The range is 1024 to 2147483647. The default is 2048 bytes. • (Optional) *severity-level-number* | *type*—Specifies either the logging severity level or the logging type. The severity range is 0 to 7.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**terminal monitor** **Example:** `Switch# terminal monitor`	Logs messages to a nonconsole terminal during the current session. Terminal parameter-setting commands are set locally and do not remain in effect after the session has ended. You must perform this step for each session to see the debugging messages.

Synchronizing Log Messages

You can synchronize unsolicited messages and **debug** privileged EXEC command output with solicited device output and prompts for a specific console port line or virtual terminal line. You can identify the types of messages to be output asynchronously based on the level of severity. You can also configure the maximum number of buffers for storing asynchronous messages for the terminal after which messages are dropped.

When synchronous logging of unsolicited messages and **debug** command output is enabled, unsolicited device output appears on the console or printed after solicited device output appears or is printed. Unsolicited messages and **debug** command output appears on the console after the prompt for user input is returned. Therefore, unsolicited messages and **debug** command output are not interspersed with solicited device output and prompts. After the unsolicited messages appear, the console again displays the user prompt.

This task is optional.

SUMMARY STEPS

1. **configure terminal**
2. **line** [**console** | **vty**] *line-number* [*ending-line-number*]
3. **logging synchronous** [**level** [*severity-level* | **all**] | **limit** *number-of-buffers*]

4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**line** [**console** | **vty**] *line-number* [*ending-line-number*] **Example:** `Switch(config)# line console`	Specifies the line to be configured for synchronous logging of messages. • **console** —Specifies configurations that occur through the switch console port or the Ethernet management port. • **line vty** *line-number*—Specifies which vty lines are to have synchronous logging enabled. You use a vty connection for configurations that occur through a Telnet session. The range of line numbers is from 0 to 15. You can change the setting of all 16 vty lines at once by entering: line vty 0 15 You can also change the setting of the single vty line being used for your current connection. For example, to change the setting for vty line 2, enter: line vty 2 When you enter this command, the mode changes to line configuration.
Step 3	**logging synchronous** [**level** [*severity-level* | **all**] | **limit** *number-of-buffers*] **Example:** `Switch(config)# logging synchronous level 3 limit 1000`	Enables synchronous logging of messages. • (Optional) **level** *severity-level*—Specifies the message severity level. Messages with a severity level equal to or higher than this value are printed asynchronously. Low numbers mean greater severity and high numbers mean lesser severity. The default is 2. • (Optional) **level all**—Specifies that all messages are printed asynchronously regardless of the severity level. • (Optional) **limit** *number-of-buffers*—Specifies the number of buffers to be queued for the terminal after which new messages are dropped. The range is 0 to 2147483647. The default is 20.

	Command or Action	Purpose

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Disabling Message Logging

Message logging is enabled by default. It must be enabled to send messages to any destination other than the console. When enabled, log messages are sent to a logging process, which logs messages to designated locations asynchronously to the processes that generated the messages.

Disabling the logging process can slow down the switch because a process must wait until the messages are written to the console before continuing. When the logging process is disabled, messages appear on the console as soon as they are produced, often appearing in the middle of command output.

The **logging synchronous** global configuration command also affects the display of messages to the console. When this command is enabled, messages appear only after you press **Return**.

To reenable message logging after it has been disabled, use the **logging on** global configuration command.

This task is optional.

SUMMARY STEPS

1. **configure terminal**
2. **no logging console**
3. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**no logging console** **Example:** `Switch(config)# no logging console`	Disables message logging.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Enabling and Disabling Time Stamps on Log Messages

By default, log messages are not time-stamped.

This task is optional.

SUMMARY STEPS

1. **configure terminal**
2. Use one of these commands:
   - **service timestamps log uptime**
   - **service timestamps log datetime**[**msec** | **localtime** | **show-timezone**]
3. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 2	Use one of these commands:
	• **service timestamps log uptime**
	• **service timestamps log datetime**[**msec** | **localtime** | **show-timezone**]
	Example:
	`Switch(config)# service timestamps log uptime`
	or
	`Switch(config)# service timestamps log datetime`
		Enables log time stamps.
		• **log uptime**—Enables time stamps on log messages, showing the time since the system was rebooted.
		• **log datetime**—Enables time stamps on log messages. Depending on the options selected, the time stamp can include the date, time in milliseconds relative to the local time zone, and the time zone name.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Enabling and Disabling Sequence Numbers in Log Messages

If there is more than one log message with the same time stamp, you can display messages with sequence numbers to view these messages. By default, sequence numbers in log messages are not displayed.

This task is optional.

SUMMARY STEPS

1. **configure terminal**
2. **service sequence-numbers**
3. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**service sequence-numbers** **Example:** `Switch(config)# service sequence-numbers`	Enables sequence numbers.

Step 3	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Defining the Message Severity Level

Limit messages displayed to the selected device by specifying the severity level of the message.

This task is optional.

SUMMARY STEPS

1. **configure terminal**
2. **logging console** *level*
3. **logging monitor** *level*
4. **logging trap** *level*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**logging console** *level* **Example:** `Switch(config)# logging console 3`	Limits messages logged to the console. By default, the console receives debugging messages and numerically lower levels.
Step 3	**logging monitor** *level* **Example:** `Switch(config)# logging monitor 3`	Limits messages logged to the terminal lines. By default, the terminal receives debugging messages and numerically lower levels.
Step 4	**logging trap** *level* **Example:** `Switch(config)# logging trap 3`	Limits messages logged to the syslog servers. By default, syslog servers receive informational messages and numerically lower levels.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Limiting Syslog Messages Sent to the History Table and to SNMP

This task explains how to limit syslog messages that are sent to the history table and to SNMP.

This task is optional.

SUMMARY STEPS

1. **configure terminal**
2. **logging history** *level*
3. **logging history size** *number*
4. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**logging history** *level* **Example:** `Switch(config)# logging history 3`	Changes the default level of syslog messages stored in the history file and sent to the SNMP server. By default, **warnings**, **errors**, **critical**, **alerts**, and **emergencies** messages are sent.
Step 3	**logging history size** *number* **Example:** `Switch(config)# logging history size 200`	Specifies the number of syslog messages that can be stored in the history table. The default is to store one message. The range is 0 to 500 messages.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Logging Messages to a UNIX Syslog Daemon

This task is optional.

Note Some recent versions of UNIX syslog daemons no longer accept by default syslog packets from the network. If this is the case with your system, use the UNIX **man syslogd** command to decide what options must be added to or removed from the syslog command line to enable logging of remote syslog messages.

Before you begin

- Log in as root.
- Before you can send system log messages to a UNIX syslog server, you must configure the syslog daemon on a UNIX server.

SUMMARY STEPS

1. Add a line to the file /etc/syslog.conf.
2. Enter these commands at the UNIX shell prompt.
3. Make sure the syslog daemon reads the new changes.

DETAILED STEPS

	Command or Action	Purpose
Step 1	Add a line to the file /etc/syslog.conf. **Example:**	• **local7**—Specifies the logging facility.

	Command or Action	Purpose
	`local7.debug /usr/adm/logs/cisco.log`	- **debug**—Specifies the syslog level. The file must already exist, and the syslog daemon must have permission to write to it.

Step 2	Enter these commands at the UNIX shell prompt.
	Example:
	`$ touch /var/log/cisco.log`
	`$ chmod 666 /var/log/cisco.log`
		Creates the log file. The syslog daemon sends messages at this level or at a more severe level to this file.

Step 3	Make sure the syslog daemon reads the new changes. **Example:** ``$ kill -HUP `cat /etc/syslog.pid` ``	For more information, see the **man syslog.conf** and **man syslogd** commands on your UNIX system.

Monitoring and Maintaining System Message Logs

Monitoring Configuration Archive Logs

Command	Purpose
show archive log config {**all** | **number** [*end-number*] | **user** *username* [**session** *number*] *number* [*end-number*] | **statistics**} [**provisioning**]	Displays the entire configuration log or the log for specified parameters.

Configuration Examples for System Message Logs

Example: Switch System Message

This example shows a partial switch system message on a switch:

```
00:00:46: %LINK-3-UPDOWN: Interface Port-channel1, changed state to up
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet0/1, changed state to up
00:00:47: %LINK-3-UPDOWN: Interface GigabitEthernet0/2, changed state to up
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed state to down
00:00:48: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state
 to down 2
*Mar  1 18:46:11: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
18:47:02: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
*Mar  1 18:48:50.483 UTC: %SYS-5-CONFIG_I: Configured from console by vty2 (10.34.195.36)
```

Additional References for System Message Logs

Related Documents

Related Topic	Document Title
System message log commands	*Catalyst 2960-L Switch System Management Command Reference*
Platform-independent command references	*Cisco IOS 15.3M&T Command References*
Platform-independent configuration information	*Cisco IOS 15.3M&T Configuration Guides*

Standards and RFCs

Standard/RFC	Title
None	—

MIBs

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information For System Message Logs

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 55

Configuring Online Diagnostics

Information About Configuring Online Diagnostics

Online Diagnostics

With online diagnostics, you can test and verify the hardware functionality of the Switch while the Switch is connected to a live network.

The online diagnostics contain packet switching tests that check different hardware components and verify the data path and the control signals.

The online diagnostics detect problems in these areas:

- Hardware components
- Interfaces (Ethernet ports and so forth)
- Solder joints

Online diagnostics are categorized as on-demand, scheduled, or health-monitoring diagnostics. On-demand diagnostics run from the CLI; scheduled diagnostics run at user-designated intervals or at specified times when the Switch is connected to a live network; and health-monitoring runs in the background with user-defined intervals. By default, the health-monitoring test runs for every 30 seconds.

After you configure online diagnostics, you can manually start diagnostic tests or display the test results. You can also see which tests are configured for the Switch and the diagnostic tests that have already run.

Note The Catalyst 2960L switch is not stackable. Hence, the **switch** *number* keyword is not supported on this switch.

How to Configure Online Diagnostics

Starting Online Diagnostic Tests

After you configure diagnostic tests to run on the switch, use the **diagnostic start** privileged EXEC command to begin diagnostic testing.

After starting the tests, you cannot stop the testing process.

Use this privileged EXEC command to manually start online diagnostic testing.

SUMMARY STEPS

1. **diagnostic start test** {*name* | *test-id* | *test-id-range* | **all** | **basic** | **non-disruptive** }

DETAILED STEPS

	Command or Action	Purpose

Step 1	**diagnostic start test** {*name* | *test-id* | *test-id-range* | **all** | **basic** | **non-disruptive** }
	Example:
	`Switch# diagnostic start test basic`
		Starts the diagnostic tests.
		You can specify the tests by using one of these options:
		• *name*—Enters the name of the test.
		• *test-id*—Enters the ID number of the test.
		• *test-id-range*—Enters the range of test IDs by using integers separated by a comma and a hyphen.
		• **all**—Starts all of the tests.
		• **basic**— Starts the basic test suite.
		• **non-disruptive**—Starts the non-disruptive test suite.

Configuring Online Diagnostics

You must configure the failure threshold and the interval between tests before enabling diagnostic monitoring.

Scheduling Online Diagnostics

You can schedule online diagnostics to run at a designated time of day or on a daily, weekly, or monthly basis for a switch. Use the **no** form of this command to remove the scheduling.

SUMMARY STEPS

1. **configure terminal**
2. **diagnostic schedule test** {*name* | *test-id* | *test-id-range* | **all** | **basic** | **non-disruptive** |} {**daily** | **on** *mm dd yyyy hh:mm* | **weekly** *day-of-week hh:mm*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**diagnostic schedule test** {*name* | *test-id* | *test-id-range* | **all** | **basic** | **non-disruptive** |} {**daily** | **on** *mm dd yyyy hh:mm* | **weekly** *day-of-week hh:mm*} **Example:** `Switch(config)# diagnostic schedule test 1-5 on July 3 2013 23:10`	Schedules on-demand diagnostic tests for a specific day and time. When specifying the tests to be scheduled, use these options: • *name*—Name of the test that appears in the **show diagnostic content** command output. • *test-id*—ID number of the test that appears in the **show diagnostic content** command output. • *test-id-range*—ID numbers of the tests that appear in the **show diagnostic content** command output. • **all**—All test IDs. • **basic**—Starts the basic on-demand diagnostic tests. • **non-disruptive**—Starts the non-disruptive test suite. You can schedule the tests as follows: • Daily—Use the **daily** *hh:mm* parameter. • Specific day and time—Use the **on** *mm dd yyyy hh:mm* parameter. • Weekly—Use the **weekly** *day-of-week hh:mm* parameter.

Configuring Health-Monitoring Diagnostics

You can configure health-monitoring diagnostic testing on a Switch while it is connected to a live network. You can configure the execution interval for each health-monitoring test, enable the Switch to generate a syslog message because of a test failure, and enable a specific test.

Use the **no** form of this command to disable testing.

By default, health monitoring is disabled, but the Switch generates a syslog message when a test fails.

Follow these steps to configure and enable the health-monitoring diagnostic tests:

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **diagnostic monitor interval test** {*name* | *test-id* | *test-id-range* | **all**} *hh:mm:ss milliseconds day*
4. **diagnostic monitor syslog**
5. **diagnostic monitor threshold** *number* **test** {*name* | *test-id* | *test-id-range* | **all**} **failure count** *count*
6. **diagnostic monitor test** {*name* | *test-id* | *test-id-range* | **all**}
7. **end**
8. **show running-config**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**diagnostic monitor interval test** {*name* | *test-id* | *test-id-range* | **all**} *hh:mm:ss milliseconds day* **Example:** `Switch(config)# diagnostic monitor interval test 1 12:30:00 750 5`	Configures the health-monitoring interval of the specified tests. When specifying the tests, use one of these parameters: • *name*—Name of the test that appears in the **show diagnostic content** command output. • *test-id*—ID number of the test that appears in the **show diagnostic content** command output. • *test-id-range*—ID numbers of the tests that appear in the **show diagnostic content** command output. • **all**—All of the diagnostic tests. When specifying the interval, set these parameters: • *hh:mm:ss*—Monitoring interval in hours, minutes, and seconds. The range for *hh* is 0 to 24, and the range for *mm* and *ss* is 0 to 60. • *milliseconds*—Monitoring interval in milliseconds (ms). The range is from 0 to 999. • *day*—Monitoring interval in the number of days. The range is from 0 to 20.

	Command or Action	Purpose
Step 4	**diagnostic monitor syslog** **Example:** `Switch(config)# diagnostic monitor syslog`	(Optional) Configures the switch to generate a syslog message when a health-monitoring test fails.
Step 5	**diagnostic monitor threshold** *number* **test** {*name* | *test-id* | *test-id-range* | **all**} **failure count** *count* **Example:** `Switch(config)# diagnostic monitor threshold test 1 failure count 20`	(Optional) Sets the failure threshold for the health-monitoring tests. When specifying the tests, use one of these parameters: • *name*—Name of the test that appears in the **show diagnostic content** command output. • *test-id*—ID number of the test that appears in the **show diagnostic content** command output. • *test-id-range*—ID numbers of the tests that appear in the **show diagnostic content** command output. • **all**—All of the diagnostic tests. The range for the failure threshold *count* is 0 to 99.

Step 6	**diagnostic monitor test** {*name* | *test-id* | *test-id-range* | **all**}
	Example:
	`Switch(config)# diagnostic monitor test 1`
		Enables the specified health-monitoring tests.
		When specifying the tests, use one of these parameters:
		• *name*—Name of the test that appears in the **show diagnostic content** command output.
		• *test-id*—ID number of the test that appears in the **show diagnostic content** command output.
		• *test-id-range*—ID numbers of the tests that appear in the **show diagnostic content** command output.
		• **all**—All of the diagnostic tests.

Step 7	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 9	**copy running-config startup-config** **Example:**	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	`Switch# copy running-config startup-config`	

What to do next

Use the **no diagnostic monitor interval test***test-id* | *test-id-range* } global configuration command to change the interval to the default value or to zero. Use the **no diagnostic monitor syslog** command to disable generation of syslog messages when a health-monitoring test fails. Use the **diagnostic monitor threshold test***test-id* | *test-id-range* }**failure count**command to remove the failure threshold.

Monitoring and Maintaining Online Diagnostics

Displaying Online Diagnostic Tests and Test Results

You can display the online diagnostic tests that are configured for the Switch and check the test results by using the privileged EXEC **show** commands in this table:

Table 114: Commands for Diagnostic Test Configuration and Results

Command	Purpose
show diagnostic content	Displays the online diagnostics configured for a switch.
show diagnostic status	Displays the currently running diagnostic tests.
show diagnostic result switch [*number* | **all**] [**detail** | **test** {*name* | *test-id* | *test-id-range* | **all**} [**detail**]]	Displays the online diagnostics test results.
show diagnostic detail]	Displays the online diagnostics test results.
show diagnostic schedule	Displays the online diagnostics test schedule.
show diagnostic post	Displays the POST results. (The output is the same as the **show post** command output.)

Configuration Examples for Online Diagnostic Tests

Starting Online Diagnostic Tests

After you configure diagnostic tests to run on the switch, use the **diagnostic start** privileged EXEC command to begin diagnostic testing.

After starting the tests, you cannot stop the testing process.

Use this privileged EXEC command to manually start online diagnostic testing.

SUMMARY STEPS

1. **diagnostic start test** {*name* | *test-id* | *test-id-range* | **all** | **basic** | **non-disruptive** }

DETAILED STEPS

	Command or Action	Purpose

Step 1	**diagnostic start test** {*name* | *test-id* | *test-id-range* | **all** | **basic** | **non-disruptive** }
	Example:
	`Switch# diagnostic start test basic`
		Starts the diagnostic tests.
		You can specify the tests by using one of these options:
		• *name*—Enters the name of the test.
		• *test-id*—Enters the ID number of the test.
		• *test-id-range*—Enters the range of test IDs by using integers separated by a comma and a hyphen.
		• **all**—Starts all of the tests.
		• **basic**— Starts the basic test suite.
		• **non-disruptive**—Starts the non-disruptive test suite.

Example: Configure a Health Monitoring Test

This example shows how to configure a health-monitoring test:

```
Switch(config)# diagnostic monitor threshold test 1 failure count 50
Switch(config)# diagnostic monitor interval test TestPortAsicLoopback
```

Note The Catalyst 2960L switch is not stackable. Hence, the **switch** *number* keyword is not supported on this switch.

Examples: Schedule Diagnostic Test

This example shows how to schedule diagnostic testing for a specific day and time on a specific switch:

```
Switch(config)# diagnostic schedule test DiagThermalTest on June 3 2013  22:25
```

This example shows how to schedule diagnostic testing to occur weekly at a certain time on a specific switch:

```
Switch(config)# diagnostic schedule switch 1 test 1,2,4-6 weekly saturday 10:30
```

Note The Catalyst 2960L switch is not stackable. Hence, the **switch** *number* keyword is not supported on this switch.

Displaying Online Diagnostics: Examples

This example shows how to display the online diagnostic detailed information on a switch:

```
Switch# show diagnostic switch detail

:   SerialNo :

  Overall Diagnostic Result : UNTESTED

  Test results: (. = Pass, F = Fail, U = Untested)

  ___________________________________________________________________________

    1) TestPortAsicLoopback ------------> U

          Error code ------------------> 3 (DIAG_SKIPPED)
          Total run count -------------> 0
          Last test testing type ------> n/a
          Last test execution time ----> n/a
          First test failure time -----> n/a
          Last test failure time ------> n/a
          Last test pass time ---------> n/a
          Total failure count ---------> 0
          Consecutive failure count ---> 0
  ___________________________________________________________________________

    2) TestPortAsicCam -----------------> U

          Error code ------------------> 3 (DIAG_SKIPPED)
          Total run count -------------> 0
          Last test testing type ------> n/a
          Last test execution time ----> n/a
          First test failure time -----> n/a
          Last test failure time ------> n/a
          Last test pass time ---------> n/a
          Total failure count ---------> 0
          Consecutive failure count ---> 0
  ___________________________________________________________________________

    3) TestPortAsicMem -----------------> U

          Error code ------------------> 3 (DIAG_SKIPPED)
          Total run count -------------> 0
          Last test testing type ------> n/a
          Last test execution time ----> n/a
          First test failure time -----> n/a
          Last test failure time ------> n/a
          Last test pass time ---------> n/a
          Total failure count ---------> 0
          Consecutive failure count ---> 0
  ___________________________________________________________________________
```

This example shows how to display the online diagnostics that are configured on a switch:

```
Switch# show diagnostic content

:

  Diagnostics test suite attributes:
      B/* - Basic ondemand test / NA
    P/V/* - Per port test / Per device test / NA
    D/N/* - Disruptive test / Non-disruptive test / NA
      S/* - Only applicable to standby unit / NA
      X/* - Not a health monitoring test / NA
      F/* - Fixed monitoring interval test / NA
      E/* - Always enabled monitoring test / NA
      A/I - Monitoring is active / Monitoring is inactive
      R/* - Switch will reload after test list completion / NA
      P/* - will partition stack / NA

                                                          Test Interval   Thre-
  ID   Test Name                          Attributes      day hh:mm:ss.ms shold
  ==== ================================== ============    =============== =====
    1) TestPortAsicLoopback ------------> B*D*X**IR*      not configured  n/a
    2) TestPortAsicCam -----------------> B*D*X**IR*      not configured  n/a
    3) TestPortAsicMem -----------------> B*D*X**IR*      not configured  n/a
```

This example shows how to display the online diagnostic results for a switch:

```
Switch# show diagnostic result

:   SerialNo :

  Overall Diagnostic Result : UNTESTED

  Test results: (. = Pass, F = Fail, U = Untested)

    1) TestPortAsicLoopback ------------> U
    2) TestPortAsicCam -----------------> U
    3) TestPortAsicMem -----------------> U
```

This example shows how to display the online diagnostic test status:

```
Switch# show diagnostic status


<BU> - Bootup Diagnostics, <HM> - Health Monitoring Diagnostics,
<OD> - OnDemand Diagnostics, <SCH> - Scheduled Diagnostics

====== ================================= =============================== ======
Card   Description                       Current Running Test            Run by
------ --------------------------------- ------------------------------- ------
                                         N/A                             N/A

====== ================================= =============================== ======
Switch#
```

This example shows how to display the online diagnostic test schedule for a switch:

```
Switch# show diagnostic schedule

Current Time = 17:06:07 IST Tue Sep 11 2018
```

```
Diagnostic is not scheduled.
```

CHAPTER 56

Troubleshooting the Software Configuration

This chapter describes how to identify and resolve software problems related to the Cisco IOS software on the switch. Depending on the nature of the problem, you can use the command-line interface (CLI), Device Manager, or Network Assistant to identify and solve problems.

Additional troubleshooting information, such as LED descriptions, is provided in the hardware installation guide.

Information About Troubleshooting the Software Configuration

Software Failure on a Switch

Switch software can be corrupted during an upgrade by downloading the incorrect file to the switch, and by deleting the image file. In all of these cases, the switch does not pass the power-on self-test (POST), and there is no connectivity.

Related Topics

Recovering from a Software Failure

Lost or Forgotten Password on a Switch

The default configuration for the switch allows an end user with physical access to the switch to recover from a lost password by interrupting the boot process during power-on and by entering a new password. These recovery procedures require that you have physical access to the switch.

Note On these switches, a system administrator can disable some of the functionality of this feature by allowing an end user to reset a password only by agreeing to return to the default configuration. If you are an end user trying to reset a password when password recovery has been disabled, a status message reminds you to return to the default configuration during the recovery process.

Related Topics

Recovering from a Lost or Forgotten Password

Power over Ethernet Ports

A Power over Ethernet (PoE) switch port automatically supplies power to one of these connected devices if the switch detects that there is no power on the circuit:

- a Cisco pre-standard powered device (such as a Cisco IP Phone or a Cisco Aironet Access Point)
- an IEEE 802.3af-compliant powered device
- an IEEE 802.3at-compliant powered device

A powered device can receive redundant power when it is connected to a PoE switch port and to an AC power source. The device does not receive redundant power when it is only connected to the PoE port.

After the switch detects a powered device, the switch determines the device power requirements and then grants or denies power to the device. The switch can also detect the real-time power consumption of the device by monitoring and policing the power usage.

For more information, see the "Configuring PoE" chapter in the *Catalyst 2960-L Switch Interface and Hardware Component Configuration Guide*.

Related Topics

Scenarios to Troubleshoot Power over Ethernet (PoE), on page 1088

Disabled Port Caused by Power Loss

If a powered device (such as a Cisco IP Phone 7910) that is connected to a PoE Switch port and powered by an AC power source loses power from the AC power source, the device might enter an error-disabled state. To recover from an error-disabled state, enter the **shutdown** interface configuration command, and then enter the **no shutdown** interface command. You can also configure automatic recovery on the Switch to recover from the error-disabled state.

On a Switch, the **errdisable recovery cause loopback** and the **errdisable recovery interval** *seconds* global configuration commands automatically take the interface out of the error-disabled state after the specified period of time.

Monitoring PoE Port Status

- **show controllers power inline** privileged EXEC command
- **show power inline** EXEC command
- **debug ilpower** privileged EXEC command

Disabled Port Caused by False Link-Up

If a Cisco powered device is connected to a port and you configure the port by using the **power inline never** interface configuration command, a false link-up can occur, placing the port into an error-disabled state. To take the port out of the error-disabled state, enter the **shutdown** and the **no shutdown** interface configuration commands.

You should not connect a Cisco powered device to a port that has been configured with the **power inline never** command.

Ping

The Switch supports IP ping, which you can use to test connectivity to remote hosts. Ping sends an echo request packet to an address and waits for a reply. Ping returns one of these responses:

- Normal response—The normal response (*hostname* is alive) occurs in 1 to 10 seconds, depending on network traffic.
- Destination does not respond—If the host does not respond, a *no-answer* message is returned.
- Unknown host—If the host does not exist, an *unknown host* message is returned.
- Destination unreachable—If the default gateway cannot reach the specified network, a *destination-unreachable* message is returned.
- Network or host unreachable—If there is no entry in the route table for the host or network, a *network or host unreachable* message is returned.

Related Topics

Executing Ping, on page 1082
Example: Pinging an IP Host, on page 1090

Layer 2 Traceroute

The Layer 2 traceroute feature allows the switch to identify the physical path that a packet takes from a source device to a destination device. Layer 2 traceroute supports only unicast source and destination MAC addresses. Traceroute finds the path by using the MAC address tables of the Switch in the path. When the Switch detects a device in the path that does not support Layer 2 traceroute, the Switch continues to send Layer 2 trace queries and lets them time out.

The Switch can only identify the path from the source device to the destination device. It cannot identify the path that a packet takes from source host to the source device or from the destination device to the destination host.

Layer 2 Traceroute Guidelines

- Cisco Discovery Protocol (CDP) must be enabled on all the devices in the network. For Layer 2 traceroute to function properly, do not disable CDP.

  If any devices in the physical path are transparent to CDP, the switch cannot identify the path through these devices.

- A Switch is reachable from another Switch when you can test connectivity by using the **ping** privileged EXEC command. All Switch in the physical path must be reachable from each other.

- The maximum number of hops identified in the path is ten.
- You can enter the **traceroute mac** or the **traceroute mac ip** privileged EXEC command on a Switch that is not in the physical path from the source device to the destination device. All Switch in the path must be reachable from this switch.
- The **traceroute mac** command output shows the Layer 2 path only when the specified source and destination MAC addresses belong to the same VLAN. If you specify source and destination MAC addresses that belong to different VLANs, the Layer 2 path is not identified, and an error message appears.
- If you specify a multicast source or destination MAC address, the path is not identified, and an error message appears.
- If the source or destination MAC address belongs to multiple VLANs, you must specify the VLAN to which both the source and destination MAC addresses belong. If the VLAN is not specified, the path is not identified, and an error message appears.
- The **traceroute mac ip** command output shows the Layer 2 path when the specified source and destination IP addresses belong to the same subnet. When you specify the IP addresses, the Switch uses the Address Resolution Protocol (ARP) to associate the IP addresses with the corresponding MAC addresses and the VLAN IDs.
    - If an ARP entry exists for the specified IP address, the Switch uses the associated MAC address and identifies the physical path.
    - If an ARP entry does not exist, the Switch sends an ARP query and tries to resolve the IP address. If the IP address is not resolved, the path is not identified, and an error message appears.
- When multiple devices are attached to one port through hubs (for example, multiple CDP neighbors are detected on a port), the Layer 2 traceroute feature is not supported. When more than one CDP neighbor is detected on a port, the Layer 2 path is not identified, and an error message appears.
- This feature is not supported in Token Ring VLANs.

IP Traceroute

You can use IP traceroute to identify the path that packets take through the network on a hop-by-hop basis. The command output displays all network layer (Layer 3) devices, such as routers, that the traffic passes through on the way to the destination.

Your Switch can participate as the source or destination of the **traceroute** privileged EXEC command and might or might not appear as a hop in the **traceroute** command output. If the Switch is the destination of the traceroute, it is displayed as the final destination in the traceroute output. Intermediate Switch do not show up in the traceroute output if they are only bridging the packet from one port to another within the same VLAN. However, if the intermediate Switch is a multilayer Switch that is routing a particular packet, this Switch shows up as a hop in the traceroute output.

The **traceroute** privileged EXEC command uses the Time To Live (TTL) field in the IP header to cause routers and servers to generate specific return messages. Traceroute starts by sending a User Datagram Protocol (UDP) datagram to the destination host with the TTL field set to 1. If a router finds a TTL value of 1 or 0, it drops the datagram and sends an Internet Control Message Protocol (ICMP) time-to-live-exceeded message to the sender. Traceroute finds the address of the first hop by examining the source address field of the ICMP time-to-live-exceeded message.

