System Management Configuration Guide for Cisco NCS 540 Series Routers, IOS XR Release 6.5.x

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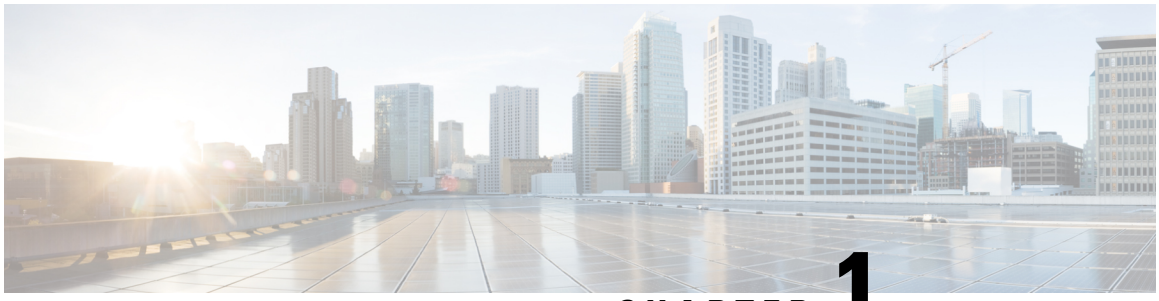


CHAPTER 1

Configuring Manageability

This module describes the configuration required to enable the Extensible Markup Language (XML) agent services. The XML Parser Infrastructure provides parsing and generation of XML documents with Document Object Model (DOM), Simple Application Programming Interface (API) for XML (SAX), and Document Type Definition (DTD) validation capabilities:

- DOM allows customers to programmatically create, manipulate, and generate XML documents.
- SAX supports user-defined functions for XML tags.
- DTD allows for validation of defined document types.

Information about XML Manageability

The Cisco IOS XR Extensible Markup Language (XML) API provides a programmable interface to the router for use by external management applications. This interface provides a mechanism for router configuration and monitoring utilizing XML formatted request and response streams. The XML interface is built on top of the Management Data API (MDA), which provides a mechanism for Cisco IOS XR components to publish their data models through MDA schema definition files.

Cisco IOS XR software provides the ability to access the router via XML using a dedicated TCP connection, Secure Socket Layer (SSL), or a specific VPN routing and forwarding (VRF) instance.

How to Configure Manageability

Configuring the XML Agent

This explains how to configure the XML agent.

Procedure

	Command or Action	Purpose
Step 1	**xml agent** [**ssl**] **Example:** `RP/0/(config)# xml agent ssl`	Enables Extensible Markup Language (XML) requests over a dedicated TCP connection and enters XML agent configuration mode. Use the **ssl** keyword to enable XML requests over Secure Socket Layer (SSL).
Step 2	**iteration on size** *iteration-size* **Example:** `RP/0/(config-xml-agent)# iteration on size 500`	Configures the iteration size for large XML agent responses in KBytes. The default is 48.
Step 3	**session timeout** *timeout* **Example:** `RP/0/(config-xml-agent)# session timeout 5`	Configures an idle timeout for the XML agent in minutes. By default, there is no timeout.
Step 4	**throttle** {**memory** *size* | **process-rate** *tags*} **Example:** `RP/0/(config-xml-agent)# throttle memory 300`	Configures the XML agent processing capabilities. • Specify the memory size in Mbytes. Values can range from 100 to 600. The default is 300. • Specify the process-rate as the number of tags that the XML agent can process per second. Values can range from 1000 to 30000. By default the process rate is not throttled.
Step 5	**vrf** { **vrfname** | **ipv4**} [**access-list** *access-list-name*] **Example:** `RP/0/(config-xml-agent)# vrf vrf1`	Configures the dedicated agent or SSL agent to receive and send messages via the specified VPN routing and forwarding (VRF) instance.

Configuration Examples for Manageability

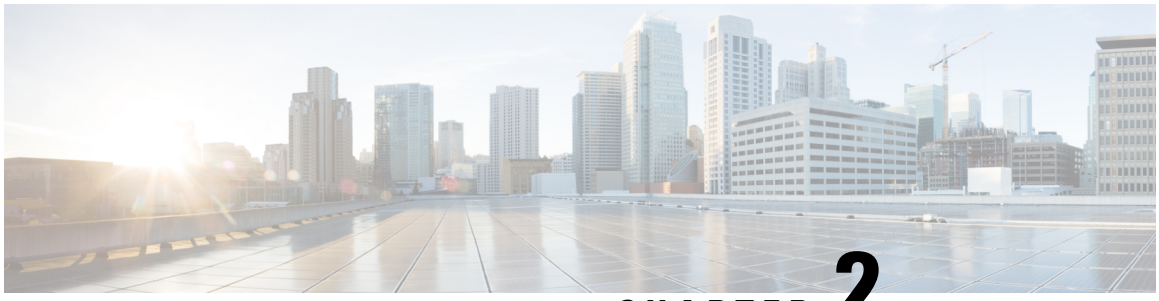
Enabling VRF on an XML Agent: Example

The following example shows how to configure the XML SSL agent to receive and send messages through VRF1, VRF2, and the default VRF:

```
RP/0/RP0/CPU0:router(config)# xml agent ssl
RP/0/RP0/CPU0:router(config-xml-ssl)# vrf VRF1
RP/0/RP0/CPU0:router(config-xml-ssl-vrf)# vrf VRF2
```

The following example removes access for VRF2 from the dedicated XML agent:

```
RP/0/RP0/CPU0:router(config)# xml agent ssl
RP/0/RP0/CPU0:router(config-xml-ssl)# no vrf VRF2
```



CHAPTER 2

Configuring Physical and Virtual Terminals

Line templates define standard attribute settings for incoming and outgoing transport over physical and virtual terminal lines (vtys). Vty pools are used to apply template settings to ranges of vtys.

This module describes the tasks you need to implement physical and virtual terminals on your Cisco IOS XR network.

Prerequisites for Implementing Physical and Virtual Terminals

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Information About Implementing Physical and Virtual Terminals

To implement physical and virtual terminals, you need to understand the concepts in this section.

Line Templates

The following line templates are available in the Cisco IOS XR software.

- Default line template—The default line template that applies to a physical and virtual terminal lines.
- Console line template—The line template that applies to the console line.
- User-defined line templates—User-defined line templates that can be applied to a range of virtual terminal lines.

Line Template Configuration Mode

Changes to line template attributes are made in line template configuration mode. To enter line template configuration mode, issue the **line** command from , specifying the template to be modified. These line templates can be configured with the **line** command:

- console—console template
- default—default template
- template—user-defined template

After you specify a template with the **line** command, the router enters line template configuration mode where you can set the terminal attributes for the specified line. This example shows how to specify the attributes for the console:

```
RP/0/(config)# line console
RP/0/(config-line)#
```

From line template configuration mode, use the online help feature (**?**) to view all available options. Some useful options include:

- absolute-timeout—Specifies a timeout value for line disconnection.
- escape-character—Changes the line escape character.
- exec-timeout—Specifies the EXEC timeout.
- length—Sets the number of lines displayed on the screen.
- session-limit—Specifies the allowable number of outgoing connections.
- session-timeout—Specifies an interval for closing the connection if there is no input traffic.
- timestamp—Displays the timestamp before each command.
- width—Specifies the width of the display terminal.

Note The *default* session-limit for line template is applicable to Telnet sessions only. It is not applicable for SSH sessions.

Line Template Guidelines

The following guidelines apply to modifying the console template and to configuring a user-defined template:

- Modify the templates for the physical terminal lines on the router (the console port) from line template configuration mode. Use the **line console** command from to enter line template configuration mode for the console template.
- Modify the template for virtual lines by configuring a user-defined template with the **line** *template-name* command, configuring the terminal attributes for the user-defined template from line template configuration, and applying the template to a range of virtual terminal lines using the **vty pool** command.

Note Before creating or modifying the vty pools, enable the telnet server using the **telnet server** command in . See Cisco IOS XR IP Addresses and Services Configuration Guide and Cisco IOS XR IP Addresses and Services Command Reference for more information.

Terminal Identification

The physical terminal lines for the console port is identified by its location, expressed in the format of *rack*/*slot*/*module* , on the active or standby route processor (RP) where the respective console port resides. For virtual terminals, physical location is not applicable; the Cisco IOS XR software assigns a vty identifier to vtys according to the order in which the vty connection has been established.

vty Pools

Each virtual line is a member of a pool of connections using a common line template configuration. Multiple vty pools may exist, each containing a defined number of vtys as configured in the vty pool. The Cisco IOS XR software supports the following vty pools by default:

- Default vty pool—The default vty pool consists of five vtys (vtys 0 through 4) that each reference the default line template.
- Default fault manager pool—The default fault manager pool consists of six vtys (vtys 100 through 105) that each reference the default line template.

In addition to the default vty pool and default fault manager pool, you can also configure a user-defined vty pool that can reference the default template or a user-defined template.

When configuring vty pools, follow these guidelines:

- The vty range for the default vty pool must start at vty 0 and must contain a minimum of five vtys.
- The vty range from 0 through 99 can reference the default vty pool.
- The vty range from 5 through 99 can reference a user-defined vty pool.
- The vty range from 100 is reserved for the fault manager vty pool.
- The vty range for fault manager vty pools must start at vty 100 and must contain a minimum of six vtys.
- A vty can be a member of only one vty pool. A vty pool configuration will fail if the vty pool includes a vty that is already in another pool.
- If you attempt to remove an active vty from the active vty pool when configuring a vty pool, the configuration for that vty pool will fail.

How to Implement Physical and Virtual Terminals on Cisco IOS XR Software

Modifying Templates

This task explains how to modify the terminal attributes for the console and default line templates. The terminal attributes that you set will modify the template settings for the specified template.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.

Step 2	**line** {**console** | **default**}
	Example:
	`RP/0/(config)# line console`
	or
	`RP/0/(config)# line default`
		Enters line template configuration mode for the specified line template.
		• **console** —Enters line template configuration mode for the console template.
		• **default** —Enters line template configuration mode for the default line template.

Step 3	Configure the terminal attribute settings for the specified template using the commands in line template configuration mode.	—

Step 4	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/(config-line)# end`
	or
	`RP/0/(config-line)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Creating and Modifying vty Pools

This task explains how to create and modify vty pools.

You can omit Step 3 to Step 5 (**line template** and **exit** commands) if you are configuring the default line template to reference a vty pool.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**telnet** {**ipv4** | **ipv6**} **server max-servers** *limit* **Example:** `RP/0/RP0/CPU0:router(config)# telnet ipv4 server max-servers 10`	Specifies the number of allowable Telnet servers. Up to 100 Telnet servers are allowed. **Note** By default no Telnet servers are allowed. You must configure this command in order to enable the use of Telnet servers.
Step 3	**line template** *template-name* **Example:** `RP/0/RP0/CPU0:router(config)# line template 1`	Enters line template configuration mode for a user-defined template.
Step 4	Configure the terminal attribute settings for the specified line template using the commands in line template configuration mode.	—
Step 5	**exit** **Example:** `RP/0/RP0/CPU0:router(config-line)# exit`	Exits line template configuration mode and returns the router to global configuration mode.

Step 6	**vty-pool** {**default** | *pool-name* | **eem**} *first-vty last-vty* [**line-template** {**default** | *template-name*}]
	Example:
	`RP/0/RP0/CPU0:router(config)#vty-pool default 0 5 line-template default`
	or
	`RP/0/RP0/CPU0:router(config)#vty-pool pool1 5 50 line-template template1`
	or
		Creates or modifies vty pools.
		• If you do not specify a line template with the **line-template** keyword, a vty pool defaults to the default line template.
		• **default** —Configures the default vty pool.
		  • The default vty pool must start at vty 0 and must contain a minimum of five vtys (vtys 0 through 4).
		  • You can resize the default vty pool by increasing the range of vtys that compose the default vty pool.

	Command or Action	Purpose

	`RP/0/RP0/CPU0:router(config)#vty-pool eem 100 105 line-template template1`
	
	`RP/0/RP0/CPU0:router(config)#vty-pool default 0 5 line-template template1`
		• *pool-name* —Creates a user-defined vty pool.
		  • A user-defined pool must start at least at vty 5, depending on whether the default vty pool has been resized.
		  • If the range of vtys for the default vty pool has been resized, use the first range value free from the default line template. For example, if the range of vtys for the default vty pool has been configured to include 10 vtys (vty 0 through 9), the range value for the user-defined vty pool must start with vty 10.
		• **eem** —Configures the embedded event manager pool.
		  • The default embedded event manager vty pool must start at vty 100 and must contain a minimum of six vtys (vtys 100 through 105).
		• **line-template** *template-name* —Configures the vty pool to reference a user-defined template.

Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Monitoring Terminals and Terminal Sessions

This task explains how to monitor terminals and terminal sessions using the **show** EXEC commands available for physical and terminal lines.

Note The commands can be entered in any order.

Procedure

	Command or Action	Purpose

Step 1	(Optional) **show line** [**aux location** *node-id* | **console location** *node-id* | **vty** *number*]
	Example:
	`RP/0/# show line`
		Displays the terminal parameters of terminal lines.
		• Specifying the **show line aux location** *node-id* EXEC command displays the terminal parameters of the auxiliary line.
		• Specifying the **show line console location** *node-id* EXEC command displays the terminal parameters of the console.
		  • For the **location** *node-id* keyword and argument, enter the location of the Route Processor (RP) on which the respective auxiliary or console port resides.
		  • The *node-id* argument is expressed in the format of *rack*/*slot*/*module* .
		• Specifying the **show line vty** *number* EXEC command displays the terminal parameters for the specified vty.

Step 2	(Optional) **show terminal** **Example:** `RP/0/# show terminal`	Displays the terminal attribute settings for the current terminal line.
Step 3	(Optional) **show users** **Example:** `RP/0/# show users`	Displays information about the active lines on the router.

Configuration Examples for Implementing Physical and Virtual Terminals

Modifying the Console Template: Example

This configuration example shows how to modify the terminal attribute settings for the console line template:

```
RP/0/RP0/CPU0:router# show running-config line console
line console
  exec-timeout 0 0
  escape-character 0x5a
  session-limit 10
  disconnect-character 0x59
  session-timeout 100
  transport input telnet
  transport output telnet
```

In this configuration example, the following terminal attributes are applied to the console line template:

- The EXEC time out for terminal sessions is set to 0 minutes, 0 seconds. Setting the EXEC timeout to 0 minutes and 0 seconds disables the EXEC timeout function; thus, the EXEC session for the terminal session will never time out.
- The escape character is set to the 0x5a hexadecimal value (the 0x5a hexadecimal value translates into the “Z” character).
- The session limit for outgoing terminal sessions is set to 10 connections.
- The disconnect character is set to 0x59 hexadecimal value (the 0x59 hexadecimal character translates into the “Y” character).
- The session time out for outgoing terminal sessions is set to 100 minutes (1 hour and 40 minutes).
- The allowed transport protocol for incoming terminal sessions is Telnet.
- The allowed transport protocol for outgoing terminal sessions is Telnet.

To verify that the terminal attributes for the console line template have been applied to the console, use the **show line** command:

```
RP/0/:router# show line console location 0/0/CPU0
Tue Nov 24 03:10:24.656 UTC
Tty             Speed     Overruns           Acc I/O
*con0/0/CPU0      9600       0/0               -/-

Line "con0_RP1_CPU0", Location "0/RP1/CPU0", Type "Console"
Length: 24 lines, Width: 80 columns
Baud rate (TX/RX) is 9600, "No" Parity, 2 stopbits, 8 databits
Template: console
Capabilities: Timestamp Enabled
Allowed transports are telnet.
```

Modifying the Default Template: Example

This configuration example shows how to override the terminal settings for the default line template:

```
line default
  exec-timeout 0 0
  width 512
  length 512
```

In this example, the following terminal attributes override the default line template default terminal attribute settings:

- The EXEC timeout for terminal sessions is set to 0 minutes and 0 seconds. Setting the EXEC timeout to 0 minutes and 0 seconds disables the EXEC timeout function; thus, the EXEC session for the terminal session will never time out (the default EXEC timeout for the default line template is 10 minutes).
- The width of the terminal screen for the terminals referencing the default template is set to 512 characters (the default width for the default line template is 80 characters).
- The length, the number of lines that will display at one time on the terminal referencing the default template, is set to 512 lines (the default length for the default line template is 24 lines).