To identify the next hop, traceroute sends a UDP packet with a TTL value of 2. The first router decrements the TTL field by 1 and sends the datagram to the next router. The second router sees a TTL value of 1, discards the datagram, and returns the time-to-live-exceeded message to the source. This process continues until the TTL is incremented to a value large enough for the datagram to reach the destination host (or until the maximum TTL is reached).

To learn when a datagram reaches its destination, traceroute sets the UDP destination port number in the datagram to a very large value that the destination host is unlikely to be using. When a host receives a datagram destined to itself containing a destination port number that is unused locally, it sends an ICMP *port-unreachable* error to the source. Because all errors except port-unreachable errors come from intermediate hops, the receipt of a port-unreachable error means that this message was sent by the destination port.

Related Topics

Executing IP Traceroute, on page 1083

Example: Performing a Traceroute to an IP Host, on page 1091

Time Domain Reflector Guidelines

You can use the Time Domain Reflector (TDR) feature to diagnose and resolve cabling problems. When running TDR, a local device sends a signal through a cable and compares the reflected signal to the initial signal.

TDR is supported only on 10/100/1000 copper Ethernet ports. It is not supported on 10-Gigabit Ethernet ports and on SFP module ports.

TDR can detect these cabling problems:

- Open, broken, or cut twisted-pair wires—The wires are not connected to the wires from the remote device.
- Shorted twisted-pair wires—The wires are touching each other or the wires from the remote device. For example, a shorted twisted pair can occur if one wire of the twisted pair is soldered to the other wire.

  If one of the twisted-pair wires is open, TDR can find the length at which the wire is open.

Use TDR to diagnose and resolve cabling problems in these situations:

- Replacing a Switch
- Setting up a wiring closet
- Troubleshooting a connection between two devices when a link cannot be established or when it is not operating properly

When you run TDR, the Switch reports accurate information in these situations:

- The cable for the gigabit link is a solid-core cable.
- The open-ended cable is not terminated.

When you run TDR, the Switch does not report accurate information in these situations:

- The cable for the gigabit link is a twisted-pair cable or is in series with a solid-core cable.
- The link is a 10-megabit or a 100-megabit link.
- The cable is a stranded cable.

- The link partner is a Cisco IP Phone.
- The link partner is not IEEE 802.3 compliant.

Debug Commands

⚠ **Caution** Because debugging output is assigned high priority in the CPU process, it can render the system unusable. For this reason, use **debug** commands only to troubleshoot specific problems or during troubleshooting sessions with Cisco technical support staff. It is best to use **debug** commands during periods of lower network traffic and fewer users. Debugging during these periods decreases the likelihood that increased **debug** command processing overhead will affect system use.

All **debug** commands are entered in privileged EXEC mode, and most **debug** commands take no arguments.

Related Topics

Redirecting Debug and Error Message Output, on page 1083
Example: Enabling All System Diagnostics, on page 1092

Onboard Failure Logging on the Switch

You can use the onboard failure logging (OBFL) feature to collect information about the Switch. The information includes uptime, temperature, and voltage information and helps Cisco technical support representatives to troubleshoot Switch problems. We recommend that you keep OBFL enabled and do not erase the data stored in the flash memory.

By default, OBFL is enabled. It collects information about the Switch and small form-factor pluggable (SFP) modules. The Switch stores this information in the flash memory:

- CLI commands—Record of the OBFL CLI commands that are entered on a standalone Switch.
- Environment data—Unique device identifier (UDI) information for a standalone Switch and for all the connected FRU devices: the product identification (PID), the version identification (VID), and the serial number.
- Message—Record of the hardware-related system messages generated by a standalone Switch .
- Power over Ethernet (PoE)—Record of the power consumption of PoE ports on a standalone Switch .
- Temperature—Temperature of a standalone Switch .
- Uptime data—Time when a standalone Switch starts, the reason the Switch restarts, and the length of time the Switch has been running since it last restarted.
- Voltage—System voltages of a standalone Switch .

You should manually set the system clock or configure it by using Network Time Protocol (NTP).

When the Switch is running, you can retrieve the OBFL data by using the **show logging onboard** privileged EXEC commands. If the Switch fails, contact your Cisco technical support representative to find out how to retrieve the data.

When an OBFL-enabled Switch is restarted, there is a 10-minute delay before logging of new data begins.

Related Topics

Configuring OBFL, on page 1084

Displaying OBFL Information

Possible Symptoms of High CPU Utilization

Excessive CPU utilization might result in these symptoms, but the symptoms might also result from other causes:

Note You may see increased system memory usage when Cisco Catalyst 4500E Supervisor Engine 8-E is used in wireless mode.

- Spanning tree topology changes
- EtherChannel links brought down due to loss of communication
- Failure to respond to management requests (ICMP ping, SNMP timeouts, slow Telnet or SSH sessions)
- UDLD flapping
- IP SLAs failures because of SLAs responses beyond an acceptable threshold
- DHCP or IEEE 802.1x failures if the switch does not forward or respond to requests

Layer 3 switches:

- Dropped packets or increased latency for packets routed in software

How to Troubleshoot the Software Configuration

Recovering from a Software Failure

Switch software can be corrupted during an upgrade by downloading the wrong file to the switch, and by deleting the image file. In all of these cases, the switch does not pass the power-on self-test (POST), and there is no connectivity.

This procedure uses the Xmodem Protocol to recover from a corrupt or wrong image file. There are many software packages that support the Xmodem Protocol, and this procedure is largely dependent on the emulation software that you are using.

This recovery procedure requires that you have physical access to the switch.

Step 1 From your PC, download the software image tar file (*image_filename.tar*) from Cisco.com. The Cisco IOS image is stored as a bin file in a directory in the tar file. For information about locating the software image files on Cisco.com, see the release notes.

Step 2 Extract the bin file from the tar file. If you are using Windows, use a zip program that can read a tar file. Use the zip program to navigate. If you are using Windows, use a zip program that can read a tar file. Use the zip program to navigate. If you are using UNIX, follow these steps:

a) Display the contents of the tar file by using the **tar -tvf** <*image_filename.tar*> UNIX command.

Example:

```
unix-1% tar -tvf image_filename.tar
```

b) Locate the bin file, and extract it by using the **tar -xvf** <*image_filename.tar*> <*image_filename.bin*> UNIX command.

Example:

```
unix-1% tar -xvf image_filename.tar image_filename.bin
x c2960x-universalk9-mz-150-2.EX1/c2960x-universalk9-mz-150-2.EX1.bin, 2928176 bytes, 5720
tape blocks
```

c) Verify that the bin file was extracted by using the **ls -l** <*image_filename.bin*> UNIX command.

Example:

```
unix-1% ls -l image_filename.bin
-rw-r--r--   1 boba      2928176 Apr 21 12:01
c2960x-universalk9-mz.150-2.0.66.UCP/c2960x-universalk9-mz.150-2.0.66.UCP.bin
```

Step 3 Connect your PC with terminal-emulation software supporting the Xmodem Protocol to the switch console port.

Step 4 Set the line speed on the emulation software to 9600 baud.

Step 5 Unplug the switch power cord.

Step 6 Press the **Mode** button, and at the same time reconnect the power cord to the switch. You can release the Mode button a second or two after the LED above port 1 goes off. Several lines of information about the software appear along with instructions.

Example:

```
The system has been interrupted prior to initializing the flash file system. The following
commands will initialize the flash file system, and finish loading the operating system
software#

flash_init

load_helper

boot
```

Step 7 Initialize the flash file system.

Example:

```
switch: flash_init
```

Step 8 If you had set the console port speed to any speed other than 9600, it has been reset to that particular speed. Change the emulation software line speed to match that of the switch console port.

Step 9 Load any helper files.

Example:

```
switch: load_helper
```

Step 10 Start the file transfer by using the Xmodem Protocol.

Example:

```
switch: copy xmodem: flash:image_filename.bin
```

Step 11 After the Xmodem request appears, use the appropriate command on the terminal-emulation software to start the transfer and to copy the software image into flash memory.

Step 12 Boot the newly downloaded Cisco IOS image.

Example:

```
switch: boot flash:image_filename.bin
```

Step 13 Use the **archive download-sw** privileged EXEC command to download the software image to the switch.

Step 14 Use the **reload** privileged EXEC command to restart the switch and to verify that the new software image is operating properly.

Step 15 Delete the **flash**:*image_filename.bin* file from the switch.

Recovering from a Lost or Forgotten Password

The default configuration for the switch allows an end user with physical access to the switch to recover from a lost password by interrupting the boot process during power-on and by entering a new password. These recovery procedures require that you have physical access to the switch.

Note On these switches, a system administrator can disable some of the functionality of this feature by allowing an end user to reset a password only by agreeing to return to the default configuration. If you are an end user trying to reset a password when password recovery has been disabled, a status message shows this during the recovery process.

You enable or disable password recovery by using the **service password-recovery** global configuration command.

Step 1 Connect a terminal or PC to the switch.

- Connect a terminal or a PC with terminal-emulation software to the switch console port.

  Or

- Connect a PC to the Ethernet management port.

Step 2 Set the line speed on the emulation software to 9600 baud.

Step 3 On a switch, power off the switch.

Step 4 Reconnect the power cord to the switch. Within 15 seconds, press the **Mode** button while the System LED is still flashing green. Continue pressing the **Mode** button until all the system LEDs turn on and remain solid, then release the **Mode** button.

Several lines of information about the software appear with instructions, informing you if the password recovery procedure has been disabled or not.

- If you see a message that begins with this statement:

  ```
  The system has been interrupted prior to initializing the flash file system. The following commands
   will initialize the flash file system
  ```

  proceed to the "Procedure with Password Recovery Enabled" section, and follow the steps.

- If you see a message that begins with this statement:

  ```
  The password-recovery mechanism has been triggered, but is currently disabled.
  ```

  proceed to the "Procedure with Password Recovery Disabled" section, and follow the steps.

Step 5 After recovering the password, reload the switch.

On a switch:

```
Switch> reload
Proceed with reload? [confirm] y
```

Procedure with Password Recovery Enabled

If the password-recovery operation is enabled, this message appears:

```
The system has been interrupted prior to initializing the flash file system. The following
 commands will initialize the flash file system, and finish loading the operating system
software:

flash_init
load_helper
boot
```

Step 1 Initialize the flash file system.

```
Switch: flash_init
```

Step 2 If you had set the console port speed to any number other than 9600, it has been reset to that particular speed. Change the emulation software line speed to match that of the switch console port.

Step 3 Load any helper files.

```
Switch: load_helper
```

Step 4 Display the contents of flash memory.

```
Switch: dir: flash:
Directory of flash:
   13  drwx         192   Mar 01 2013 22:30:48
c2960x-universalk9-mz-150-2.EX1/c2960x-universalk9-mz-150-2.EX1.bin
   11  -rwx        5825   Mar 01 2013 22:31:59  config.text

16128000 bytes total (10003456 bytes free)
```

Step 5 Rename the configuration file to config.text.old

This file contains the password definition.

```
Switch: rename flash: config.text flash: config.text.old
```

Step 6 Boot up the system.

```
Switch: boot
```

You are prompted to start the setup program. Enter **N** at the prompt.

```
Continue with the configuration dialog?? [yes/no]: No
```

Step 7 At the switch prompt, enter privileged EXEC mode.

```
Switch> enable
Switch#
```

Step 8 Rename the configuration file to its original name.

```
Switch# rename flash: config.text.old flash: config.text
```

Step 9 Copy the configuration file into memory

```
Switch# copy flash: config.text system: running-config
Source filename [config.text]?
Destination filename [running-config]?
```

Press **Return** in response to the confirmation prompts. The configuration file is now reloaded, and you can change the pasword.

Step 10 Enter global configuration mode.

```
Switch# configure terminal
```

Step 11 Change the password.

```
Switch(config)# enable secret password
```

The secret password can be from 1 to 25 alphanumeric characters, can start with a number, is case sensitive, and allows spaces but ignores leading spaces.

Step 12 Return to privileged EXEC mode.

```
Switch(config)# exit
Switch#
```

Step 13 Write the running configuration to the startup configuration file.

```
Switch# copy running-config startup-config
```

The new password is now in the startup configuration.

Note This procedure is likely to leave your switch virtual interface in a shutdown state. You can see which interface is in this state by entering the **show running-config** privileged EXEC command. To reenable the interface, enter the **interface vlan** *vlan-id* global configuration command, and specify the VLAN ID of the shutdown interface. With the switch in interface configuration mode, enter the **no shutdown** command.

Step 14 Boot the switch with the *packages.conf* file from flash.

```
Switch: boot flash:packages.conf
```

Step 15 Reload the switch.

```
Switch# reload
```

Procedure with Password Recovery Disabled

If the password-recovery mechanism is disabled, this message appears:

```
The password-recovery mechanism has been triggered, but
is currently disabled.  Access to the boot loader prompt
through the password-recovery mechanism is disallowed at
this point.  However, if you agree to let the system be
reset back to the default system configuration, access
to the boot loader prompt can still be allowed.

Would you like to reset the system back to the default configuration (y/n)?
```

Caution Returning the Switch to the default configuration results in the loss of all existing configurations. We recommend that you contact your system administrator to verify if there are backup Switch and VLAN configuration files.

- If you enter **n** (no), the normal boot process continues as if the **Mode** button had not been pressed; you cannot access the boot loader prompt, and you cannot enter a new password. You see the message:

  ```
  Press Enter to continue........
  ```

- If you enter **y** (yes), the configuration file in flash memory and the VLAN database file are deleted. When the default configuration loads, you can reset the password.

Step 1 Choose to continue with password recovery and delete the existing configuration:

```
Would you like to reset the system back to the default configuration (y/n)? Y
```

Step 2 Display the contents of flash memory:

```
Switch: dir flash:
```

The Switch file system appears.

```
Directory of flash:
   13  drwx         192   Mar 01 2013 22:30:48  c2960x-universalk9-mz.150-2.0.63.UCP.bin
16128000 bytes total (10003456 bytes free)
```

Step 3 Boot up the system:

```
Switch: boot
```

You are prompted to start the setup program. To continue with password recovery, enter **N** at the prompt:

```
Continue with the configuration dialog? [yes/no]: N
```

Step 4 At the Switch prompt, enter privileged EXEC mode:

```
Switch> enable
```

Step 5 Enter global configuration mode:

```
Switch# configure terminal
```

Step 6 Change the password:

```
Switch(config)# enable secret password
```

The secret password can be from 1 to 25 alphanumeric characters, can start with a number, is case sensitive, and allows spaces but ignores leading spaces.

Step 7 Return to privileged EXEC mode:

```
Switch(config)# exit
Switch#
```

Note Before continuing to Step 9, power on any connected stack members and wait until they have completely initialized.

Step 8 Write the running configuration to the startup configuration file:

```
Switch# copy running-config startup-config
```

The new password is now in the startup configuration.

Step 9 You must now reconfigure the Switch. If the system administrator has the backup Switch and VLAN configuration files available, you should use those.

Recovering from a Command Switch Failure

If you have not configured a standby command switch, and your command switch loses power or fails in some other way, management contact with the member switches is lost, and you must install a new command switch. However, connectivity between switches that are still connected is not affected, and the member switches forward packets as usual. You can manage the members as standalone switches through the console port, or, if they have IP addresses, through the other management interfaces.

You can prepare for a command switch failure by assigning an IP address to a member switch or another switch that is command-capable, making a note of the command-switch password, and cabling your cluster to provide redundant connectivity between the member switches and the replacement command switch. These sections describe two solutions for replacing a failed command switch:

- Replacing a Failed Command Switch with a Cluster Member
- Replacing a Failed Command Switch with Another Switch

These recovery procedures require that you have physical access to the switch. For information on command-capable switches, see the release notes.

Replacing a Failed Command Switch with a Cluster Member

To replace a failed command switch with a command-capable member in the same cluster, follow these steps

Step 1 Disconnect the command switch from the member switches, and physically remove it from the cluster.

Step 2 Insert the member switch in place of the failed command switch, and duplicate its connections to the cluster members.

Step 3 Start a CLI session on the new command switch.

You can access the CLI by using the console port or, if an IP address has been assigned to the switch, by using Telnet. For details about using the console port, see *Catalyst 2960-X Switch Hardware Installation Guide*.

Step 4 At the switch prompt, enter privileged EXEC mode.

Example:

```
Switch> enable
Switch#
```

Step 5 Enter the password of the *failed command switch*.

Step 6 Enter global configuration mode.

Example:

```
Switch# configure terminal

Enter configuration commands, one per line. End with CNTL/Z.
```

Step 7 Remove the member switch from the cluster.

Example:

```
Switch(config)# no cluster commander-address
```

Step 8 Return to privileged EXEC mode.

Example:

```
Switch(config)# end
Switch#
```

Step 9 Use the setup program to configure the switch IP information. This program prompts you for IP address information and passwords. From privileged EXEC mode, enter EXEC mode, enter **setup**, and press **Return**.

Example:

```
Switch# setup

 --- System Configuration Dialog ---
Continue with configuration dialog? [yes/no]: y
At any point you may enter a question mark '?' for help.
Use ctrl-c to abort configuration dialog at any prompt.
Default settings are in square brackets '[]'.
Basic management setup configures only enough connectivity
for management of the system, extended setup will ask you
to configure each interface on the system
Would you like to enter basic management setup? [yes/no]:
```

Step 10 Enter **Y** at the first prompt.

Example:

```
The prompts in the setup program vary depending on the member switch that you selected to be the
command switch:
Continue with configuration dialog? [yes/no]: y

or

Configuring global parameters:
```

If this prompt does not appear, enter **enable**, and press **Return**. Enter **setup**, and press **Return** to start the setup program.

Step 11 Respond to the questions in the setup program.

When prompted for the hostname, it is limited to 28 characters and 31 characters on a member switch. Do not use -*n*, where *n* is a number, as the last characters in a hostname for any switch. When prompted for the Telnet (virtual terminal) password, it is 1 to 25 alphanumeric characters, is case sensitive, allows spaces, but ignores leading spaces.

Step 12 When prompted for the **enable secret** and **enable** passwords, enter the passwords of the *failed command switch* again.

Step 13 When prompted, make sure to enable the switch as the cluster command switch, and press **Return.**

Step 14 When prompted, assign a name to the cluster, and press **Return**.

The cluster name can be 1 to 31 alphanumeric characters, dashes, or underscores.

Step 15 After the initial configuration displays, verify that the addresses are correct.

Step 16 If the displayed information is correct, enter **Y**, and press **Return**.

If this information is not correct, enter **N**, press **Return**, and begin again at Step 9.

Step 17 Start your browser, and enter the IP address of the new command switch.

Step 18 From the Cluster menu, select **Add to Cluster** to display a list of candidate switches to add to the cluster.

Replacing a Failed Command Switch with Another Switch

To replace a failed command switch with a switch that is command-capable but not part of the cluster, follow these steps:

Step 1 Insert the new switch in place of the failed command switch, and duplicate its connections to the cluster members.

Step 2 You can access the CLI by using the console port or, if an IP address has been assigned to the switch, by using Telnet. For details about using the console port, see the switch hardware installation guide.

Step 3 At the switch prompt, enter privileged EXEC mode.

Example:

```
Switch> enable
Switch#
```

Step 4 Enter the password of the *failed command switch*.

Step 5 Use the setup program to configure the switch IP information. This program prompts you for IP address information and passwords. From privileged EXEC mode, enter EXEC mode, enter **setup**, and press **Return**.

Example:

```
Switch# setup

 --- System Configuration Dialog ---
Continue with configuration dialog? [yes/no]: y
At any point you may enter a question mark '?' for help.
Use ctrl-c to abort configuration dialog at any prompt.
Default settings are in square brackets '[]'.
Basic management setup configures only enough connectivity
for management of the system, extended setup will ask you
to configure each interface on the system
Would you like to enter basic management setup? [yes/no]:
```

Step 6 Enter **Y** at the first prompt.

Example:

```
The prompts in the setup program vary depending on the member switch that you selected to be the
command switch:
Continue with configuration dialog? [yes/no]: y

or

Configuring global parameters:
```

If this prompt does not appear, enter **enable**, and press **Return**. Enter **setup**, and press **Return** to start the setup program.

Step 7 Respond to the questions in the setup program.

When prompted for the hostname, it is limited to 28 characters and 31 characters on a member switch. Do not use -*n*, where *n* is a number, as the last characters in a hostname for any switch. When prompted for the Telnet (virtual terminal) password, it is 1 to 25 alphanumeric characters, is case sensitive, allows spaces, but ignores leading spaces.

Step 8 When prompted for the **enable secret** and **enable** passwords, enter the passwords of the *failed command switch* again.

Step 9 When prompted, make sure to enable the switch as the cluster command switch, and press **Return.**

Step 10 When prompted, assign a name to the cluster, and press **Return**.

The cluster name can be 1 to 31 alphanumeric characters, dashes, or underscores.

Step 11 After the initial configuration displays, verify that the addresses are correct.

Step 12 If the displayed information is correct, enter **Y**, and press **Return**.

If this information is not correct, enter **N**, press **Return**, and begin again at Step 9.

Step 13 Start your browser, and enter the IP address of the new command switch.

Step 14 From the Cluster menu, select **Add to Cluster** to display a list of candidate switches to add to the cluster.

Preventing Autonegotiation Mismatches

The IEEE 802.3ab autonegotiation protocol manages the Switch settings for speed (10 Mb/s, 100 Mb/s, and 1000 Mb/s, excluding SFP module ports) and duplex (half or full). There are situations when this protocol can incorrectly align these settings, reducing performance. A mismatch occurs under these circumstances:

- A manually set speed or duplex parameter is different from the manually set speed or duplex parameter on the connected port.
- A port is set to autonegotiate, and the connected port is set to full duplex with no autonegotiation.

To maximize Switch performance and ensure a link, follow one of these guidelines when changing the settings for duplex and speed:

- Let both ports autonegotiate both speed and duplex.
- Manually set the speed and duplex parameters for the ports on both ends of the connection.

Note If a remote device does not autonegotiate, configure the duplex settings on the two ports to match. The speed parameter can adjust itself even if the connected port does not autonegotiate.

Troubleshooting SFP Module Security and Identification

Cisco small form-factor pluggable (SFP) modules have a serial EEPROM that contains the module serial number, the vendor name and ID, a unique security code, and cyclic redundancy check (CRC). When an SFP module is inserted in the Switch, the Switch software reads the EEPROM to verify the serial number, vendor name and vendor ID, and recompute the security code and CRC. If the serial number, the vendor name or vendor ID, the security code, or CRC is invalid, the software generates a security error message and places the interface in an error-disabled state.

Note The security error message references the GBIC_SECURITY facility. The Switch supports SFP modules and does not support GBIC modules. Although the error message text refers to GBIC interfaces and modules, the security messages actually refer to the SFP modules and module interfaces.

If you are using a non-Cisco SFP module, remove the SFP module from the Switch, and replace it with a Cisco module. After inserting a Cisco SFP module, use the **errdisable recovery cause gbic-invalid** global configuration command to verify the port status, and enter a time interval for recovering from the error-disabled state. After the elapsed interval, the Switch brings the interface out of the error-disabled state and retries the operation. For more information about the **errdisable recovery** command, see the command reference for this release.

If the module is identified as a Cisco SFP module, but the system is unable to read vendor-data information to verify its accuracy, an SFP module error message is generated. In this case, you should remove and reinsert the SFP module. If it continues to fail, the SFP module might be defective.

Monitoring SFP Module Status

You can check the physical or operational status of an SFP module by using the **show interfaces transceiver** privileged EXEC command. This command shows the operational status, such as the temperature and the current for an SFP module on a specific interface and the alarm status. You can also use the command to check the speed and the duplex settings on an SFP module. For more information, see the **show interfaces transceiver** command in the command reference for this release.

Executing Ping

If you attempt to ping a host in a different IP subnetwork, you must define a static route to the network or have IP routing configured to route between those subnets.

IP routing is disabled by default on all Switch.

Note Though other protocol keywords are available with the **ping** command, they are not supported in this release.

Use this command to ping another device on the network from the Switch:

Command	Purpose
ping ip *host* | *address* `Switch# ping 172.20.52.3`	Pings a remote host through IP or by supplying the hostname or network address.

Related Topics

Ping, on page 1067

Example: Pinging an IP Host, on page 1090

Monitoring Temperature

The Switch monitors the temperature conditions and uses the temperature information to control the fans.

Use the **show env temperature status** privileged EXEC command to display the temperature value, state, and thresholds. The temperature value is the temperature in the Switch (not the external temperature).

Monitoring the Physical Path

You can monitor the physical path that a packet takes from a source device to a destination device by using one of these privileged EXEC commands:

Table 115: Monitoring the Physical Path

Command	Purpose
tracetroute mac [**interface** *interface-id*] {*source-mac-address*} [**interface** *interface-id*] {*destination-mac-address*} [**vlan** *vlan-id*] [**detail**]	Displays the Layer 2 path taken by the packets from the specified source MAC address to the specified destination MAC address.
tracetroute mac ip {*source-ip-address* | *source-hostname*}{*destination-ip-address* | *destination-hostname*} [**detail**]	Displays the Layer 2 path taken by the packets from the specified source IP address or hostname to the specified destination IP address or hostname.

Executing IP Traceroute

Note Though other protocol keywords are available with the **traceroute** privileged EXEC command, they are not supported in this release.

Command	Purpose
traceroute ip *host* `Switch# traceroute ip 192.51.100.1`	Traces the path that packets take through the network.

Related Topics

IP Traceroute , on page 1068
Example: Performing a Traceroute to an IP Host, on page 1091

Running TDR and Displaying the Results

To run TDR, enter the **test cable-diagnostics tdr interface** *interface-id* privileged EXEC command.

To display the results, enter the **show cable-diagnostics tdr interface** *interface-id* privileged EXEC command.

Redirecting Debug and Error Message Output

By default, the network server sends the output from **debug** commands and system error messages to the console. If you use this default, you can use a virtual terminal connection to monitor debug output instead of connecting to the console port or the Ethernet management port.

Possible destinations include the console, virtual terminals, internal buffer, and UNIX hosts running a syslog server. The syslog format is compatible with 4.3 Berkeley Standard Distribution (BSD) UNIX and its derivatives.

Note Be aware that the debugging destination you use affects system overhead. When you log messages to the console, very high overhead occurs. When you log messages to a virtual terminal, less overhead occurs. Logging messages to a syslog server produces even less, and logging to an internal buffer produces the least overhead of any method.

For more information about system message logging, see *Configuring System Message Logging*.

Related Topics

Debug Commands, on page 1070

Using the show platform forward Command

The output from the **show platform forward** privileged EXEC command provides some useful information about the forwarding results if a packet entering an interface is sent through the system. Depending upon the parameters entered about the packet, the output provides lookup table results and port maps used to calculate forwarding destinations, bitmaps, and egress information.

Most of the information in the output from the command is useful mainly for technical support personnel, who have access to detailed information about the Switch application-specific integrated circuits (ASICs). However, packet forwarding information can also be helpful in troubleshooting.

Configuring OBFL

Caution We recommend that you do not disable OBFL and that you do not remove the data stored in the flash memory.

- To enable OBFL, use the **hw-switch switch** [*switch-number*] **logging onboard** [**message level** *level*] global configuration command. On switches, the range for *switch-number* is from 1 to 9. Use the **message level** *level* parameter to specify the severity of the hardware-related messages that the switch generates and stores in the flash memory.
- To copy the OBFL data to the local network or a specific file system, use the **copy onboard switch** *switch-number* **url** *url-destination* privileged EXEC command.
- To disable OBFL, use the **no hw-switch switch** [*switch-number*] **logging onboard** [**message level**] global configuration command.
- To clear all the OBFL data in the flash memory except for the uptime and CLI command information, use the **clear onboard switch** *switch-number* privileged EXEC command.
- You can enable or disable OBFL on a member switch from the active stack.

For more information about the commands in this section, see the command reference for this release.

Related Topics

Onboard Failure Logging on the Switch, on page 1070

Displaying OBFL Information

Verifying Troubleshooting of the Software Configuration

Displaying OBFL Information

Table 116: Commands for Displaying OBFL Information

Command	Purpose
show logging onboard [**module**[*switch-number*]]**clilog** `Switch# show logging onboard  1 clilog`	Displays the OBFL CLI commands that were entered on a standalone switch.
show logging onboard [**module**[*switch-number*]] **environment** `Switch# show logging onboard 1 environment`	Displays the UDI information for a standalone switch and for all the connected FRU devices: the PID, the VID, and the serial number.
show logging onboard [**module**[*switch-number*]] **message** `Switch# show logging onboard 1 message`	Displays the hardware-related messages generated by a standalone switch.
show logging onboard [**module**[*switch-number*]] **poe** `Switch# show logging onboard 1 poe`	Displays the power consumption of PoE ports on a standalone switch.
show logging onboard [**module**[*switch-number*]] **temperature** `Switch# show logging onboard 1 temperature`	Displays the temperature of a standalone switch or.
show logging onboard [**module**[*switch-number*]] **uptime** `Switch# show logging onboard 1 uptime`	Displays the time when a standalone switch or the specified stack members start, the reason the standalone switch or specified stack members restart, and the length of time that the standalone switch have been running since they last restarted.
show logging onboard [**module**[*switch-number*]] **voltage** `Switch# show logging onboard 1 voltage`	Displays the system voltages of a standalone switch.
show logging onboard [**module**[*switch-number*]] **continuous** `Switch# show logging onboard 1 continuous`	Displays the data in the continuous file.