Configuring a User-Defined Template to Reference the Default vty Pool: Example

This configuration example shows how to configure a user-defined line template (named test in this example) for vtys and to configure the line template test to reference the default vty pool:

```
line template test
  exec-timeout 100 0
  width 100
  length 100
  exit
vty-pool default 0 4 line-template test
```

Configuring a User-Defined Template to Reference a User-Defined vty Pool: Example

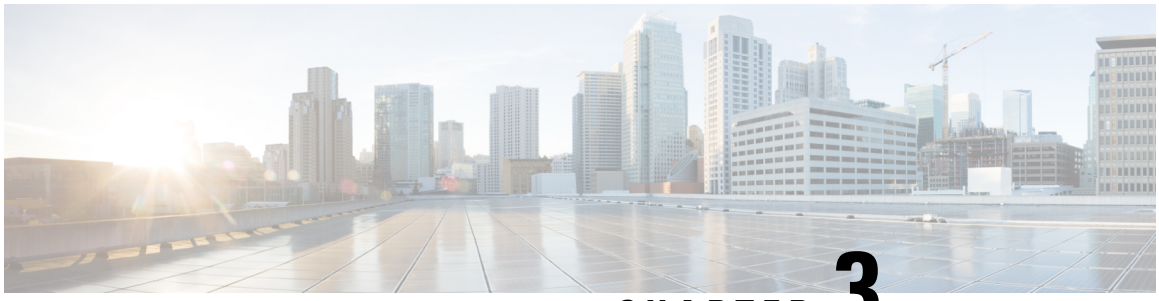
This configuration example shows how to configure a user-defined line template (named test2 in this example) for vtys and to configure the line template test to reference a user-defined vty pool (named pool1 in this example):

```
line template test2
  exec-timeout 0 0
  session-limit 10
  session-timeout 100
  transport input all
  transport output all
  exit
vty-pool pool1 5 50 line-template test2
```

Configuring a User-Defined Template to Reference the Fault Manager vty Pool: Example

This configuration example shows how to configure a user-defined line template (named test3 in this example) for vtys and to configure the line template test to reference the fault manager vty pool:

```
line template test3
  width 110
  length 100
  session-timeout 100
  exit
  vty-pool eem 100 105 line-template test3
```



CHAPTER 3

Configuring Simple Network Management Protocol

Simple Network Management Protocol (SNMP) is an application-layer protocol that provides a message format for communication between SNMP managers and agents. SNMP provides a standardized framework and a common language used for the monitoring and management of devices in a network.

This module describes the tasks you need to implement SNMP on your Cisco IOS XR network.

Prerequisites for Implementing SNMP

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Restrictions for SNMP use on Cisco IOS XR Software

SNMP outputs are only 32-bits wide and therefore cannot display any information greater than 2^{32}. 2^{32} is equal to 4.29 Gigabits.

Note A 10 Gigabit interface is greater than 2^{32}, so if you are trying to display speed information regarding the interface, you might see concatenated results.

To display correct speed of an interface greater than 10 Gigabit, ifHighSpeed can be used.

The recommended maximum number of object identifiers (OIDs) that can be accommodated in a single SNMP request is 75. A request with more than 75 OIDs can result in SNMP requests being dropped with SNMP polling timeout.

Information about Implementing SNMP

To implement SNMP, you need to understand the concepts described in this section.

SNMP Functional Overview

The SNMP framework consists of three parts:

- SNMP manager
- SNMP agent
- Management Information Base (MIB)

SNMP Manager

The SNMP manager is the system used to control and monitor the activities of network hosts using SNMP. The most common managing system is called a *network management system* (NMS). The term NMS can be applied to either a dedicated device used for network management, or the applications used on such a device. A variety of network management applications are available for use with SNMP. These features range from simple command-line applications to feature-rich graphical user interfaces (such as the CiscoWorks 2000 line of products).

SNMP Agent

The SNMP agent is the software component within the managed device that maintains the data for the device and reports these data, as needed, to managing systems. The agent and MIB reside on the router. To enable the SNMP agent, you must define the relationship between the manager and the agent.

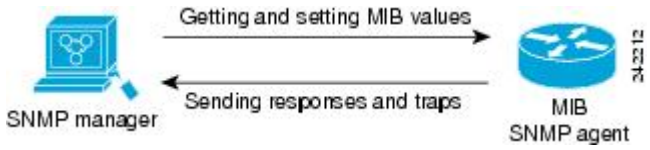
MIB

The *Management Information Base* (MIB) is a virtual information storage area for network management information, which consists of collections of managed objects. Within the MIB there are collections of related objects, defined in MIB modules. MIB modules are written in the SNMP MIB module language, as defined in STD 58, RFC 2578, RFC 2579, and RFC 2580. Note that individual MIB modules are also referred to as MIBs; for example, the Interfaces Group MIB (IF-MIB) is a MIB module within the MIB on your system.

The SNMP agent contains MIB variables whose values the SNMP manager can request or change through Get or Set operations. A manager can get a value from an agent or store a value into that agent. The agent gathers data from the MIB, the repository for information about device parameters and network data. The agent can also respond to manager requests to get or set data.

This figure illustrates the communications relationship between the SNMP manager and agent. A manager can send the agent requests to get and set MIB values. The agent can respond to these requests. Independent of this interaction, the agent can send unsolicited notifications (traps) to the manager to notify the manager of network conditions.

Figure 1: Communication Between an SNMP Agent and Manager



SNMP Versions

Cisco IOS XR software supports the following versions of SNMP:

- Simple Network Management Protocol Version 1 (SNMPv1)
- Simple Network Management Protocol Version 2c (SNMPv2c)
- Simple Network Management Protocol Version 3 (SNMPv3)

Both SNMPv1 and SNMPv2c use a community-based form of security. The community of managers able to access the agent MIB is defined by an IP address access control list and password.

SNMPv2c support includes a bulk retrieval mechanism and more detailed error message reporting to management stations. The bulk retrieval mechanism supports the retrieval of tables and large quantities of information, minimizing the number of round-trips required. The SNMPv2c improved error handling support 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 now report the error type. Three kinds of exceptions are also reported: no such object exceptions, no such instance exceptions, and end of MIB view exceptions.

SNMPv3 is a security model. A *security model* is an authentication strategy that is set up for a user and the group in which the user resides. A *security level* is the permitted level of security within a security model. A combination of a security model and a security level will determine which security mechanism is employed when an SNMP packet is handled. See Security Models and Levels for SNMPv1, v2, v3, on page 18 for a list of security levels available in SNMPv3. The SNMPv3 feature supports RFCs 3411 to 3418.

You must configure the SNMP agent to use the version of SNMP supported by the management station. An agent can communicate with multiple managers; for this reason, you can configure the Cisco IOS-XR software to support communications with one management station using the SNMPv1 protocol, one using the SNMPv2c protocol, and another using SMNPv3.

Comparison of SNMPv1, v2c, and v3

SNMP v1, v2c, and v3 all support the following operations:

- get-request—Retrieves a value from a specific variable.
- get-next-request—Retrieves the value following the named variable; this operation is often used to retrieve variables from within a table. With this operation, an SNMP manager does not need to know the exact variable name. The SNMP manager searches sequentially to find the needed variable from within the MIB.
- get-response—Operation that replies to a get-request, get-next-request, and set-request sent by an NMS.
- set-request—Operation that stores a value in a specific variable.
- trap—Unsolicited message sent by an SNMP agent to an SNMP manager when some event has occurred.

This table identifies other key SNMP features supported by the SNMP v1, v2c, and v3.

Table 1: SNMPv1, v2c, and v3 Feature Support

Feature	SNMP v1	SNMP v2c	SNMP v3
Get-Bulk Operation	No	Yes	Yes

Feature	SNMP v1	SNMP v2c	SNMP v3
Inform Operation	No	Yes (No on the Cisco IOS XR software)	Yes (No on the Cisco IOS XR software)
64 Bit Counter	No	Yes	Yes
Textual Conventions	No	Yes	Yes
Authentication	No	No	Yes
Privacy (Encryption)	No	No	Yes
Authorization and Access Controls (Views)	No	No	Yes

Security Models and Levels for SNMPv1, v2, v3

The security level determines if an SNMP message needs to be protected from disclosure and if the message needs to be authenticated. The various security levels that exist within a security model are as follows:

- noAuthNoPriv—Security level that does not provide authentication or encryption.
- authNoPriv—Security level that provides authentication but does not provide encryption.
- authPriv—Security level that provides both authentication and encryption.

Three security models are available: SNMPv1, SNMPv2c, and SNMPv3. The security model combined with the security level determine the security mechanism applied when the SNMP message is processed.

The below table identifies what the combinations of security models and levels mean.

Table 2: SNMP Security Models and Levels

Model	Level	Authentication	Encryption	What Happens
v1	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
v2c	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
v3	noAuthNoPriv	Username	No	Uses a username match for authentication.
v3	authNoPriv	HMAC-MD5 or HMAC-SHA	No	Provides authentication based on the HMAC[1]-MD5[2] algorithm or the HMAC-SHA[3].
v3	authPriv	HMAC-MD5 or HMAC-SHA	DES	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms. Provides DES[4] 56-bit encryption in addition to authentication based on the CBC[5] DES (DES-56) standard.

Model	Level	Authentication	Encryption	What Happens
v3	authPriv	HMAC-MD5 or HMAC-SHA	3DES	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms. Provides 168-bit 3DES[6] level of encryption.
v3	authPriv	HMAC-MD5 or HMAC-SHA	AES	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms. Provides 128-bit AES[7] level of encryption.

1 Hash-Based Message Authentication Code
2 Message Digest 5
3 Secure Hash Algorithm
4 Data Encryption Standard
5 Cipher Block Chaining
6 Triple Data Encryption Standard
7 Advanced Encryption Standard

Use of 3DES and AES encryption standards requires that the security package (k9sec) be installed. For information on installing software packages, see *Upgrading and Managing Cisco IOS XR Software*.

SNMPv3 Benefits

SNMPv3 provides secure access to devices by providing authentication, encryption and access control. These added security benefits secure SNMP against the following security threats:

- Masquerade—The threat that an SNMP user may assume the identity of another SNMP user to perform management operations for which that SNMP user does not have authorization.
- Message stream modification—The threat that messages may be maliciously reordered, delayed, or replayed (to an extent that is greater than can occur through the natural operation of a subnetwork service) to cause SNMP to perform unauthorized management operations.
- Disclosure—The threat that exchanges between SNMP engines could be eavesdropped. Protecting against this threat may be required as a matter of local policy.

In addition, SNMPv3 provides access control over protocol operations on SNMP managed objects.

SNMPv3 Costs

SNMPv3 authentication and encryption contribute to a slight increase in the response time when SNMP operations on MIB objects are performed. This cost is far outweighed by the security advantages provided by SNMPv3.

This table shows the order of response time (from least to greatest) for the various security model and security level combinations.

Table 3: Order of Response Times from Least to Greatest

Security Model	Security Level
SNMPv2c	noAuthNoPriv
SNMPv3	noAuthNoPriv

Security Model	Security Level
SNMPv3	authNoPriv
SNMPv3	authPriv

User-Based Security Model

SNMPv3 User-Based Security Model (USM) refers to SNMP message-level security and offers the following services:

- Message integrity—Ensures that messages have not been altered or destroyed in an unauthorized manner and that data sequences have not been altered to an extent greater than can occur nonmaliciously.
- Message origin authentication—Ensures that the claimed identity of the user on whose behalf received data was originated is confirmed.
- Message confidentiality—Ensures that information is not made available or disclosed to unauthorized individuals, entities, or processes.

SNMPv3 authorizes management operations only by configured users and encrypts SNMP messages.

USM uses two authentication protocols:

- HMAC-MD5-96 authentication protocol
- HMAC-SHA-96 authentication protocol

USM uses Cipher Block Chaining (CBC)-DES (DES-56) as the privacy protocol for message encryption.

View-Based Access Control Model

The View-Based Access Control Model (VACM) enables SNMP users to control access to SNMP managed objects by supplying read, write, or notify access to SNMP objects. It prevents access to objects restricted by views. These access policies can be set when user groups are configured with the **snmp-server group** command.

MIB Views

For security reasons, it is often valuable to be able to restrict the access rights of some groups to only a subset of the management information within the management domain. To provide this capability, access to a management object is controlled through MIB views, which contain the set of managed object types (and, optionally, the specific instances of object types) that can be viewed.

Access Policy

Access policy determines the access rights of a group. The three types of access rights are as follows:

- read-view access—The set of object instances authorized for the group when objects are read.
- write-view access—The set of object instances authorized for the group when objects are written.
- notify-view access—The set of object instances authorized for the group when objects are sent in a notification.

IP Precedence and DSCP Support for SNMP

SNMP IP Precedence and differentiated services code point (DSCP) support delivers QoS specifically for SNMP traffic. You can change the priority setting so that SNMP traffic generated in a router is assigned a specific QoS class. The IP Precedence or IP DSCP code point value is used to determine how packets are handled in weighted random early detection (WRED).

After the IP Precedence or DSCP is set for the SNMP traffic generated in a router, different QoS classes cannot be assigned to different types of SNMP traffic in that router.

The IP Precedence value is the first three bits in the type of service (ToS) byte of an IP header. The IP DSCP code point value is the first six bits of the differentiate services (DiffServ Field) byte. You can configure up to eight different IP Precedence markings or 64 different IP DSCP markings.

Session MIB support on subscriber sessions

SNMP monitoring requires information about subscribers of all types. The CISCO-SUBSCRIBER-SESSION-MIB is defined to model per-subscriber data as well as aggregate subscriber (PPPoE) data. It is required to support notifications (traps) for aggregate session counts crossing configured thresholds. Generic MIB Data Collector Manager (DCM) support for CISCO-SUBSCRIBER-SESSION-MIB, helps faster data collection and also better handling of parallel data.

SNMP Notifications

A key feature of SNMP is the ability to generate notifications from an SNMP agent. These notifications do not require that requests be sent from the SNMP manager. On Cisco IOS XR software, unsolicited (asynchronous) notifications can be generated only as *traps*. Traps are messages alerting the SNMP manager to a condition on the network. Notifications can indicate improper user authentication, restarts, the closing of a connection, loss of connection to a neighbor router, or other significant events.

Note Inform requests (inform operations) are supported in Cisco IOS XR software.

Traps are less reliable than informs because the receiver does not send any acknowledgment when it receives a trap. The sender cannot determine if the trap was received. An SNMP manager that receives an inform request acknowledges the message with an SNMP response protocol data unit (PDU). If the manager does not receive an inform request, it does not send a response. If the sender never receives a response, the inform request can be sent again. Thus, informs are more likely to reach their intended destination.

However, traps are often preferred because informs consume more resources in the router and in the network. Unlike a trap, which is discarded as soon as it is sent, an inform request must be held in memory until a response is received or the request times out. Also, traps are sent only once, and an inform may be retried several times. The retries increase traffic and contribute to a higher overhead on the network. Thus, traps and inform requests provide a trade-off between reliability and resources.

Figure 2: Trap Received by the SNMP Manager

In this illustration, the agent router sends a trap to the SNMP manager. Although the manager receives the trap, it does not send any acknowledgment to the agent. The agent has no way of knowing that the trap reached its destination.

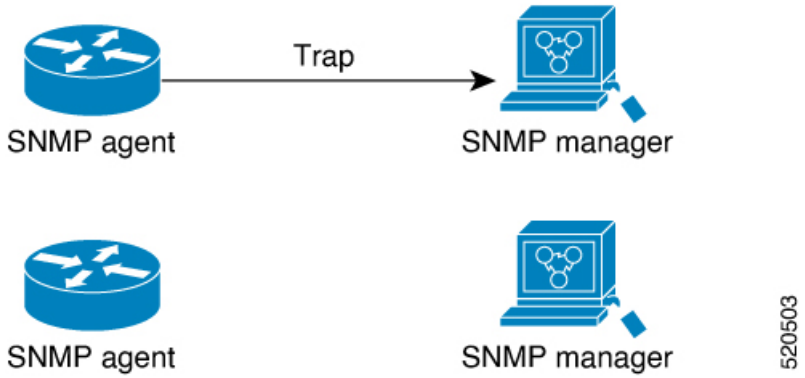
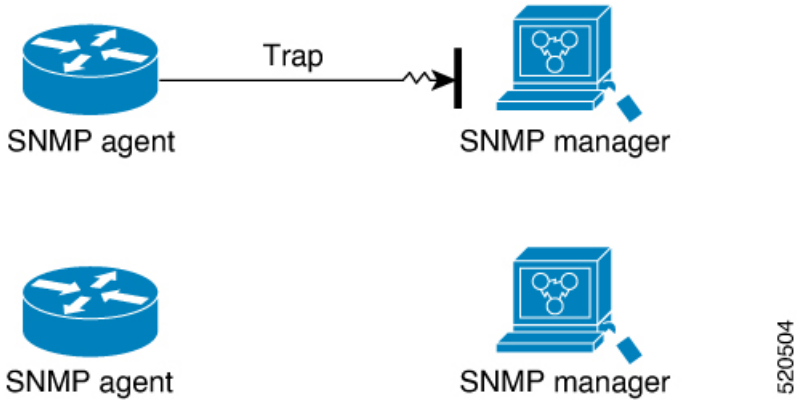


Figure 3: Trap Not Received by the SNMP Manager

In this illustration, the agent sends a trap to the manager, but the trap does not reach the manager. Because the agent has no way of knowing that the trap did not reach its destination, the trap is not sent again. The manager never receives the trap.



Session Types

The supported session types are:

- PPPoE
- IP SUB PKT
- IP SUB DHCP

How to Implement SNMP on Cisco IOS XR Software

This section describes how to implement SNMP.

The **snmp-server** commands enable SNMP on Management Ethernet interfaces by default. For information on how to enable SNMP server support on other inband interfaces, see the *Implementing Management Plane Protection on Cisco IOS XR Software* module in .

Configuring SNMPv3

This task explains how to configure SNMPv3 for network management and monitoring.

Note No specific command enables SNMPv3; the first **snmp-server** global configuration command (config), that you issue enables SNMPv3. Therefore, the sequence in which you issue the **snmp-server** commands for this task does not matter.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	(Optional) **snmp-server engineid local** *engine-id* **Example:** `RP/0/(config)# snmp-server engineID local 00:00:00:09:00:00:00:a1:61:6c:20:61`	Specifies the identification number of the local SNMP engine.
Step 3	**snmp-server view** *view-name oid-tree* {**included** | **excluded**} **Example:** `RP/0/(config)# snmp-server view view_name 1.3.6.1.2.1.1.5 included`	Creates or modifies a view record.
Step 4	**snmp-server group** *name* {**v1** | **v2c** | **v3** {**auth** | **noauth** | **priv**}} [**read** *view*] [**write** *view*] [**notify** *view*] [*access-list-name*] **Example:** `RP/0/(config)# snmp-server group group_name v3 noauth read view_name1 write view_name2`	Configures a new SNMP group or a table that maps SNMP users to SNMP views.
Step 5	**snmp-server user** *username groupname* {**v1** | **v2c** | **v3** [**auth** {**md5** | **sha**} {**clear** | **encrypted**} *auth-password* [**priv des56** {**clear**	Configures a new user to an SNMP group.

	Command or Action	Purpose
	| **encrypted**} *priv-password*]]} [*access-list-name*] **Example:** `RP/0/(config)# snmp-server user noauthuser group_name v3`	
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.
Step 7	(Optional) **show snmp** **Example:** `RP/0/# show snmp`	Displays information about the status of SNMP.
Step 8	(Optional) **show snmp engineid** **Example:** `RP/0/# show snmp engineid`	Displays information about the local SNMP engine.
Step 9	(Optional) **show snmp group** **Example:** `RP/0/# show snmp group`	Displays information about each SNMP group on the network.
Step 10	(Optional) **show snmp users** **Example:** `RP/0/# show snmp users`	Displays information about each SNMP username in the SNMP users table.
Step 11	(Optional) **show snmp view** **Example:** `RP/0/# show snmp view`	Displays information about the configured views, including the associated MIB view family name, storage type, and status.

Configuring SNMPv3: Examples

Setting an Engine ID

This example shows how to set the identification of the local SNMP engine:

```
config
snmp-server engineID local 00:00:00:09:00:00:00:a1:61:6c:20:61
```

Note After the engine ID has been configured, the SNMP agent restarts.

Verifying the Identification of the Local SNMP Engines

This example shows how to verify the identification of the local SNMP engine:

```
show snmp engineid

SNMP engineID 00000009000000a1ffffffff
```

Creating a View

There are two ways to create a view:

- You can include the object identifier (OID) of an ASN.1 subtree of a MIB family from a view by using the **included** keyword of the **snmp-server view** command.
- You can exclude the OID subtree of the ASN.1 subtree of a MIB family from a view by using the **excluded** keyword of the **snmp-server view** command.

This example shows how to create a view that includes the sysName (1.3.6.1.2.1.1.5) object:

```
config
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1.5 included
```

This example shows how to create a view that includes all the OIDs of a system group:

```
config
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1 included
```

This example shows how to create a view that includes all the OIDs under the system group except the sysName object (1.3.6.1.2.1.1.5), which has been excluded:

```
config
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1 included
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1.5 excluded
```

Verifying Configured Views

This example shows how to display information about the configured views:

```
RP/0/# show snmp view

  v1default 1.3.6.1 - included nonVolatile active
  SNMP_VIEW1 1.3.6.1.2.1.1 - included nonVolatile active
  SNMP_VIEW1 1.3.6.1.2.1.1.5 - excluded nonVolatile active
```

Creating Groups

If you do not explicitly specify a notify, read, or write view, the Cisco IOS XR software uses the v1 default (1.3.6.1). This example shows how to create a group that utilizes the default view:

```
RP/0/# snmp-server group group-name v3 auth
```

The following configuration example shows how to create a group that has read access to all the OIDs in the system except the sysUpTime object (1.3.6.1.2.1.1.3), which has been excluded from the view applied to the group, but write access only to the sysName object (1.3.6.1.2.1.1.5):

```
!
  snmp-server view view_name1 1.3.6.1.2.1.1 included
  snmp-server view view_name1 1.3.6.1.2.1.1.3 excluded
  snmp-server view view_name2 1.3.6.1.2.1.1.5 included
  snmp-server group group_name1 v3 auth read view_name1 write view_name2
  !
```

Verifying Groups

This example shows how to verify the attributes of configured groups:

```
RP/0/# show snmp group

  groupname: group_name1                  security model:usm
  readview : view_name1                   writeview: view_name2
  notifyview: v1default
  row status: nonVolatile
```

Creating and Verifying Users

Given the following SNMPv3 view and SNMPv3 group configuration:

```
!
  snmp-server view view_name 1.3.6.1.2.1.1 included
  snmp-server group group_name v3 noauth read view_name write view-name
  !
```

This example shows how to create a noAuthNoPriv user with read and write view access to a system group:

```
config
  snmp-server user noauthuser group_name v3
```

Note The user must belong to a noauth group before a noAuthNoPriv user can be created.

This example shows how to verify the attributes that apply to the SNMP user:

```
RP/0/# show snmp user

  User name: noauthuser
  Engine ID: localSnmpID
  storage-type: nonvolatile active
```

Given the following SNMPv3 view and SNMPv3 group configuration:

```
!
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1 included
  snmp-server group SNMP_GROUP1 v3 auth notify SNMP_VIEW1 read SNMP_VIEW1 write SNMP_VIEW1
 !
```

This example shows how to create a user with authentication (including encryption), read, and write view access to a system group:

```
config
  snmp-server user userv3authpriv SNMP_GROUP1 v3 auth md5 password123 priv aes 128 password123
```

Given the following SNMPv3 view and SNMPv3 group configuration:

```
!
  snmp-server view view_name 1.3.6.1.2.1.1 included
  snmp group group_name v3 priv read view_name write view_name
  !
```

This example shows how to create authNoPriv user with read and write view access to a system group:

```
RP/0/# snmp-server user authuser group_name v3 auth md5 clear auth_passwd
```

Note Because the group is configured at a security level of Auth, the user must be configured as "auth" at a minimum to access this group ("priv" users could also access this group). The authNoPriv user configured in this group, authuser, must supply an authentication password to access the view. In the example, auth_passwd is set as the authentication password string. Note that **clear** keyword is specified before the auth_passwd password string. The **clear** keyword indicates that the password string being supplied is unencrypted.

This example shows how to verify the attributes that apply to SNMP user:

```
RP/0/# show snmp user

  User name: authuser
  Engine ID: localSnmpID
  storage-type: nonvolatile active
```

Given the following SNMPv3 view and SNMPv3 group configuration:

```
!
  snmp view view_name 1.3.6.1.2.1.1 included
  snmp group group_name v3 priv read view_name write view_name
  !
```

This example shows how to create an authPriv user with read and write view access to a system group:

```
config
  snmp-server user privuser group_name v3 auth md5 clear auth_passwd priv des56 clear
priv_passwd
```

Note Because the group has a security level of Priv, the user must be configured as a "priv" user to access this group. In this example, the user, privuser, must supply both an authentication password and privacy password to access the OIDs in the view.

This example shows how to verify the attributes that apply to the SNMP user:

```
RP/0/# show snmp user

  User name: privuser
  Engine ID: localSnmpID
  storage-type: nonvolatile active
```

Configuring SNMP Trap Notifications

This task explains how to configure the router to send SNMP trap notifications.

Note You can omit #unique_45 if you have already completed the steps documented under the #unique_45 task.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**snmp-server group** *name* {**v1 v2 v3** {**auth** | **noauth** | **priv**}} [**read** *view*] **write** *view*] [**notify** *view*] [*access-list-name*] **Example:** `RP/0/(config)# snmp-server group group_name v3 noauth read view_name1 writer view_name2`	Configures a new SNMP group or a table that maps SNMP users to SNMP views.
Step 3	**snmp-server user** *username groupname* {**v1 v2c v3** {**auth** | **md5** | **sha**} {**clear** | **encrypted**} *auth-password*] [**priv des56** {**clear** | *access-list-name*] **Example:** `RP/0/(config)# snmp-server group group_name v3 noauth read view_name1 writer view_name2`	Configures a new SNMP group or a table that maps SNMP users to SNMP views.
Step 4	[**snmp-server host** *address* [**traps**] [**version** {**1** | **2c** | **3** [**auth** | **priv**]}] *community-string* [**udp-port** *port*] [*notification-type*] **Example:** `RP/0/(config)# snmp-server host 12.26.25.61 traps version 3 noauth userV3noauth`	Specifies SNMP trap notifications, the version of SNMP to use, the security level of the notifications, and the recipient (host) of the notifications.
Step 5	**snmp-server traps** [*notification-type*] **Example:** `RP/0/(config)# snmp-server traps bgp`	Enables the sending of trap notifications and specifies the type of trap notifications to be sent. • If a trap is not specified with the *notification-type* argument, all supported trap notifications are enabled on the router. To display which trap notifications are available on your router, enter the **snmp-server traps ?** command.
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session.

	Command or Action	Purpose
		end —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.
Step 7	(Optional) **show snmp host** **Example:** `RP/0/# show snmp host`	Displays information about the configured SNMP notification recipient (host), port number, and security model.

Configuring Trap Notifications: Example

The following example configures an SNMP agent to send out different types of traps. The configuration includes a v2c user, a noAuthNoPriv user, anauthNoPriv user, and an AuthPriv user.

Note The default User Datagram Protocol (UDP) port is 161. If you do not a specify a UDP port with the **udp-port** keyword and *port* argument, then the configured SNMP trap notifications are sent to port 161.

```
!
  snmp-server host 10.50.32.170 version 2c public udp-port 2345
  snmp-server host 10.50.32.170 version 3 auth userV3auth udp-port 2345
  snmp-server host 10.50.32.170 version 3 priv userV3priv udp-port 2345
  snmp-server host 10.50.32.170 version 3 noauth userV3noauth udp-port 2345
  snmp-server user userv2c groupv2c v2c
  snmp-server user userV3auth groupV3auth v3 auth md5 encrypted 140F0A13
 snmp-server user userV3priv groupV3priv v3 auth md5 encrypted 021E1C43 priv des56 encrypted
1110001C
  snmp-server user userV3noauth groupV3noauth v3 LROwner
  snmp-server view view_name 1.3 included
  snmp-server community public RW
  snmp-server group groupv2c v2c read view_name
  snmp-server group groupV3auth v3 auth read view_name
  snmp-server group groupV3priv v3 priv read view_name
  snmp-server group groupV3noauth v3 noauth read view_name
  !
```

In the following example, the output of the **show snmp host** commaand shows how to verify the configuration SNMP trap notification recipients host, the recipients of SNMP trap notifications. The output displays the following information:

- IP address of the configured notification host
- UDP port where SNMP notification messages are sent
- Type of trap configured
- Security level of the configured user
- Security model configured

```
Notification host: 10.50.32.170 udp-port: 2345 type: trap
user: userV3auth security model: v3 auth

Notification host: 10.50.32.170 udp-port: 2345 type: trap
user: userV3noauth security model: v3 noauth

Notification host: 10.50.32.170 udp-port: 2345 type: trap
user: userV3priv security model: v3 priv

Notification host: 10.50.32.170 udp-port: 2345 type: trap
user: userv2c security model: v2c
```

Setting the Contact, Location, and Serial Number of the SNMP Agent

This task explains how to set the system contact string, system location string, and system serial number of the SNMP agent.

Note The sequence in which you issue the **snmp-server** commands for this task does not matter.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	(Optional) **snmp-server contact** *system-contact-string* **Example:** `RP/0/(config)# snmp-server contact Dial System Operator at beeper # 27345`	Sets the system contact string.
Step 3	(Optional) **snmp-server location** *system-location* **Example:**	Sets the system location string.

	Command or Action	Purpose
	`RP/0/(config)# snmp-server location Building 3/Room 214`	
Step 4	(Optional) **snmp-server chassis-id** *serial-number* **Example:** `RP/0/(config)# snmp-server chassis-id 1234456`	Sets the system serial number.
Step 5	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Defining the Maximum SNMP Agent Packet Size

This task shows how to configure the largest SNMP packet size permitted when the SNMP server is receiving a request or generating a reply.

Note The sequence in which you issue the **snmp-server** commands for this task does not matter.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	(Optional) **snmp-server packetsize** *byte-count* **Example:** `RP/0/(config)# snmp-server packetsize 1024`	Sets the maximum packet size.

	Command or Action	Purpose
Step 3	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Changing Notification Operation Values

After SNMP notifications have been enabled, you can specify a value other than the default for the source interface, message queue length, or retransmission interval.

This task explains how to specify a source interface for trap notifications, the message queue length for each host, and the retransmission interval.

Note The sequence in which you issue the **snmp-server** commands for this task does not matter.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	(Optional) **snmp-server trap-source** *type interface-path-id* **Example:** `RP/0/(config)# snmp-server trap-source POS 0/0/1/0`	Specifies a source interface for trap notifications.
Step 3	(Optional) **snmp-server queue-length** *length* **Example:** `RP/0/(config)# snmp-server queue-length 20`	Establishes the message queue length for each notification.