Command	Purpose
show logging onboard [**module**[*switch-number*]] **detail** `Switch# show logging onboard 1 detail`	Displays both the continuous and summary data .
show logging onboard [**module**[*switch-number*]] **end***hh:mm:ss* `Switch# show logging onboard 1 end 13:00:15 jul 2013`	Displays end time and date on a standalone switch.
show logging onboard [**module**[*switch-number*]] `Switch# show logging onboard 1`	Displays OBFL information about the specified switches in the system.
show logging onboard [**module**[*switch-number*]] **raw** `Switch# show logging onboard 1 raw`	Displays the raw information on a standalone switch.
show logging onboard [**module**[*switch-number*]] **start** `Switch# show logging onboard 1 start  13:00:10 jul 2013`	Displays the start time and date on a standalone switch.
show logging onboard [**module**[*switch-number*]] **status** `Switch# show logging onboard 1 status`	Displays status information on a standalone switch.
show logging onboard [**module**[*switch-number*]] **summary** `Switch# show logging onboard 1 summary`	Displays both the data in the summary file

For more information, see the *Catalyst 2960-X Switch System Management Command Reference*.

Example: Verifying the Problem and Cause for High CPU Utilization

To determine if high CPU utilization is a problem, enter the **show processes cpu sorted** privileged EXEC command. Note the underlined information in the first line of the output example.

```
Switch# show processes cpu sorted
CPU utilization for five seconds: 8%/0%; one minute: 7%; five minutes: 8%
PID Runtime(ms) Invoked uSecs 5Sec 1Min 5Min TTY Process
309 42289103 752750 56180 1.75% 1.20% 1.22% 0 RIP Timers
140 8820183 4942081 1784 0.63% 0.37% 0.30% 0 HRPC qos request
100 3427318 16150534 212 0.47% 0.14% 0.11% 0 HRPC pm-counters
192 3093252 14081112 219 0.31% 0.14% 0.11% 0 Spanning Tree
143 8 37 216 0.15% 0.01% 0.00% 0 Exec
...
<output truncated>
```

This example shows normal CPU utilization. The output shows that utilization for the last 5 seconds is 8%/0%, which has this meaning:

- The total CPU utilization is 8 percent, including both time running Cisco IOS processes and time spent handling interrupts.
- The time spent handling interrupts is zero percent.

Table 117: Troubleshooting CPU Utilization Problems

Type of Problem	Cause	Corrective Action
Interrupt percentage value is almost as high as total CPU utilization value.	The CPU is receiving too many packets from the network.	Determine the source of the network packet. Stop the flow, or change the switch configuration. See the section on “Analyzing Network Traffic.”
Total CPU utilization is greater than 50% with minimal time spent on interrupts.	One or more Cisco IOS process is consuming too much CPU time. This is usually triggered by an event that activated the process.	Identify the unusual event, and troubleshoot the root cause. See the section on “Debugging Active Processes.”

Scenarios for Troubleshooting the Software Configuration

Scenarios to Troubleshoot Power over Ethernet (PoE)

Table 118: Power over Ethernet Troubleshooting Scenarios

Symptom or Problem	Possible Cause and Solution
Only one port does not have PoE. Trouble is on only one switch port. PoE and non-PoE devices do not work on this port, but do on other ports.	Verify that the powered device works on another PoE port. Use the **show run**, or **show interface status** user EXEC commands to verify that the port is not shut down or error-disabled. **Note** Most switches turn off port power when the port is shut down, even though the IEEE specifications make this optional. Verify that **power inline never** is not configured on that interface or port. Verify that the Ethernet cable from the powered device to the switch port is good: Connect a known good non-PoE Ethernet device to the Ethernet cable, and make sure that the powered device establishes a link and exchanges traffic with another host. **Note** Cisco powered device works only with straight cable and not with crossover one. Verify that the total cable length from the switch front panel to the powered device is not more than 100 meters. Disconnect the Ethernet cable from the switch port. Use a short Ethernet cable to connect a known good Ethernet device directly to this port on the switch front panel (not on a patch panel). Verify that it can establish an Ethernet link and exchange traffic with another host, or ping the port VLAN SVI. Next, connect a powered device to this port, and verify that it powers on. If a powered device does not power on when connected with a patch cord to the switch port, compare the total number of connected powered devices to the switch power budget (available PoE). Use the **show power inline** command to verify the amount of available power.

Symptom or Problem	Possible Cause and Solution
No PoE on all ports or a group of ports. Trouble is on all switch ports. Nonpowered Ethernet devices cannot establish an Ethernet link on any port, and PoE devices do not power on.	If there is a continuous, intermittent, or reoccurring alarm related to power, replace the power supply if possible it is a field-replaceable unit. Otherwise, replace the switch. If the problem is on a consecutive group of ports but not all ports, the power supply is probably not defective, and the problem could be related to PoE regulators in the switch. Use the **show log** privileged EXEC command to review alarms or system messages that previously reported PoE conditions or status changes. If there are no alarms, use the **show interface status** command to verify that the ports are not shut down or error-disabled. If ports are error-disabled, use the **shut** and **no shut** interface configuration commands to reenable the ports. Use the **show env power** and **show power inline** privileged EXEC commands to review the PoE status and power budget (available PoE). Review the running configuration to verify that **power inline never** is not configured on the ports. Connect a nonpowered Ethernet device directly to a switch port. Use only a short patch cord. Do not use the existing distribution cables. Enter the **shut** and **no shut** interface configuration commands, and verify that an Ethernet link is established. If this connection is good, use a short patch cord to connect a powered device to this port and verify that it powers on. If the device powers on, verify that all intermediate patch panels are correctly connected. Disconnect all but one of the Ethernet cables from switch ports. Using a short patch cord, connect a powered device to only one PoE port. Verify the powered device does not require more power than can be delivered by the switch port. Use the **show power inline** privileged EXEC command to verify that the powered device can receive power when the port is not shut down. Alternatively, watch the powered device to verify that it powers on. If a powered device can power on when only one powered device is connected to the switch, enter the **shut** and **no shut** interface configuration commands on the remaining ports, and then reconnect the Ethernet cables one at a time to the switch PoE ports. Use the **show interface status** and **show power inline** privileged EXEC commands to monitor inline power statistics and port status. If there is still no PoE at any port, a fuse might be open in the PoE section of the power supply. This normally produces an alarm. Check the log again for alarms reported earlier by system messages.

Symptom or Problem	Possible Cause and Solution
Cisco pre-standard powered device disconnects or resets. After working normally, a Cisco phone intermittently reloads or disconnects from PoE.	Verify all electrical connections from the switch to the powered device. Any unreliable connection results in power interruptions and irregular powered device functioning such as erratic powered device disconnects and reloads. Verify that the cable length is not more than 100 meters from the switch port to the powered device. Notice what changes in the electrical environment at the switch location or what happens at the powered device when the disconnect occurs. Notice whether any error messages appear at the same time a disconnect occurs. Use the **show log** privileged EXEC command to review error messages. Verify that an IP phone is not losing access to the Call Manager immediately before the reload occurs. (It might be a network problem and not a PoE problem.) Replace the powered device with a non-PoE device, and verify that the device works correctly. If a non-PoE device has link problems or a high error rate, the problem might be an unreliable cable connection between the switch port and the powered device.
IEEE 802.3af-compliant or IEEE 802.3at-compliant powered devices do not work on Cisco PoE switch. A non-Cisco powered device is connected to a Cisco PoE switch, but never powers on or powers on and then quickly powers off. Non-PoE devices work normally.	Use the **show power inline** command to verify that the switch power budget (available PoE) is not depleted before or after the powered device is connected. Verify that sufficient power is available for the powered device type before you connect it. Use the **show interface status** command to verify that the switch detects the connected powered device. Use the **show log** command to review system messages that reported an overcurrent condition on the port. Identify the symptom precisely: Does the powered device initially power on, but then disconnect? If so, the problem might be an initial surge-in (or *inrush*) current that exceeds a current-limit threshold for the port.

Related Topics

Power over Ethernet Ports, on page 1066

Configuration Examples for Troubleshooting Software

Example: Pinging an IP Host

This example shows how to ping an IP host:

```
Switch# ping 172.20.52.3
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echoes to 172.20.52.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
Switch#
```

Table 119: Ping Output Display Characters

Character	Description
!	Each exclamation point means receipt of a reply.
.	Each period means the network server timed out while waiting for a reply.
U	A destination unreachable error PDU was received.
C	A congestion experienced packet was received.
I	User interrupted test.
?	Unknown packet type.
&	Packet lifetime exceeded.

To end a ping session, enter the escape sequence (**Ctrl-^ X** by default). Simultaneously press and release the **Ctrl**, **Shift**, and **6** keys and then press the **X** key.

Related Topics

Ping, on page 1067
Executing Ping, on page 1082

Example: Performing a Traceroute to an IP Host

This example shows how to perform a **traceroute** to an IP host:

```
Switch# traceroute ip 192.0.2.10

Type escape sequence to abort.
Tracing the route to 192.0.2.10

  1 192.0.2.1 0 msec 0 msec 4 msec
  2 192.0.2.203 12 msec 8 msec 0 msec
  3 192.0.2.100 4 msec 0 msec 0 msec
  4 192.0.2.10 0 msec 4 msec 0 msec
```

The display shows the hop count, the IP address of the router, and the round-trip time in milliseconds for each of the three probes that are sent.

Table 120: Traceroute Output Display Characters

Character	Description
*	The probe timed out.
?	Unknown packet type.

Character	Description
A	Administratively unreachable. Usually, this output means that an access list is blocking traffic.
H	Host unreachable.
N	Network unreachable.
P	Protocol unreachable.
Q	Source quench.
U	Port unreachable.

To end a trace in progress, enter the escape sequence (**Ctrl-^ X** by default). Simultaneously press and release the **Ctrl**, **Shift**, and **6** keys and then press the **X** key.

Related Topics

IP Traceroute , on page 1068

Executing IP Traceroute, on page 1083

Example: Enabling All System Diagnostics

Caution Because debugging output takes priority over other network traffic, and because the **debug all** privileged EXEC command generates more output than any other **debug** command, it can severely diminish switch performance or even render it unusable. In virtually all cases, it is best to use more specific **debug** commands.

This command disables all-system diagnostics:

```
Switch# debug all
```

The **no debug all** privileged EXEC command disables all diagnostic output. Using the **no debug all** command is a convenient way to ensure that you have not accidentally left any **debug** commands enabled.

Related Topics

Debug Commands, on page 1070

Additional References for Troubleshooting Software Configuration

Related Documents

Related Topic	Document Title
Troubleshooting commands	*Catalyst 2960-X Switch System Management Command Reference*

Related Topic	Document Title
Interface and hardware component configuration	*Catalyst 2960-X Switch Interface and Hardware Component Configuration Guide*
Platform-independent command references	*Cisco IOS 15.3M&T Command References*
Platform-independent configuration information	*Cisco IOS 15.3M&T Configuration Guides*

Standards and RFCs

Standard/RFC	Title
None	—

MIBs

MIB	MIBs Link
All supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for Troubleshooting Software Configuration

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 57

Information About Licensing

Restrictions for Configuring Licenses

- Members of a switch stack must run the same license level (base license level and add-on). If the license level is different with a mismatched base license, the switch will not join the stack until it is changed and rebooted from the active stack. Mismatched addon licenses are automatically synced by the active stack.
- A permanent license can be moved from one device to another. To activate a license, you must reboot your switch.
- An expired evaluation license cannot be reactivated after reboot.

Information About Licensing

Overview of License Levels

Software features on the switch are available with base (also known as feature sets) and add-on license levels. Their validity duration determines the license type.

- **Base license levels** for a switch are indicated by the switch model number. They are always permanent licenses, without an expiration date.
- **Add-on license levels** provide Cisco innovations on the switch, as well as on the Cisco Digital Network Architecture Center (Cisco DNA Center). Add-on licenses may be ordered only with a term license type, for a three, five, or seven year period.

Base Licenses

The switch is shipped with a LAN Lite base license. The model number is an indicator of the license level. See the last suffix in the model number, –LL indicates a LAN Lite model. For example, Catalyst WS-C2960L-8TS-LL has a LAN Lite image

Note The base license level is bound to the hardware model and cannot be changed.

Add-On Licenses

The DNA essentials add-on license is available.

The following guidelines apply to Add-on Licenses:

- A Reboot is not required when you configure an add-on license.
- Add-on licenses may be ordered for a three, five, or seven year period.
- You must set up Cisco SSM to receive daily e-mail alerts, to be notified of expiring add-on licenses that you want to renew.
- Only the DNA Essentials add-on license is available. (Although visible on the CLI, the DNA Advantage license level is not available).

License States

You can also access the license information by using the **show license** command in the privileged EXEC mode.

Table 121: Right-to-use license states

License State	Description
Active, In Use	EULA was accepted and the license is in use after device reboot.
Active, Not In Use	EULA was accepted and the switch is ready to use when the license is enabled.
Not Activated	EULA was not accepted.

The following example shows how to display the license level of the switch. The example shows LAN Base as the active license and as the one that is in use.

```
Switch# show license

Index 1
 License Name    : lanlite
 Period left     : 0  minute  0  second
 License Type: Permanent
 License State: Inactive
Index 2
```

```
 License Name    : lanbase
 Period left     : 0  minute  0  second
 License Type: Permanent
 License State: Active, In use

Index 3
 License Name    : dna-essentials
 Period left     : CSSM Managed
 License Type    : Subscription
 License State   : Active, In use

Index 4
 License Name    : dna-advantage
 Period left     : CSSM Managed
 License Type    : Subscription
 License State   : Not Activated
```

Guidelines to follow when monitoring your image based license state:

- A purchased permanent license is set to Active, In Use state only after a switch reboot.
- If more than one license was purchased, a reboot will activate the license with the highest feature set. For instance, the LAN Base license is activated and not the LAN Lite license.
- The remaining licenses purchased after switch reboot, stay in Active, Not In Use state.

Guidelines for License Types

Licenses may be of the permanent or term type only.

- Permanent: For a license level, and without an expiration date. The basic license type for the switch is determined by the model and is always permanent.
- Term: For a license level, and for a three, five, or seven year period. Add-on licenses (DNA Essentials and DNA Advantage) may be ordered only with a term license type.

Ordering with Smart Accounts

We recommend that you use Smart Accounts to order devices as well as licenses. Smart Accounts enable you to manage all of your software licenses for switches, routers, firewalls, access-points or tools from one centralized website. To create Smart Accounts, use the Cisco Smart Software Manager (Cisco SSM).

Note This is especially relevant to the term licenses that you order, because information about the expiry of term licenses is available only through the Cisco SSM website.

For more information about Cisco SSM, see: http://www.cisco.com/c/en/us/buy/smart-accounts/software-licensing.html

License Activation for Switch Stacks

LAN Base models can stack with LAN Base models only.

The active stack is activated with a license from its active console. The license level for members in the stack can be activated at the same time.

To change the license level, do not disconnect a newly added stack member if the stack cables are connected. Instead, use the active console to set the new member's license level at the same license level as an active stack and reboot the new member to join the stack.

Reboot is required only for the base license; not when you configure an add-on license

How to Configure Add-On License Levels

The following sections provide information on how to configure Add-on License Levels.

Activating an Image Based Add-on License

The following steps can be used to activate an image based license.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **license boot level addon** *addon-license*
4. **license accept end user agreement force**
5. **show license right-to-use usage**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**license boot level addon** *addon-license* **Example:** `Device(config)# license boot level addon dna-essentials`	Specifies the add-on license level. The following options are available: • DNA Essentials
Step 4	**license accept end user agreement force** **Example:**	Enables acceptance of the end-user license agreement (EULA).

	Command or Action	Purpose
	`Device(config)# license accept end user agreement force`	**Note** To configure an add-on license EULA acceptance is not mandatory, but you will not be able to use or configure the DNAC features until you complete this step.
Step 5	**show license right-to-use usage** **Example:** `Device(config)# show license right-to-use usage`	Displays detailed usage information. Other options are available with the **show license right-to-use command**.

Rehosting a License

To rehost a license, you have to deactivate the license from one device and then activate the same license on another device. The following steps can be used to rehost a license.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **license right-to-use deactivate [license-level] slot***slot-num*
4. **license right-to-use activate [license-level]***slot-num* [**acceptEULA**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**license right-to-use deactivate [license-level] slot***slot-num* **Example:** `Device(config)# license right-to-use deactivate dna-essentials slot 1`	Deactivates the license on one device.
Step 4	**license right-to-use activate [license-level]***slot-num* [**acceptEULA**] **Example:** `Device(config)# license right-to-use activate dna-essentials slot 2`	Activates the license on another device.

Monitoring Licenses

Use the following commands in the privilege EXEC mode to monitor license information:

Command	Purpose
show license right-to-use default	Displays the default license information.
show license right-to-use detail	Displays detailed information of all the licenses in the switch stack.
show license right-to-use eula	Displays the end user license agreement.
show license right-to-use slot slot-number	Displays the license information for a specific slot in a switch stack.
show license right-to-use summary	Displays a summary of the license information on the entire switch stack.
show license right-to-use usage [slot slot-number]	Displays detailed information about usage for all licenses in the switch stack.

Configuration Examples for License Levels

The following sections provide examples for configuring license levels.

Reference

-

Example: Displaying the detailed license information

The following examples shows how to display the detailed information of all the licenses in a stack using the **show license right-to-use detail** command.

```
Device# show license right-to-use detail
Index 1
  License Name    : Advanced Enterprise Services
  Period left     : Lifetime
  License Type    : permanent
  License State   : Active, In use
Index 2
  License Name    : dna-essentials
  Period left     : CSSM Managed
  License Type    : Subscription
  License State   : Not Activated
Index 3
  License Name    : dna-advantage
  Period left     : CSSM Managed
  License Type    : Subscription
  License State   : Active, In use
```

Example: Displaying a summary of the license information

The following examples shows how to display a summary of the license information using the **show license right-to-use summary** command.

```
Device# show license right-to-use summary
License Name                  Type          Period left
-------------------------------------------------------
lanlite                       Permanent     0  minute  0  second
lanbase                       Permanent     0  minute  0  second
dna-essentials                Subscription  CSSM Managed
-------------------------------------------------------

License Level In Use: lanbase  addon: dna-essentials
License Level on Reboot: lanbase  addon: dna-essentials

Example: show license right-to-use usage

FEX-0#show license right-to-use usage
slot         License Name                  Type          In-use   EULA
----------------------------------------------------------------------
0            lanlite                       Permanent     yes      yes
0            lanbase                       Permanent     yes      yes
             dna-essentials                Subscription  yes      yes
             dna-advantage                 Subscription  no       yes
```

Example: Displaying the end user license agreement

The following example shows how to display the end user license agreement.

```
Device# show license right-to-use eula subscription
Feature name             EULA Accepted
------------             -------------
dna-essentials           yes
dna-advantage            no
PLEASE READ THE FOLLOWING TERMS  CAREFULLY. INSTALLING THE LICENSE OR
LICENSE KEY PROVIDED FOR ANY CISCO SOFTWARE PRODUCT, PRODUCT FEATURE,
AND OR SUBSEQUENTLY PROVIDED SOFTWARE FEATURES (COLLECTIVELY, THE ?SOFTWARE?),
USING SUCH SOFTWARE, AND/OR ACTIVATION OF THE SOFTWARE COMMAND LINE INTERFACE
CONSTITUTES  YOUR  FULL ACCEPTANCE  OF  THE FOLLOWING TERMS.YOU MUST NOT PROCEED
FURTHER IF YOU ARE NOT WILLING TO BE BOUND BY ALL THE TERMS SET FORTH HEREIN.

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90-day trial period). Cisco reserves the right to terminate any such Software feature
electronically or by any other means available. While Cisco may provide alerts, it is
your  sole  responsibility to  monitor your usage of any such term Software feature to
ensure that your systems and networks are prepared for a shutdown of the Software feature.
To memorialize your acceptance of these terms and activate your license to use the Software,
please execute the command "license accept end user agreement force".
```

Feature History for Information About Licensing

Release	Modification
Cisco IOS Release 15.2(6)E1	This feature was introduced.

PART X

Working with the Cisco IOS File System, Configuration Files, and Software Images

CHAPTER 58

Working with the Cisco IOS File System, Configuration Files, and Software Images

Working with the Flash File System

Information About the Flash File System

The flash file system is a single flash device on which you can store files. It also provides several commands to help you manage software bundles and configuration files. The default flash file system on the switch is named flash:.

As viewed from the active switch, flash: refers to the local flash device, which is the device attached to the same switch on which the file system is being viewed.

Only one user at a time can manage the software bundles and configuration files .

Displaying Available File Systems

To display the available file systems on your switch, use the **show file systems** privileged EXEC command as shown in this example for a standalone switch:

```
Switch# show file systems
File Systems:
     Size(b)      Free(b)        Type    Flags    Prefixes
*   15998976      5135872       flash     rw      flash:
           -            -      opaque     rw      bs:
           -            -      opaque     rw      vb:
      524288       520138       nvram     rw      nvram:
           -            -     network     rw      tftp:
```

```
-           -     opaque     rw     null:
-           -     opaque     rw     system:
-           -     opaque     ro     xmodem:
-           -     opaque     ro     ymodem:
```

Table 122: show file systems Field Descriptions

Field	Value
Size(b)	Amount of memory in the file system in bytes.
Free(b)	Amount of free memory in the file system in bytes.
Type	Type of file system. **disk**—The file system is for a flash memory device, USB flash, and crashinfo file. **network**—The file system for network devices; for example, an FTP server or and HTTP server. **nvram**—The file system is for a NVRAM device. **opaque**—The file system is a locally generated pseudo file system (for example, the system) or a download interface, such as brimux. **unknown**—The file system is an unknown type.
Flags	Permission for file system. **ro**—read-only. **rw**—read/write. **wo**—write-only.

Field	Value
Prefixes	Alias for file system. **crashinfo:**—Crashinfo file. **flash:**—Flash file system. **ftp:**—FTP server. **http:**—HTTP server. **https:**—Secure HTTP server. **nvram:**—NVRAM. **null:**—Null destination for copies. You can copy a remote file to null to find its size. **rcp:**—Remote Copy Protocol (RCP) server. **scp:**—Session Control Protocol (SCP) server. **system:**—Contains the system memory, including the running configuration. **tftp:**—TFTP network server. **usbflash0:**—USB flash memory. **xmodem:**—Obtain the file from a network machine by using the Xmodem protocol. **ymodem:**—Obtain the file from a network machine by using the Ymodem protocol.

Setting the Default File System

You can specify the file system or directory that the system uses as the default file system by using the **cd** *filesystem:* privileged EXEC command. You can set the default file system to omit the *filesystem:* argument from related commands. For example, for all privileged EXEC commands that have the optional *filesystem:* argument, the system uses the file system specified by the **cd** command.

By default, the default file system is *flash:*.

You can display the current default file system as specified by the **cd** command by using the **pwd** privileged EXEC command.

Displaying Information About Files on a File System

You can view a list of the contents of a file system before manipulating its contents. For example, before copying a new configuration file to flash memory, you might want to verify that the file system does not already contain a configuration file with the same name. Similarly, before copying a flash configuration file to another location, you might want to verify its filename for use in another command. To display information about files on a file system, use one of the privileged EXEC commands listed in the following table.

Table 123: Commands for Displaying Information About Files

Command	Description
dir [/all] [*filesystem:filename***]**	Displays a list of files on a file system.
show file systems	Displays more information about each of the files on a file system.
show file information *file-url*	Displays information about a specific file.
show file descriptors	Displays a list of open file descriptors. File descriptors are the internal representations of open files. You can use this command to see if another user has a file open.

Changing Directories and Displaying the Working Directory

Follow these steps to change directories and to display the working directory:

SUMMARY STEPS

1. **enable**
2. **dir** *filesystem:*
3. **cd** *directory_name*
4. **pwd**
5. **cd**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**dir** *filesystem:* **Example:** `Switch# dir flash:`	Displays the directories on the specified file system. For *filesystem:*, use flash: for the system board flash device.
Step 3	**cd** *directory_name* **Example:** `Switch# cd new_configs`	Navigates to the specified directory. The command example shows how to navigate to the directory named *new_configs*.
Step 4	**pwd** **Example:**	Displays the working directory.

	Command or Action	Purpose
	`Switch# pwd`	
Step 5	**cd** **Example:** `Switch# cd`	Navigates to the default directory.

Creating Directories

Beginning in privileged EXEC mode, follow these steps to create a directory:

SUMMARY STEPS

1. **dir** *filesystem:*
2. **mkdir** *directory_name*
3. **dir** *filesystem:*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**dir** *filesystem:* **Example:** `Switch# dir flash:`	Displays the directories on the specified file system. For *filesystem:*, use flash: for the system board flash device.
Step 2	**mkdir** *directory_name* **Example:** `Switch# mkdir new_configs`	Creates a new directory. Directory names are case sensitive and are limited to 45 characters between the slashes (/); the name cannot contain control characters, spaces, slashes, quotes, semicolons, or colons.
Step 3	**dir** *filesystem:* **Example:** `Switch# dir flash:`	Verifies your entry.

Removing Directories

To remove a directory with all its files and subdirectories, use the **delete /force /recursive** *filesystem:/file-url* privileged EXEC command.

Use the **/recursive** keyword to delete the named directory and all subdirectories and the files contained in it. Use the **/force** keyword to suppress the prompting that confirms a deletion of each file in the directory. You are prompted only once at the beginning of this deletion process.

For *filesystem*, use **flash:** for the system board flash device. For *file-url*, enter the name of the directory to be deleted. All of the files in the directory and the directory are removed.

Caution When directories are deleted, their contents cannot be recovered.

Copying Files

To copy a file from a source to a destination, use the **copy** *source-url destination-url* privileged EXEC command. For the source and destination URLs, you can use **running-config** and **startup-config** keyword shortcuts. For example, the **copy running-config startup-config** command saves the currently running configuration file to the NVRAM section of flash memory to be used as the configuration during system initialization.

You can also copy from special file systems (**xmodem:**, **ymodem:**) as the source for the file from a network machine that uses the Xmodem or Ymodem protocol.

Network file system URLs include ftp:, rcp:, and tftp: and have these syntaxes:

- FTP—ftp:[[//username [:password]@location]/directory]/filename
- RCP—rcp:[[//username@location]/directory]/filename
- TFTP—tftp:[[//location]/directory]/filename

Local writable file systems include flash:.

Some invalid combinations of source and destination exist. Specifically, you cannot copy these combinations:

- From a running configuration to a running configuration
- From a startup configuration to a startup configuration
- From a device to the same device (for example, the **copy flash: flash:** command is invalid)

Deleting Files

When you no longer need a file on a flash memory device, you can permanently delete it. To delete a file or directory from a specified flash device, use the **delete** [**/force**] [**/recursive**] [*filesystem:*]*/file-url* privileged EXEC command.

Use the **/recursive** keyword for deleting a directory and all subdirectories and the files contained in it. Use the **/force** keyword to suppress the prompting that confirms a deletion of each file in the directory. You are prompted only once at the beginning of this deletion process. Use the **/force** and **/recursive** keywords for deleting old software images that were installed by using the **archive download-sw** command but are no longer needed.

If you omit the *filesystem:* option, the switch uses the default device specified by the **cd** command. For *file-url*, you specify the path (directory) and the name of the file to be deleted.

When you attempt to delete any files, the system prompts you to confirm the deletion.

Caution When files are deleted, their contents cannot be recovered.

This example shows how to delete the file *myconfig* from the default flash memory device:

```
Switch# delete myconfig
```

Creating, Displaying and Extracting Files

You can create a file and write files into it, list the files in a file, and extract the files from a file as described in the next sections.

Beginning in privileged EXEC mode, follow these steps to create a file, display the contents, and extract it:

SUMMARY STEPS

1. **archive tar /create** *destination-url* **flash:** */file-url*
2. **archive tar /table** *source-url*
3. **archive tar /xtract** *source-url* **flash:**/*file-url* [*dir/file...*]
4. **more** [/**ascii** | /**binary** | /**ebcdic**] /*file-url*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**archive tar /create** *destination-url* **flash:** */file-url* **Example:** `switch# archive tar /create tftp:172.20.10.30/saved. flash:/new-configs`	Creates a file and adds files to it. For destination-url, specify the destination URL alias for the local or network file system and the name of the file to create: • Local flash file system syntax: **flash:** • FTP syntax: **ftp**:[[//*username*[:*password*]@*location*]/*directory*]/-*filename*. • RCP syntax: **rcp**:[[//*username*@*location*]/*directory*]/-*filename*. • TFTP syntax: **tftp**:[[//*location*]/*directory*]/-*filename*. For **flash:**/*file-url*, specify the location on the local flash file system in which the new file is created. You can also specify an optional list of files or directories within the source directory to add to the new file. If none are specified, all files and directories at this level are written to the newly created file.
Step 2	**archive tar /table** *source-url* **Example:** `switch# archive tar /table flash: /new_configs`	Displays the contents of a file. For *source-url*, specify the source URL alias for the local or network file system. The -*filename*. is the file to display. These options are supported: • Local flash file system syntax: **flash:**

	Command or Action	Purpose
		• FTP syntax: **ftp**:[[//*username*[:*password*]@*location*]/*directory*]/*-filename*. • RCP syntax: **rcp**:[[//*username@location*]/*directory*]/*-filename*. • TFTP syntax: **tftp**:[[//*location*]/*directory*]/*-filename*. You can also limit the file displays by specifying a list of files or directories after the file. Only those files appear. If none are specified, all files and directories appear.

Step 3	**archive tar /xtract** *source-url* **flash:**/*file-url* [*dir/file...*]
	Example:
	`switch# archive tar /xtract`
	`tftp:/172.20.10.30/saved.`
	`flash:/new-configs`
		Extracts a file into a directory on the flash file system.
		For *source-url*, specify the source URL alias for the local file system. The *-filename.* is the file from which to extract files. These options are supported:
		• Local flash file system syntax:
		flash:
		• FTP syntax:
		ftp:[[//*username*[:*password*]@*location*]/*directory*]/*-filename*.
		• RCP syntax:
		rcp:[[//*username@location*]/*directory*]/*-filename*.
		• TFTP syntax:
		tftp:[[//*location*]/*directory*]/*-filename*.
		For **flash:**/*file-url* [*dir/file...*], specify the location on the local flash file system from which the file is extracted. Use the *dir/file...* option to specify a list of files or directories within the file to be extracted. If none are specified, all files and directories are extracted.

Step 4	**more** [/**ascii** | /**binary** | /**ebcdic**] /*file-url*
	Example:
	`switch# more`
	`flash:/new-configs`
		Displays the contents of any readable file, including a file on a remote file system.

Working with Configuration Files

Information on Configuration Files

Configuration files contain commands entered to customize the function of the Cisco IOS software. A way to create a basic configuration file is to use the setup program or to enter the setup privileged EXEC command.

You can copy (download) configuration files from a TFTP, FTP, or RCP server to the running configuration or startup configuration of the switch. You might want to perform this for one of these reasons:

- To restore a backed-up configuration file.
- To use the configuration file for another switch. For example, you might add another switch to your network and want it to have a configuration similar to the original switch. By copying the file to the new switch, you can change the relevant parts rather than recreating the whole file.
- To load the same configuration commands on all the switches in your network so that all the switches have similar configurations.

You can copy (upload) configuration files from the switch to a file server by using TFTP, FTP, or RCP. You might perform this task to back up a current configuration file to a server before changing its contents so that you can later restore the original configuration file from the server.

The protocol you use depends on which type of server you are using. The FTP and RCP transport mechanisms provide faster performance and more reliable delivery of data than TFTP. These improvements are possible because FTP and RCP are built on and use the TCP/IP stack, which is connection-oriented.

Guidelines for Creating and Using Configuration Files

Creating configuration files can aid in your switch configuration. Configuration files can contain some or all of the commands needed to configure one or more switches. For example, you might want to download the same configuration file to several switches that have the same hardware configuration.

Use these guidelines when creating a configuration file:

- We recommend that you connect through the console port or Ethernet management port for the initial configuration of the switch. If you are accessing the switch through a network connection instead of through a direct connection to the console port or Ethernet management port, keep in mind that some configuration changes (such as changing the switch IP address or disabling ports) can cause a loss of connectivity to the switch.
- If no password has been set on the switch, we recommend that you set one by using the **enable secret** *secret-password* global configuration command.

Note The **copy** {**ftp:** | **rcp:** | **tftp:**} **system:running-config** privileged EXEC command loads the configuration files on the switch as if you were entering the commands at the command line. The switch does not erase the existing running configuration before adding the commands. If a command in the copied configuration file replaces a command in the existing configuration file, the existing command is erased. For example, if the copied configuration file contains a different IP address in a particular command than the existing configuration, the IP address in the copied configuration is used. However, some commands in the existing configuration might not be replaced or negated. In this case, the resulting configuration file is a mixture of the existing configuration file and the copied configuration file, with the copied configuration file having precedence.

To restore a configuration file to an exact copy of a file stored on a server, copy the configuration file directly to the startup configuration (by using the **copy** {**ftp:** | **rcp:** | **tftp:**} **nvram:startup-config** privileged EXEC command), and reload the switch.

Configuration File Types and Location

Startup configuration files are used during system startup to configure the software. Running configuration files contain the current configuration of the software. The two configuration files can be different. For example, you might want to change the configuration for a short time period rather than permanently. In this case, you would change the running configuration but not save the configuration byusing the copy running-config startup-config privileged EXEC command.

The running configuration is saved in DRAM; the startup configuration is stored in the NVRAM section of flash memory.

Creating a Configuration File By Using a Text Editor

When creating a configuration file, you must list commands logically so that the system can respond appropriately. This is one method of creating a configuration file:

SUMMARY STEPS

1. Copy an existing configuration from a switch to a server.
2. Open the configuration file in a text editor, such as vi or emacs on UNIX or Notepad on a PC.
3. Extract the portion of the configuration file with the desired commands, and save it in a new file.
4. Copy the configuration file to the appropriate server location. For example, copy the file to the TFTP directory on the workstation (usually /tftpboot on a UNIX workstation).
5. Make sure the permissions on the file are set to world-read.

DETAILED STEPS

Step 1 Copy an existing configuration from a switch to a server.

Step 2 Open the configuration file in a text editor, such as vi or emacs on UNIX or Notepad on a PC.

Step 3 Extract the portion of the configuration file with the desired commands, and save it in a new file.

Step 4 Copy the configuration file to the appropriate server location. For example, copy the file to the TFTP directory on the workstation (usually /tftpboot on a UNIX workstation).

Step 5 Make sure the permissions on the file are set to world-read.

Copying Configuration Files By Using TFTP

You can configure the switch by using configuration files you create, download from another switch, ordownload from a TFTP server. You can copy (upload) configuration files to a TFTP server for storage.

Preparing to Download or Upload a Configuration File By Using TFTP

Before you begin downloading or uploading a configuration file by using TFTP, do these tasks:

- Ensure that the workstation acting as the TFTP server is properly configured. On a Sun workstation, make sure that the /etc/inetd.conf file contains this line:

```
tftp dgram udp wait root /usr/etc/in.tftpd in.tftpd -p -s /tftpboot
```

Make sure that the /etc/services file contains this line:

```
tftp 69/udp
```

Note You must restart the inetd daemon after modifying the /etc/inetd.conf and /etc/services files. To restart the daemon, either stop the inetd process and restart it, or enter a **fastboot** command (on the SunOS 4.x) or a **reboot** command (on Solaris 2.x or SunOS 5.x). For more information on the TFTP daemon, see the documentation for your workstation.

- Ensure that the switch has a route to the TFTP server. The switch and the TFTP server must be in the same subnetwork if you do not have a router to route traffic between subnets. Check connectivity to the TFTP server by using the **ping** command.
- Ensure that the configuration file to be downloaded is in the correct directory on the TFTP server (usually /tftpboot on a UNIX workstation).
- For download operations, ensure that the permissions on the file are set correctly. The permissionon the file should be world-read.
- Before uploading the configuration file, you might need to create an empty file on the TFTP server. To create an empty file, enter the **touch** *filename* command, where *filename* is the name of the file you will use when uploading it to the server.
- During upload operations, if you are overwriting an existing file (including an empty file, if you had to create one) on the server, ensure that the permissions on the file are set correctly. Permissions on the file should be world-write.

Downloading the Configuration File By Using TFTP

To configure the switch by using a configuration file downloaded from a TFTP server, follow these steps:

SUMMARY STEPS

1. Copy the configuration file to the appropriate TFTP directory on the workstation.
2. Verify that the TFTP server is properly configured.
3. Log into the switch through the console port, the Ethernet management port, or a Telnet session.
4. Download the configuration file from the TFTP server to configure the switch.

DETAILED STEPS

Step 1 Copy the configuration file to the appropriate TFTP directory on the workstation.

Step 2 Verify that the TFTP server is properly configured.

Step 3 Log into the switch through the console port, the Ethernet management port, or a Telnet session.

Step 4 Download the configuration file from the TFTP server to configure the switch.

Specify the IP address or hostname of the TFTP server and the name of the file to download.

Use one of these privileged EXEC commands:

```
copy tftp:[[[//location]/directory]/filename] system:running-config
copy tftp:[[[//location]/directory]/filename] nvram:startup-config
```

```
copy tftp:[[[//location]/directory]/filename] flash[n]:/directory/startup-config
```

The configuration file downloads, and the commands are executed as the file is parsed line-by-line.

Example

This example shows how to configure the software from the file tokyo-confg at IP address 172.16.2.155:

```
Switch# copy tftp://172.16.2.155/tokyo-confg system:running-config
Configure using tokyo-confg from 172.16.2.155? [confirm] y
Booting tokyo-confg from 172.16.2.155:!!! [OK - 874/16000 bytes]
```

Uploading the Configuration File By Using TFTP

To upload a configuration file from a switch to a TFTP server for storage, follow these steps:

SUMMARY STEPS

1. Verify that the TFTP server is properly configured.
2. Log into the switch through the console port, the Ethernet management port, or a Telnet session
3. Upload the switch configuration to the TFTP server. Specify the IP address or hostname of the TFTP server and the destination filename.

DETAILED STEPS

Step 1 Verify that the TFTP server is properly configured.

Step 2 Log into the switch through the console port, the Ethernet management port, or a Telnet session

Step 3 Upload the switch configuration to the TFTP server. Specify the IP address or hostname of the TFTP server and the destination filename.

Use **one** of these privileged EXEC commands:

- **copy system:running-config tftp:**[[[//*location*]/*directory*]/*filename*]
- **copy nvram:startup-config tftp:**[[[//*location*]/*directory*]/*filename*]
- **copy flash**[n]:/*directory*/**startup-config tftp:**[[[//*location*]/*directory*]/*filename*]

The file is uploaded to the TFTP server.

Example

This example shows how to upload a configuration file from a switch to a TFTP server:

```
Switch# copy system:running-config tftp://172.16.2.155/tokyo-confg
Write file tokyo-confg on host 172.16.2.155? [confirm] y
```

```
#
Writing tokyo-confg!!! [OK]
```

Copying a Configuration File from the Switch to an FTP Server

You can copy a configuration file from the switch to an FTP server.

Understanding the FTP Username and Password

The FTP protocol requires a client to send a remote username and password on each FTP request to a server. When you copy a configuration file from the switch to a server using FTP, the Cisco IOS software sends the first valid username it encounters in the following sequence:

1. The username specified in the **copy** EXEC command, if a username is specified.
2. The username set by the **ip ftp username** global configuration command, if the command is configured.
3. Anonymous.

The switch sends the first valid password it encounters in the following sequence:

1. The password specified in the **copy** command, if a password is specified.
2. The password set by the **ip ftp password** command, if the command is configured.
3. The switch forms a password *username @switchname.domain* . The variable *username* is the username associated with the current session, *switchname* is the configured host name, and *domain* is the domain of the switch.

The username and password must be associated with an account on the FTP server. If you are writing to the server, the FTP server must be properly configured to accept the FTP write request from the user on the switch.

If the server has a directory structure, the configuration file or image is written to or copied from the directory associated with the username on the server. For example, if the system image resides in the home directory of a user on the server, specify that user name as the remote username.

Refer to the documentation for your FTP server for more information.

Use the **ip ftp username** and **ip ftp password** global configuration commands to specify a username and password for all copies. Include the username in the **copy** EXEC command if you want to specify a username for that copy operation only.

Preparing to Download or Upload a Configuration File By Using FTP

Before you begin downloading or uploading a configuration file by using FTP, do these tasks:

- Ensure that the switch has a route to the FTP server. The switch and the FTP server must be in the same subnetwork if you do not have a router to route traffic between subnets. Check connectivity to the FTP server by using the **ping** command.
- If you are accessing the switch through the console or a Telnet session and you do not have a valid username, make sure that the current FTP username is the one that you want to use for the FTP download. You can enter the **show users** privileged EXEC command to view the valid username. If you do not want to use this username, create a new FTP username by using the **ip ftp username** *username* global configuration command during all copy operations. The new username is stored in NVRAM. If you are accessing the switch through a Telnet session and you have a valid username, this username is used, and

you do not need to set the FTP username. Include the username in the **copy** command if you want to specify a username for only that copy operation.

- When you upload a configuration file to the FTP server, it must be properly configured to accept the write request from the user on the switch.

For more information, see the documentation for your FTP server.

Downloading a Configuration File By Using FTP

Beginning in privileged EXEC mode, follow these steps to download a configuration file by using FTP:

SUMMARY STEPS

1. **configure terminal**
2. **ip ftp username** *username*
3. **ip ftp password** *password*
4. **end**
5. Do one of the following:
   - **copy system:running-config ftp:** [[[//[*username* [:*password*]@]*location*]/*directory*]/*filename*]
   - **copy nvram:startup-config ftp:** [[[//[*username* [:*password*]@]*location*]/*directory*]/*filename*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal**	Enter global configuration mode on the switch. This step is required only if you override the default remote username or password (see Steps 2, 3, and 4).
Step 2	**ip ftp username** *username*	(Optional) Change the default remote username.
Step 3	**ip ftp password** *password*	(Optional) Change the default password.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	Do one of the following: • **copy system:running-config ftp:** [[[//[*username* [:*password*]@]*location*]/*directory*]/*filename*] • **copy nvram:startup-config ftp:** [[[//[*username* [:*password*]@]*location*]/*directory*]/*filename*]	Using FTP, copy the configuration file from a network server to the running configuration or to the startup configuration file.

Example

This example shows how to copy a configuration file named host1-confg from the netadmin1 directory on the remote server with an IP address of 172.16.101.101 and to load and run those commands on the switch:

```
Switch# copy ftp://netadmin1:mypass@172.16.101.101/host1-confg
system:running-config
Configure using host1-confg from 172.16.101.101? [confirm]
```

```
Connected to 172.16.101.101
Loading 1112 byte file host1-confg:![OK]
Switch#
%SYS-5-CONFIG: Configured from host1-config by ftp from 172.16.101.101
```

This example shows how to specify a remote username of netadmin1. The software copies the configuration file host2-confg from the netadmin1 directory on the remote server with an IP address of 172.16.101.101 to the switch startup configuration.

```
Switch# configure terminal
Switch(config)# ip ftp username netadmin1
Switch(config)# ip ftp password mypass
Switch(config)# end
Switch# copy ftp: nvram:startup-config
Address of remote host [255.255.255.255]? 172.16.101.101
Name of configuration file[rtr2-confg]? host2-confg
Configure using host2-confg from 172.16.101.101?[confirm]
Connected to 172.16.101.101
Loading 1112 byte file host2-confg:![OK]
[OK]
Switch#
%SYS-5-CONFIG_NV:Non-volatile store configured from host2-config by ftp from 172.16.101.101
```

Uploading a Configuration File By Using FTP

Beginning in privileged EXEC mode, follow these steps to upload a configuration file by using FTP:

SUMMARY STEPS

1. **configure terminal**
2. **ip ftp username** *username*
3. **ip ftp password** *password*
4. **end**
5. Do one of the following:
   - **copy system:running-config ftp:** [[[//[*username* [**:***password*]**@**]*location*]/*directory*]/*filename*]
     or
   - **copy nvram:startup-config ftp:** [[[//[*username* [**:***password*]**@**]*location*]/*directory*]/*filename*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal**	Enter global configuration mode on the switch. This step is required only if you override the default remote username or password (see Steps 2, 3, and 4).
Step 2	**ip ftp username** *username*	(Optional) Change the default remote username.
Step 3	**ip ftp password** *password*	(Optional) Change the default password.
Step 4	**end**	Return to privileged EXEC mode.

	Command or Action	Purpose
Step 5	Do one of the following: • **copy system:running-config ftp:** [[[//[*username* [**:***password*]**@**]*location*]/*directory*]/*filename*] or • **copy nvram:startup-config ftp:** [[[//[*username* [**:***password*]**@**]*location*]/*directory*]/*filename*]	Using FTP, store the switch running or startup configuration file to the specified location.

Example

This example shows how to copy the running configuration file named switch2-confg to the netadmin1 directory on the remote host with an IP address of 172.16.101.101:

```
Switch# copy system:running-config
ftp://netadmin1:mypass@172.16.101.101/switch2-confg
Write file switch2-confg on host 172.16.101.101?[confirm]
Building configuration...[OK]
Connected to 172.16.101.101
Switch#
```

This example shows how to store a startup configuration file on a server by using FTP to copy the file:

```
Switch# configure terminal
Switch(config)# ip ftp username netadmin2
Switch(config)# ip ftp password mypass
Switch(config)# end
Switch# copy nvram:startup-config ftp:
Remote host[]? 172.16.101.101
Name of configuration file to write [switch2-confg]?
Write file switch2-confg on host 172.16.101.101?[confirm]
![OK]
```

Copying Configuration Files By Using RCP

The RCP provides another method of downloading, uploading, and copying configuration files between remote hosts and the switch. Unlike TFTP, which uses User Datagram Protocol (UDP), a connectionless protocol, RCP uses TCP, which is connection-oriented.

To use RCP to copy files, the server from or to which you will be copying files must support RCP. The RCP copy commands rely on the rsh server (or daemon) on the remote system. To copy files by using RCP, you do not need to create a server for file distribution as you do with TFTP. You only need to have access to a server that supports the remote shell (rsh). (Most UNIX systems support rsh.) Because you are copying a file from one place to another, you must have read permission on the source file and write permission on the destination file. If the destination file does not exist, RCP creates it for you.

The RCP requires a client to send a remote username with each RCP request to a server. When you copy a configuration file from the switch to a server, the Cisco IOS software sends the first valid username inthis list:

- The username specified in the **copy** command if a username is specified.

- The username set by the **ip rcmd remote-username** *username* global configuration command if the command is configured.
- The remote username associated with the current TTY (terminal) process. For example, if the user is connected to the router through Telnet and was authenticated through the **username** command, the switch software sends the Telnet username as the remote username.
- The switch hostname.

For a successful RCP copy request, you must define an account on the network server for the remote username. If the server has a directory structure, the configuration file is written to or copied from the directory associated with the remote username on the server. For example, if the configuration file is in the home directory of a user on the server, specify that user's name as the remote username.

Preparing to Download or Upload a Configuration File By Using RCP

Before you begin downloading or uploading a configuration file by using RCP, do these tasks:

- Ensure that the workstation acting as the RCP server supports the remote shell (rsh).
- Ensure that the switch has a route to the RCP server. The switch and the server must be in the same subnetwork if you do not have a router to route traffic between subnets. Check connectivity to the RCP server by using the **ping** command.
- If you are accessing the switch through the console or a Telnet session and you do not have a valid username, make sure that the current RCP username is the one that you want to use for the RCP download. You can enter the show users privileged EXEC command to view the valid username. If you do not want to use this username, create a new RCP username by using the ip rcmd remote-username username global configuration command to be used during all copy operations. The new username is stored in NVRAM. If you are accessing the switch through a Telnet session and you have a valid username, this username is used, and you do not need to set the RCP username. Include the username in the copy command if you want to specify a username for only that copy operation.
- When you upload a file to the RCP server, it must be properly configured to accept the RCP write request from the user on the switch. For UNIX systems, you must add an entry to the .rhosts file for the remote user on the RCP server. For example, suppose that the switch contains these configuration lines:

  ```
  hostname Switch1
  ip rcmd remote-username User0
  ```

If the switch IP address translates to Switch1.company.com, the .rhosts file for User0 on the RCPserver should contain this line:

```
Switch1.company.com Switch1
```

For more information, see the documentation for your RCP server.

Downloading a Configuration File By Using RCP

Beginning in privileged EXEC mode, follow these steps to download a configuration file by using RCP:

SUMMARY STEPS

1. **configure terminal**
2. **ip rcmd remote-username** *username*
3. **end**

4. Do one of the following:

- **copy rcp:**[[[//*username@*]*location*]/*directory*]/*filename]***system:running-config**
- **copy rcp:**[[[//*username@*]*location*]/*directory*]/*filename]***nvram:startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal**	Enter global configuration mode on the switch. This step is required only if you override the default remote username (see Steps 2 and 3).
Step 2	**ip rcmd remote-username** *username*	(Optional) Change the default remote username.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	Do one of the following: • **copy rcp:**[[[//*username@*]*location*]/*directory*]/*filename]***system:running-config** • **copy rcp:**[[[//*username@*]*location*]/*directory*]/*filename]***nvram:startup-config**	Using RCP, copy the configuration file from a network server to the running configuration or to the startup configuration file.

Example

This example shows how to copy a configuration file named host1-confg from the netadmin1 directory on the remote server with an IP address of 172.16.101.101 and load and run those commands on the switch:

```
Switch# copy rcp://netadmin1@172.16.101.101/host1-confg system:running-config
Configure using host1-confg from 172.16.101.101? [confirm]
Connected to 172.16.101.101
Loading 1112 byte file host1-confg:![OK]
Switch#
%SYS-5-CONFIG: Configured from host1-config by rcp from 172.16.101.101
```

This example shows how to specify a remote username of *netadmin1*. Then it copies the configuration file *host2-confg* from the *netadmin1* directory on the remote server with an IP address of 172.16.101.101to the startup configuration:

```
Switch# configure terminal
Switch(config)# ip rcmd remote-username netadmin1
Switch(config)# end
Switch# copy rcp: nvram:startup-config
Address of remote host [255.255.255.255]? 172.16.101.101
Name of configuration file[rtr2-confg]? host2-confg
Configure using host2-confg from 172.16.101.101?[confirm]
Connected to 172.16.101.101
Loading 1112 byte file host2-confg:![OK]
[OK]
Switch#
%SYS-5-CONFIG_NV:Non-volatile store configured from host2-config by rcp from 172.16.101.101
```

Uploading a Configuration File By Using RCP

Beginning in privileged EXEC mode, follow these steps to upload a configuration file by using RCP

SUMMARY STEPS

1. **configure terminal**
2. **ip rcmd remote-username** *username*
3. **end**
4. Do one of the following:
   - **copy system:running-config rcp:**[[[//*username@*]*location*]/*directory*]/*filename]*
   - **copy nvram:startup-config rcp:**[[[//*username@*]*location*]/*directory*]/*filename]*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal**	Enter global configuration mode on the switch. This step is required only if you override the default remote username (see Steps 2 and 3).
Step 2	**ip rcmd remote-username** *username*	(Optional) Specify the remote username.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	Do one of the following: • **copy system:running-config rcp:**[[[//*username@*]*location*]/*directory*]/*filename]* • **copy nvram:startup-config rcp:**[[[//*username@*]*location*]/*directory*]/*filename]*	Using RCP, copy the configuration file from a switch running configuration or startup configuration file to a network server.

Example

This example shows how to copy the running configuration file named switch2-confg to the netadmin1 directory on the remote host with an IP address of 172.16.101.101:

```
Switch# copy system:running-config
rcp://netadmin1@172.16.101.101/switch2-confg
Write file switch-confg on host 172.16.101.101?[confirm]
Building configuration...[OK]
Connected to 172.16.101.101
Switch#
```

This example shows how to store a startup configuration file on a server:

```
Switch# configure terminal
Switch(config)# ip rcmd remote-username netadmin2
Switch(config)# end
Switch# copy nvram:startup-config rcp:
Remote host[]? 172.16.101.101
Name of configuration file to write [switch2-confg]?
```

```
Write file switch2-confg on host 172.16.101.101?[confirm]
![OK]
```

Clearing Configuration Information

You can clear the configuration information from the startup configuration. If you reboot the switch with no startup configuration, the switch enters the setup program so that you can reconfigure the switch with all new settings.

Clearing the Startup Configuration File

To clear the contents of your startup configuration, use the **erase nvram**: or the **erase startup-config** privileged EXEC command.

Note You cannot restore the startup configuration file after it has been deleted.

Deleting a Stored Configuration File

To delete a saved configuration from flash memory, use the delete flash:filename privileged EXEC command. Depending on the setting of the file prompt global configuration command, you might be prompted for confirmation before you delete a file. By default, the switch prompts for confirmation on destructive file operations. For more information about the file prompt command, see the Cisco IOS Command Reference for Release 12.4.

Note You cannot restore a file after it has been deleted.

Replacing and Rolling Back Configurations

The configuration replacement and rollback feature replaces the running configuration with any saved Cisco IOS configuration file. You can use the rollback function to roll back to a previous configuration.

Information on Configuration Replacement and Rollback

Configuration Archive

The Cisco IOS configuration archive is intended to provide a mechanism to store, organize, and manage an archive of Cisco IOS configuration files to enhance the configuration rollback capability provided by the **configure replace** command. Before this feature was introduced, you could save copies of the running configuration using the **copy running-config** *destination-url* command, storing the replacement file either locally or remotely. However, this method lacked any automated file management. On the other hand, the Configuration Replace and Configuration Rollback feature provides the capability to automatically save copies of the running configuration to the Cisco IOS configuration archive. These archived files serve as checkpoint configuration references and can be used by the **configure replace** command to revert to previous configuration states.

The **archive config** command allows you to save Cisco IOS configurations in the configuration archive using a standard location and filename prefix that is automatically appended with an incremental version number (and optional timestamp) as each consecutive file is saved. This functionality provides a means for consistent identification of saved Cisco IOS configuration files. You can specify how many versions of the running configuration are kept in the archive. After the maximum number of files are saved in the archive, the oldest file is automatically deleted when the next, most recent file is saved. The **show archive** command displays information for all configuration files saved in the Cisco IOS configuration archive.

The Cisco IOS configuration archive, in which the configuration files are stored and available for use with the **configure replace** command, can be located on the following file systems: FTP, HTTP, RCP, TFTP.

Configuration Replace

The **configure replace** privileged EXEC command replaces the running configuration with any saved configuration file. When you enter the **configure replace** command, the running configuration is compared with the specified replacement configuration, and a set of configuration differences is generated. The resulting differences are used to replace the configuration. The configuration replacement operation is usually completed in no more than three passes. To prevent looping behavior no more than five passes are performed.

You can use the **copy** *source-url* **running-config** privileged EXEC command to copy a stored configuration file to the running configuration. When using this command as an alternative to the **configure replace** *target-ur*l privileged EXEC command, note these major differences:

- The **copy**source-url**running-config** command is a merge operation and preserves all the commands from both the source file and the running configuration. This command does not remove commands from the running configuration that are not present in the source file. In contrast, the **configure replace**target-url command removes commands from the running configuration that are not present in the replacement file and adds commands to the running configuration that are not present.
- You can use a partial configuration file as the source file for the **copy**source-url**running-config** command. You must use a complete configuration file as the replacement file for the **configure replace**target-url command.

Configuration Rollback

You can also use the **configure replace** command to roll back changes that were made since the previous configuration was saved. Instead of basing the rollback operation on a specific set of changes that were applied, the configuration rollback capability reverts to a specific configuration based on a saved configuration file.

If you want the configuration rollback capability, you must first save the running configuration before making any configuration changes. Then, after entering configuration changes, you can use that saved configuration file to roll back the changes by using the **configure replace**target-url command.

You can specify any saved configuration file as the rollback configuration. You are not limited to a fixed number of rollbacks, as is the case in some rollback models.

Configuration Guidelines

Follow these guidelines when configuring and performing configuration replacement and rollback:

- Make sure that the switch has free memory larger than the combined size of the two configuration files (the running configuration and the saved replacement configuration). Otherwise, the configuration replacement operation fails.

- Make sure that the switch also has sufficient free memory to execute the configuration replacement or rollback configuration commands.
- Certain configuration commands, such as those pertaining to physical components of a networking device (for example, physical interfaces), cannot be added or removed from the running configuration.
  - A configuration replacement operation cannot remove the **interface**interface-id command line from the running configuration if that interface is physically present on the device.
  - The **interface**interface-id command line cannot be added to the running configuration if no such interface is physically present on the device.
- When using the **configure replace** command, you must specify a saved configuration as the replacement configuration file for the running configuration. The replacement file must be a complete configuration generated by a Cisco IOS device (for example, a configuration generated by the **copy running-config**destination-url command).

Note If you generate the replacement configuration file externally, it must comply with the format of files generated by Cisco IOS devices.

Configuring the Configuration Archive

Using the **configure replace** command with the configuration archive and with the **archive config** command is optional but offers significant benefit for configuration rollback scenarios. Before using the **archive config command**, you must first configure the configuration archive. Starting in privileged EXEC mode, follow these steps to configure the configuration archive:

SUMMARY STEPS

1. **configure terminal**
2. **archive**
3. **path***url*
4. **maximum***number*
5. **time-period** *minutes*
6. **end**
7. **show running-config**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**archive**	Enter archive configuration mode.
Step 3	**path***url*	Specify the location and filename prefix for the files in the configuration archive

	Command or Action	Purpose
Step 4	**maximum***number*	(Optional) Set the maximum number of archive files of the running configuration to be saved in the configuration archive . *number*-Maximum files of the running configuration file in the configuration archive. Valid values are from 1 to 14. The default is 10. **Note** Before using this command, you must first enter the **path** archive configuration command to specify the location and filename prefix for the files in the configuration archive.
Step 5	**time-period** *minutes*	(Optional) Set the time increment for automatically saving an archive file of the running configuration in the configuration archive. *minutes*-Specify how often, in minutes, to automatically save an archive file of the running configuration in the configuration archive
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show running-config**	Verify the configuration.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Performing a Configuration Replacement or Rollback Operation

Starting in privileged EXEC mode, follow these steps to replace the running configuration file with a saved configuration file:

SUMMARY STEPS

1. **archive config**
2. **configure terminal**
3. Make necessary changes to the running configuration.
4. **exit**
5. **configure replace** *target-url* [**list**] [**force**] [**time** *seconds*] [**nolock**]
6. **configure confirm**
7. **copy running-config startup-config**

DETAILED STEPS

Step 1 **archive config**

(Optional) Save the running configuration file to the configuration archive.

Note Enter the **path** archive configuration command before using this command.

Step 2 **configure terminal**

Enter global configuration mode.