	Command or Action	Purpose
Step 4	(Optional) **snmp-server trap-timeout** *seconds* **Example:** `RP/0/(config)# snmp-server trap-timeout 20`	Defines how often to resend notifications on the retransmission queue.
Step 5	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Setting IP Precedence and DSCP Values

This task describes how to configure IP Precedence or IP DSCP for SNMP traffic.

Before you begin

SNMP must be configured.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	Use one of the following commands: • **snmp-server ipv4 precedence** *value* • **snmp-server ipv4 dscp** *value* **Example:** `RP/0/(config)# snmp-server dscp 24`	Configures an IP precedence or IP DSCP value for SNMP traffic.
Step 3	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions:

	Command or Action	Purpose
		• **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Setting an IP Precedence Value for SNMP Traffic: Example

The following example shows how to set the SNMP IP Precedence value to 7:

```
configure
  snmp-server ipv4 precedence 7
  exit

  Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]: y
```

Setting an IP DSCP Value for SNMP Traffic: Example

The following example shows how to set the IP DSCP value of SNMP traffic to 45:

```
configure
  snmp-server ipv4 dscp 45
  exit

  Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]: y
```

Displaying SNMP Context Mapping

The SNMP agent serves queries based on SNMP contexts created by the client features. There is a context mapping table. Each entry in the context mapping table includes a context name, the name of the feature that created the context, and the name of the specific instance of the feature.

Procedure

	Command or Action	Purpose
Step 1	**show snmp context-mapping** **Example:** `RP/0/# show snmp context-mapping`	Displays the SNMP context mapping table.

Monitoring Packet Loss

It is possible to monitor packet loss by configuring the generation of SNMP traps when packet loss exceeds a specified threshold. The configuration described in this task enables the creation of entries in the MIB tables of the EVENT-MIB. This can then be monitored for packet loss using SNMP GET operations.

Before you begin

Note Entries created in the EVENT-MIB MIB tables using the configuration described in this task cannot be altered using an SNMP SET.

Entries to the EVENT-MIB MIB tables created using an SNMP SET cannot be altered using the configuration described in this task.

Procedure

	Command or Action	Purpose
Step 1	**snmp-server mibs eventmib packet-loss** *type interface-path-id* **falling** *lower-threshold* **interval** *sampling-interval* **rising** *upper-threshold* **Example:** `RP/0/(config)# snmp-server mibs eventmib packet-loss falling 1 interval 5 rising 2`	Generates SNMP EVENT-MIB traps for the interface when the packet loss exceeds the specified thresholds. Up to 100 interfaces can be monitored. **falling** *lower-threshold* —Specifies the lower threshold. When packet loss between two intervals falls below this threshold and an mteTriggerRising trap was generated previously, a SNMP mteTriggerFalling trap is generated. This trap is not generated until the packet loss exceeds the upper threshold and then falls back below the lower threshold. **interval** *sampling-interval* —Specifies how often packet loss statistics are polled. This is a value between 5 and 1440 minutes, in multiples of 5. **rising** *upper-threshold* —Specifies the upper threshold. When packet loss between two intervals increases above this threshold, an SNMP mteTriggreRising trap is generated. This trap is not generated until the packet loss drops below the lower threshold and then rises above the upper threshold.

Configuring MIB Data to be Persistent

Many SNMP MIB definitions define arbitrary 32-bit indices for their object tables. MIB implementations often do a mapping from the MIB indices to some internal data structure that is keyed by some other set of data. In these MIB tables the data contained in the table are often other identifiers of the element being

modelled. For example, in the ENTITY-MIB, entries in the entPhysicalTable are indexed by the 31-bit value, entPhysicalIndex, but the entities could also be identified by the entPhysicalName or a combination of the other objects in the table.

Because of the size of some MIB tables, significant processing is required to discover all the mappings from the 32-bit MIB indices to the other data which the network management station identifies the entry. For this reason, it may be necessary for some MIB indices to be persistent across process restarts, switchovers, or device reloads. The ENTITY-MIB entPhysicalTable and CISCO-CLASS-BASED-QOS-MIB are two such MIBs that often require index values to be persistent.

Also, because of query response times and CPU utilization during CISCO-CLASS-BASED-QOS-MIB statistics queries, it is desirable to cache service policy statistics.

Procedure

	Command or Action	Purpose
Step 1	(Optional) **snmp-server entityindex persist** **Example:** `RP/0/(config)# snmp-server entityindex persist`	Enables the persistent storage of ENTITY-MIB data.
Step 2	(Optional) **snmp-server mibs cbqosmib persist** **Example:** `RP/0/(config)# snmp-server mibs cbqosmib persist`	Enables persistent storage of the CISCO-CLASS-BASED-QOS-MIB data.
Step 3	(Optional) **snmp-server cbqosmib cache refresh time** *time* **Example:** `RP/0/(config)# snmp-server mibs cbqosmib cache refresh time 45`	Enables QoS MIB caching with a specified cache refresh time.
Step 4	(Optional) **snmp-server cbqosmib cache service-policy count** *count* **Example:** `RP/0/(config)# snmp-server mibs cbqosmib cache service-policy count 50`	Enables QoS MIB caching with a limited number of service policies to cache.
Step 5	**snmp-server ifindex persist** **Example:** `RP/0/(config)# snmp-server ifindex persist`	Enables ifIndex persistence globally on all Simple Network Management Protocol (SNMP) interfaces.

Configuring LinkUp and LinkDown Traps for a Subset of Interfaces

By specifying a regular expression to represent the interfaces for which you are interested in setting traps, you can enable or disable linkUp and linkDown traps for a large number of interfaces simultaneously.

Before you begin

SNMP must be configured.

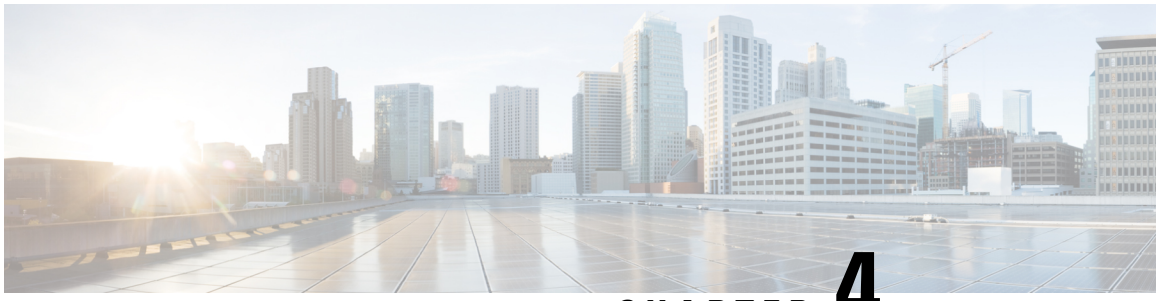
Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.

Step 2	**snmp-server interface subset** *subset-number* **regular-expression** *expression*
	Example:
	`RP/0/(config)# snmp-server interface subset 10 regular-expression "^Gig[a-zA-Z]+[0-9/]+\."`
	`RP/0/(config-snmp-if-subset)#`
		Enters snmp-server interface mode for the interfaces identified by the regular expression.
		The subset-number argument identifies the set of interfaces, and also assigns a priority to the subset in the event that an interface is included in more than one subset. Lower numbers have higher priority and their configuration takes precedent over interface subsets with higher numbers.
		The *expression* argument must be entered surrounded by double quotes.
		Refer to the *Understanding Regular Expressions, Special Characters, and Patterns* module in for more information regarding regular expressions.

Step 3	**notification linkupdown disable** **Example:** `RP/0/(config-snmp-if-subset)# notification linkupdown disable`	Disables linkUp and linkDown traps for all interfaces being configured. To enable previously disabled interfaces, use the **no** form of this command.
Step 4	Use the **commit** or **end** command.	**commit** —Saves the configuration changes, and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes.

	Command or Action	Purpose
		• **Cancel** —Remains in the configuration mode, without committing the configuration changes.
Step 5	(Optional) **show snmp interface notification subset** *subset-number* **Example:** `RP/0/# show snmp interface notification subset 10`	Displays the linkUp and linkDown notification status for all interfaces identified by the subset priority.
Step 6	(Optional) **show snmp interface notification regular-expression** *expression* **Example:** `RP/0/# show snmp interface notification regular-expression "^Gig[a-zA-Z]+[0-9/]+\."`	Displays the linkUp and linkDown notification status for all interfaces identified by the regular expression.
Step 7	(Optional) **show snmp interface notification** *type interface-path-id* **Example:** `RP/0/# show snmp interface notification tengige 0/4/0/3.10`	Displays the linkUp and linkDown notification status for the specified interface.



CHAPTER 4

Configuring Object Tracking

This module describes the configuration of object tracking on your Cisco IOS XR network. For complete descriptions of the commands listed in this module, see **Additional References** section. To locate documentation for other commands that might appear in the course of performing a configuration task, see **Technical Documentation** section in the Additional References topic.

Configuring Object Tracking

This module describes the configuration of object tracking on your Cisco IOS XR network. For complete descriptions of the commands listed in this module, see **Additional References** section. To locate documentation for other commands that might appear in the course of performing a configuration task, see **Technical Documentation** section in the Additional References topic.

Prerequisites for Implementing Object Tracking

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Note Object Tracking is an optional package. You must check if this package is installed on your system by running the command **show install active summary**.

Information about Object Tracking

Object tracking is a mechanism to track an object and to take an action on another object with no relationship to the tracked objects, based on changes to the properties of the object being tracked.

Each tracked object is identified by a unique name specified on the tracking command-line interface (CLI). Cisco IOS XR processes then use this name to track a specific object.

The tracking process periodically polls the tracked object and reports any changes to its state in terms of its being up or down, either immediately or after a delay, as configured by the user.

Multiple objects can also be tracked by means of a list, using a flexible method for combining objects with Boolean logic. This functionality includes:

- **Boolean AND function—**When a tracked list has been assigned a Boolean AND function, each object defined within a subset must be in an up state, so that the tracked object can also be in the up state.
- **Boolean OR function—**When the tracked list has been assigned a Boolean OR function, it means that at least one object defined within a subset must also be in an up state, so that the tracked object can also be in the up state.

How to Implement Object Tracking

This section describes the various object tracking procedures.

Tracking the Line Protocol State of an Interface

Perform this task in global configuration mode to track the line protocol state of an interface.

A tracked object is considered up when a line protocol of the interface is up.

After configuring the tracked object, you may associate the interface whose state should be tracked and specify the number of seconds to wait before the tracking object polls the interface for its state.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**track** *track-name* **Example:** `RP/0/(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.
Step 3	**type line-protocol state** **Example:**	Creates a track based on the line protocol of an interface.

	Command or Action	Purpose
	`RP/0/(config-track)# type line-protocol state`	
Step 4	**interface** *type* *interface-path-id* **Example:** `RP/0/(config-track-line-prot)# interface atm 0/2/0/0.1`	Specifies the interface to track the protocol state. • *type*—Specifies the interface type. For more information, use the question mark (?) online help function. • *interface-path-id*—Identifies a physical interface or a virtual interface. **Note** Use the **show interfaces** command to see a list of all possible interfaces currently configured on the router. **Note** The loopback and null interfaces are always in the up state and, therefore, cannot be tracked.
Step 5	**exit** **Example:** `RP/0/(config-track-line-prot)# exit`	Exits the track line protocol configuration mode.
Step 6	(Optional) **delay** {**up** *seconds* | **down** *seconds*} **Example:** `RP/0/(config-track)# delay up 10`	Schedules the delay that can occur between tracking whether the object is up or down.

Step 7	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/(config-track)# end`
	or
	`RP/0/(config-track)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session

	Command or Action	Purpose
		without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Tracking IP Route Reachability

When a host or a network goes down on a remote site, routing protocols notify the router and the routing table is updated accordingly. The routing process is configured to notify the tracking process when the route state changes due to a routing update.

A tracked object is considered up when a routing table entry exists for the route and the route is accessible.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**track** *track-name* **Example:** `RP/0/(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.
Step 3	**type route reachability** **Example:** `RP/0/(config-track)# type route reachability vrf internet`	Configures the routing process to notify the tracking process when the state of the route changes due to a routing update.

Step 4	Use one of the following commands:
	• **vrf** *vrf-table-name*
	• **route ipv4** *IP-prefix/mask*
	Example:
	`RP/0/(config-track-route)# vrf vrf-table-4`
	or
	`RP/0/(config-track-route)# route ipv4 10.56.8.10/16`
		Configures the type of IP route to be tracked, which can consist of either of the following, depending on your router type:
		• *vrf-table-name*—A VRF table name.
		• *IP-prefix/mask*—An IP prefix consisting of the network and subnet mask (for example, 10.56.8.10/16).

	Command or Action	Purpose
Step 5	**exit** **Example:** `RP/0/(config-track-line-prot)# exit`	Exits the track line protocol configuration mode.
Step 6	(Optional) **delay** {**up** *seconds* | **down** *seconds*} **Example:** `RP/0/(config-track)# delay up 10`	Schedules the delay that can occur between tracking whether the object is up or down.
Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes, and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration mode, without committing the configuration changes.

Building a Track Based on a List of Objects

Perform this task in the global configuration mode to create a tracked list of objects (which, in this case, are lists of interfaces or prefixes) using a Boolean expression to determine the state of the list.

A tracked list contains one or more objects. The Boolean expression enables two types of calculations by using either AND or OR operators. For example, when tracking two interfaces, using the AND operator, up means that *both* interfaces are up, and down means that *either* interface is down.

Note An object must exist before it can be added to a tracked list.

The NOT operator is specified for one or more objects and negates the state of the object.

After configuring the tracked object, you must associate the interface whose state should be tracked and you may optionally specify the number of seconds to wait before the tracking object polls the interface for its state.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**track** *track-name* **Example:** `RP/0/(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.
Step 3	**type list boolean** { **and** | **or** } **Example:** `RP/0/(config-track)# type list boolean and`	Configures a Boolean list object and enters track list configuration mode. • **boolean**—Specifies that the state of the tracked list is based on a Boolean calculation. • **and**—Specifies that the list is up if all objects are up, or down if one or more objects are down. For example when tracking two interfaces, up means that both interfaces are up, and down means that either interface is down. • **or**—Specifies that the list is up if at least one object is up. For example, when tracking two interfaces, up means that either interface is up, and down means that both interfaces are down.
Step 4	**object** *object-name* [**not**] **Example:** `RP/0/(config-track-list)# object 3 not`	Specifies the object to be tracked by the list • *obect-name*—Name of the object to track. • **not**—Negates the state of the object.
Step 5	**exit** **Example:** `RP/0/(config-track-line-prot)# exit`	Exits the track line protocol configuration mode.
Step 6	(Optional) **delay** {**up** *seconds* | **down** *seconds*} **Example:** `RP/0/(config-track)# delay up 10`	Schedules the delay that can occur between tracking whether the object is up or down.
Step 7	Use one of the following commands:	Saves configuration changes.

	Command or Action	Purpose

	• **end**
	• **commit**
	Example:
	`RP/0/(config-track)# end`
	or
	`RP/0/(config-track)# commit`
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Building a Track Based on a List of Objects - Threshold Percentage

Perform this task in the global configuration mode to create a tracked list of objects (which, in this case, are lists of interfaces or prefixes) using a threshold percentage to determine the state of the list.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**track** *track-name* **Example:** `RP/0/(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.
Step 3	**type list threshold percentage** **Example:**	Configures a track of type threshold percentage list.

	Command or Action	Purpose
	`RP/0/(config-track)# type list threshold percentage`	

Step 4	**object** *object-name*
	Example:
	`RP/0/(config-track-list-threshold)# object 1`
	`RP/0/(config-track-list-threshold)# object 2`
	`RP/0/(config-track-list-threshold)# object 3`
	`RP/0/(config-track-list-threshold)# object 4`
		Configures object 1, object 2, object 3 and object 4 as members of track type track1.