Step 3 Make necessary changes to the running configuration.

—

Step 4 **exit**

Return to privileged EXEC mode.

Step 5 **configure replace** *target-url* [**list**] [**force**] [**time** *seconds*] [**nolock**]

Replace the running configuration file with a saved configuration file.

target-url—URL (accessible by the file system) of the saved configuration file that is to replace the running configuration, such as the configuration file created in Step 2 by using the **archive config** privileged EXEC command

list —Display a list of the command entries applied by the software parser during each pass of the configuration replacement operation. The total number of passes also appears.

force —Replace the running configuration file with the specified saved configuration file without prompting you for confirmation.

time*seconds*—Specify the time (in seconds) within which you must enter the **configure confirm** command to confirm replacement of the running configuration file. If you do not enter the **configure confirm** command within the specified time limit, the configuration replacement operation is automatically stopped. (In other words, the running configuration file is restored to the configuration that existed before you entered the **configure replace** command).

Note You must first enable the configuration archive before you can use the **time** seconds command line option.

nolock— Disable the locking of the running configuration file that prevents other users from changing the running configuration during a configuration replacement operation.

Step 6 **configure confirm**

(Optional) Confirm replacement of the running configuration with a saved configuration file.

Note Use this command only if the **time** seconds keyword and argument of the **configure replace** command are specified.

Step 7 **copy running-config startup-config**

(Optional) Save your entries in the configuration file.

Working with Software Images

Information on Working with Software Images

This section describes how to archive (download and upload) software image files, which contain the system software, the Cisco IOS code, and the embedded device manager software.

Note Instead of using the **copy** privileged EXEC command or the **archive tar** privileged EXEC command, we recommend using the **archive download-sw** and **archive upload-sw** privileged EXEC commands to download and upload software image files.

You can download a switch image file from a TFTP, FTP, or RCP server to upgrade the switch software. If you do not have access to a TFTP server, you can download a software image file directly to your PC or workstation by using a web browser (HTTP) and then by using the device manager or Cisco Network Assistant to upgrade your switch. For information about upgrading your switch by using a TFTP server or a web browser (HTTP), see the release notes.

You can replace the current image with the new one or keep the current image in flash memory after a download.

You upload a switch image file to a TFTP, FTP, or RCP server for backup purposes. You can use this uploaded image for future downloads to the same switch or to another of the same type.

The protocol that you use depends on which type of server you are using. The FTP and RCP transport mechanisms provide faster performance and more reliable delivery of data than TFTP. These improvements are possible because FTP and RCP are built on and use the TCP/IP stack, which is connection-oriented.

Note For a list of software images and the supported upgrade paths, see the release notes.

Image Location on the Switch

The Cisco IOS image is stored as a .bin file in a directory that shows the version number. A subdirectory contains the files needed for web management. The image is stored on the system board flash memory (flash:).

You can use the **show version** privileged EXEC command to see the software version that is currently running on your switch. In the display, check the line that begins with System image file is... . It shows the directory name in flash memory where the image is stored.

You can also use the **dir** filesystem : privileged EXEC command to see the directory names of other software images that might be stored in flash memory.

File Format of Images on a Server or Cisco.com

Software images located on a server or downloaded from Cisco.com are provided in a tar file format, which contains these files:

- An info file, which serves as a table of contents for the tar file
- One or more subdirectories containing other images and files, such as Cisco IOS images and web management files

This example shows some of the information contained in the info file. The table provides additional details about this information:

```
system_type:0x00000000:image-name
    image_family:xxxx
    info_end:

version_suffix:xxxx
    version_directory:image-name
    image_system_type_id:0x00000000
    image_name:image-nameB.bin
    ios_image_file_size:6398464
    total_image_file_size:8133632
    image_feature:IP|LAYER_3|PLUS|MIN_DRAM_MEG=128
    image_family:xxxx

    board_ids:0x401100c4 0x00000000 0x00000001 0x00000003 0x00000002 0x00008000 0x00008002

0x40110000
    info_end
```

Table 124: info File Description

Field	Description
version_suffix	Specifies the Cisco IOS image version string suffix
version_directory	Specifies the directory where the Cisco IOS image and the HTML subdirectory are installed
image_name	Specifies the name of the Cisco IOS image within the tar file
ios_image_file_size	Specifies the Cisco IOS image size in the tar file, which is an approximate measure of how much flash memory is required to hold just the Cisco IOS image
total_image_file_size	Specifies the size of all the images (the Cisco IOS image and the web management files) in the tar file, which is an approximate measure of how much flash memory is required to hold them
image_feature	Describes the core functionality of the image
image_min_dram	Specifies the minimum amount of DRAM needed to run this image
image_family	Describes the family of products on which the software can be installed

Copying Image Files Using TFTP

You can download a switch image from a TFTP server or upload the image from the switch to a TFTP server.

You download a switch image file from a server to upgrade the switch software. You can overwrite the current image with the new one or keep the current image after a download.

You upload a switch image file to a server for backup purposes; this uploaded image can be used for future downloads to the same or another switch of the same type .

Note Instead of using the **copy** privileged EXEC command or the **archive tar** privileged EXEC command, we recommend using the **archive download-sw** and **archive upload-sw** privileged EXEC commands to download and upload software image files.

Preparing to Download or Upload an Image File By Using TFTP

Before you begin downloading or uploading an image file by using TFTP, do these tasks:

- Ensure that the workstation acting as the TFTP server is properly configured. On a Sun workstation, make sure that the /etc/inetd.conf file contains this line:

  ```
  tftp dgram udp wait root /usr/etc/in.tftpd in.tftpd -p -s /tftpboot
  ```

  Make sure that the /etc/services file contains this line:

  ```
  tftp 69/udp
  ```

  Note You must restart the inetd daemon after modifying the /etc/inetd.conf and /etc/services files. To restart the daemon, either stop the inetd process and restart it, or enter a fastboot command (on the SunOS 4.x) or a **reboot** command (on Solaris 2.x or SunOS 5.x). For more information on the TFTP daemon, see the documentation for your workstation.

- Ensure that the switch has a route to the TFTP server. The switch and the TFTP server must be in the same subnetwork if you do not have a router to route traffic between subnets. Check connectivity to the TFTP server by using the **ping** command.
- Ensure that the image to be downloaded is in the correct directory on the TFTP server (usually /tftpboot on a UNIX workstation).
- For download operations, ensure that the permissions on the file are set correctly. The permission on the file should be world-read.
- Before uploading the image file, you might need to create an empty file on the TFTP server. To create an empty file, enter the **touch** filename command, where filename is the name of the file you will use when uploading the image to the server.
- During upload operations, if you are overwriting an existing file (including an empty file, if you had to create one) on the server, ensure that the permissions on the file are set correctly. Permissions on the file should be world-write.

Downloading an Image File By Using TFTP

You can download a new image file and replace the current image or keep the current image.

Beginning in privileged EXEC mode, follow Steps 1 through 3 to download a new image from a TFTP server and overwrite the existing image. To keep the current image, go to Step 3.

SUMMARY STEPS

1. Copy the image to the appropriate TFTP directory on the workstation. Make sure that the TFTP server is properly configured.
2. Log into the switch through the console port or a Telnet session.
3. **archive download-sw /overwrite /reload tftp:** [[// *location*] / *directory*] / *image-name***.tar**
4. **archive download-sw /leave-old-sw /reload tftp:** [[// *location*] / *directory*] / *image-name***.tar**

DETAILED STEPS

Step 1 Copy the image to the appropriate TFTP directory on the workstation. Make sure that the TFTP server is properly configured.

—

Step 2 Log into the switch through the console port or a Telnet session.

—

Step 3 **archive download-sw /overwrite /reload tftp:** [[// *location*] / *directory*] / *image-name***.tar**

Download the image file from the TFTP server to the switch, and overwrite the current image.

- The **/overwrite** option overwrites the software image in flash memory with the downloaded image.
- The **/reload** option reloads the system after downloading the image unless the configuration has been changed and not been saved.
- For // *location* , specify the IP address of the TFTP server.
- For /*directory*/*image-name***.tar** specify the directory (optional) and the image to download. Directory and image names are case sensitive.

Step 4 **archive download-sw /leave-old-sw /reload tftp:** [[// *location*] / *directory*] / *image-name***.tar**

Download the image file from the TFTP server to the switch, and keep the current image.

- The /**leave-old-sw** option keeps the old software version after a download.
- The /**reload** option reloads the system after downloading the image unless the configuration has been changed and not been saved.
- For //*location*, specify the IP address of the TFTP server.
- For /*directory*/*image-name***.tar** specify the directory (optional) and the image to download. Directory and image names are case sensitive.

The download algorithm verifies that the image is appropriate for the switch model and that enough DRAM is present, or it cancels the process and reports an error. If you specify the **/overwrite** option, the download algorithm removes the existing image on the flash device whether or not it is the same as the new one, downloads the new image, and then reloads the software.

Note If the flash device has sufficient space to hold two images and you want to overwrite one of these images with the same version, you must specify the **/overwrite** option.

If you specify the **/leave-old-sw**, the existing files are not removed. If there is not enough space to install the new image and keep the running image, the download process stops, and an error message is displayed.

The algorithm installs the downloaded image on the system board flash device (flash:). The image is placed into a new directory named with the software version string, and the BOOT environment variable is updated to point to the newly installed image.

If you keep the old image during the download process (you specified the /**leave-old-sw** keyword), you can remove it by entering the **delete** /**force** /**recursive** *filesystem* :/ *file-url* privileged EXEC command. For *filesystem*, use **flash:** for the system board flash device. For *file-url*, enter the directory name of the old image. All the files in the directory and the directory are removed.

Note For the download and upload algorithms to operate properly, do not rename image names

Uploading an Image File Using TFTP

You can upload an image from the switch to a TFTP server. You can later download this image to the switch or to another switch of the same type.

Use the upload feature only if the web management pages associated with the embedded device manager have been installed with the existing image.

Beginning in privileged EXEC mode, follow these steps to upload an image to a TFTP server:

SUMMARY STEPS

1. Make sure the TFTP server is properly configured
2. Log into the switch through the console port or a Telnet session.
3. **archive upload-sw tftp:**[[// *location*]/*directory*]/*image-name* **.tar**

DETAILED STEPS

Step 1 Make sure the TFTP server is properly configured

—

Step 2 Log into the switch through the console port or a Telnet session.

—

Step 3 **archive upload-sw tftp:**[[// *location*]/*directory*]/*image-name* **.tar**

Upload the currently running switch image to the TFTP server.

- For // *location* , specify the IP address of the TFTP server.
- For /*directory*/*image-name***.tar** specify the directory (optional) and the name of the software image to be uploaded. Directory and image names are case sensitive. The *image-name***.tar** is the name of the software image to be stored on the server.

  The **archive upload-sw** privileged EXEC command builds an image file on the server by uploading these files in order: info, the Cisco IOS image, and the web management files. After these files are uploaded, the upload algorithm creates the tar file format.

Note For the download and upload algorithms to operate properly, do not rename image names.

Copying Image Files Using FTP

You can download a switch image from an FTP server or upload the image from the switch to an FTP server.

You download a switch image file from a server to upgrade the switch software. You can overwrite the current image with the new one or keep the current image after a download.

You upload a switch image file to a server for backup purposes. You can use this uploaded image for future downloads to the switch or another switch of the same type.

Note Instead of using the **copy** privileged EXEC command or the **archive tar** privileged EXEC command, we recommend using the **archive download-sw** and **archive upload-sw** privileged EXEC commands to download and upload software image files.

Preparing to Download or Upload an Image File By Using FTP

You can copy images files to or from an FTP server.

The FTP protocol requires a client to send a remote username and password on each FTP request to a server. When you copy an image file from the switch to a server by using FTP, the Cisco IOS software sends the first valid username in this list:

- The username specified in the **archive download-sw** or **archive upload-sw** privileged EXEC command if a username is specified.
- The username set by the **ip ftp username** username global configuration command if the command is configured.
- Anonymous.

The switch sends the first valid password in this list:

- The password specified in the **archive download-sw** or **archive upload-sw** privileged EXEC command if a password is specified.
- The password set by the **ip ftp password** password global configuration command if the command is configured.
- The switch forms a password named username@switchname.domain. The variable username is the username associated with the current session, switchname is the configured hostname, and domain is the domain of the switch.

The username and password must be associated with an account on the FTP server. If you are writing to the server, the FTP server must be properly configured to accept the FTP write request from you.

Use the **ip ftp username** and **ip ftp password** commands to specify a username and password for all copies. Include the username in the **archive download-sw** or **archive upload-sw** privileged EXEC command if you want to specify a username only for that operation.

If the server has a directory structure, the image file is written to or copied from the directory associated with the username on the server. For example, if the image file resides in the home directory of a user on the server, specify that user's name as the remote username.

Before you begin downloading or uploading an image file by using FTP, do these tasks:

- Ensure that the switch has a route to the FTP server. The switch and the FTP server must be in the same subnetwork if you do not have a router to route traffic between subnets. Check connectivity to the FTP server by using the **ping** command.
- If you are accessing the switch through the console or a Telnet session and you do not have a valid username, make sure that the current FTP username is the one that you want to use for the FTP download. You can enter the **show users** privileged EXEC command to view the valid username. If you do not want to use this username, create a new FTP username by using the **ip ftp username** username global configuration command. This new name will be used during all archive operations. The new username is stored in NVRAM. If you are accessing the switch through a Telnet session and you have a valid username, this username is used, and you do not need to set the FTP username. Include the username in the **archive download-sw** or **archive upload-sw** privileged EXEC command if you want to specify a username for that operation only.
- When you upload an image file to the FTP server, it must be properly configured to accept the write request from the user on the switch.

For more information, see the documentation for your FTP server.

Downloading an Image File By Using FTP

You can download a new image file and overwrite the current image or keep the current image.

Beginning in privileged EXEC mode, follow Steps 1 through 7 to download a new image from an FTP server and overwrite the existing image. To keep the current image, go to Step 7.

SUMMARY STEPS

1. Verify that the FTP server is properly configured.
2. Log into the switch through the console port or a Telnet session.
3. **configure terminal**
4. **ip ftp username** *username*
5. **ip ftp password***password*
6. **end**
7. **archive download-sw /overwrite/reload**
   ftp: [[//*username* [**:***password*] **@***location*] /*directory*] /*image-name***.tar**
8. **archive download-sw /leave-old-sw/reload**
   ftp: [[//*username* [**:***password*] **@***location*] /*directory*] /*image-name***.tar**

DETAILED STEPS

Step 1 Verify that the FTP server is properly configured.

—

Step 2 Log into the switch through the console port or a Telnet session.

—

Step 3 **configure terminal**

Enter global configuration mode.

This step is required only if you override the default remote username or password (see Steps 4, 5, and 6).

Step 4 **ip ftp username** *username*

(Optional) Change the default remote username.

Step 5 **ip ftp password***password*

(Optional) Change the default password.

Step 6 **end**

Return to privileged EXEC mode.

Step 7 **archive download-sw /overwrite/reload ftp:**[[//*username*[**:***password*]**@***location*]/*directory*]/*image-name***.tar**

Download the image file from the FTP server to the switch, and overwrite the current image.

- The /**overwrite** option overwrites the software image in flash memory with the downloaded image.
- The /**reload** option reloads the system after downloading the image unless the configuration has been changed and not been saved.
- For //*username* [:*password*]specify the username and password; these must be associated with an account on the FTP server.
- For **@** *location*, specify the IP address of the FTP server.
- For *directory*/*image-name***.tar**, specify the directory (optional) and the image to download. Directory and image names are case sensitive.

Step 8 **archive download-sw /leave-old-sw/reload ftp:**[[//*username*[**:***password*]**@***location*]/*directory*]/*image-name***.tar**

Download the image file from the FTP server to the switch, and keep the current image.

- The /**leave-old-sw** option keeps the old software version after a download.
- The /**reload** option reloads the system after downloading the image unless the configuration has been changed and not been saved.
- For //*username* [:*password*]specify the username and password; these must be associated with an account on the FTP server.
- For **@** *location*, specify the IP address of the FTP server.
- For *directory*/*image-name***.tar**, specify the directory (optional) and the image to download. Directory and image names are case sensitive.

The download algorithm verifies that the image is appropriate for the switch model and that enough DRAM is present, or it cancels the process and reports an error. If you specify the /**overwrite** option, the download algorithm removes the existing image on the flash device, whether or not it is the same as the new one, downloads the new image, and then reloads the software.

Note If the flash device has sufficient space to hold two images and you want to overwrite one of these images with the same version, you must specify the /**overwrite** option.

If you specify the /**leave-old-sw**, the existing files are not removed. If there is not enough space to install the new image and keep the running image, the download process stops, and an error message is displayed.

The algorithm installs the downloaded image onto the system board flash device (flash:). The image is placed into a new directory named with the software version string, and the BOOT environment variable is updated to point to the newly installed image.

If you kept the old image during the download process (you specified the /**leave-old-sw** keyword), you can remove it by entering the **delete**/**force**/**recursive** *filesystem :/ file-url* privileged EXEC command. For *filesystem*, use **flash:** for the system board flash device. For *file-url*, enter the directory name of the old software image. All the files in the directory and the directory are removed.

Note For the download and upload algorithms to operate properly, do not rename image names.

Uploading an Image File By Using FTP

You can upload an image from the switch to an FTP server. You can later download this image to the same switch or to another switch of the same type.

Use the upload feature only if the web management pages associated with the embedded device manager have been installed with the existing image.

Beginning in privileged EXEC mode, follow these steps to upload an image to an FTP server:

SUMMARY STEPS

1. **configure terminal**
2. **ip ftp username***username*
3. **ip ftp password***password*
4. **end**
5. **archive upload-sw ftp:** [[/ / [*username* [**:** *password*] **@**] *location*] / *directory*] / *image-name***.tar**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal**	Enter global configuration mode. This step is required only if you override the default remote username or password (see Steps 2, 3,and 4.)
Step 2	**ip ftp username***username*	Optional) Change the default remote username.
Step 3	**ip ftp password***password*	(Optional) Change the default password.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**archive upload-sw ftp:** [[/ / [*username* [**:** *password*] **@**] *location*] / *directory*] / *image-name***.tar**	Upload the currently running switch image to the FTP server. • For //*username***:***password*, specify the username and password. These must be associated with an account on the FTP server.

	Command or Action	Purpose
		• For **@***location*, specify the IP address of the FTP server. • For /*directory*/*image-name***.tar**, specify the directory (optional) and the name of the software image to be uploaded. Directory and image names are case sensitive. The *image-name* **.tar** is the name of the software image to be stored on the server. The **archive upload-sw** command builds an image file on the server by uploading these files in order: info, the Cisco IOS image, and the web management files. After these files are uploaded, the upload algorithm creates the tar file format. **Note** For the download and upload algorithms to operate properly, do not rename image names.

Copying Image Files Using RCP

You can download a switch image from an RCP server or upload the image from the switch to an RCP server.

You download a switch image file from a server to upgrade the switch software. You can overwrite the current image with the new one or keep the current image after a download. You upload a switch image file to a server for backup purposes. You can use this uploaded image for future downloads to the same switch or another of the same type.

Note Instead of using the **copy** privileged EXEC command or the **archive tar** privileged EXEC command, we recommend using the **archive download-sw** and **archive upload-sw** privileged EXEC commands to download and upload software image files.

Preparing to Download or Upload an Image File Using RCP

RCP provides another method of downloading and uploading image files between remote hosts and the switch. Unlike TFTP, which uses User Datagram Protocol (UDP), a connectionless protocol, RCP uses TCP, which is connection-oriented.

To use RCP to copy files, the server from or to which you will be copying files must support RCP. The RCP copy commands rely on the rsh server (or daemon) on the remote system. To copy files by using RCP, you do not need to create a server for file distribution as you do with TFTP. You only need to have access to a server that supports the remote shell (rsh). (Most UNIX systems support rsh.) Because you are copying a file from one place to another, you must have read permission on the source file and write permission on the destination file. If the destination file does not exist, RCP creates it for you.

RCP requires a client to send a remote username on each RCP request to a server. When you copy an image from the switch to a server by using RCP, the Cisco IOS software sends the first valid username in this list:

- The username specified in the **archive download-sw** or **archive upload-sw** privileged EXEC command if a username is specified.

- The username set by the **ip rcmd remote-username***username* global configuration command if the command is entered.
- The remote username associated with the current TTY (terminal) process. For example, if the user is connected to the router through Telnet and was authenticated through the **username** command, the switch software sends the Telnet username as the remote username.
- The switch hostname.

For the RCP copy request to execute successfully, an account must be defined on the network server for the remote username. If the server has a directory structure, the image file is written to or copied from the directory associated with the remote username on the server. For example, if the image file resides in the home directory of a user on the server, specify that user's name as the remote username.

Before you begin downloading or uploading an image file by using RCP, do these tasks:

- Ensure that the workstation acting as the RCP server supports the remote shell (rsh).
- Ensure that the switch has a route to the RCP server. The switch and the server must be in the same subnetwork if you do not have a router to route traffic between subnets. Check connectivity to the RCP server by using the **ping** command.
- If you are accessing the switch through the console or a Telnet session and you do not have a valid username, make sure that the current RCP username is the one that you want to use for the RCP download. You can enter the **show users** privileged EXEC command to view the valid username. If you do not want to use this username, create a new RCP username by using the **ip rcmd remote-username***username* global configuration command to be used during all archive operations. The new username is stored in NVRAM. If you are accessing the switch through a Telnet session and you have a valid username, this username is used, and there is no need to set the RCP username. Include the username in the **archive download-sw** or **archive upload-sw** privileged EXEC command if you want to specify a username only for that operation.
- When you upload an image to the RCP to the server, it must be properly configured to accept the RCP write request from the user on the switch. For UNIX systems, you must add an entry to the .rhosts file for the remote user on the RCP server.

For example, suppose the switch contains these configuration lines:

```
hostname Switch1
ip rcmd remote-username User0
```

If the switch IP address translates to *Switch1.company.com*, the .rhosts file for User0 on the RCP server should contain this line:

```
Switch1.company.com Switch1
```

For more information, see the documentation for your RCP server.

Downloading an Image File using RCP

You can download a new image file and replace or keep the current image.

Beginning in privileged EXEC mode, follow Steps 1 through 6 to download a new image from an RCP server and overwrite the existing image. To keep the current image, go to Step 6.

SUMMARY STEPS

1. Verify that the RCP server is properly configured.
2. Log into the switch through the console port or a Telnet session.

3. **configure terminal**
4. **ip rcmd remote-username** *username*
5. **end**
6. **archive download-sw /overwrite/reload rcp:**[[[//*username@*]/*location*]/*directory*]/*image-name***.tar**
7. **archive download-sw /leave-old-sw/reload rcp:**[[[//[*username@*]*location*]/*directory*]/*image-name***.tar**

DETAILED STEPS

Step 1 Verify that the RCP server is properly configured.

—

Step 2 Log into the switch through the console port or a Telnet session.

—

Step 3 **configure terminal**

Enter global configuration mode.

This step is required only if you override the default remote username or password (see Steps 4, 5, and 6).

Step 4 **ip rcmd remote-username** *username*

(Optional) Specify the remote username.

Step 5 **end**

Return to privileged EXEC mode.

Step 6 **archive download-sw /overwrite/reload rcp:**[[[//*username@*]/*location*]/*directory*]/*image-name***.tar**

Download the image file from the RCP server to the switch, and overwrite the current image.

- The /**overwrite** option overwrites the software image in flash memory with the downloaded image.
- The /**reload** option reloads the system after downloading the image unless the configuration has been changed and not been saved.
- For //*username* specify the username. For the RCP copy request to execute successfully, an account must be defined on the network server for the remote username.
- For **@** *location*, specify the IP address of theRCP server.
- For /*directory*/*image-name***.tar**, specify the directory (optional) and the image to download. Directory and image names are case sensitive.

Step 7 **archive download-sw /leave-old-sw/reload rcp:**[[[//[*username@*]*location*]/*directory*]/*image-name***.tar**

Download the image file from the FTP server to the switch, and keep the current image.

- The /**leave-old-sw** option keeps the old software version after a download.
- The /**reload** option reloads the system after downloading the image unless the configuration has been changed and not been saved.
- For //*username*specify the username. For the RCP copy request to execute, an account must be defined on the network server for the remote username.
- For **@** *location*, specify the IP address of the RCP server.

- For /*directory*]/*image-name***.tar**, specify the directory (optional) and the image to download. Directory and image names are case sensitive.

The download algorithm verifies that the image is appropriate for the switch model and that enough DRAM is present, or it cancels the process and reports an error. If you specify the /**overwrite** option, the download algorithm removes the existing image on the flash device, whether or not it is the same as the new one, downloads the new image, and then reloads the software.

Note If the flash device has sufficient space to hold two images and you want to overwrite one of these images with the same version, you must specify the /**overwrite** option.

If you specify the /**leave-old-sw**, the existing files are not removed. If there is not enough space to install the new image and keep the running image, the download process stops, and an error message is displayed.

The algorithm installs the downloaded image onto the system board flash device (flash:). The image is placed into a new directory named with the software version string, and the BOOT environment variable is updated to point to the newly installed image.

If you kept the old image during the download process (you specified the /**leave-old-sw** keyword), you can remove it by entering the **delete**/**force**/**recursive** *filesystem :/ file-url* privileged EXEC command. For *filesystem*, use **flash:** for the system board flash device. For *file-url*, enter the directory name of the old software image. All the files in the directory and the directory are removed.

Note For the download and upload algorithms to operate properly, do not rename image names.

Uploading an Image File using RCP

You can upload an image from the switch to an RCP server. You can later download this image to the same switch or to another switch of the same type.

The upload feature should be used only if the web management pages associated with the embedded device manager have been installed with the existing image.

Beginning in privileged EXEC mode, follow these steps to upload an image to an RCP server:

SUMMARY STEPS

1. **configure terminal**
2. **ip rcmd remote-username***username*
3. **end**
4. **archive upload-sw rcp:** [[[/ / [*username@*] *location*] / *directory*] / *image-name***.tar**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal**	Enter global configuration mode. This step is required only if you override the default remote username or password (see Steps 2 and 3.)
Step 2	**ip rcmd remote-username***username*	Optional) Specify the remote username.

	Command or Action	Purpose
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**archive upload-sw** **rcp:** [[[// [*username***@**] *location*] / *directory*] / *image-name***.tar**	Upload the currently running switch image to the RCP server. • For //*username*, specify the username; for the RCP copy request to execute, an account must be defined on the network server for the remote username. • For **@***location*, specify the IP address of the RCP server. • For /*directory*/*image-name***.tar**, specify the directory (optional) and the name of the software image to be uploaded. Directory and image names are case sensitive. • The *image-name***.tar** is the name of software image to be stored on the server. The **archive upload-sw** command builds an image file on the server by uploading these files in order: info, the Cisco IOS image, and the web management files. After these files are uploaded, the upload algorithm creates the tar file format. **Note** For the download and upload algorithms to operate properly, do not rename image names.

PART XI

VLAN

CHAPTER 59

Configuring VTP

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for VTP

Before you create VLANs, you must decide whether to use the VLAN Trunking Protocol (VTP) in your network. Using VTP, you can make configuration changes centrally on one or more switches and have those changes automatically communicated to all the other switches in the network. Without VTP, you cannot send information about VLANs to other switches.

VTP is designed to work in an environment where updates are made on a single switch and are sent through VTP to other switches in the domain. It does not work well in a situation where multiple updates to the VLAN database occur simultaneously on switches in the same domain, which would result in an inconsistency in the VLAN database.

The switch supports a total of 256 VLANs. If the switch is notified by VTP of a new VLAN and the switch is already using the maximum available hardware resources, it sends a message that there are not enough hardware resources available and shuts down the VLAN. The output of the **show vlan** user EXEC command shows the VLAN in a suspended state.

Because trunk ports send and receive VTP advertisements, you must ensure that at least one trunk port is configured on the switch and that this trunk port is connected to the trunk port of another switch. Otherwise, the switch cannot receive any VTP advertisements.

Restrictions for VTP

Note Before adding a VTP client switch to a VTP domain, always verify that its VTP configuration revision number is lower than the configuration revision number of the other switches in the VTP domain. Switches in a VTP domain always use the VLAN configuration of the switch with the highest VTP configuration revision number. If you add a switch that has a revision number higher than the revision number in the VTP domain, it can erase all VLAN information from the VTP server and VTP domain.

The following are restrictions for configuring VTPs:

- It is normal to have approximately 10 access interfaces or 5 trunk interfaces to flap simultaneously with negligible impact to CPU utilization. If there are more interfaces that flap simultaneously, then CPU usage may be excessively high.

Information About VTP

VTP

VTP is a Layer 2 messaging protocol that maintains VLAN configuration consistency by managing the addition, deletion, and renaming of VLANs on a network-wide basis. VTP minimizes misconfigurations and configuration inconsistencies that can cause several problems, such as duplicate VLAN names, incorrect VLAN-type specifications, and security violations.

VTP version 1 and version 2 support only normal-range VLANs (VLAN IDs 1 to 1005). VTP version 3 supports the entire VLAN range (VLANs 1 to 4094). Extended range VLANs (VLANs 1006 to 4094) are supported only in VTP version 3.

You cannot convert from VTP version 3 to VTP version 2 if extended VLANs are configured in the domain.

VTP Domain

A VTP domain (also called a VLAN management domain) consists of one switch or several interconnected switches under the same administrative responsibility sharing the same VTP domain name. A switch can be in only one VTP domain. You make global VLAN configuration changes for the domain.

By default, the switch is in the VTP no-management-domain state until it receives an advertisement for a domain over a trunk link (a link that carries the traffic of multiple VLANs) or until you configure a domain name. Until the management domain name is specified or learned, you cannot create or modify VLANs on a VTP server, and VLAN information is not propagated over the network.

If the switch receives a VTP advertisement over a trunk link, it inherits the management domain name and the VTP configuration revision number. The switch then ignores advertisements with a different domain name or an earlier configuration revision number.

When you make a change to the VLAN configuration on a VTP server, the change is propagated to all switches in the VTP domain. VTP advertisements are sent over all IEEE trunk connections, including IEEE 802.1Q. VTP dynamically maps VLANs with unique names and internal index associates across multiple LAN types. Mapping eliminates excessive device administration required from network administrators.

If you configure a switch for VTP transparent mode, you can create and modify VLANs, but the changes are not sent to other switches in the domain, and they affect only the individual switch. However, configuration changes made when the switch is in this mode are saved in the switch running configuration and can be saved to the switch startup configuration file.

VTP Modes

Table 125: VTP Modes

VTP Mode	Description
VTP server	In VTP server mode, you can create, modify, and delete VLANs, and specify other configuration parameters (such as the VTP version) for the entire VTP domain. VTP servers advertise their VLAN configurations to other switches in the same VTP domain and synchronize their VLAN configurations with other switches based on advertisements received over trunk links. VTP server is the default mode. In VTP server mode, VLAN configurations are saved in NVRAM. If the switch detects a failure while writing a configuration to NVRAM, VTP mode automatically changes from server mode to client mode. If this happens, the switch cannot be returned to VTP server mode until the NVRAM is functioning.
VTP client	A VTP client functions like a VTP server and transmits and receives VTP updates on its trunks, but you cannot create, change, or delete VLANs on a VTP client. VLANs are configured on another switch in the domain that is in server mode. In VTP versions 1 and 2 in VTP client mode, VLAN configurations are not saved in NVRAM. In VTP version 3, VLAN configurations are saved in NVRAM in client mode.

VTP Mode	Description
VTP transparent	VTP transparent switches do not participate in VTP. A VTP transparent switch does not advertise its VLAN configuration and does not synchronize its VLAN configuration based on received advertisements. However, in VTP version 2 or version 3, transparent switches do forward VTP advertisements that they receive from other switches through their trunk interfaces. You can create, modify, and delete VLANs on a switch in VTP transparent mode. When the switch is in VTP transparent mode, the VTP and VLAN configurations are saved in NVRAM, but they are not advertised to other switches. In this mode, VTP mode and domain name are saved in the switch running configuration, and you can save this information in the switch startup configuration file by using the **copy running-config startup-config** privileged EXEC command.
VTP off	A switch in VTP off mode functions in the same manner as a VTP transparent switch, except that it does not forward VTP advertisements on trunks.

VTP Advertisements

Each switch in the VTP domain sends periodic global configuration advertisements from each trunk port to a reserved multicast address. Neighboring switches receive these advertisements and update their VTP and VLAN configurations as necessary.

VTP advertisements distribute this global domain information:

- VTP domain name
- VTP configuration revision number
- Update identity and update timestamp
- MD5 digest VLAN configuration, including maximum transmission unit (MTU) size for each VLAN
- Frame format

VTP advertisements distribute this VLAN information for each configured VLAN:

- VLAN IDs (including IEEE 802.1Q)
- VLAN name
- VLAN type
- VLAN state
- Additional VLAN configuration information specific to the VLAN type

In VTP version 3, VTP advertisements also include the primary server ID, an instance number, and a start index.

VTP Version 2

If you use VTP in your network, you must decide which version of VTP to use. By default, VTP operates in version 1.

VTP version 2 supports these features that are not supported in version 1:

- Token Ring support—VTP version 2 supports Token Ring Bridge Relay Function (TrBRF) and Token Ring Concentrator Relay Function (TrCRF) VLANs.
- Unrecognized Type-Length-Value (TLV) support—A VTP server or client propagates configuration changes to its other trunks, even for TLVs it is not able to parse. The unrecognized TLV is saved in NVRAM when the switch is operating in VTP server mode.
- Version-Dependent Transparent Mode—In VTP version 1, a VTP transparent switch inspects VTP messages for the domain name and version and forwards a message only if the version and domain name match. Although VTP version 2 supports only one domain, a VTP version 2 transparent switch forwards a message only when the domain name matches.
- Consistency Checks—In VTP version 2, VLAN consistency checks (such as VLAN names and values) are performed only when you enter new information through the CLI or SNMP. Consistency checks are not performed when new information is obtained from a VTP message or when information is read from NVRAM. If the MD5 digest on a received VTP message is correct, its information is accepted.

VTP Version 3

VTP version 3 supports these features that are not supported in version 1 or version 2:

- Enhanced authentication—You can configure the authentication as **hidden** or **secret**. When **hidden**, the secret key from the password string is saved in the VLAN database file, but it does not appear in plain text in the configuration. Instead, the key associated with the password is saved in hexadecimal format in the running configuration. You must reenter the password if you enter a takeover command in the domain. When you enter the **secret** keyword, you can directly configure the password secret key.
- Support for extended range VLAN (VLANs 1006 to 4094) database propagation—VTP versions 1 and 2 propagate only VLANs 1 to 1005.

  Note VTP pruning still applies only to VLANs 1 to 1005, and VLANs 1002 to 1005 are still reserved and cannot be modified.

- Support for any database in a domain—In addition to propagating VTP information, version 3 can propagate Multiple Spanning Tree (MST) protocol database information. A separate instance of the VTP protocol runs for each application that uses VTP.
- VTP primary server and VTP secondary servers—A VTP primary server updates the database information and sends updates that are honored by all devices in the system. A VTP secondary server can only back up the updated VTP configurations received from the primary server to its NVRAM.

By default, all devices come up as secondary servers. You can enter the **vtp primary** privileged EXEC command to specify a primary server. Primary server status is only needed for database updates when the administrator issues a takeover message in the domain. You can have a working VTP domain without any primary servers. Primary server status is lost if the device reloads or domain parameters change, even when a password is configured on the switch.

VTP Pruning

VTP pruning increases network available bandwidth by restricting flooded traffic to those trunk links that the traffic must use to reach the destination devices. Without VTP pruning, a switch floods broadcast, multicast, and unknown unicast traffic across all trunk links within a VTP domain even though receiving switches might discard them. VTP pruning is disabled by default.

VTP pruning blocks unneeded flooded traffic to VLANs on trunk ports that are included in the pruning-eligible list. Only VLANs included in the pruning-eligible list can be pruned. By default, VLANs 2 through 1001 are pruning eligible switch trunk ports. If the VLANs are configured as pruning-ineligible, the flooding continues. VTP pruning is supported in all VTP versions.

With VTP versions 1 and 2, when you enable pruning on the VTP server, it is enabled for the entire VTP domain. In VTP version 3, you must manually enable pruning on each switch in the domain. Making VLANs pruning-eligible or pruning-ineligible affects pruning eligibility for those VLANs on that trunk only (not on all switches in the VTP domain).

VTP pruning takes effect several seconds after you enable it. VTP pruning does not prune traffic from VLANs that are pruning-ineligible. VLAN 1 and VLANs 1002 to 1005 are always pruning-ineligible; traffic from these VLANs cannot be pruned. Extended-range VLANs (VLAN IDs higher than 1005) are also pruning-ineligible.

VTP Configuration Guidelines

VTP Configuration Requirements

When you configure VTP, you must configure a trunk port so that the switch can send and receive VTP advertisements to and from other switches in the domain.

VTP Settings

The VTP information is saved in the VTP VLAN database. When VTP mode is transparent, the VTP domain name and mode are also saved in the switch running configuration file, and you can save it in the switch startup configuration file by entering the **copy running-config startup-config** privileged EXEC command. You must use this command if you want to save VTP mode as transparent, even if the switch resets.

When you save VTP information in the switch startup configuration file and reboot the switch, the switch configuration is selected as follows:

- If the VTP mode is transparent in the startup configuration and the VLAN database and the VTP domain name from the VLAN database matches that in the startup configuration file, the VLAN database is ignored (cleared), and the VTP and VLAN configurations in the startup configuration file are used. The VLAN database revision number remains unchanged in the VLAN database.

- If the VTP mode or domain name in the startup configuration do not match the VLAN database, the domain name and VTP mode and configuration for VLAN IDs 1 to 1005 use the VLAN database information.

Domain Names for Configuring VTP

When configuring VTP for the first time, you must always assign a domain name. You must configure all switches in the VTP domain with the same domain name. Switches in VTP transparent mode do not exchange VTP messages with other switches, and you do not need to configure a VTP domain name for them.

Note If the NVRAM and DRAM storage is sufficient, all switches in a VTP domain should be in VTP server mode.

Caution Do not configure a VTP domain if all switches are operating in VTP client mode. If you configure the domain, it is impossible to make changes to the VLAN configuration of that domain. Make sure that you configure at least one switch in the VTP domain for VTP server mode.

Passwords for the VTP Domain

You can configure a password for the VTP domain, but it is not required. If you do configure a domain password, all domain switches must share the same password and you must configure the password on each switch in the management domain. Switches without a password or with the wrong password reject VTP advertisements.

If you configure a VTP password for a domain, a switch that is booted without a VTP configuration does not accept VTP advertisements until you configure it with the correct password. After the configuration, the switch accepts the next VTP advertisement that uses the same password and domain name in the advertisement.

If you are adding a new switch to an existing network with VTP capability, the new switch learns the domain name only after the applicable password has been configured on it.

Caution When you configure a VTP domain password, the management domain does not function properly if you do not assign a management domain password to each switch in the domain.

VTP Version

Follow these guidelines when deciding which VTP version to implement:

- All switches in a VTP domain must have the same domain name, but they do not need to run the same VTP version.
- A VTP version 2-capable switch can operate in the same VTP domain as a switch running VTP version 1 if version 2 is disabled on the version 2-capable switch (version 2 is disabled by default).
- If a switch running VTP version 1, but capable of running VTP version 2, receives VTP version 3 advertisements, it automatically moves to VTP version 2.

- If a switch running VTP version 3 is connected to a switch running VTP version 1, the VTP version 1 switch moves to VTP version 2, and the VTP version 3 switch sends scaled-down versions of the VTP packets so that the VTP version 2 switch can update its database.
- A switch running VTP version 3 cannot move to version 1 or 2 if it has extended VLANs.
- Do not enable VTP version 2 on a switch unless all of the switches in the same VTP domain are version-2-capable. When you enable version 2 on a switch, all of the version-2-capable switches in the domain enable version 2. If there is a version 1-only switch, it does not exchange VTP information with switches that have version 2 enabled.
- Cisco recommends placing VTP version 1 and 2 switches at the edge of the network because they do not forward VTP version 3 advertisements.
- If there are TrBRF and TrCRF Token Ring networks in your environment, you must enable VTP version 2 or version 3 for Token Ring VLAN switching to function properly. To run Token Ring and Token Ring-Net, disable VTP version 2.
- VTP version 1 and version 2 do not propagate configuration information for extended range VLANs (VLANs 1006 to 4094). You must configure these VLANs manually on each device. VTP version 3 supports extended-range VLANs and support for extended range VLAN database propagation.
- When a VTP version 3 device trunk port receives messages from a VTP version 2 device, it sends a scaled-down version of the VLAN database on that particular trunk in VTP version 2 format. A VTP version 3 device does not send VTP version 2-formatted packets on a trunk unless it first receives VTP version 2 packets on that trunk port.
- When a VTP version 3 device detects a VTP version 2 device on a trunk port, it continues to send VTP version 3 packets, in addition to VTP version 2 packets, to allow both kinds of neighbors to coexist on the same trunk.
- A VTP version 3 device does not accept configuration information from a VTP version 2 or version 1 device.
- Two VTP version 3 regions can only communicate in transparent mode over a VTP version 1 or version 2 region.
- Devices that are only VTP version 1 capable cannot interoperate with VTP version 3 devices.
- VTP version 1 and version 2 do not propagate configuration information for extended range VLANs (VLANs 1006 to 4094). You must manually configure these VLANs on each device.

Default VTP Configuration

The following table shows the default VTP configuration.

Table 126: Default VTP Configuration

Feature	Default Setting
VTP domain name	Null
VTP mode (VTP version 1 and version 2)	Server
VTP mode (VTP version 3)	The mode is the same as the mode in VTP version 1 or 2 before conversion to version 3.

Feature	Default Setting
VTP version	Version 1
MST database mode	Transparent
VTP version 3 server type	Secondary
VTP password	None
VTP pruning	Disabled

How to Configure VTP

Configuring VTP Mode

You can configure VTP mode as one of these:

- VTP server mode—In VTP server mode, you can change the VLAN configuration and have it propagated throughout the network.
- VTP client mode—In VTP client mode, you cannot change its VLAN configuration. The client switch receives VTP updates from a VTP server in the VTP domain and then modifies its configuration accordingly.
- VTP transparent mode—In VTP transparent mode, VTP is disabled on the switch. The switch does not send VTP updates and does not act on VTP updates received from other switch. However, a VTP transparent switch running VTP version 2 does forward received VTP advertisements on its trunk links.
- VTP off mode—VTP off mode is the same as VTP transparent mode except that VTP advertisements are not forwarded.

When you configure a domain name, it cannot be removed; you can only reassign a switch to a different domain.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vtp domain** *domain-name*
4. **vtp mode** {**client** | **server** | **transparent** | **off**} {**vlan** | **mst** | **unknown**}
5. **vtp password** *password*
6. **end**
7. **show vtp status**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. - Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**vtp domain** *domain-name* **Example:** `Switch(config)# vtp domain eng_group`	Configures the VTP administrative-domain name. The name can be 1 to 32 characters. All switches operating in VTP server or client mode under the same administrative responsibility must be configured with the same domain name. This command is optional for modes other than server mode. VTP server mode requires a domain name. If the switch has a trunk connection to a VTP domain, the switch learns the domain name from the VTP server in the domain. You should configure the VTP domain before configuring other VTP parameters.

Step 4	**vtp mode** {**client** | **server** | **transparent** | **off**} {**vlan** | **mst** | **unknown**}
	Example:
	`Switch(config)# vtp mode server`
		Configures the switch for VTP mode (client, server, transparent, or off).
		- **vlan**—The VLAN database is the default if none are configured.
		- **mst**—The multiple spanning tree (MST) database.
		- **unknown**—An unknown database type.

Step 5	**vtp password** *password* **Example:** `Switch(config)# vtp password mypassword`	(Optional) Sets the password for the VTP domain. The password can be 8 to 64 characters. If you configure a VTP password, the VTP domain does not function properly if you do not assign the same password to each switch in the domain.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 7	**show vtp status** **Example:** `Switch# show vtp status`	Verifies your entries in the *VTP Operating Mode* and the *VTP Domain Name* fields of the display.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves the configuration in the startup configuration file. Only VTP mode and domain name are saved in the switch running configuration and can be copied to the startup configuration file.

Configuring a VTP Version 3 Password

You can configure a VTP version 3 password on the switch.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vtp version 3**
4. **vtp password** *password* [**hidden** | **secret**]
5. **end**
6. **show vtp password**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**vtp version 3** **Example:** `Switch(config)# vtp version 3`	Enables VTP version 3 on the device. The default is VTP version 1.

	Command or Action	Purpose
Step 4	**vtp password** *password* [**hidden** | **secret**] **Example:** `Switch(config)# vtp password mypassword hidden`	(Optional) Sets the password for the VTP domain. The password can be 8 to 64 characters. • (Optional) **hidden**—Saves the secret key generated from the password string in the nvram:vlan.dat file. If you configure a takeover by configuring a VTP primary server, you are prompted to reenter the password. • (Optional) **secret**—Directly configures the password. The secret password must contain 32 hexadecimal characters.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show vtp password** **Example:** `Switch# show vtp password`	Verifies your entries. The output appears like this: VTP password: 89914640C8D90868B6A0D8103847A733
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring a VTP Version 3 Primary Server

When you configure a VTP server as a VTP primary server, the takeover operation starts.

SUMMARY STEPS

1. **vtp version 3**
2. **vtp primary** [**vlan** | **mst**] [**force**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**vtp version 3** **Example:** `Switch(config)# vtp version 3`	Enables VTP version 3 on the device. The default is VTP version 1.

	Command or Action	Purpose
Step 2	**vtp primary** [**vlan** | **mst**] [**force**] **Example:** `Switch# vtp primary vlan force`	Changes the operational state of a switch from a secondary server (the default) to a primary server and advertises the configuration to the domain. If the switch password is configured as **hidden**, you are prompted to reenter the password. • (Optional) **vlan**—Selects the VLAN database as the takeover feature. This is the default. • (Optional) **mst**—Selects the multiple spanning tree (MST) database as the takeover feature. • (Optional) **force**—Overwrites the configuration of any conflicting servers. If you do not enter **force**, you are prompted for confirmation before the takeover.

Enabling the VTP Version

VTP version 2 and version 3 are disabled by default.

- When you enable VTP version 2 on a switch , every VTP version 2-capable switch in the VTP domain enables version 2. To enable VTP version 3, you must manually configure it on each switch .
- With VTP versions 1 and 2, you can configure the version only on switches in VTP server or transparent mode. If a switch is running VTP version 3, you can change to version 2 when the switch is in client mode if no extended VLANs exist, and no hidden password was configured.

Caution VTP version 1 and VTP version 2 are not interoperable on switches in the same VTP domain. Do not enable VTP version 2 unless every switch in the VTP domain supports version 2.

- In TrCRF and TrBRF Token Ring environments, you must enable VTP version 2 or VTP version 3 for Token Ring VLAN switching to function properly. For Token Ring and Token Ring-Net media, disable VTP version 2.
-

Caution In VTP version 3, both the primary and secondary servers can exist on an instance in the domain.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vtp version** {**1** | **2** | **3**}
4. **end**
5. **show vtp status**

6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.

Step 3	**vtp version** {**1** | **2** | **3**}
	Example:
	`Switch(config)# vtp version 2`
		Enables the VTP version on the switch. The default is VTP version 1.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show vtp status** **Example:** `Switch# show vtp status`	Verifies that the configured VTP version is enabled.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Enabling VTP Pruning

Before you begin

VTP pruning is not designed to function in VTP transparent mode. If one or more switches in the network are in VTP transparent mode, you should do one of these actions:

- Turn off VTP pruning in the entire network.

- Turn off VTP pruning by making all VLANs on the trunk of the switch upstream to the VTP transparent switch pruning ineligible.

To configure VTP pruning on an interface, use the **switchport trunk pruning vlan** interface configuration command. VTP pruning operates when an interface is trunking. You can set VLAN pruning-eligibility, whether or not VTP pruning is enabled for the VTP domain, whether or not any given VLAN exists, and whether or not the interface is currently trunking.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vtp pruning**
4. **end**
5. **show vtp status**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**vtp pruning** **Example:** `Switch(config)# vtp pruning`	Enables pruning in the VTP administrative domain. By default, pruning is disabled. You need to enable pruning on only one switch in VTP server mode.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show vtp status** **Example:** `Switch# show vtp status`	Verifies your entries in the *VTP Pruning Mode* field of the display.

Configuring VTP on a Per-Port Basis

With VTP version 3, you can enable or disable VTP on a per-port basis. You can enable VTP only on ports that are in trunk mode. Incoming and outgoing VTP traffic are blocked, not forwarded.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **vtp**
5. **end**
6. **show running-config interface** *interface-id*
7. **show vtp status**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet0/1`	Identifies an interface, and enters interface configuration mode.
Step 4	**vtp** **Example:** `Switch(config-if)# vtp`	Enables VTP on the specified port.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 6	**show running-config interface** *interface-id* **Example:** `Switch# show running-config interface gigabitethernet 0/1`	Verifies the change to the port.
Step 7	**show vtp status** **Example:** `Switch# show vtp status`	Verifies the configuration.

Adding a VTP Client Switch to a VTP Domain

Follow these steps to verify and reset the VTP configuration revision number on a switch *before* adding it to a VTP domain.

Before you begin

Before adding a VTP client to a VTP domain, always verify that its VTP configuration revision number is *lower* than the configuration revision number of the other switches in the VTP domain. Switches in a VTP domain always use the VLAN configuration of the switch with the highest VTP configuration revision number. With VTP versions 1 and 2, adding a switch that has a revision number higher than the revision number in the VTP domain can erase all VLAN information from the VTP server and VTP domain. With VTP version 3, the VLAN information is not erased.

You can use the **vtp mode transparent** global configuration command to disable VTP on the switch and then to change its VLAN information without affecting the other switches in the VTP domain.

SUMMARY STEPS

1. **enable**
2. **show vtp status**
3. **configure terminal**
4. **vtp domain** *domain-name*
5. **end**
6. **show vtp status**
7. **configure terminal**
8. **vtp domain** *domain-name*
9. **end**
10. **show vtp status**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable**	Enables privileged EXEC mode.

	Command or Action	Purpose
	Example: `Switch> `**`enable`**	• Enter your password if prompted.
Step 2	**show vtp status** **Example:** `Switch# `**`show vtp status`**	Checks the VTP configuration revision number. If the number is 0, add the switch to the VTP domain. If the number is greater than 0, follow these substeps: • Write down the domain name. • Write down the configuration revision number. • Continue with the next steps to reset the switch configuration revision number.
Step 3	**configure terminal** **Example:** `Switch# `**`configure terminal`**	Enters global configuration mode.
Step 4	**vtp domain** *domain-name* **Example:** `Switch(config)# `**`vtp domain domain123`**	Changes the domain name from the original one displayed in Step 1 to a new name.

Step 5	**end**
	Example:
	`Switch(config)# `**`end`**
		Returns to privileged EXEC mode. The VLAN information on the switch is updated and the configuration revision number is reset to 0.

Step 6	**show vtp status** **Example:** `Switch# `**`show vtp status`**	Verifies that the configuration revision number has been reset to 0.
Step 7	**configure terminal** **Example:** `Switch# `**`configure terminal`**	Enters global configuration mode.
Step 8	**vtp domain** *domain-name* **Example:**	Enters the original domain name on the switch

	Command or Action	Purpose
	`Switch(config)# vtp domain domain012`	

Step 9	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode. The VLAN information on the switch is updated.

Step 10	**show vtp status** **Example:** `Switch# show vtp status`	(Optional) Verifies that the domain name is the same as in Step 1 and that the configuration revision number is 0.

Monitoring VTP

This section describes commands used to display and monitor the VTP configuration.

You monitor VTP by displaying VTP configuration information: the domain name, the current VTP revision, and the number of VLANs. You can also display statistics about the advertisements sent and received by the switch.

Table 127: VTP Monitoring Commands

Command	Purpose
show vtp counters	Displays counters about VTP messages that have been sent and received.
show vtp devices [**conflict**]	Displays information about all VTP version 3 devices in the domain. Conflicts are VTP version 3 devices with conflicting primary servers. The **show vtp devices** command does not display information when the switch is in transparent or off mode.
show vtp interface [*interface-id*]	Displays VTP status and configuration for all interfaces or the specified interface.
show vtp password	Displays the VTP password. The form of the password displayed depends on whether or not the **hidden** keyword was entered and if encryption is enabled on the switch.
show vtp status	Displays the VTP switch configuration information.

Configuration Examples for VTP

Example: Configuring a Switch as the Primary Server

This example shows how to configure a switch as the primary server for the VLAN database (the default) when a hidden or secret password was configured:

```
Switch# vtp primary vlan
VTP Feature Conf Revision Primary Server Device ID Device Description
------------ ---- -------- -------------- -------------- ----------------------
VLAN Yes 25 bcf1.f2e4.9700 0c75.bd07.4a00 P3A_NEW
VLAN Yes 547 0c75.bd07.4a00 40a6.e8db.9780 Switch_A
MST Yes 10 006c.bc4e.2500 40a6.e8db.9780 Switch_A
VLAN Yes 25 bcf1.f2e4.9700 e8b7.489c.cc00 Switch_B-11

Do you want to continue? [confirm]
Switch#
Jun 17 01:08:50.758 PST: %SW_VLAN-4-VTP_PRIMARY_SERVER_CHG: 006c.bc4e.2500 has become the
primary server for the VLAN VTP feature
```

Example: Configuring Switch as VTP Server

This example shows how to configure the switch as a VTP server with the domain name *eng_group* and the password *mypassword*:

```
Switch(config)# vtp domain eng_group
Setting VTP domain name to eng_group.

Switch(config)# vtp mode server
Setting device to VTP Server mode for VLANS.

Switch(config)# vtp password mypassword
Setting device VLAN database password to mypassword.
Switch(config)# end
```

Example: Enabling VTP on the Interface

To enable VTP on the interface, use the **vtp** interface configuration command. To disable VTP on the interface, use the **no vtp** interface configuration command.

```
Switch(config)# interface gigabitethernet0/1
Switch(config-if)# vtp
Switch(config-if)# end
```

Example: Creating the VTP Password

The follow is an example of creating the VTP password.

```
Switch(config)# vtp password mypassword hidden
Generating the secret associated to the password.
Switch(config)# end
Switch# show vtp password
VTP password: 89914640C8D90868B6A0D8103847A733
```

Where to Go Next

After configuring VTP, you can configure the following:

- VLANS
- VLAN Trunking
- VLAN Membership Policy Server (VMPS)
- Voice VLANs

Additional References

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for VTP

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 60

VLANs

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for VLANs

The following are prerequisites and considerations for configuring VLANs:

- Before you create VLANs, you must decide whether to use VLAN Trunking Protocol (VTP) to maintain global VLAN configuration for your network.
- The switch supports 256 VLANs in VTP client, server, and transparent modes.

Restrictions for VLANs

The following are restrictions for configuring VLANs:

- To avoid warning messages of high CPU utilization with a normal-range VLAN configuration, we recommend that you have no more than 256 VLANs. If a large number of access interfaces or trunk interfaces flap simultaneously, then CPU usage may be excessively high.

Information About VLANs

Logical Networks

A VLAN is a switched network that is logically segmented by function, project team, or application, without regard to the physical locations of the users. VLANs have the same attributes as physical LANs, but you can group end stations even if they are not physically located on the same LAN segment. Any switch port can belong to a VLAN, and unicast, broadcast, and multicast packets are forwarded and flooded only to end stations in the VLAN. Each VLAN is considered a logical network, and packets destined for stations that do not belong to the VLAN must be forwarded through a router or a switch supporting fallback bridging. Because a VLAN is considered a separate logical network, it contains its own bridge Management Information Base (MIB) information and can support its own implementation of spanning tree.

VLANs are often associated with IP subnetworks. For example, all the end stations in a particular IP subnet belong to the same VLAN. Interface VLAN membership on the switch is assigned manually on an interface-by-interface basis. When you assign switch interfaces to VLANs by using this method, it is known as interface-based, or static, VLAN membership.

Traffic between VLANs must be routed.

The switch can route traffic between VLANs by using switch virtual interfaces (SVIs). An SVI must be explicitly configured and assigned an IP address to route traffic between VLANs.

Supported VLANs

The switch supports VLANs in VTP client, server, and transparent modes. VLANs are identified by a number from 1 to 4094. VLAN IDs 1002 through 1005 are reserved for Token Ring and FDDI VLANs.

VTP version 1 and version 2 support only normal-range VLANs (VLAN IDs 1 to 1005). In these versions, the switch must be in VTP transparent mode when you create VLAN IDs from 1006 to 4094. Cisco IOS Release 12.2(52)SE and later support VTP version 3. VTP version 3 supports the entire VLAN range (VLANs 1 to 4094). Extended range VLANs (VLANs 1006 to 4094) are supported only in VTP version 3. You cannot convert from VTP version 3 to VTP version 2 if extended VLANs are configured in the domain.

Although the switch stack supports a total of 1,000 (normal range and extended range) VLANs, the number of configured features affects the use of the switch hardware.

The switch supports per-VLAN spanning-tree plus (PVST+) or rapid PVST+ with a maximum of 64 spanning-tree instances. One spanning-tree instance is allowed per VLAN. The switch supports only IEEE 802.1Q trunking methods for sending VLAN traffic over Ethernet ports.

VLAN Port Membership Modes

You configure a port to belong to a VLAN by assigning a membership mode that specifies the kind of traffic the port carries and the number of VLANs to which it can belong.

When a port belongs to a VLAN, the switch learns and manages the addresses associated with the port on a per-VLAN basis.

Table 128: Port Membership Modes and Characteristics

Membership Mode	VLAN Membership Characteristics	VTP Characteristics
Static-access	A static-access port can belong to one VLAN and is manually assigned to that VLAN.	VTP is not required. If you do not want VTP to globally propagate information, set the VTP mode to transparent. To participate in VTP, there must be at least one trunk port on the switch connected to a trunk port of a second switch.
Trunk (IEEE 802.1Q) : • IEEE 802.1Q—Industry-standard trunking encapsulation.	A trunk port is a member of all VLANs by default, including extended-range VLANs, but membership can be limited by configuring the allowed-VLAN list. You can also modify the pruning-eligible list to block flooded traffic to VLANs on trunk ports that are included in the list.	VTP is recommended but not required. VTP maintains VLAN configuration consistency by managing the addition, deletion, and renaming of VLANs on a network-wide basis. VTP exchanges VLAN configuration messages with other switches over trunk links.
Dynamic access	A dynamic-access port can belong to one VLAN (VLAN ID 1 to 4094) and is dynamically assigned by a VLAN Member Policy Server (VMPS). The VMPS can be a Catalyst 6500 series switch, for example, but never a Catalyst switch. The Catalyst switch is a VMPS client. You can have dynamic-access ports and trunk ports on the same switch, but you must connect the dynamic-access port to an end station or hub and not to another switch.	VTP is required. Configure the VMPS and the client with the same VTP domain name. To participate in VTP, at least one trunk port on the switch must be connected to a trunk port of a second switch .
Voice VLAN	A voice VLAN port is an access port attached to a Cisco IP Phone, configured to use one VLAN for voice traffic and another VLAN for data traffic from a device attached to the phone.	VTP is not required; it has no effect on a voice VLAN.