Step 5	**threshold percentage up** *percentage* **down** *percentage* **Example:** `RP/0/(config-track-list-threshold)# threshold percentage up 50 down 33`	Configures the percentage of objects that need to be UP or DOWN for the list to be considered UP or Down respectively. For example, if object 1, object 2, and object 3 are in the UP state and object 4 is in the DOWN state, the list is considered to be in the UP state.

Step 6	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/(config-track)# end`
	or
	`RP/0/(config-track)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Building a Track Based on a List of Objects - Threshold Weight

Perform this task in the global configuration mode to create a tracked list of objects (which, in this case, are lists of interfaces or prefixes) using a threshold weight to determine the state of the list.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**track** *track-name* **Example:** `RP/0/(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.
Step 3	**type list threshold weight** **Example:** `RP/0/(config-track)# type list threshold weight`	Configures a a track of type, threshold weighted list.

Step 4	**object** *object-name* **weight** *weight*
	Example:
	`RP/0/(config-track-list-threshold)# object 1 weight 10`
	`RP/0/(config-track-list-threshold)# object 2 weight 5`
	`RP/0/(config-track-list-threshold)# object 3 weight 3`
		Configures object 1, object 2 and object 3 as members of track t1 and with weights 10, 5 and 3 respectively.

Step 5	**threshold weight up** *weight* **down** *weight* **Example:** `RP/0/(config-track-list-threshold)# threshold weight up 10 down 5`	Configures the range of weights for the objects that need to be UP or DOWN for the list to be considered UP or DOWN respectively. In this example, the list is considered to be in the DOWN state because objects 1 and 2 are in the UP state and the cumulative weight is 15 (not in the 10-5 range).
Step 6	Use one of the following commands: • **end** • **commit** **Example:** `RP/0/(config-track)# end` or	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`

	Command or Action	Purpose
	`RP/0/(config-track)# commit`	• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Tracking IPSLA Reachability

Use this task to enable the tracking of the return code of IP service level agreement (SLA) operations.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters global configuration mode.
Step 2	**track** *track-name* **Example:** `RP/0/(config)# track t1`	Enters track configuration mode.
Step 3	**type rtr** *ipsla-no* **reachability** **Example:** `RP/0/(config-track)# type rtr 100 reachability`	Specifies the IP SLA operation ID to be tracked for reachability. Values for the *ipsla-no* can range from1 to 2048.
Step 4	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session.

	Command or Action	Purpose
		• **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring IPSLA Tracking: Example

This example shows the configuration of IPSLA tracking:

```
RP/0/(config)# track track1
RP/0/(config-track)# type rtr 1 reachability
RP/0/(config-track)# delay up 5
RP/0/(config-track)# delay down 10
```

Configuration Examples for Configuring Object Tracking

Tracking Whether the Interface Is Up or Down: Running Configuration Example

```
track connection100
  type list boolean and
    object object3 not
    delay up 10
    !
interface service-ipsec 23
  line-protocol track connection100
  !
```

Tracking the Line Protocol State of an Interface: Running Configuration Example

In this example, traffic arrives from interface service-ipsec1 and exits through interface gigabitethernet0/0/0/3:

```
track IPSec1
  type line-protocol state
    interface gigabitethernet0/0/0/3
    !
interface service-ipsec 1
  ipv4 address 70.0.0.1 255.255.255.0
  profile vrf1_profile_ipsec
  line-protocol track IPSec1
  tunnel source 80.0.0.1
  tunnel destination 80.0.0.2
  service-location preferred-active 0/0/1
```

```
  !
```

This example displays the output from the **show track** command after performing the previous example:

```
RP/0/# show run track

  Track IPSec1
  Interface GigabitEthernet0_0_0_3 line-protocol
  !
    Line protocol is UP
    1 change, last change 10:37:32 UTC Thu Sep 20 2007
    Tracked by:
    service-ipsec1
    !
```

Tracking IP Route Reachability: Running Configuration Example

In this example, traffic arriving from interface service-ipsec1 has its destination in network 7.0.0.0/24. This tracking procedure follows the state of the routing protocol prefix to signal when there are changes in the routing table.

```
track PREFIX1
  type route reachability
    route ipv4 7.0.0.0/24
    !
  interface service-ipsec 1
  vrf 1
  ipv4 address 70.0.0.2 255.255.255.0
  profile vrf_1_ipsec
  line-protocol track PREFIX1
  tunnel source 80.0.0.2
  tunnel destination 80.0.0.1
  service-location preferred-active 0/2/0
```

Building a Track Based on a List of Objects: Running Configuration Example

In this example, traffic arriving from interface service-ipsec1 exits through interface gigabitethernet0/0/0/3 and interface ATM 0/2/0/0.1. The destination of the traffic is at network 7.0.0.0/24.

If either one of the interfaces or the remote network goes down, the flow of traffic must stop. To do this, we use a Boolean AND expression.

```
track C1
 type route reachability
  route ipv4 3.3.3.3/32
 !
!
track C2
 type route reachability
  route ipv4 1.2.3.4/32
 !
!
track C3
```

```
 type route reachability
  route ipv4 10.0.20.2/32
 !
!
track C4
 type route reachability
  route ipv4 10.0.20.0/24
 !
!
track OBJ
 type list boolean and
  object C1
  object C2
 !
!
track OBJ2
 type list boolean or
  object C1
  object C2
 !
```

Additional References

The following sections provide references related to implementing object tracking for IPSec network security.

Related Documents

Related Topic	Document Title
IP SLA configuration information	*Implementing IP Service Level Agreements on* module in
IP SLA commands	*IP Service Level Agreement Commands on* module in
Object tracking commands	*Object Tracking Commands on* module in

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

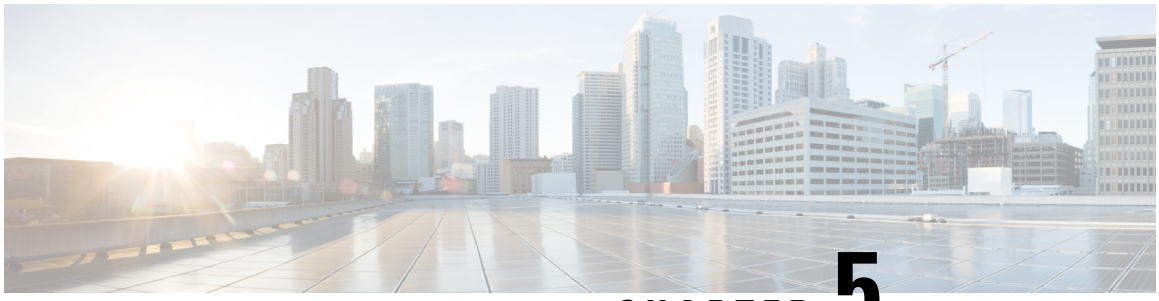
MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at the following URL and choose a platform under the Cisco Access Products menu: https://cfnng-stg.cisco.com/mibs.

RFCs

RFCs	Title
RFC 2401	*Security Architecture for the Internet Protocol*

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/cisco/web/support/index.html



CHAPTER 5

Configuring Cisco Discovery Protocol

Cisco Discovery Protocol (CDP) is a media- and protocol-independent protocol that runs on all Cisco-manufactured equipment including routers, bridges, access and communication servers, and switches. Using CDP, you can view information about all the Cisco devices that are directly attached to the device.

Prerequisites for Implementing CDP

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Note CDP is an optional package. You must check if this package is installed on your system by running the command **show install active summary**.

Information About Implementing CDP

CDP is primarily used to obtain protocol addresses of neighboring devices and discover the platform of those devices. CDP can also be used to display information about the interfaces your router uses. CDP is media- and protocol-independent, and runs on all equipment manufactured by Cisco, including routers, bridges, access servers, and switches.

Use of SNMP with the CDP MIB allows network management applications to learn the device type and the SNMP agent address of neighboring devices and to send SNMP queries to those devices. CDP uses the CISCO-CDP-MIB.

CDP runs on all media that support Subnetwork Access Protocol (SNAP), including LAN, Frame Relay, and ATM physical media. CDP runs over the data link layer only. Therefore, two systems that support different network-layer protocols can learn about each other.

Each device configured for CDP sends periodic messages, known as *advertisements*, to a multicast address. Each device advertises at least one address at which it can receive SNMP messages. The advertisements also contain time-to-live, or hold-time, information, which indicates the length of time a receiving device holds CDP information before discarding it. Each device also listens to the periodic CDP messages sent by others to learn about neighboring devices and determine when their interfaces to the media go up or down.

CDP Version-2 (CDPv2) is the most recent release of the protocol and provides more intelligent device tracking features. These features include a reporting mechanism that allows for more rapid error tracking, thereby reducing costly downtime. Reported error messages can be sent to the console or to a logging server, and can cover instances of unmatching native VLAN IDs (IEEE 802.1Q) on connecting ports, and unmatching port duplex states between connecting devices.

CDPv2 **show** commands can provide detailed output on VLAN Trunking Protocol (VTP) management domain and duplex modes of neighbor devices, CDP-related counters, and VLAN IDs of connecting ports.

Type-length-value fields (TLVs) are blocks of information embedded in CDP advertisements. This table summarizes the TLV definitions for CDP advertisements.

Table 4: Type-Length-Value Definitions for CDPv2

TLV	Definition
Device-ID TLV	Identifies the device name in the form of a character string.
Address TLV	Contains a list of network addresses of both receiving and sending devices.
Port-ID TLV	Identifies the port on which the CDP packet is sent.
Capabilities TLV	Describes the functional capability for the device in the form of a device type; for example, a switch.
Version TLV	Contains information about the software release version on which the device is running.
Platform TLV	Describes the hardware platform name of the device, for example, Cisco 4500.
VTP Management Domain TLV	Advertises the system's configured VTP management domain name-string. Used by network operators to verify VTP domain configuration in adjacent network nodes.
Native VLAN TLV	Indicates, per interface, the assumed VLAN for untagged packets on the interface. CDP learns the native VLAN for an interface. This feature is implemented only for interfaces that support the IEEE 802.1Q protocol.
Full/Half Duplex TLV	Indicates status (duplex configuration) of CDP broadcast interface. Used by network operators to diagnose connectivity problems between adjacent network elements.

How to Implement CDP on Cisco IOS XR Software

Enabling CDP

To enable CDP, you must first enable CDP globally on the router and then enable CDP on a per-interface basis. This task explains how to enable CDP globally on the router and then enable CDP on an interface.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**cdp** **Example:** `RP/0/(config)# cdp`	Enables CDP globally.
Step 3	**interface** *type interface-path-id* **Example:** `RP/0/(config)# int TenGigE 0/5/0/11/1`	Enters interface configuration mode.
Step 4	**cdp** **Example:** `RP/0/(config-if)# cdp`	Enables CDP on an interface.
Step 5	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Modifying CDP Default Settings

This task explains how to modify the default version, hold-time setting, and timer settings.

Note The commands can be entered in any order.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**cdp advertise v1** **Example:** `RP/0/(config)# cdp advertise v1`	Configures CDP to use only version 1 (CDPv1) in communicating with neighboring devices. • By default, when CDP is enabled, the router sends CDPv2 packets. CDP also sends and receives CDPv1 packets if the device with which CDP is interacting does not process CDPv2 packets. • In this example, the router is configured to send and receive only CDPv1 packets.
Step 3	**cdp holdtime** *seconds* **Example:** `RP/0/(config)# cdp holdtime 30`	Specifies the amount of time that the receiving networking device will hold a CDP packet sent from the router before discarding it. • By default, when CDP is enabled, the receiving networking device holds a CDP packet for 180 seconds before discarding it. **Note** The CDP hold time must be set to a higher number of seconds than the time between CDP transmissions, which is set with the **cdp timer** command. • In this example, the value of hold-time for the *seconds* argument is set to 30.
Step 4	**cdp timer** *seconds* **Example:** `RP/0/(config)# cdp timer 20`	Specifies the frequency at which CDP update packets are sent. • By default, when CDP is enabled, CDP update packets are sent at a frequency of once every 60 seconds.

	Command or Action	Purpose
		Note A lower timer setting causes CDP updates to be sent more frequently. • In this example, CDP update packets are configured to be sent at a frequency of once every 20 seconds.
Step 5	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.
Step 6	(Optional) **show cdp** **Example:** `RP/0/# show cdp`	Displays global CDP information. The output displays the CDP version running on the router, the hold time setting, and the timer setting.

Monitoring CDP

This task shows how to monitor CDP.

Note The commands can be entered in any order.

Procedure

	Command or Action	Purpose
Step 1	**show cdp entry** {***** | *entry-name*} [**protocol** | **version**] **Example:** `RP/0/RSP0/CPU0:router# show cdp entry *`	Displays information about a specific neighboring device or all neighboring devices discovered using CDP.

	Command or Action	Purpose
Step 2	**show cdp interface** [*type interface-path-id* | **location** *node-id*] **Example:** `RP/0/RSP0/CPU0:router# show cdp interface pos 0/0/0/1`	Displays information about the interfaces on which CDP is enabled.
Step 3	**show cdp neighbors** [*type interface-path-id* | **location** *node-id*] [**detail**] **Example:** `RP/0/RSP0/CPU0:router# show cdp neighbors`	Displays detailed information about neighboring devices discovered using CDP.
Step 4	**show cdp traffic** [**location** *node-id*] **Example:** `RP/0/RSP0/CPU0:router# show cdp traffic`	Displays information about the traffic gathered between devices using CDP.

Configuration Examples for Implementing CDP

Enabling CDP: Example

The following example shows how to configure CDP globally and then enable CDP on Ethernet interface TenGigE 0/5/0/11/1:

```
cdp
interface 0/5/0/11/1
cdp
```

Modifying Global CDP Settings: Example

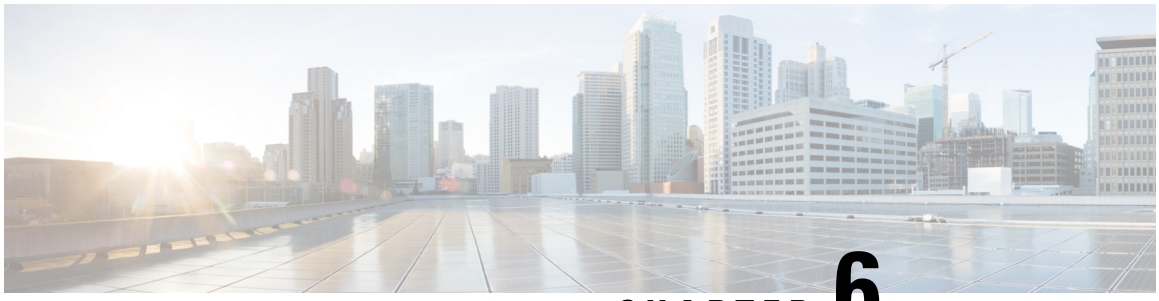
The following example shows how to modify global CDP settings. In this example, the timer setting is set to 20 seconds, the hold-time setting is set to 30 seconds, and the version of CDP used to communicate with neighboring devices is set to CDPv1:

```
cdp timer 20
cdp holdtime 30
cdp advertise v1
```

The following example shows how to use the **show cdp** command to verify the CDP global settings:

```
RP/0/# show cdp

  Global CDP information:
  Sending CDP packets every 20 seconds
```

```
Sending a holdtime value of 30 seconds
Sending CDPv2 advertisements is not enabled
```



CHAPTER 6

Configuring Periodic MIB Data Collection and Transfer

This document describes how to periodically transfer selected MIB data from your router to a specified Network Management System (NMS). The periodic MIB data collection and transfer feature is also known as bulk statistics.

Prerequisites for Periodic MIB Data Collection and Transfer

To use periodic MIB data collection and transfer, you should be familiar with the Simple Network Management Protocol (SNMP) model of management information. You should also know what MIB information you want to monitor on your network devices, and the OIDs or object names for the MIB objects to be monitored.