VLAN Configuration Files

Configurations for VLAN IDs 1 to 1005 are written to the vlan.dat file (VLAN database), and you can display them by entering the **show vlan** privileged EXEC command. The vlan.dat file is stored in flash memory. If the VTP mode is transparent, they are also saved in the switch running configuration file.

You use the interface configuration mode to define the port membership mode and to add and remove ports from VLANs. The results of these commands are written to the running-configuration file, and you can display the file by entering the **show running-config** privileged EXEC command.

When you save VLAN and VTP information (including extended-range VLAN configuration information) in the startup configuration file and reboot the switch, the switch configuration is selected as follows:

- If the VTP mode is transparent in the startup configuration, and the VLAN database and the VTP domain name from the VLAN database matches that in the startup configuration file, the VLAN database is ignored (cleared), and the VTP and VLAN configurations in the startup configuration file are used. The VLAN database revision number remains unchanged in the VLAN database.
- If the VTP mode or domain name in the startup configuration does not match the VLAN database, the domain name and VTP mode and configuration for the VLAN IDs 1 to 1005 use the VLAN database information.
- In VTP versions 1 and 2, if VTP mode is server, the domain name and VLAN configuration for VLAN IDs 1 to 1005 use the VLAN database information. VTP version 3 also supports VLANs 1006 to 4094.
- From image 15.0(02)SE6, on vtp transparent and off modes, vlans get created from startup-config even if they are not applied to the interface.

Note Ensure that you delete the vlan.dat file along with the configuration files before you reset the switch configuration using **write erase** command. This ensures that the switch reboots correctly on a reset.

Normal-Range VLAN Configuration Guidelines

Normal-range VLANs are VLANs with IDs from 1 to 1005.

Follow these guidelines when creating and modifying normal-range VLANs in your network:

- Normal-range VLANs are identified with a number between 1 and 1001. VLAN numbers 1002 through 1005 are reserved for Token Ring and FDDI VLANs.
- VLAN configurations for VLANs 1 to 1005 are always saved in the VLAN database. If the VTP mode is transparent, VTP and VLAN configurations are also saved in the switch running configuration file.
- If the switch is in VTP server or VTP transparent mode, you can add, modify or remove configurations for VLANs 2 to 1001 in the VLAN database. (VLAN IDs 1 and 1002 to 1005 are automatically created and cannot be removed.)
- Extended-range VLANs created in VTP transparent mode are not saved in the VLAN database and are not propagated. VTP version 3 supports extended range VLAN (VLANs 1006 to 4094) database propagation in VTP server mode.
- Before you can create a VLAN, the switch must be in VTP server mode or VTP transparent mode. If the switch is a VTP server, you must define a VTP domain or VTP will not function.
- The switch does not support Token Ring or FDDI media. The switch does not forward FDDI, FDDI-Net, TrCRF, or TrBRF traffic, but it does propagate the VLAN configuration through VTP.
- The switch supports 64 spanning tree instances. If a switch has more active VLANs than supported spanning-tree instances, spanning tree can be enabled on 64 VLANs and is disabled on the remaining VLANs.

  If you have already used all available spanning-tree instances on a switch, adding another VLAN anywhere in the VTP domain creates a VLAN on that switch that is not running spanning-tree. If you have the default allowed list on the trunk ports of that switch (which is to allow all VLANs), the new VLAN is carried on all trunk ports. Depending on the topology of the network, this could create a loop in the new VLAN that would not be broken, particularly if there are several adjacent switches that all have run out of spanning-tree instances. You can prevent this possibility by setting allowed lists on the trunk ports of switches that have used up their allocation of spanning-tree instances.

If the number of VLANs on the switch exceeds the number of supported spanning-tree instances, we recommend that you configure the IEEE 802.1s Multiple STP (MSTP) on your switch to map multiple VLANs to a single spanning-tree instance.

Related Topics

Creating or Modifying an Ethernet VLAN
Deleting a VLAN , on page 1174
Assigning Static-Access Ports to a VLAN
Monitoring VLANs
Example: Creating a VLAN Name, on page 1180

Extended-Range VLAN Configuration Guidelines

Extended-range VLANs are VLANs with IDs from 1006 to 4094.

VTP 3 only supports extended-range VLANs.

Follow these guidelines when creating extended-range VLANs:

- VLAN IDs in the extended range are not saved in the VLAN database and are not recognized by VTP unless the switch is running VTP version 3.
- You cannot include extended-range VLANs in the pruning eligible range.
- For VTP version 1 or 2, you can set the VTP mode to transparent in global configuration mode. You should save this configuration to the startup configuration so that the switch boots up in VTP transparent mode. Otherwise, you lose the extended-range VLAN configuration if the switch resets. If you create extended-range VLANs in VTP version 3, you cannot convert to VTP version 1 or 2.

Related Topics

Creating an Extended-Range VLAN
Creating an Extended-Range VLAN with an Internal VLAN ID
Monitoring VLANs
Creating an Extended-Range VLAN
Example: Creating an Extended-Range VLAN, on page 1181

Default VLAN Configurations

Default Ethernet VLAN Configuration

The following table displays the default configuration for Ethernet VLANs.

Note The switch supports Ethernet interfaces exclusively. Because FDDI and Token Ring VLANs are not locally supported, you only configure FDDI and Token Ring media-specific characteristics for VTP global advertisements to other switches.

Table 129: Ethernet VLAN Defaults and Range

Parameter	Default	Range
VLAN ID	1	1 to 4094. **Note** Extended-range VLANs (VLAN IDs 1006 to 4094) are only saved in the VLAN database in VTP version 3.
VLAN name	VLANxxxx, where xxxx represents four numeric digits (including leading zeros) equal to the VLAN ID number	No range
IEEE 802.10 SAID	100001 (100000 plus the VLAN ID)	1 to 4294967294
IEEE 802.10 SAID	1500	576-18190

Default VLAN Configuration

You can change only the MTU size and the remote SPAN configuration state on extended-range VLANs; all other characteristics must remain at the default state.

How to Configure VLANs

How to Configure Normal-Range VLANs

You can set these parameters when you create a new normal-range VLAN or modify an existing VLAN in the VLAN database:

- VLAN ID
- VLAN name
- VLAN type
  - Ethernet
  - Fiber Distributed Data Interface [FDDI]
  - FDDI network entity title [NET]

  - TrBRF or TrCRF
  - Token Ring
  - Token Ring-Net
- VLAN state (active or suspended)
- Security Association Identifier (SAID)
- Bridge identification number for TrBRF VLANs
- Ring number for FDDI and TrCRF VLANs
- Parent VLAN number for TrCRF VLANs
- Spanning Tree Protocol (STP) type for TrCRF VLANs
- VLAN number to use when translating from one VLAN type to another

You can cause inconsistency in the VLAN database if you attempt to manually delete the vlan.dat file. If you want to modify the VLAN configuration, follow the procedures in this section.

Creating or Modifying an Ethernet VLAN

Each Ethernet VLAN in the VLAN database has a unique, 4-digit ID that can be a number from 1 to 1001. VLAN IDs 1002 to 1005 are reserved for Token Ring and FDDI VLANs. To create a normal-range VLAN to be added to the VLAN database, assign a number and name to the VLAN.

Note With VTP version 1 and 2, if the switch is in VTP transparent mode, you can assign VLAN IDs greater than 1006, but they are not added to the VLAN database.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vlan** *vlan-id*
4. **name** *vlan-name*
5. **end**
6. **show vlan** {**name** *vlan-name* | **id** *vlan-id*}
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**vlan** *vlan-id* **Example:** `Switch(config)# vlan 20`	Enters a VLAN ID, and enters VLAN configuration mode. Enter a new VLAN ID to create a VLAN, or enter an existing VLAN ID to modify that VLAN. **Note** The available VLAN ID range for this command is 1 to 4094.
Step 4	**name** *vlan-name* **Example:** `Switch(config-vlan)# name test20`	(Optional) Enters a name for the VLAN. If no name is entered for the VLAN, the default is to append the *vlan-id* value with leading zeros to the word VLAN. For example, VLAN0004 is a default VLAN name for VLAN 4.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show vlan** {**name** *vlan-name* | **id** *vlan-id*}
	Example:
	`Switch# show vlan name test20 id 20`
		Verifies your entries.

Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Deleting a VLAN

When you delete a VLAN from a switch that is in VTP server mode, the VLAN is removed from the VLAN database for all switches in the VTP domain. When you delete a VLAN from a switch that is in VTP transparent mode, the VLAN is deleted only on that specific switch .

You cannot delete the default VLANs for the different media types: Ethernet VLAN 1 and FDDI or Token Ring VLANs 1002 to 1005.

Caution When you delete a VLAN, any ports assigned to that VLAN become inactive. They remain associated with the VLAN (and thus inactive) until you assign them to a new VLAN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no vlan** *vlan-id*
4. **end**
5. **show vlan brief**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**no vlan** *vlan-id* **Example:** `Switch(config)# no vlan 4`	Removes the VLAN by entering the VLAN ID.

Step 4	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 5	**show vlan brief** **Example:** `Switch# show vlan brief`	Verifies the VLAN removal.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Related Topics

Supported VLANs
Normal-Range VLAN Configuration Guidelines, on page 1170
Monitoring VLANs

Assigning Static-Access Ports to a VLAN

You can assign a static-access port to a VLAN without having VTP globally propagate VLAN configuration information by disabling VTP (VTP transparent mode).

If you assign an interface to a VLAN that does not exist, the new VLAN is created.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-id*
3. **switchport mode access**
4. **switchport access vlan** *vlan-id*
5. **end**
6. **show running-config interface** *interface-id*
7. **show interfaces** *interface-id* **switchport**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Enters the interface to be added to the VLAN.
Step 3	**switchport mode access** **Example:** `Switch(config-if)# switchport mode access`	Defines the VLAN membership mode for the port (Layer 2 access port).
Step 4	**switchport access vlan** *vlan-id* **Example:** `Switch(config-if)# switchport access vlan 2`	Assigns the port to a VLAN. Valid VLAN IDs are 1 to 4094.

	Command or Action	Purpose

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show running-config interface** *interface-id* **Example:** `Switch# show running-config interface gigabitethernet 0/1`	Verifies the VLAN membership mode of the interface.
Step 7	**show interfaces** *interface-id* **switchport** **Example:** `Switch# show interfaces gigabitethernet 0/1 switchport`	Verifies your entries in the *Administrative Mode* and the *Access Mode VLAN* fields of the display.

Related Topics

Example: Configuring a Port as Access Port, on page 1180

How to Configure Extended-Range VLANs

With VTP version 1 and version 2, when the switch is in VTP transparent mode (VTP disabled), you can create extended-range VLANs (in the range 1006 to 4094). VTP version supports extended-range VLANs in server or transparent move. Extended-range VLANs enable service providers to extend their infrastructure to a greater number of customers. The extended-range VLAN IDs are allowed for any **switchport** commands that allow VLAN IDs.

With VTP version 1 or 2, extended-range VLAN configurations are not stored in the VLAN database, but because VTP mode is transparent, they are stored in the switch running configuration file, and you can save the configuration in the startup configuration file by using the **copy running-config startup-config** privileged EXEC command. Extended-range VLANs created in VTP version 3 are stored in the VLAN database.

Creating an Extended-Range VLAN

You create an extended-range VLAN in global configuration mode by entering the vlan global configuration command with a VLAN ID from 1006 to 4094. The extended-range VLAN has the default Ethernet VLAN characteristics and the MTU size. See the description of the vlan global configuration command in the command reference for the default settings of all parameters. In VTP version 1 or 2, if you enter an extended-range VLAN ID when the switch is not in VTP transparent mode, an error message is generated when you exit VLAN configuration mode, and the extended-range VLAN is not created.

In VTP version 1 and 2, extended-range VLANs are not saved in the VLAN database; they are saved in the switch running configuration file. You can save the extended-range VLAN configuration in the switch startup configuration file by using the copy running-config startup-config privileged EXEC command. VTP version 3 saves extended-range VLANs in the VLAN database.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vtp mode transparent**
4. **vlan** *vlan-id*
5. **mtu** *mtu size*
6. **end**
7. **show vlan id** *vlan-id*
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**vtp mode transparent** **Example:** `Switch(config)# vtp mode transparent`	Configures the switch for VTP transparent mode, disabling VTP. **Note** This step is not required for VTP version 3.

Step 4	**vlan** *vlan-id*
	Example:
	`Switch(config)# vlan 2000`
	`Switch(config-vlan)#`
		Enters an extended-range VLAN ID and enters VLAN configuration mode. The range is 1006 to 4094.

Step 5	**mtu** *mtu size* **Example:**	Modifies the VLAN by changing the MTU size.

Step 6	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 7	**show vlan id** *vlan-id* **Example:** `Switch# show vlan id 2000`	Verifies that the VLAN has been created.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring VLANs

Table 130: Privileged EXEC show Commands

Command	Purpose
show interfaces [**vlan** *vlan-id*]	Displays characteristics for all interfaces or for the specified VLAN configured on the switch.
show vlan [**brief** | **group** [**group-name** *name*] |**id** *vlan-id* | **ifindex** | **internal** | **mtu** | **name** *name* **summary**]]	Displays parameters for all VLANs or the specified VLAN on the switch. The following command options are available: • **brief**—Displays VTP VLAN status in brief. • **group**—Displays the VLAN group with its name and the connected VLANs that are available. • **id**—Displays VTP VLAN status by identification number. • **ifindex**—Displays SNMP ifIndex. • **mtu**—Displays VLAN MTU information. • **name**—Display the VTP VLAN information by specified name. • **summary**—Displays a summary of VLAN information.

Command	Purpose
show vlan [**access-log** {**config** | **flow** | **statistics**} | **access-map** *name* | **brief** | **dot1q** { **tag native** } | **filter** [**access-map** | **vlan**] | **group** [**group-name** *name*] | **id** *vlan-id* | **ifindex** | **internal usage** | **mtu** | **name** *name* | **summary**]	Displays parameters for all VLANs or the specified VLAN on the switch . The following command options are available: • **access-log**—Displays the VACL logging. • **access-map**—Displays the VLAN access-maps. • **brief**—Displays VTP VLAN status in brief. • **dot1q**—Displays the dot1q parameters. • **filter**—Displays VLAN filter information. • **group**—Displays the VLAN group with its name and the connected VLANs that are available. • **id**—Displays VTP VLAN status by identification number. • **ifindex**—Displays SNMP ifIndex. • **mtu**—Displays VLAN MTU information. • **name**—Display the VTP VLAN information by specified name. • **summary**—Displays a summary of VLAN information.

Configuration Examples

Example: Creating a VLAN Name

This example shows how to create Ethernet VLAN 20, name it test20, and add it to the VLAN database:

```
Switch# configure terminal
Switch(config)# vlan 20
Switch(config-vlan)# name test20
Switch(config-vlan)# end
```

Related Topics

Creating or Modifying an Ethernet VLAN
Normal-Range VLAN Configuration Guidelines, on page 1170

Example: Configuring a Port as Access Port

This example shows how to configure a port as an access port in VLAN 2:

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# switchport mode access
Switch(config-if)# switchport access vlan 2
Switch(config-if)# end
```

Related Topics

Assigning Static-Access Ports to a VLAN , on page 1176

Example: Creating an Extended-Range VLAN

This example shows how to create a new extended-range VLAN with all default characteristics, enter VLAN configuration mode, and save the new VLAN in the switch startup configuration file:

```
Switch(config)# vtp mode transparent
Switch(config)# vlan 2000
Switch(config-vlan)# end
Switch# copy running-config startup config
```

Related Topics

Creating an Extended-Range VLAN

Extended-Range VLAN Configuration Guidelines, on page 1171

Where to Go Next

After configuring VLANs, you can configure the following:

- VLAN Trunking Protocol (VTP)
- VLAN trunks

CHAPTER 61

Configuring VLAN Trunks

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for VLAN Trunks

The IEEE 802.1Q trunks impose these limitations on the trunking strategy for a network:

- In a network of Cisco switches connected through IEEE 802.1Q trunks, the switches maintain one spanning-tree instance for each VLAN allowed on the trunks. Non-Cisco devices might support one spanning-tree instance for all VLANs.

  When you connect a Cisco switch to a non-Cisco device through an IEEE 802.1Q trunk, the Cisco switch combines the spanning-tree instance of the VLAN of the trunk with the spanning-tree instance of the non-Cisco IEEE 802.1Q switch. However, spanning-tree information for each VLAN is maintained by Cisco switches separated by a cloud of non-Cisco IEEE 802.1Q switches. The non-Cisco IEEE 802.1Q cloud separating the Cisco switches is treated as a single trunk link between the switches.

- Make sure the native VLAN for an IEEE 802.1Q trunk is the same on both ends of the trunk link. If the native VLAN on one end of the trunk is different from the native VLAN on the other end, spanning-tree loops might result.
- Disabling spanning tree on the native VLAN of an IEEE 802.1Q trunk without disabling spanning tree on every VLAN in the network can potentially cause spanning-tree loops. We recommend that you leave spanning tree enabled on the native VLAN of an IEEE 802.1Q trunk or disable spanning tree on every VLAN in the network. Make sure your network is loop-free before disabling spanning tree.

Information About VLAN Trunks

Trunking Overview

A trunk is a point-to-point link between one or more Ethernet switch interfaces and another networking device such as a router or a switch. Ethernet trunks carry the traffic of multiple VLANs over a single link, and you can extend the VLANs across an entire network.

Note You can configure a trunk on a single Ethernet interface or on an EtherChannel bundle.

Trunking Modes

Ethernet trunk interfaces support different trunking modes. You can set an interface as trunking or nontrunking or to negotiate trunking with the neighboring interface. To autonegotiate trunking, the interfaces must be in the same VTP domain.

Trunk negotiation is managed by the Dynamic Trunking Protocol (DTP), which is a Point-to-Point Protocol (PPP). However, some internetworking devices might forward DTP frames improperly, which could cause misconfigurations.

Layer 2 Interface Modes

Table 131: Layer 2 Interface Modes

Mode	Function
switchport mode access	Puts the interface (access port) into permanent nontrunking mode and negotiates to convert the link into a nontrunk link. The interface becomes a nontrunk interface regardless of whether or not the neighboring interface is a trunk interface.
switchport mode dynamic auto	Makes the interface able to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to **trunk** or **desirable** mode. The default switchport mode for all Ethernet interfaces is **dynamic auto**.

Mode	Function
switchport mode dynamic desirable	Makes the interface actively attempt to convert the link to a trunk link. The interface becomes a trunk interface if the neighboring interface is set to **trunk**, **desirable**, or **auto** mode.
switchport mode trunk	Puts the interface into permanent trunking mode and negotiates to convert the neighboring link into a trunk link. The interface becomes a trunk interface even if the neighboring interface is not a trunk interface.
switchport nonegotiate	Prevents the interface from generating DTP frames. You can use this command only when the interface switchport mode is **access** or **trunk**. You must manually configure the neighboring interface as a trunk interface to establish a trunk link.

Allowed VLANs on a Trunk

By default, a trunk port sends traffic to and receives traffic from all VLANs. All VLAN IDs, 1 to 4094, are allowed on each trunk. However, you can remove VLANs from the allowed list, preventing traffic from those VLANs from passing over the trunk.

To reduce the risk of spanning-tree loops or storms, you can disable VLAN 1 on any individual VLAN trunk port by removing VLAN 1 from the allowed list. When you remove VLAN 1 from a trunk port, the interface continues to send and receive management traffic, for example, Cisco Discovery Protocol (CDP), Port Aggregation Protocol (PAgP), Link Aggregation Control Protocol (LACP), DTP, and VTP in VLAN 1.

If a trunk port with VLAN 1 disabled is converted to a nontrunk port, it is added to the access VLAN. If the access VLAN is set to 1, the port will be added to VLAN 1, regardless of the **switchport trunk allowed** setting. The same is true for any VLAN that has been disabled on the port.

A trunk port can become a member of a VLAN if the VLAN is enabled, if VTP knows of the VLAN, and if the VLAN is in the allowed list for the port. When VTP detects a newly enabled VLAN and the VLAN is in the allowed list for a trunk port, the trunk port automatically becomes a member of the enabled VLAN. When VTP detects a new VLAN and the VLAN is not in the allowed list for a trunk port, the trunk port does not become a member of the new VLAN.

Load Sharing on Trunk Ports

Load sharing divides the bandwidth supplied by parallel trunks connecting switches. To avoid loops, STP normally blocks all but one parallel link between switches. Using load sharing, you divide the traffic between the links according to which VLAN the traffic belongs.

You configure load sharing on trunk ports by using STP port priorities or STP path costs. For load sharing using STP port priorities, both load-sharing links must be connected to the same switch. For load sharing using STP path costs, each load-sharing link can be connected to the same switch or to two different switches.

Network Load Sharing Using STP Priorities

When two ports on the same switch form a loop, the switch uses the STP port priority to decide which port is enabled and which port is in a blocking state. You can set the priorities on a parallel trunk port so that the port carries all the traffic for a given VLAN. The trunk port with the higher priority (lower values) for a VLAN is forwarding traffic for that VLAN. The trunk port with the lower priority (higher values) for the same VLAN remains in a blocking state for that VLAN. One trunk port sends or receives all traffic for the VLAN.

Network Load Sharing Using STP Path Cost

You can configure parallel trunks to share VLAN traffic by setting different path costs on a trunk and associating the path costs with different sets of VLANs, blocking different ports for different VLANs. The VLANs keep the traffic separate and maintain redundancy in the event of a lost link.

Feature Interactions

Trunking interacts with other features in these ways:

- A trunk port cannot be a secure port.
- Trunk ports can be grouped into EtherChannel port groups, but all trunks in the group must have the same configuration. When a group is first created, all ports follow the parameters set for the first port to be added to the group. If you change the configuration of one of these parameters, the switch propagates the setting that you entered to all ports in the group:
    - Allowed-VLAN list.
    - STP port priority for each VLAN.
    - STP Port Fast setting.
    - Trunk status:

      If one port in a port group ceases to be a trunk, all ports cease to be trunks.
- We recommend that you configure no more than 24 trunk ports in Per VLAN Spanning Tree (PVST) mode and no more than 40 trunk ports in Multiple Spanning Tree (MST) mode.
- If you try to enable IEEE 802.1x on a trunk port, an error message appears, and IEEE 802.1x is not enabled. If you try to change the mode of an IEEE 802.1x-enabled port to trunk, the port mode is not changed.
- A port in dynamic mode can negotiate with its neighbor to become a trunk port. If you try to enable IEEE 802.1x on a dynamic port, an error message appears, and IEEE 802.1x is not enabled. If you try to change the mode of an IEEE 802.1x-enabled port to dynamic, the port mode is not changed.

Default Layer 2 Ethernet Interface VLAN Configuration

The following table shows the default Layer 2 Ethernet interface VLAN configuration.

Table 132: Default Layer 2 Ethernet Interface VLAN Configuration

Feature	Default Setting
Interface mode	**switchport mode dynamic auto**
Allowed VLAN range	VLANs 1 to 4094
VLAN range eligible for pruning	VLANs 2 to 1001

Feature	Default Setting
Default VLAN (for access ports)	VLAN 1
Native VLAN (for IEEE 802.1Q trunks)	VLAN 1

How to Configure VLAN Trunks

To avoid trunking misconfigurations, configure interfaces connected to devices that do not support DTP to not forward DTP frames, that is, to turn off DTP.

- If you do not intend to trunk across those links, use the **switchport mode access** interface configuration command to disable trunking.
- To enable trunking to a device that does not support DTP, use the **switchport mode trunk** and **switchport nonegotiate** interface configuration commands to cause the interface to become a trunk but to not generate DTP frames.

Configuring an Ethernet Interface as a Trunk Port

Configuring a Trunk Port

Because trunk ports send and receive VTP advertisements, to use VTP you must ensure that at least one trunk port is configured on the switch and that this trunk port is connected to the trunk port of a second switch. Otherwise, the switch cannot receive any VTP advertisements.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport mode** {**dynamic** {**auto** | **desirable**} | **trunk**}
5. **switchport access vlan** *vlan-id*
6. **switchport trunk native vlan** *vlan-id*
7. **end**
8. **show interfaces** *interface-id* **switchport**
9. **show interfaces** *interface-id* **trunk**
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Specifies the port to be configured for trunking, and enters interface configuration mode.

Step 4	**switchport mode** {**dynamic** {**auto** | **desirable**} | **trunk**}
	Example:
	`Switch(config-if)# switchport mode dynamic desirable`
		Configures the interface as a Layer 2 trunk (required only if the interface is a Layer 2 access port or tunnel port or to specify the trunking mode).
		• **dynamic auto**—Sets the interface to a trunk link if the neighboring interface is set to trunk or desirable mode. This is the default.
		• **dynamic desirable**—Sets the interface to a trunk link if the neighboring interface is set to trunk, desirable, or auto mode.
		• **trunk**—Sets the interface in permanent trunking mode and negotiate to convert the link to a trunk link even if the neighboring interface is not a trunk interface.

Step 5	**switchport access vlan** *vlan-id* **Example:** `Switch(config-if)# switchport access vlan 200`	(Optional) Specifies the default VLAN, which is used if the interface stops trunking.
Step 6	**switchport trunk native vlan** *vlan-id* **Example:** `Switch(config-if)# switchport trunk native vlan 200`	Specifies the native VLAN for IEEE 802.1Q trunks.

Step 7	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 8	**show interfaces** *interface-id* **switchport** **Example:** `Switch# show interfaces gigabitethernet 0/2 switchport`	Displays the switch port configuration of the interface in the *Administrative Mode* and the *Administrative Trunking Encapsulation* fields of the display.
Step 9	**show interfaces** *interface-id* **trunk** **Example:** `Switch# show interfaces gigabitethernet 0/2 trunk`	Displays the trunk configuration of the interface.
Step 10	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Defining the Allowed VLANs on a Trunk

VLAN 1 is the default VLAN on all trunk ports in all Cisco switches, and it has previously been a requirement that VLAN 1 always be enabled on every trunk link. You can use the VLAN 1 minimization feature to disable VLAN 1 on any individual VLAN trunk link so that no user traffic (including spanning-tree advertisements) is sent or received on VLAN 1.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport mode trunk**
5. **end**
6. **show interfaces** *interface-id* **switchport**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Specifies the port to be configured, and enters interface configuration mode.
Step 4	**switchport mode trunk** **Example:** `Switch(config-if)# switchport mode trunk`	Configures the interface as a VLAN trunk port.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show interfaces** *interface-id* **switchport** **Example:** `Switch# show interfaces gigabitethernet 0/1 switchport`	Verifies your entries in the *Trunking VLANs Enabled* field of the display.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Changing the Pruning-Eligible List

The pruning-eligible list applies only to trunk ports. Each trunk port has its own eligibility list. VTP pruning must be enabled for this procedure to take effect.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport trunk pruning vlan** {**add** | **except** | **none** | **remove**} *vlan-list* [,*vlan* [,*vlan* [,,,]]

5. **end**
6. **show interfaces** *interface-id* **switchport**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface fastethernet0/1-48`	Selects the trunk port for which VLANs should be pruned, and enters interface configuration mode.
Step 4	**switchport trunk pruning vlan** {**add** | **except** | **none** | **remove**} *vlan-list* [,*vlan* [,*vlan* [,,,]]	Configures the list of VLANs allowed to be pruned from the trunk. For explanations about using the **add**, **except**, **none**, and **remove** keywords, see the command reference for this release. Separate non-consecutive VLAN IDs with a comma and no spaces; use a hyphen to designate a range of IDs. Valid IDs are 2 to 1001. Extended-range VLANs (VLAN IDs 1006 to 4094) cannot be pruned. VLANs that are pruning-ineligible receive flooded traffic. The default list of VLANs allowed to be pruned contains VLANs 2 to 1001.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 6	**show interfaces** *interface-id* **switchport** **Example:** `Switch# show interfaces gigabitethernet 0/1`	Verifies your entries in the *Pruning VLANs Enabled* field of the display.

	Command or Action	Purpose
	`switchport`	
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring the Native VLAN for Untagged Traffic

A trunk port configured with IEEE 802.1Q tagging can receive both tagged and untagged traffic. By default, the switch forwards untagged traffic in the native VLAN configured for the port. The native VLAN is VLAN 1 by default.

The native VLAN can be assigned any VLAN ID.

If a packet has a VLAN ID that is the same as the outgoing port native VLAN ID, the packet is sent untagged; otherwise, the switch sends the packet with a tag.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport trunk native vlan** *vlan-id*
5. **end**
6. **show interfaces** *interface-id* **switchport**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:**	Defines the interface that is configured as the IEEE 802.1Q trunk, and enters interface configuration mode.

	Command or Action	Purpose
	`Switch(config)# interface gigabitethernet 0/2`	
Step 4	**switchport trunk native vlan** *vlan-id* **Example:** `Switch(config-if)# switchport trunk native vlan 12`	Configures the VLAN that is sending and receiving untagged traffic on the trunk port. For *vlan-id*, the range is 1 to 4094.

Step 5	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 6	**show interfaces** *interface-id* **switchport** **Example:** `Switch# show interfaces gigabitethernet 0/2 switchport`	Verifies your entries in the *Trunking Native Mode VLAN* field.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Trunk Ports for Load Sharing

Configuring Load Sharing Using STP Port Priorities

These steps describe how to configure a network with load sharing using STP port priorities.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vtp domain** *domain-name*
4. **vtp mode server**
5. **end**
6. **show vtp status**
7. **show vlan**
8. **configure terminal**
9. **interface** *interface-id*
10. **switchport mode trunk**

11. **end**
12. **show interfaces** *interface-id* **switchport**
13. Repeat the above steps on Switch A for a second port in the switch.
14. Repeat the above steps on Switch B to configure the trunk ports that connect to the trunk ports configured on Switch A.
15. **show vlan**
16. **configure terminal**
17. **interface** *interface-id*
18. **spanning-tree vlan** *vlan-range* **port-priority** *priority-value*
19. **exit**
20. **interface** *interface-id*
21. **spanning-tree vlan** *vlan-range* **port-priority** *priority-value*
22. **end**
23. **show running-config**
24. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode on Switch A.
Step 3	**vtp domain** *domain-name* **Example:** `Switch(config)# vtp domain workdomain`	Configures a VTP administrative domain. The domain name can be 1 to 32 characters.
Step 4	**vtp mode server** **Example:** `Switch(config)# vtp mode server`	Configures Switch A as the VTP server.

Step 5	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 6	**show vtp status** **Example:** `Switch# show vtp status`	Verifies the VTP configuration on both Switch A and Switch B. In the display, check the *VTP Operating Mode* and the *VTP Domain Name* fields.
Step 7	**show vlan** **Example:** `Switch# show vlan`	Verifies that the VLANs exist in the database on Switch A.
Step 8	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 9	**interface** *interface-id* **Example:** `Switch(config)# interface fastethernet0/1-48`	Defines the interface to be configured as a trunk, and enters interface configuration mode.
Step 10	**switchport mode trunk** **Example:** `Switch(config-if)# switchport mode trunk`	Configures the port as a trunk port.

Step 11	**end**
	Example:
	`Switch(config-if)# end`
		Returns to privileged EXEC mode.

Step 12	**show interfaces** *interface-id* **switchport** **Example:** `Switch# show interfaces gigabitethernet 0/1 switchport`	Verifies the VLAN configuration.
Step 13	Repeat the above steps on Switch A for a second port in the switch.	
Step 14	Repeat the above steps on Switch B to configure the trunk ports that connect to the trunk ports configured on Switch A.	

	Command or Action	Purpose
Step 15	**show vlan** **Example:** `Switch# show vlan`	When the trunk links come up, VTP passes the VTP and VLAN information to Switch B. This command verifies that Switch B has learned the VLAN configuration.
Step 16	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode on Switch A.
Step 17	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Defines the interface to set the STP port priority, and enters interface configuration mode.
Step 18	**spanning-tree vlan** *vlan-range* **port-priority** *priority-value* **Example:** `Switch(config-if)# spanning-tree vlan 8-10 port-priority 16`	Assigns the port priority for the VLAN range specified. Enter a port priority value from 0 to 240. Port priority values increment by 16.
Step 19	**exit** **Example:** `Switch(config-if)# exit`	Returns to global configuration mode.
Step 20	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/2`	Defines the interface to set the STP port priority, and enters interface configuration mode.
Step 21	**spanning-tree vlan** *vlan-range* **port-priority** *priority-value* **Example:** `Switch(config-if)# spanning-tree vlan 3-6 port-priority 16`	Assigns the port priority for the VLAN range specified. Enter a port priority value from 0 to 240. Port priority values increment by 16.
Step 22	**end** **Example:**	Returns to privileged EXEC mode.

	Command or Action	Purpose
	`Switch(config-if)# end`	
Step 23	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 24	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Load Sharing Using STP Path Cost

These steps describe how to configure a network with load sharing using STP path costs.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport mode trunk**
5. **exit**
6. Repeat Steps 2 through 4 on a second interface in Switch A .
7. **end**
8. **show running-config**
9. **show vlan**
10. **configure terminal**
11. **interface** *interface-id*
12. **spanning-tree vlan** *vlan-range* **cost** *cost-value*
13. **end**
14. Repeat Steps 9 through 13 on the other configured trunk interface on Switch A, and set the spanning-tree path cost to 30 for VLANs 8, 9, and 10.
15. **exit**
16. **show running-config**
17. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
	`Switch> enable`	
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode on Switch A.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Defines the interface to be configured as a trunk, and enters interface configuration mode.
Step 4	**switchport mode trunk** **Example:** `Switch(config-if)# switchport mode trunk`	Configures the port as a trunk port.
Step 5	**exit** **Example:** `Switch(config-if)# exit`	Returns to global configuration mode.
Step 6	Repeat Steps 2 through 4 on a second interface in Switch A .	

Step 7	**end**
	Example:
	`Switch(config)# end`
		Returns to privileged EXEC mode.

Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries. In the display, make sure that the interfaces are configured as trunk ports.
Step 9	**show vlan** **Example:** `Switch# show vlan`	When the trunk links come up, Switch A receives the VTP information from the other switches. This command verifies that Switch A has learned the VLAN configuration.

	Command or Action	Purpose
Step 10	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 11	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Defines the interface on which to set the STP cost, and enters interface configuration mode.
Step 12	**spanning-tree vlan** *vlan-range* **cost** *cost-value* **Example:** `Switch(config-if)# spanning-tree vlan 2-4 cost 30`	Sets the spanning-tree path cost to 30 for VLANs 2 through 4.

Step 13	**end**
	Example:
	`Switch(config-if)# end`
		Returns to global configuration mode.

Step 14	Repeat Steps 9 through 13 on the other configured trunk interface on Switch A, and set the spanning-tree path cost to 30 for VLANs 8, 9, and 10.	
Step 15	**exit** **Example:** `Switch(config)# exit`	Returns to privileged EXEC mode.
Step 16	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries. In the display, verify that the path costs are set correctly for both trunk interfaces.
Step 17	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuration Examples for VLAN Trunking

Example: Configuring a Trunk Port

The following example shows how to configure a port as an IEEE 802.1Q trunk. The example assumes that the neighbor interface is configured to support IEEE 802.1Q trunking.

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)# interface gigabitethernet0/2
Switch(config-if)# switchport mode dynamic desirable
Switch(config-if)# end
```