Information About Periodic MIB Data Collection and Transfer

SNMP Objects and Instances

A type (or class) of SNMP management information is called an object. A specific instance from a type of management information is called an object instance (or SNMP variable). To configure a bulk statistics collection, you must specify the object types to be monitored using a bulk statistics object list and the specific instances of those objects to be collected using a bulk statistics schema.

MIBs, MIB tables, MIB objects, and object indices can all be specified using a series of numbers called an object identifier (OID). OIDs are used in configuring a bulk statistics collection in both the bulk statistics object lists (for general objects) and in the bulk statistics schemas (for specific object instances).

Bulk Statistics Object Lists

To group the MIB objects to be polled, you need to create one or more object lists. A bulk statistics object list is a user-specified set of MIB objects that share the same MIB index. Object lists are identified using a name that you specify. Named bulk statistics object lists allow the same configuration to be reused in different bulk statistics schemas.

All the objects in an object list must share the same MIB index. However, the objects do not need to be in the same MIB and do not need to belong to the same MIB table. For example, it is possible to group ifInOctets and a CISCO-IF-EXTENSION-MIB object in the same schema, because the containing tables for both objects are indexed by the ifIndex.

Bulk Statistics Schemas

Data selection for the Periodic MIB Data Collection and Transfer Mechanism requires the definition of a schema with the following information:

- Name of an object list.
- Instance (specific instance or series of instances defined using a wild card) that needs to be retrieved for objects in the specified object list.
- How often the specified instances need to be sampled (polling interval). The default polling interval is 5 minutes.

A bulk statistics schema is also identified using a name that you specify. This name is used when configuring the transfer options.

Bulk Statistics Transfer Options

After configuring the data to be collected, a single virtual file (VFile or *bulk statistics file*) with all collected data is created. This file can be transferred to a network management station using FTP or TFTP. You can specify how often this file should be transferred. The default transfer interval is once every 30 minutes. You can also configure a secondary destination for the file to be used if, for whatever reason, the file cannot be transferred to the primary network management station.

The value of the transfer interval is also the collection period (collection interval) for the local bulk statistics file. After the collection period ends, the bulk statistics file is frozen, and a new local bulk statistics file is created for storing data. The frozen bulk statistics file is then transferred to the specified destination.

By default, the local bulk statistics file is deleted after successful transfer to an network management station.

Benefits of Periodic MIB Data Collection and Transfer

Periodic MIB data collection and transfer (bulk statistics feature) allows many of the same functions as the bulk file MIB (CISCO-BULK-FILE-MIB.my), but offers some key advantages. The main advantage is that this feature can be configured through the CLI and does not require an external monitoring application.

Periodic MIB data collection and transfer is mainly targeted for medium to high-end platforms that have sufficient local storage (volatile or permanent) to store bulk statistics files. Locally storing bulk statistics files helps minimize loss of data during temporary network outages.

This feature also has more powerful data selection features than the bulk file MIB; it allows grouping of MIB objects from different tables into data groups (object lists). It also incorporates a more flexible instance selection mechanism, where the application is not restricted to fetching an entire MIB table.

How to Configure Periodic MIB Data Collection and Transfer

Configuring a Bulk Statistics Object List

The first step in configuring the Periodic MIB Data Collection and Transfer Mechanism is to configure one or more object lists.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**snmp-server mib bulkstat object-list** *list-name* **Example:** `snmp-server mib bulkstat object-list ifMib`	Defines an SNMP bulk statistics object list and enters bulk statistics object list configuration mode.

Step 3	**add** {**oid** | *object-name*}
	Example:
	`RP/0/(config-bulk-objects)# add 1.3.6.1.2.1.2.2.1.11`
	`RP/0/(config-bulk-objects)# add ifAdminStatus`
	`RP/0/(config-bulk-objects)# add ifDescr`
		Adds a MIB object to the bulk statistics object list. Repeat as desired until all objects to be monitored in this list are added.
		Note All the objects in a bulk statistics object list have to be indexed by the same MIB index. However, the objects in the object list do not need to belong to the same MIB or MIB table.
		When specifying an object name instead of an OID (using the add command), only object names with mappings shown in the **show snmp mib object** command output can be used.

Step 4	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session.

	Command or Action	Purpose
		• **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring a Bulk Statistics Schema

The second step in configuring periodic MIB data collection and transfer is to configure one or more schemas.

Before you begin

The bulk statistics object list to be used in the schema must be defined.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.

Step 2	**snmp-server mib bulkstat schema** *schema-name*
	Example:
	`RP/0/(config)# snmp-server mib bulkstat schema intE0`
	`RP/0/(config-bulk-sc)#`
		Names the bulk statistics schema and enters bulk statistics schema mode.

Step 3	**object-list** *list-name* **Example:** `RP/0/(config-bulk-sc)# object-list ifMib`	Specifies the bulk statistics object list to be included in this schema. Specify only one object list per schema. If multiple object-list commands are executed, the earlier ones are overwritten by newer commands.
Step 4	Do one of the following: • **instance exact** {**interface** *interface-id* [**sub-if**] | **oid** *oid*} • **instance wild** {**interface** *interface-id* [**sub-if**] | **oid** *oid*} • **instance range start** *oid* **end** *oid* • **instance repetition** *oid* **max** *repeat-number*	Specifies the instance information for objects in this schema: • The **instance exact** command indicates that the specified instance, when appended to the object list, represents the complete OID. • The **instance wild** command indicates that all subindices of the specified OID belong

	Command or Action	Purpose

	Example:
	`RP/0/(config-bulk-sc)# instance wild oid 1`
	or
	`RP/0/(config-bulk-sc)# instance exact interface TenGigE 0/1.25`
	or
	`RP/0/(config-bulk-sc)# instance range start 1 end 2`
	or
	`RP/0/(config-bulk-sc)# instance repetition 1 max 4`
		to this schema. The wild keyword allows you to specify a partial, "wild carded" instance.
		• The **instance range** command indicates a range of instances on which to collect data.
		• The **instance repetition** command indicates data collection to repeat for a certain number of instances of a MIB object.
		Note Only one **instance** command can be configured per schema. If multiple **instance** commands are executed, the earlier ones are overwritten by new commands.

Step 5	**poll-interval** *minutes* **Example:** `RP/0/(config-bulk-sc)# poll-interval 10`	Sets how often data should be collected from the object instances specified in this schema, in minutes. The default is once every 5 minutes. The valid range is from 1 to 20000.
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring Bulk Statistics Transfer Options

The final step in configuring periodic MIB data collection and transfer is to configure the transfer options. The collected MIB data are kept in a local file-like entity called a VFile (virtual file, referred to as a bulk statistics file in this document). This file can be transferred to a remote network management station at intervals you specify.

Before you begin

The bulk statistics object lists and bulk statistics schemas must be defined before configuring the bulk statistics transfer options.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/# configure`	Enters mode.
Step 2	**snmp-server mib bulkstat transfer-id** *transfer-id* **Example:** `RP/0/(config)# snmp-server mib bulkstat transfer bulkstat1`	Identifies the transfer configuration with a name (*transfer-id* argument) and enters bulk statistics transfer configuration mode.
Step 3	**buffer-size** *bytes* **Example:** `RP/0/(config-bulk-tr)# buffersize 3072`	(Optional) Specifies the maximum size for the bulk statistics data file, in bytes. The valid range is from 1024 to 2147483647 bytes. The default buffer size is 2048 bytes. **Note** If the maximum buffer size for a bulk statistics file is reached before the transfer interval time expires, all additional data received is deleted. To correct this behavior, you can decrease the polling frequency, or increase the size of the bulk statistics buffer.
Step 4	**Example:**	(Optional) Specifies the format of the bulk statistics data file (VFile). The default is schemaASCII. **Note** Transfers can only be performed using schemaASCII (cdcSchemaASCII) format. SchemaASCII is a human-readable format that contains parser-friendly hints for parsing data values.

Step 5	**schema** *schema-name*
	Example:
	`RP/0/(config-bulk-tr)# schema TenGigE 0/5/0/11/1`
	`RP/0/(config-bulk-tr)# schema TenGigE/0-CAR`
	`RP/0/(config-bulk-tr)# schema TenGigE 0/5/0/11/1`
		Specifies the bulk statistics schema to be transferred. Repeat this command as desired. Multiple schemas can be associated with a single transfer configuration; all collected data are placed in a single bulk data file (VFile).

	Command or Action	Purpose
Step 6	**transfer-interval** *minutes* **Example:** `RP/0/(config-bulk-tr)# transfer-interval 20`	(Optional) Specifies how often the bulk statistics file are transferred, in minutes. The default value is once every 30 minutes. The transfer interval is the same as the collection interval.
Step 7	**url primary** *url* **Example:** `RP/0/(config-bulk-tr)# url primary ftp://user:password@host/folder/bulkstat1`	Specifies the network management system (host) that the bulk statistics data file is transferred to, and the protocol to use for transfer. The destination is specified as a Uniform Resource Locator (URL). FTP or TFTP can be used for the bulk statistics file transfer.
Step 8	**url secondary** *url* **Example:** `RP/0/(config-bulk-tr)# url secondary tftp://10.1.0.1/tftpboot/user/bulkstat1`	(Optional) Specifies a backup transfer destination and protocol for use in the event that transfer to the primary location fails. FTP or TFTP can be used for the bulk statistics file transfer.
Step 9	**retry** *number* **Example:** `RP/0/(config-bulk-tr)# retry 1`	(Optional) Specifies the number of transmission retries. The default value is 0 (in other words, no retries). If an attempt to send the bulk statistics file fails, the system can be configured to attempt to send the file again using this command. One retry includes an attempt first to the primary destination then, if the transmission fails, to the secondary location. For example, if the retry value is 1, an attempt is made first to the primary URL, then to the secondary URL, then to the primary URL again, then to the secondary URL again. The valid range is from 0 to 100. If all retries fail, the next normal transfer occurs after the configured transfer-interval time.
Step 10	**retain** *minutes* **Example:** `RP/0/(config-bulk-tr)# retain 60`	(Optional) Specifies how long the bulk statistics file should be kept in system memory, in minutes, after the completion of the collection interval and a transmission attempt is made. The default value is 0. Zero (0) indicates that the file is deleted immediately after the transfer is attempted. The valid range is from 0 to 20000.

	Command or Action	Purpose
		Note If the retry command is used, you should configure a retain interval larger than 0. The interval between retries is the retain interval divided by the retry number. For example, if **retain 10** and **retry 2** are configured, two retries are attempted once every 5 minutes. Therefore, if retain 0 is configured, no retries are attempted.
Step 11	**enable** **Example:** `RP/0/(config-bulk-tr)# enable`	Begins the bulk statistics data collection and transfer process for this configuration. • For successful execution of this action, at least one schema with non-zero number of objects must be configured. • Periodic collection and file transfer begins only if this command is configured. Conversely, the **no enable** command stops the collection process. A subsequent **enable** starts the operations again. • Each time the collection process is started using the **enable** command, data is collected into a new bulk statistics file. When the **no enable** command is used, the transfer process for any collected data immediately begins (in other words, the existing bulk statistics file is transferred to the specified management station).
Step 12	**commit** *minutes* **Example:** `RP/0/(config-bulk-tr)# retain 60`	If the maximum buffer size for a bulk statistics file is reached before the transfer interval time expires, the transfer operation is still initiated, but any bulk statistics data received after the file was full, and before it was transferred, are deleted. To correct this behavior, you can decrease the polling frequency, or increase the size of the bulk statistics buffer. If **retain 0** is configured, no retries are attempted. This is because the interval between retries is the retain value divided by the retry value. For example, if **retain 10** and **retry 2** are configured, retries are attempted once every 5 minutes. Therefore, if you configure the retry command, you should also configure an appropriate value for the retain command.

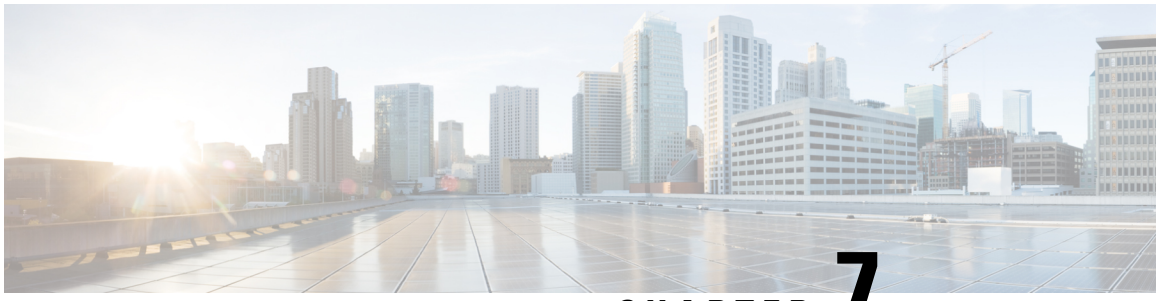
Periodic MIB Data Collection and Transfer: Example

This example shows how to configure periodic MIB data collection and transfer:

```
snmp-server mib bulkstat object-list cempo
add cempMemPoolName
add cempMemPoolType
!
snmp-server mib bulkstat schema cempWild
object-list cempo
instance wild oid 8695772
poll-interval 1
!
snmp-server mib bulkstat schema cempRepeat
object-list cempo
instance repetition 8695772.1 max 4294967295
poll-interval 1
!
snmp-server mib bulkstat transfer-id cempt1
enable
url primary tftp://223.255.254.254/auto/tftp-sjc-users3/username/dumpdcm
schema cempWild
schema cempRepeat
transfer-interval 2
!
```

This example shows sample bulk statistics file content:

```
Schema-def cempt1.cempWild "%u, %s, %s, %d" Epochtime instanceoid
            1.3.6.1.4.1.9.9.221.1.1.1.1.3 1.3.6.1.4.1.9.9.221.1.1.1.1.2
cempt1.cempWild: 1339491515, 8695772.1, processor, 2
cempt1.cempWild: 1339491515, 8695772.2, reserved, 11
cempt1.cempWild: 1339491515, 8695772.3, image, 12
cempt1.cempWild: 1339491575, 8695772.1, processor, 2
cempt1.cempWild: 1339491575, 8695772.2, reserved, 11
cempt1.cempWild: 1339491575, 8695772.3, image, 12
Schema-def cempt1.cempRepeat "%u, %s, %s, %d" Epochtime instanceoid
            1.3.6.1.4.1.9.9.221.1.1.1.1.3 1.3.6.1.4.1.9.9.221.1.1.1.1.2
cempt1.cempRepeat: 1339491515, 8695772.1, processor, 2
cempt1.cempRepeat: 1339491515, 8695772.2, reserved, 11
cempt1.cempRepeat: 1339491515, 8695772.3, image, 12
cempt1.cempRepeat: 1339491515, 26932192.1, processor, 2
cempt1.cempRepeat: 1339491515, 26932192.2, reserved, 11
cempt1.cempRepeat: 1339491515, 26932192.3, image, 12
cempt1.cempRepeat: 1339491515, 35271015.1, processor, 2
cempt1.cempRepeat: 1339491515, 35271015.2, reserved, 11
cempt1.cempRepeat: 1339491515, 35271015.3, image, 12
cempt1.cempRepeat: 1339491515, 36631989.1, processor, 2
cempt1.cempRepeat: 1339491515, 36631989.2, reserved, 11
cempt1.cempRepeat: 1339491515, 36631989.3, image, 12
cempt1.cempRepeat: 1339491515, 52690955.1, processor, 2
cempt1.cempRepeat: 1339491515, 52690955.2, reserved, 11
cempt1.cempRepeat: 1339491515, 52690955.3, image, 12
```



CHAPTER 7

Configuring Flexible Command Line Interface

This module describes how to configure and use flexible command line interface (CLI) configuration groups.

Flexible CLI Configuration Groups

Flexible command line interface (CLI) configuration groups provide the ability to minimize repetitive configurations by defining a series of configuration statements in a configuration group, and then applying this group to multiple hierarchical levels in the router configuration tree.