Example: Removing a VLAN from a Port

This example shows how to remove VLAN 2 from the allowed VLAN list on a port:

```
Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# switchport trunk allowed vlan remove 2
Switch(config-if)# end
```

Where to Go Next

After configuring VLAN trunks, you can configure the following:

- VLANs

Additional References

Standards and RFCs

Standard/RFC	Title
—	—

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for VLAN Trunks

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

CHAPTER 62

Configuring Voice VLANs

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Prerequisites for Voice VLANs

The following are the prerequisites for voice VLANs:

- Voice VLAN configuration is only supported on switch access ports; voice VLAN configuration is not supported on trunk ports.

Note Trunk ports can carry any number of voice VLANs, similar to regular VLANs. The configuration of voice VLANs is not supported on trunk ports.

- Before you enable voice VLAN, we recommend that you enable QoS on the switch by entering the **mls qos** global configuration command and configure the port trust state to trust by entering the **mls qos trust cos** interface configuration command.
- You must enable CDP on the switch port connected to the Cisco IP Phone to send the configuration to the phone. (CDP is globally enabled by default on all switch interfaces.)

Restrictions for Voice VLANs

You cannot configure static secure MAC addresses in the voice VLAN.

Information About Voice VLAN

Voice VLANs

The voice VLAN feature enables access ports to carry IP voice traffic from an IP phone. When the switch is connected to a Cisco IP Phone, the phone sends voice traffic with Layer 3 IP precedence and Layer 2 class of service (CoS) values, which are both set to 5 by default. Because the sound quality of an IP phone call can deteriorate if the data is unevenly sent, the switch supports quality of service (QoS) based on IEEE 802.1p CoS. QoS uses classification and scheduling to send network traffic from the switch in a predictable manner.

The Cisco IP Phone is a configurable device, and you can configure it to forward traffic with an IEEE 802.1p priority. You can configure the switch to trust or override the traffic priority assigned by a Cisco IP Phone.

Cisco IP Phone Voice Traffic

You can configure an access port with an attached Cisco IP Phone to use one VLAN for voice traffic and another VLAN for data traffic from a device attached to the phone. You can configure access ports on the switch to send Cisco Discovery Protocol (CDP) packets that instruct an attached phone to send voice traffic to the switch in any of these ways:

- In the voice VLAN tagged with a Layer 2 CoS priority value
- In the access VLAN tagged with a Layer 2 CoS priority value
- In the access VLAN, untagged (no Layer 2 CoS priority value)

Note In all configurations, the voice traffic carries a Layer 3 IP precedence value (the default is 5 for voice traffic and 3 for voice control traffic).

Cisco IP Phone Data Traffic

The switch can also process tagged data traffic (traffic in IEEE 802.1Q or IEEE 802.1p frame types) from the device attached to the access port on the Cisco IP Phone. You can configure Layer 2 access ports on the switch to send CDP packets that instruct the attached phone to configure the phone access port in one of these modes:

- In trusted mode, all traffic received through the access port on the Cisco IP Phone passes through the phone unchanged.
- In untrusted mode, all traffic in IEEE 802.1Q or IEEE 802.1p frames received through the access port on the Cisco IP Phone receive a configured Layer 2 CoS value. The default Layer 2 CoS value is 0. Untrusted mode is the default.

Note Untagged traffic from the device attached to the Cisco IP Phone passes through the phone unchanged, regardless of the trust state of the access port on the phone.

Voice VLAN Configuration Guidelines

- Because a Cisco IP Phone also supports a connection to a PC or other device, a port connecting the switch to a Cisco IP Phone can carry mixed traffic. You can configure a port to decide how the Cisco IP Phone carries voice traffic and data traffic.
- The voice VLAN should be present and active on the switch for the IP phone to correctly communicate on the voice VLAN. Use the **show vlan** privileged EXEC command to see if the VLAN is present (listed in the display). If the VLAN is not listed, create the voice VLAN.
- The Power over Ethernet (PoE) switches are capable of automatically providing power to Cisco pre-standard and IEEE 802.3af-compliant powered devices if they are not being powered by an AC power source.
- The Port Fast feature is automatically enabled when voice VLAN is configured. When you disable voice VLAN, the Port Fast feature is not automatically disabled.
- If the Cisco IP Phone and a device attached to the phone are in the same VLAN, they must be in the same IP subnet. These conditions indicate that they are in the same VLAN:
    - They both use IEEE 802.1p or untagged frames.
    - The Cisco IP Phone uses IEEE 802.1p frames, and the device uses untagged frames.
    - The Cisco IP Phone uses untagged frames, and the device uses IEEE 802.1p frames.
    - The Cisco IP Phone uses IEEE 802.1Q frames, and the voice VLAN is the same as the access VLAN.
- The Cisco IP Phone and a device attached to the phone cannot communicate if they are in the same VLAN and subnet but use different frame types because traffic in the same subnet is not routed (routing would eliminate the frame type difference).
- Voice VLAN ports can also be these port types:
    - Dynamic access port.
    - IEEE 802.1x authenticated port.

    Note If you enable IEEE 802.1x on an access port on which a voice VLAN is configured and to which a Cisco IP Phone is connected, the phone loses connectivity to the switch for up to 30 seconds.

- Protected port.
- A source or destination port for a SPAN session.
- Secure port.

Note When you enable port security on an interface that is also configured with a voice VLAN, you must set the maximum allowed secure addresses on the port to two plus the maximum number of secure addresses allowed on the access VLAN. When the port is connected to a Cisco IP Phone, the phone requires up to two MAC addresses. The phone address is learned on the voice VLAN and might also be learned on the access VLAN. Connecting a PC to the phone requires additional MAC addresses.

Default Voice VLAN Configuration

The voice VLAN feature is disabled by default.

When the voice VLAN feature is enabled, all untagged traffic is sent according to the default CoS priority of the port.

The CoS value is not trusted for IEEE 802.1p or IEEE 802.1Q tagged traffic.

How to Configure Voice VLAN

Configuring Cisco IP Phone Voice Traffic

You can configure a port connected to the Cisco IP Phone to send CDP packets to the phone to configure the way in which the phone sends voice traffic. The phone can carry voice traffic in IEEE 802.1Q frames for a specified voice VLAN with a Layer 2 CoS value. It can use IEEE 802.1p priority tagging to give voice traffic a higher priority and forward all voice traffic through the native (access) VLAN. The Cisco IP Phone can also send untagged voice traffic or use its own configuration to send voice traffic in the access VLAN. In all configurations, the voice traffic carries a Layer 3 IP precedence value (the default is 5).

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **mls qos trust cos**
5. **switchport voice** {**vlan**{*vlan-id* | **dot1p** | **none** | **untagged**}}
6. **end**
7. Use one of the following:
   - **show interfaces** *interface-id* **switchport**
   - **show running-config interface** *interface-id*

8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet 0/1`	Specifies the interface connected to the phone, and enters interface configuration mode.
Step 4	**mls qos trust cos** **Example:** `Device(config-if)# mls qos trust cos`	Configures the interface to classify incoming traffic packets by using the packet CoS value. For untagged packets, the port default CoS value is used. **Note** Before configuring the port trust state, you must first globally enable QoS by using the **mls qos** global configuration command.

Step 5	**switchport voice** {**vlan**{*vlan-id* | **dot1p** | **none** | **untagged**}}
	Example:
	`Device(config-if)# switchport voice vlan dot1p`
		Configures the voice VLAN.
		• *vlan-id*—Configures the phone to forward all voice traffic through the specified VLAN. By default, the Cisco IP Phone forwards the voice traffic with an IEEE 802.1Q priority of 5. Valid VLAN IDs are 1 to 4094.
		• **dot1p**—Configures the switch to accept voice and data IEEE 802.1p priority frames tagged with VLAN ID 0 (the native VLAN). By default, the switch drops all voice and data traffic tagged with VLAN 0. If configured for 802.1p the Cisco IP Phone forwards the traffic with an IEEE 802.1p priority of 5.
		• **none**—Allows the phone to use its own configuration to send untagged voice traffic.
		• **untagged**—Configures the phone to send untagged voice traffic.

	Command or Action	Purpose

Step 6	**end**
	Example:
	`Device(config-if)# end`
		Returns to privileged EXEC mode.

Step 7	Use one of the following:
	• **show interfaces** *interface-id* **switchport**
	• **show running-config interface** *interface-id*
	Example:
	`Device# show interfaces gigabitethernet 0/1 switchport`
	or
	`Device# show running-config interface gigabitethernet 0/1`
		Verifies your voice VLAN entries or your QoS and voice VLAN entries.

Step 8	**copy running-config startup-config** **Example:** `Device# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Monitoring Voice VLAN

To display voice VLAN configuration for an interface, use the **show interfaces** *interface-id* **switchport** privileged EXEC command.

Configuration Examples

Example: Configuring Cisco IP Phone Voice Traffic

This example shows how to configure a port connected to a Cisco IP Phone to use the CoS value to classify incoming traffic and to accept voice and data priority traffic tagged with VLAN ID 0:

```
Switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.

Switch(config)# interface gigabitethernet 0/1
Switch(config-if)# mls qos trust cos
Switch(config-if)# switchport voice vlan dot1p
Switch(config-if)# end
```

To return the port to its default setting, use the **no switchport voice vlan** interface configuration command.

Where to Go Next

After configuring voice VLANs, you can configure the following:

- VLANs
- VLAN Trunking
- VTP

Additional References

Related Documents

Related Topic	Document Title
For complete syntax and usage information for the commands used in this chapter.	Catalyst 2960-L Switch VLAN Management Command Reference

Standards and RFCs

Standard/RFC	Title
—	—

MIBs

MIB	MIBs Link
All the supported MIBs for this release.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	http://www.cisco.com/support

Feature History and Information for Voice VLAN

Release	Modification
Cisco IOS Release 15.2(5)E	This feature was introduced.

APPENDIX A

Important Notice

Disclaimer

Cisco EnergyWise enables you to reduce energy consumption in your network by turning off the power to devices when they are not in use. If IP phones are part of your network, they can also be turned off through EnergyWise, in which case calls cannot be made or received, and the phones cannot be turned on except by the network administrator or according to rules established in EnergyWise by the network administrator. Laws in the location of your network might require phones to remain available for emergencies. It is your responsibility to identify the laws that apply and to comply with them. Even in the absence of a law, we strongly recommend that you designate certain phones that will always be on and available to make and receive emergency calls. These phones should be clearly identified, and all employees or others who might require emergency access to make or receive calls should be informed of the availability of these phones.

Statement 361—VoIP and Emergency Calling Services do not Function if Power Fails

	Voice over IP (VoIP) service and the emergency calling service do not function if power fails or is disrupted. After power is restored, you might have to reset or reconfigure equipment to regain access to VoIP and the emergency calling service. In the USA, this emergency number is 911. You need to be aware of the emergency number in your country.
Waarschuwing	**Voice over IP (VoIP)-service en de service voor noodoproepen werken niet indien er een stroomstoring is. Nadat de stroomtoevoer is hersteld, dient u wellicht de configuratie van uw apparatuur opnieuw in te stellen om opnieuw toegang te krijgen tot VoIP en de noodoproepen. In de VS is het nummer voor noodoproepen 911. U dient u zelf op de hoogte te stellen van het nummer voor noodoproepen in uw land.**

Varoitus	**Voice over IP (VoIP) -palvelu ja hätäpuhelupalvelu eivät toimi, jos virta katkeaa tai sen syötössä esiintyy häiriöitä. Kun virransyöttö on taas normaali, sinun täytyy mahdollisesti asettaa tai määrittää laitteisto uudelleen, jotta voisit jälleen käyttää VoIP-palvelua ja hätäpuhelupalvelua. Yhdysvalloissa hätänumero on 911. Selvitä, mikä on omassa kotimaassasi käytössä oleva hätänumero.**
Attention	**Le service Voice over IP (VoIP) et le service d’appels d’urgence ne fonctionnent pas en cas de panne de courant. Une fois que le courant est rétabli, vous devrez peut-être réinitialiser ou reconfigurer le système pour accéder de nouveau au service VoIP et à celui des appels d’urgence. Aux États-Unis, le numéro des services d’urgence est le 911. Vous devez connaître le numéro d’appel d'urgence en vigueur dans votre pays.**
Warnung	**Bei einem Stromausfall oder eingeschränkter Stromversorgung funktionieren VoIP-Dienst und Notruf nicht. Sobald die Stromversorgung wieder hergestellt ist, müssen Sie möglicherweise die Geräte zurücksetzen oder neu konfigurieren, um den Zugang zu VoIP und Notruf wieder herzustellen. Die Notrufnummer in den USA lautet 911. Wählen Sie im Notfall die für Ihr Land vorgesehene Notrufnummer.**
Avvertenza	**l servizio Voice over IP (VoIP) e il servizio per le chiamate di emergenza non funzionano in caso di interruzione dell'alimentazione. Ristabilita l'alimentazione, potrebbe essere necessario reimpostare o riconfigurare l'attrezzatura per ottenere nuovamente l'accesso al servizio VoIP e al servizio per le chiamate di emergenza. Negli Stati Uniti, il numero di emergenza è 911. Si consiglia di individuare il numero di emergenza del proprio Paese.**
Advarsel	**Tjenesten Voice over IP (VoIP) og nødanropstjenesten fungerer ikke ved strømbrudd. Etter at strømmen har kommet tilbake, må du kanskje nullstille eller konfigurere utstyret på nytt for å få tilgang til VoIP og nødanropstjenesten. I USA er dette nødnummeret 911. Du må vite hva nødnummeret er i ditt land.**
Aviso	**O serviço Voice over IP (VoIP) e o serviço de chamadas de emergência não funcionam se houver um corte de energia. Depois do fornecimento de energia ser restabelecido, poderá ser necessário reiniciar ou reconfigurar o equipamento para voltar a utilizar os serviços VoIP ou chamadas de emergência. Nos EUA, o número de emergência é o 911. É importante que saiba qual o número de emergência no seu país.**
¡Advertencia!	**l servicio de voz sobre IP (VoIP) y el de llamadas de emergencia no funcionan si se interrumpe el suministro de energía. Tras recuperar el suministro es posible que deba que restablecer o volver a configurar el equipo para tener acceso a los servicios de VoIP y de llamadas de emergencia. En Estados Unidos el número de emergencia es el 911. Asegúrese de obtener el número de emergencia en su país.**

Varning!	**Tjänsten Voice over IP (VoIP) och larmnummertjänsten fungerar inte vid strömavbrott. Efter att strömmen kommit tillbaka måste du kanske återställa eller konfigurera om utrustningen för att få tillgång till VoIP och larmnummertjänsten. I USA är det här larmnumret 911. Du bör ta reda på det larmnummer som gäller i ditt land.**
Figyelem	**Az IP csatornán történő hangátvitel (VoIP) és a segélyhívó szolgáltatás nem működik, ha az áramellátás megszűnik vagy megszakad. Az áramellátás helyreállítását követően előfordulhat, hogy alaphelyzetbe kell állítani vagy újra kell konfigurálni a berendezést, hogy újra hozzáférhessen a VoIP és a segélyhívó szolgáltatáshoz. Az Egyesült Államokban a segélyhívó szám 911. Tisztában kell lennie a saját országának segélyhívó számával.**
Предупреждение	**Служба передачи голоса по IP (VoIP) и служба экстренных вызовов не будут работать, если произошел сбой питания. После восстановления питания, возможно, потребуется перенастроить оборудование, чтобы возобновить доступ к службе VoIP и службе экстренных вызовов. В США телефон службы экстренных вызовов 911. Вам необходимо знать телефон этой службы в своей стране.**
警告	如果电源出现故障或中断，您将无法使用 Voice over IP (VoIP) 服务与紧急呼叫服务。电源恢复之后，您可能需要重新设置或重新配置设备，以便重新获得进入 VoIP 与紧急呼叫服务的权限。在美国，此紧急呼叫号码是 911。您必须知道本国的紧急呼叫号码。
警告	電源障害や停電の場合、ボイス オーバー アイピー (VoIP) サービスと緊急呼出しサービスは機能しません。電源の回復後、VoIP と緊急呼出しサービスにアクセスするには機器をリセットまたは再設定する必要があります。米国内の緊急呼出し番号は 911 です。お住まいの地域の緊急呼出し番号をあらかじめ調べておいてください。

Statement 1071—Warning Definition

	IMPORTANT SAFETY INSTRUCTIONS **This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. Use the statement number provided at the end of each warning to locate its translation in the translated safety warnings that accompanied this device. Statement 1071** **SAVE THESE INSTRUCTIONS**
Waarschuwing	**BELANGRIJKE VEILIGHEIDSINSTRUCTIES** **Dit waarschuwingssymbool betekent gevaar. U verkeert in een situatie die lichamelijk letsel kan veroorzaken. Voordat u aan enige apparatuur gaat werken, dient u zich bewust te zijn van de bij elektrische schakelingen betrokken risico's en dient u op de hoogte te zijn van de standaard praktijken om ongelukken te voorkomen. Gebruik het nummer van de verklaring onderaan de waarschuwing als u een vertaling van de waarschuwing die bij het apparaat wordt geleverd, wilt raadplegen.** **BEWAAR DEZE INSTRUCTIES**

Varoitus	**TÄRKEITÄ TURVALLISUUSOHJEITA** **Tämä varoitusmerkki merkitsee vaaraa. Tilanne voi aiheuttaa ruumiillisia vammoja. Ennen kuin käsittelet laitteistoa, huomioi sähköpiirien käsittelemiseen liittyvät riskit ja tutustu onnettomuuksien yleisiin ehkäisytapoihin. Turvallisuusvaroitusten käännökset löytyvät laitteen mukana toimitettujen käännettyjen turvallisuusvaroitusten joukosta varoitusten lopussa näkyvien lausuntonumeroiden avulla.** **SÄILYTÄ NÄMÄ OHJEET**
Attention	**IMPORTANTES INFORMATIONS DE SÉCURITÉ** **Ce symbole d'avertissement indique un danger. Vous vous trouvez dans une situation pouvant entraîner des blessures ou des dommages corporels. Avant de travailler sur un équipement, soyez conscient des dangers liés aux circuits électriques et familiarisez-vous avec les procédures couramment utilisées pour éviter les accidents. Pour prendre connaissance des traductions des avertissements figurant dans les consignes de sécurité traduites qui accompagnent cet appareil, référez-vous au numéro de l'instruction situé à la fin de chaque avertissement.** **CONSERVEZ CES INFORMATIONS**
Warnung	**WICHTIGE SICHERHEITSHINWEISE** **Dieses Warnsymbol bedeutet Gefahr. Sie befinden sich in einer Situation, die zu Verletzungen führen kann. Machen Sie sich vor der Arbeit mit Geräten mit den Gefahren elektrischer Schaltungen und den üblichen Verfahren zur Vorbeugung vor Unfällen vertraut. Suchen Sie mit der am Ende jeder Warnung angegebenen Anweisungsnummer nach der jeweiligen Übersetzung in den übersetzten Sicherheitshinweisen, die zusammen mit diesem Gerät ausgeliefert wurden.** **BEWAHREN SIE DIESE HINWEISE GUT AUF.**
Avvertenza	**IMPORTANTI ISTRUZIONI SULLA SICUREZZA** **Questo simbolo di avvertenza indica un pericolo. La situazione potrebbe causare infortuni alle persone. Prima di intervenire su qualsiasi apparecchiatura, occorre essere al corrente dei pericoli relativi ai circuiti elettrici e conoscere le procedure standard per la prevenzione di incidenti. Utilizzare il numero di istruzione presente alla fine di ciascuna avvertenza per individuare le traduzioni delle avvertenze riportate in questo documento.** **CONSERVARE QUESTE ISTRUZIONI**
Advarsel	**VIKTIGE SIKKERHETSINSTRUKSJONER** **Dette advarselssymbolet betyr fare. Du er i en situasjon som kan føre til skade på person. Før du begynner å arbeide med noe av utstyret, må du være oppmerksom på farene forbundet med elektriske kretser, og kjenne til standardprosedyrer for å forhindre ulykker. Bruk nummeret i slutten av hver advarsel for å finne oversettelsen i de oversatte sikkerhetsadvarslene som fulgte med denne enheten.** **TA VARE PÅ DISSE INSTRUKSJONENE**

Aviso	INSTRUÇÕES IMPORTANTES DE SEGURANÇA . Este símbolo de aviso significa perigo. Você está em uma situação que poderá ser causadora de lesões corporais. Antes de iniciar a utilização de qualquer equipamento, tenha conhecimento dos perigos envolvidos no manuseio de circuitos elétricos e familiarize-se com as práticas habituais de prevenção de acidentes. Utilize o número da instrução fornecido ao final de cada aviso para localizar sua tradução nos avisos de segurança traduzidos que acompanham este dispositivo GUARDE ESTAS INSTRUÇÕES
¡Advertencia!	INSTRUCCIONES IMPORTANTES DE SEGURIDAD Este símbolo de aviso indica peligro. Existe riesgo para su integridad física. Antes de manipular cualquier equipo, considere los riesgos de la corriente eléctrica y familiarícese con los procedimientos estándar de prevención de accidentes. Al final de cada advertencia encontrará el número que le ayudará a encontrar el texto traducido en el apartado de traducciones que acompaña a este dispositivo. GUARDE ESTAS INSTRUCCIONES
Varning!	VIKTIGA SÄKERHETSANVISNINGAR Denna varningssignal signalerar fara. Du befinner dig i en situation som kan leda till personskada. Innan du utför arbete på någon utrustning måste du vara medveten om farorna med elkretsar och känna till vanliga förfaranden för att förebygga olyckor. Använd det nummer som finns i slutet av varje varning för att hitta dess översättning i de översatta säkerhetsvarningar som medföljer denna anordning. SPARA DESSA ANVISNINGAR
Figyelem	FONTOS BIZTONSÁGI ELOÍRÁSOK Ez a figyelmezeto jel veszélyre utal. Sérülésveszélyt rejto helyzetben van. Mielott bármely berendezésen munkát végezte, legyen figyelemmel az elektromos áramkörök okozta kockázatokra, és ismerkedjen meg a szokásos balesetvédelmi eljárásokkal. A kiadványban szereplo figyelmeztetések fordítása a készülékhez mellékelt biztonsági figyelmeztetések között található; a fordítás az egyes figyelmeztetések végén látható szám alapján kereshető meg. ORIZZE MEG EZEKET AZ UTASÍTÁSOKAT!
Предупреждение	Для обеспечения соответствия требованиям по предельным значениям облучени радиочастотами (РЧ) антенны данного устройства должны располагаться на расс не ближе 2 м от пользователей.
警告	如果电源出现故障或中断，您将无法使用 Voice over IP (VoIP) 服务与紧急呼叫服务。电源恢复之后， 重新设置或重新配置设备，以便重新获得进入 VoIP 与紧急呼叫服务的权限。在美国，此紧急呼叫号码 您必须知道本国的紧急呼叫号码。
警告	電源障害や停電の場合、ボイス オーバー アイピー (VoIP) サービスと緊急呼出しサービスは機能しません。電源の回復後、VoIP と緊急呼出しサービスにアクセスするには機器をリセットまたは再設定する必要があります。米国内の緊急呼出し番号は 911 です。お住まいの地域の緊急呼出し番号をあらかじめ調べておいてください。