Flexible CLI configuration groups utilize regular expressions that are checked for a match at multiple submodes of the configuration tree based on where the group is applied within the hierarchy. If a match is found at a configuration submode, the corresponding configuration defined in the group is inherited within the matched submode.

Flexible CLI configuration groups also provide an auto-inheritance feature. Auto-inheritance means that any change done to a CLI configuration group is automatically applied to the configuration in any matched submodes that have an apply-group at that hierarchical level. This allows you to make a configuration change or addition once, and have it applied automatically in multiple locations, depending on where you have applied the flexible CLI configuration group.

Flexible Configuration Restrictions

Note these restrictions while using flexible configuration groups:

- Flexible CLI configuration groups are not supported in administration configurations and corresponding apply-groups are not supported in administration configurations.
- Use of preconfigured interfaces in configuration groups is not supported.
- Downgrading from an image that supports configuration groups to an image that does not support them is not supported.

- Access lists, quality of service and route policy configurations do not support the use of configuration groups. Configurations such as these are not valid:

```
group g-not-supported
 ipv4 access-list ...
 !
 ipv6 access-list ...
 !
 ethernet-service access-list ...
 !
 class-map ...
 !
 policy-map ...
 !
 route-policy ...
 !
end-group
```

  You can, however, reference such configurations, as shown in this example:

```
group g-reference-ok
 router bgp 6500
  neighbor 7::7
   remote-as 65000
   bfd fast-detect
   update-source Loopback300
   graceful-restart disable
   address-family ipv6 unicast
       route-policy test1 in
    route-policy test2 out
    soft-reconfiguration inbound always
   !
  !
 !
 interface Bundle-Ether1005
   bandwidth 10000000
   mtu 9188
      service-policy output input_1
   load-interval 30
 !
end-group
```

- Some regular expressions are not supported within groups. For example, '?', '|' and '$,' are not supported within groups. Also some characters such as /d and /w are not supported.
  - The choice operator "|" to express multiple match expressions within a regular expression is not supported. For example, these expressions are not supported:

    `Gig.*|Gig.*\..*`—To match on either Gigabit Ethernet main interfaces or Gigabit Ethernet sub-interfaces.

    `Gig.*0/0/0/[1-5]|Gig.*0/0/0/[10-20]`—To match on either Gig.*0/0/0/[1-5] or Gig.*0/0/0/[10-20].

    `'TenGigE.*|HundredGigE.*`—To match on either TenGigE.* or HundredGigE.* .

- Commands that require a node identifier for the **location** keyword are not supported. For example, this configuration is not supported:

```
lpts pifib hardware police location 0/RP0/CPU0
```

- Overlapping regular expressions within a configuration group for the same configuration are not supported. For example:

```
group G-INTERFACE
interface 'gig.*a.*'
  mtu 1500
!
interface 'gig.*e.* '
  mtu 2000
!
end-group

interface gigabitethernet0/0/0/* ---- where * is 0 to 79 or 0 to 39
  apply-group G-INTERFACE
```

  This configuration is not permitted because it cannot be determined whether the `interface GigabitEthernet0/0/0/*` configuration inherits `mtu 1500` or `mtu 2000`. Both expressions in the configuration group match GigabitEthernet0/0/0/*.

- Up to eight configuration groups are permitted on one apply-group command.

Configuring a Configuration Group

A configuration group includes a series of configuration statements that can be used in multiple hierarchical levels in the router configuration tree. By using regular expressions in a configuration group, you can create generic commands that can be applied in multiple instances.

Use this task to create and use a configuration group.

Note Flexible CLI configurations are not available through the XML interface.

Procedure

Step 1 **configure**

Example:

```
RP/0/# configure
```

Enters mode.

Step 2 **group** *group-name*

Example:

```
RP/0/(config)# group g-interf
```

Specifies a name for a configuration group and enters group configuration mode to define the group.The *group-name* argument can have up to 32 characters and cannot contain any special characters.

Step 3 Enter configuration commands, starting from global configuration mode. Use regular expressions for interface names and other variable instances.

Example:

```
RP/0/(config)# group g-interf
RP/0/(config-GRP)# interface 'GigabitEthernet.*'
RP/0/(config-GRP-if)# mtu 1500
```

Specifies the configuration statements that you want included in this configuration group.

For more information regarding the use of regular expressions, see Configuration Group Inheritance with Regular Expressions: Example, on page 87. This example is applicable to all Gigabit Ethernet interfaces.

Step 4 **end-group**

Example:

```
RP/0/(config-GRP-if)# end-group
```

Completes the configuration of a configuration group and exits to global configuration mode.

Step 5 **apply-group**

Example:

```
RP/0/(config)# interface GigabitEthernet0/2/0/0
RP/0/(config-if)# apply-group g-interf
```

Adds the configuration of the configuration group into the router configuration applicable at the location that the group is applied. Groups can be applied in multiple locations, and their effect depends on the location and context.

The MTU value from the group g-interf is applied to the interface GigabitEthernet0/2/0/0. If this group is applied in global configuration mode, the MTU value is inherited by all Gigabit Ethernet interfaces that do not have an MTU value configured.

Simple Configuration Group: Example

This example shows how to use configuration groups to add a global configuration to the system:

```
RP/0/(config)# group g-logging
RP/0/(config-GRP)# logging trap notifications
RP/0/(config-GRP)# logging console debugging
RP/0/(config-GRP)# logging monitor debugging
RP/0/(config-GRP)# logging buffered 10000000
RP/0/(config-GRP)# end-group

RP/0/(config)# apply-group g-logging
```

When this configuration is committed, all commands contained in the g-logging configuration group are committed.

Configuration Group Applied to Different Places: Example

Configuration groups can be applied to different places, and their effect depends on the context within which they are applied. Consider this configuration group:

```
RP/0/RP0/CPU0:router(config)# group g-interfaces
RP/0/RP0/CPU0:router(config-GRP)# interface 'TenGigE.*'
RP/0/RP0/CPU0:router(config-GRP-if)# mtu 1500
RP/0/RP0/CPU0:router(config-GRP-if)# exit
RP/0/RP0/CPU0:router(config-GRP)# interface 'GigabitEthernet.*'
RP/0/RP0/CPU0:router(config-GRP-if)# mtu 1000
RP/0/RP0/CPU0:router(config-GRP-if)# exit
RP/0/RP0/CPU0:router(config-GRP)# interface 'HundredGigE.*'
RP/0/RP0/CPU0:router(config-GRP-if)# mtu 2000
RP/0/RP0/CPU0:router(config-GRP-if)# end-group
```

This group can be applied to Gigabit Ethernet, TenGigE and HundredGigE interface and in each instance the applicable MTU is applied. For instance, in the following example, the Gigabit Ethernet interface is configured to have an MTU of 1000:

```
RP/0/RP0/CPU0:router(config)# interface GigabitEthernet0/2/0/0
RP/0/RP0/CPU0:router(config-if)# apply-group g-interfaces
RP/0/RP0/CPU0:router(config-if)# ipv4 address 2.2.2.2 255.255.255.0
```

In the following example, the TenGigE interface is configured to have an MTU of 1500:

```
RP/0/RP0/CPU0:router(config)# interface TenGigE0/0/0/16
RP/0/RP0/CPU0:router(config-if)# apply-group g-interfaces
RP/0/RP0/CPU0:router(config-if)# ipv4 address 3.3.3.3 255.255.255.0
```

The same configuration group is used in both cases, but only the applicable configuration statements are used.

Verifying the Configuration of Configuration Groups

Use this task to verify the router configuration using configuration groups:

Procedure

	Command or Action	Purpose

Step 1	**show running-config group** [*group-name*]
	Example:
	`RP/0/RP0/CPU0:router# show running-config group`
	`group g-int-ge`
	` interface 'GigabitEthernet.*'`
	`  mtu 1000`
	`  negotiation auto`
	` !`
	`end-group`
		Displays the contents of all or a specific configured configuration group.

Step 2	**show running-config**
	Example:
	`show running-config`
	`Example:`
		Displays the running configuration. Any applied groups are displayed. There is no indication as to whether these configuration groups affect the actual configuration or not. In this example, although the group G-INTERFACE-MTU is

	Command or Action	Purpose

	`RP/0/RP0/CPU0:router# show running-config interface group G-INTERFACE-MTU interface 'GigabitEthernet.*' mtu 1500 ! end-group`
	
	`interface GigabitEthernet0/4/1/1 apply-group G-INTERFACE-MTU ! interface GigabitEthernet0/0/0/1 apply-group group G-INTERFACE-MTU mtu 2000`
		applied to interface GigabitEthernet0/0/0/1, the configured MTU value is 2000 and not 1500. This happens if the command mtu 2000 is configured directly on the interface. An actual configuration overrides a configuration group configuration if they are the same.

Step 3	**show running-config inheritance**
	Example:
	`RP/0/RP0/CPU0:router# show running-config inheritance`
	
	`group G-INTERFACE-MTU interface 'GigabitEthernet.*' mtu 1500 ! end-group . . interface GigabitEthernet0/4/1/1 ## Inherited from group G-INTERFACE-MTU mtu 1500 ! interface GigabitEthernet0/0/0/1 mtu 2000 ! . .`
		Displays the inherited configuration wherever a configuration group has been applied.

Step 4	**show running-config interface x/y/z inheritance** *detail*
	Example:
	`RP/0/RP0/CPU0:router# show running-config interface GigabitEthernet0/4/1/1 inheritance detailExample:`
	
	`interface GigabitEthernet0/4/1/1 ## Inherited from group G-INTERFACE-MTU mtu 1500`
		Displays the inherited configuration for a specific configuration command.

Regular Expressions in Configuration Groups

Regular expressions are used in configuration groups to make them widely applicable. Portable Operating System Interface for UNIX (POSIX) 1003.2 regular expressions are supported in the names of configuration statements. Single quotes must be used to delimit a regular expression.

Note Not all POSIX regular expressions are supported.

Regular Expressions for Interface Identifiers

Configuration groups do not accept exact interface identifiers. You must use a regular expression to identify a group of interfaces that are applicable to the configuration group. The regular expression '.*' is not allowed. You must begin the regular expression for an interface identifier with an unambiguous word, followed by the regular expression. For example, to configure Gigabit Ethernet interfaces, use the regular expression 'GigabitEthernet.*'.

To display a list of available interface types for your router configuration, enter **interface ?** at the configuration group prompt:

```
RP/0/(config-GRP)# interface ?

  ATM              'RegExp': ATM Network Interface(s)
  BVI              'RegExp': Bridge-Group Virtual Interface
  Bundle-Ether     'RegExp': Aggregated Ethernet interface(s)
  GigabitEthernet  'RegExp': GigabitEthernet/IEEE 802.3 interface(s)
  IMA              'RegExp': ATM Network Interface(s)
  Loopback         'RegExp': Loopback interface(s)
  MgmtEth          'RegExp': Ethernet/IEEE 802.3 interface(s)
  Multilink        'RegExp': Multilink network interface(s)
  Null             'RegExp': Null interface
  PW-Ether         'RegExp': PWHE Ethernet Interface
  PW-IW            'RegExp': PWHE VC11 IP Interworking Interface
  Serial           'RegExp': Serial network interface(s)
  tunnel-ip        'RegExp': GRE/IPinIP Tunnel Interface(s)
  tunnel-mte       'RegExp': MPLS Traffic Engineering P2MP Tunnel interface(s)
  tunnel-te        'RegExp': MPLS Traffic Engineering Tunnel interface(s)
  tunnel-tp        'RegExp': MPLS Transport Protocol Tunnel interface
```

Note Although you are required to enter only enough characters for the interface type to be unique, it is recommended that you enter the entire phrase. All interface types used in regular expressions are case-sensitive.

To specify a subinterface, prefix the expression with the characters \. (backslash period). For example, use `interface 'GigabitEthernet.*\..*'` to configure all Gigabit Ethernet subinterfaces.

You can specify Layer 2 transport interfaces or point-to-point interfaces as shown in these examples:

```
group g-l2t
  interface 'Gi.*\..*' l2transport
.
.
end-group
group g-ptp
  interface 'Gi.*\..*' point-to-point
.
.
end-group
```

Regular Expressions for an OSPF Configuration

Exact router process names and OSPF areas cannot be used. You must use a regular expression to specify a process name or group of OSPF areas. To specify that the OSFP area can be either a scalar value or an IP address, use the regular expression '.*', as in this example:

```
group g-ospf
router ospf '.*'
area '.*'
mtu-ignore enable
!
!
end-group
```

To specify that the OSPF area must be an IP address, use the expression '\.' as in this example:

```
group g-ospf-ipaddress
router ospf '.*\..*\..*\..*'
area '.*'
passive enable
!
!
 end-group
```

To specify that the OSPF area must be a scalar value, use the expression '1.*', as in this example:

```
group g-ospf-match-number
router ospf '.*'
area '1.*'
passive enable
!
!
end-group
```

Regular Expressions for a BGP AS

Exact BGP AS values cannot be used in configuration groups. Use a regular expression to specify either AS plain format, or AS dot format as in the format X.Y. To match AS plain format instances, use a simple regular expression. To match AS dot format instances, use two regular expressions separated by a dot, as shown in this example:

```
group g-bgp
router bgp '*'.'*'
address-family ipv4 unicast
!
!
end-group
```

Regular Expressions for ANCP

Exact Access Node Control Protocol (ANCP) sender-name identifiers cannot be used in configuration groups. Because the sender name argument can be either an IP address or a MAC address, you must specify in the regular expression which one is being used. Specify an IP address as `'.*\..*\..*\..*'`; specify a MAC address as `'.*\..*\..*'`.

Resolving to a Uniform Type

Regular expressions must resolve to a uniform type. This is an example of an illegal regular expression:

```
group g-invalid
 interface '.*'
  bundle port-priority 10
 !
interface '.*Ethernet.*'
  bundle port-priority 10
 !
end-group
```

In this example, the **bundle** command is supported for interface type GigabitEthernet but not for interface type 'FastEthernet'. The regular expressions '.*' and '.*Ethernet.*' match both GigabitEthernet and FastEthernet types. Because the **bundle** command is not applicable to both these interface types, they do not resolve to a uniform type and therefore the system does not allow this configuration.

Note If the system cannot determine from the regular expression what the configuration should be, the expression is not considered valid.

Note The regular expression '.*' is not allowed when referring to an interface identifier. You must begin the regular expression for an interface identifier with an unambiguous word, followed by the regular expression. Refer to *Regular Expressions for Interface Identifiers* in this section for more information.

Overlapping Regular Expressions

Regular expressions are used in names of configuration statements within a configuration group. This permits inheritance by the configuration when applied to matching names. Single quotes are used to delimit the regular expression. Overlapping regular expression within a configuration group for the same configuration is permitted.

The example, given below, illustrates the process of creating and applying multiple configuration groups:

```
RP/0//CPU0:router(config)#group FB_flexi_snmp
RP/0//CPU0:router(config-GRP)# snmp-server vrf '.*'
RP/0//CPU0:router(config-GRP-snmp-vrf)# host 1.1.1.1 traps version 2c group_1
RP/0//CPU0:router(config-GRP-snmp-vrf)# host 1.1.1.1 informs version 2c group_1
RP/0//CPU0:router(config-GRP-snmp-vrf)# context group_1

RP/0//CPU0:router(config-GRP-snmp-vrf)#
RP/0//CPU0:router(config-GRP-snmp-vrf)#commit

RP/0//CPU0:router(config-GRP-snmp-vrf)#root
RP/0//CPU0:router(config)#
RP/0//CPU0:router(config)#snmp-server vrf vrf1
RP/0//CPU0:router(config-snmp-vrf)#snmp-server vrf vrf10
RP/0//CPU0:router(config-snmp-vrf)#!
RP/0//CPU0:router(config-snmp-vrf)#snmp-server vrf vrf100
RP/0//CPU0:router(config-snmp-vrf)#
RP/0//CPU0:router(config-snmp-vrf)#commit

RP/0//CPU0:router(config-snmp-vrf)#root
```

```
RP/0//CPU0:router(config)#
RP/0//CPU0:router(config)#apply-group FB_flexi_snmp
RP/0//CPU0:router(config)#do sh running-config group
group FB_flexi_snmp
 snmp-server vrf '.*'
  host 1.1.1.1 traps version 2c group_1
  host 1.1.1.1 informs version 2c group_1
  context group_1
 !
end-group
apply-group FB_flexi_snmp
snmp-server vrf vrf1
!
snmp-server vrf vrf10
!
snmp-server vrf vrf100
!
RP/0//CPU0:ios#show running-config inheritance detail


group FB_flexi_snmp
 snmp-server vrf '.*'
  host 1.1.1.1 traps version 2c group_1
  host 1.1.1.1 informs version 2c group_1
  context group_1
 !
end-group
snmp-server vrf vrf1
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 traps version 2c group_1
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 informs version 2c group_1
 ## Inherited from group FB_flexi_snmp
 context group_1
!
snmp-server vrf vrf10
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 traps version 2c group_1
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 informs version 2c group_1
 ## Inherited from group FB_flexi_snmp
 context group_1
!
snmp-server vrf vrf100
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 traps version 2c group_1
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 informs version 2c group_1
 ## Inherited from group FB_flexi_snmp
 context group_1
```

The example given below demonstrates the regular expression. In this example `snmp-server vrf '.*'` and `snmp-server vrf '[\w]+` are two different regular expressions.

```
group FB_flexi_snmp
snmp-server vrf '.*'
host 1.1.1.1 traps version 2c group_1
host 1.1.1.1 informs version 2c group_1
context group_1
!
snmp-server vrf '[\w]+'
```

```
host 2.2.2.2 traps version 2c group_2
host 2.2.2.2 informs version 2c group_2
context group_2
!
end-group
```

This individual regular expression gets combined to all the three expressions - `snmp-server vrf vrf1`, `snmp-server vrf vrf10` and `snmp-server vrf vrf100` as given below.

```
apply-group FB_flexi_snmp
snmp-server vrf vrf1
!
snmp-server vrf vrf10
!
snmp-server vrf vrf100
!
```

In a configuration group, there can be instances of regular expressions overlap. In such cases, the regular expression with the highest priority is activated and inherited, when applied. It has that regular expression, which comes first in the lexicographic order that has the highest priority.

The following example shows how to use overlapping regular expressions and how the expression with higher priority is applied:

```
 group FB_flexi_snmp
 snmp-server vrf '.*'
  host 1.1.1.1 traps version 2c group_1
  host 1.1.1.1 informs version 2c group_1
  context group_1
 !
 snmp-server vrf '[\w]+'
  host 2.2.2.2 traps version 2c group_2
  host 2.2.2.2 informs version 2c group_2
  context group_2
 !
end-group
```

The expression shown below has the highest priority:

```
  group FB_flexi_snmp
  snmp-server vrf '.*'
  host 1.1.1.1 traps version 2c group_1
  host 1.1.1.1 informs version 2c group_1
  context group_1
```

The examples given above, show two different regular expression `snmp-server vrf '.*'` and `snmp-server vrf '[\w]+'`.

The expression below, shows how these two expressions get merged together:

```
apply-group FB_flexi_snmp

snmp-server vrf vrf1
!
snmp-server vrf vrf10
!
snmp-server vrf vrf100
!
```

Any change in a regular expression with lower priority will not affect the inheritance.

Any changes made to an existing regular expression, which is of less (non-top) priority, it will not have any effect on the inheritance.

```
 snmp-server vrf '[\w]+'

 host 2.2.2.2 traps version 2c group_2
 host 2.2.2.2 informs version 2c group_2
 context group_2
```

The expression with the higher priority gets inherited, as shown below:

```
group FB_flexi_snmp

snmp-server vrf '.*'

 host 1.1.1.1 traps version 2c group_1

 host 1.1.1.1 informs version 2c group_1

 context group_1
```

Apply Groups Priority Inheritance

Priority governs inheritance.

Note From the Cisco IOS XR, Release 6.3.1 onwards, you are able to enter the Flexible CLI config group definition, **apply-group** and **exclude-group** command in any order as long as the entire commit has all the group definitions needed.

Apply groups priority inheritance helps flexible configuration groups to handle common configuration statements between groups. When multiple configuration groups have common configuration statements, the inheritance priority is such that the configuration statements present in inner groups have precedence over those configuration statements present in outer groups. In case of tiebreakers, the priority is assigned in accordance to the lexicographical order of regular expressions. User defined order of commands are not accepted.

For example, a configuration statement in configuration group ONE has precedence over another group. A configuration statement in configuration group SEVEN is used only if it does not exist in any other group. Within a configuration group, inheritance priority is the longest match.

```
   apply-group SIX SEVEN
    router ospf 0
   apply-group FOUR FIVE
    area 0
   apply-group THREE
    interface GigabitEthernet0/0/0/0
   apply-group ONE TWO

  !
 !
!
```

The above example shows two scenarios. The inner most group (**apply-group ONE TWO**) has the highest priority. Case 1

The first scenario shows which group gets the priority. The example states which group is applied between different configuration groups (different groups with nothing in common). While applying group one (ONE TWO), all the seven groups matches the interface `interface GigabitEthernet0/0/0/0`- is applied.

Case 2

Here, when all have the same (common) configuration, group one will be active. That is `apply-group ONE TWO` is active. If group ONE is deleted, then group TWO will be active.

Configuration Examples Using Regular Expressions

Configuration Group with Regular Expression: Example

This example shows the definition of a configuration group for configuring Gigabit Ethernet interfaces with ISIS routing parameters, using regular expressions for the exact interface:

```
RP/0/(config)# group g-isis-gige
RP/0/(config-GRP)# router isis '.*'
RP/0/(config-GRP-isis)# interface 'GigabitEthernet.*'
RP/0/(config-GRP-isis-if)# lsp-interval 20
RP/0/(config-GRP-isis-if)# hello-interval 40
RP/0/(config-GRP-isis-if)# address-family ipv4 unicast
RP/0/(config-GRP-isis-if-af)# metric 10
RP/0/(config-GRP-isis-if-af)# end-group
RP/0/(config)#
```

To illustrate the use of this configuration group, assume that you want to configure these Gigabit Ethernet interfaces with the ISIS routing parameters:

```
router isis green
 interface GigabitEthernet0/0/0/0
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
   metric 10
  !
 !
```

```
 interface GigabitEthernet0/0/0/1
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
   metric 10
  !
 !
 interface GigabitEthernet0/0/0/2
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
   metric 10
  !
 !
 interface GigabitEthernet0/0/0/3
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
   metric 10
  !
 !
!
```

There are three possible ways to use the configuration group to configure these interfaces. The first is by applying the group within the interface configuration, as shown here:

```
router isis green
 interface GigabitEthernet0/0/0/0
     apply-group g-isis-gige
  !
 !
 interface GigabitEthernet0/0/0/1
     apply-group g-isis-gige
  !
 !
 interface GigabitEthernet0/0/0/2
     apply-group g-isis-gige
  !
 !
 interface GigabitEthernet0/0/0/3
     apply-group g-isis-gige
  !
 !
```

In this situation, only the interfaces to which you apply the configuration group inherit the configuration.

The second way to configure these interfaces using the configuration group is to apply the configuration group within the **router isis** configuration, as shown here:

```
router isis green
    apply-group g-isis-gige
 interface GigabitEthernet0/0/0/0
 !
 interface GigabitEthernet0/0/0/1
 !
 interface GigabitEthernet0/0/0/2
 !
 interface GigabitEthernet0/0/0/3
 !
```

```
!
```

In this way, any other Gigabit Ethernet interfaces that you configure in the ISIS green configuration also inherit these configurations.

The third way to configure these interfaces using the configuration group is to apply the group at the global level as shown here:

```
   apply-group g-isis-gige
router isis green
 interface GigabitEthernet0/0/0/0
 !
 interface GigabitEthernet0/0/0/1
 !
 interface GigabitEthernet0/0/0/2
 !
 interface GigabitEthernet0/0/0/3
 !
!
```

In this example, the configuration of the group is applied to all Gigabit Ethernet interfaces configured for ISIS.

Configuration Group Inheritance with Regular Expressions: Example

Local Configuration Has Precedence Over Configuration Group

An explicit configuration takes precedence over a configuration applied from a configuration group. For example, assume that this configuration is running on the router:

```
router ospf 100
 packet-size 1000
!
```

You configure this configuration group, apply it, and commit it to the configuration.

```
RP/0/(config)# group g-ospf
RP/0/(config-GRP)# router ospf '.*'
RP/0/(config-GRP-ospf)# nsf cisco
RP/0/(config-GRP-ospf)# packet-size 3000
RP/0/(config-GRP-ospf)# end-group

RP/0/(config)# apply-group g-ospf
```

The result is effectively this configuration:

```
router ospf 100
 packet-size 1000
 nsf cisco
```

Note that `packet-size 3000` is not inherited from the configuration group because the explicit local configuration has precedence.

Compatible Configuration Is Inherited

The configuration in the configuration group must match the configuration on the router to be inherited. If the configuration does not match, it is not inherited. For example, assume that this configuration is running on the router:

```
router ospf 100
 auto-cost disable
!
```

You configure this configuration and commit it to the configuration.

```
RP/0/(config)# group g-ospf
RP/0/(config-GRP)# router ospf '.*'
RP/0/(config-GRP-ospf)# area '.*'
RP/0/(config-GRP-ospf-ar)# packet-size 2000
RP/0/(config-GRP-ospf)# end-group

RP/0/(config)# apply-group g-ospf

RP/0/(config)# router ospf 200
RP/0/(config-ospf)# area 1
```

The result is effectively this configuration:

```
router ospf 100
  auto-cost disable

router ospf 200
  area 1
  packet-size 2000
```

The packet size is inherited by the ospf 200 configuration, but not by the ospf 100 configuration because the area is not configured.

Layer 2 Transport Configuration Group: Example

This example shows how to configure and apply a configuration group with Layer 2 transport subinterfaces:

```
RP/0/(config)# group g-l2trans-if
RP/0/(config-GRP)# interface 'TenGigE.*\..*' l2transport
RP/0/(config-GRP)# mtu 1514
RP/0/(config-GRP)# end-group

RP/0/(config)# interface TenGigE0/0/0/0.1 l2transport
RP/0/(config-if)# apply-group g-l2trans-if
```

When this configuration is committed, the Ten Gigabit Ethernet interface 0/0/0/0.1 inherits the 1514 MTU value. This is the output displayed from the **show running-config inheritence** command for the Ten Gigabit Ethernet interface:

```
interface TenGigE0/0/0/0.1 l2transport
 ## Inherited from group g-l2trans-if
 mtu 1514
!
```

Configuration Group Precedence: Example

When similar configuration statements are contained in multiple configuration groups, groups applied in inner configuration modes take precedence over groups applied in outer modes. This example shows two configuration groups that configure different cost values for OSPF.

```
RP/0/(config)# group g-ospf2
RP/0/(config-GRP)# router ospf '.*'
RP/0/(config-GRP-ospf)# area '.*'
RP/0/(config-GRP-ospf-ar)# cost 2
RP/0/(config-GRP-ospf-ar)# end-group

RP/0/(config)# group g-ospf100
RP/0/(config-GRP)# router ospf '.*'
RP/0/(config-GRP-ospf)# area '.*'
RP/0/(config-GRP-ospf-ar)# cost 100
RP/0/(config-GRP-ospf-ar)# end-group
```

If these configuration groups are applied as follows, the cost 2 specified in g-ospf2 is inherited by OSPF area 0 because the group is applied in a more inner configuration mode. In this case, the configuration in group g-ospf100 is ignored.

```
RP/0/(config)# router ospf 0
RP/0/(config-ospf)# apply-group g-ospf100
RP/0/(config-ospf)# area 0
RP/0/(config-ospf-ar)# apply-group g-ospf2
```

Changes to Configuration Group are Automatically Inherited: Example

When you make changes to a configuration group that is committed and applied to your router configuration, the changes are automatically inherited by the router configuration. For example, assume that this configuration is committed:

```
group g-interface-mtu
 interface ‘GigabitEthernet.*’
  mtu 1500
 !
end-group

interface POS0/4/1/0
 apply-group g-interface-mtu
!
```

Now you change the configuration group as in this example:

```
RP/0/(config)# group g-interface-mtu
RP/0/(config-GRP)# interface 'GigabitEthernet.*'
RP/0/(config-GRP-if)# mtu 2000
```

```
RP/0/(config-GRP-if)# end-group
```

When this configuration group is committed, the MTU configuration for interface GigabitEthernet0/4/1/0 is automatically updated to 2000.

Configuration Examples for Flexible CLI Configuration

Basic Flexible CLI Configuration: Example

This example shows that the Media Access Control (MAC) accounting configuration from the gd21 configuration group is applied to all Gigabit Ethernet interfaces in slot 2, ports 1 to 9.

1. Configure the configuration group that configures MAC accounting:

```
RP/0/# show running group gd21

group gd21
interface 'GigabitEthernet0/0/0/2[1-9]'
description general interface inheritance check
load-interval 30
mac-accounting ingress
mac-accounting egress
!
end-group
```

2. Check that the corresponding apply-group is configured in global configuration or somewhere in the hierarchy:

```
RP/0/# show running | in apply-group gd21

Building configuration...
apply-group gd21
```

3. Check the concise local view of the configuration of some of the interfaces:

```
RP/0/# show running interface

interface GigabiEthernet0/0/0/21
!
interface GigabitEthernet0/0/0/22
!
```

4. Verify that the match and inheritance occur on these interfaces:

```
RP/0/# show running-config inheritance interface

interface GigabitEthernet0/0/0/21
## Inherited from group gd21
description general interface inheritance check
## Inherited from group gd21
load-interval 30
## Inherited from group gd21
```

```
mac-accounting ingress
## Inherited from group gd21
mac-accounting egress
!
Interface GigabitEthernet0/0/0/22
## Inherited from group gd21
description general interface inheritance check
## Inherited from group gd21
load-interval 30
## Inherited from group gd21
mac-accounting ingress
## Inherited from group gd21
mac-accounting egress
!
!
```

5. Verify that the inherited configuration actually takes effect:

```
RP/0/# show mac-accounting GigabitEthernet0/0/0/21

GigabitEthernet0/0/0/21
  Input (96 free)
    6c9c.ed35.90fd:  1271 packets, 98426 bytes
        Total: 1271 packets, 98426 bytes
  Output (96 free)
    6c9c.ed35.90fd:   774 packets, 63265 bytes
        Total: 774 packets, 63264 bytes
```

Interface MTU Settings for Different Interface Types: Example

This example shows that an MTU value is configured on different interface types.

1. Configure an interface MTU configuration group and apply this group:

```
RP/0/# show running group l2tr

group l2tr
interface 'GigabitEthernet0/0/0/3.*'
mtu 1500
!
interface 'GigabitEthernet0/0/0/9\..*'
mtu 1400
!
interface 'GigabitEthernet0/0/0/9\..*' l2transport
mtu 1400
!
end-group

RP/0/# show running | inc apply-group

Building configuration...

apply-group l2tr
```

2. Check the concise view and the inheritance view of the various interfaces:

```
RP/0/# show running interface gigabitEthernet0/0/0/30

interface GigabitEthernet0/0/0/30
!
RP/0/# show running interface gigabitEthernet0/0/0/30  inheritance detail

interface GigabitEthernet0/0/0/30
## Inherited from group l2tr
mtu 1500
!

RP/0/# show running interface gigabitEthernet0/0/0/9.800

interface GigabitEthernet0/0/0/9.800
  encapsulation dot1q 800
!

RP/0/# show running interface gigabitEthernet0/0/0/9.800 inheritance detail

interface GigabitEthernet0/0/0/9.800
## Inherited from group l2tr
mtu 1400
encapsulation dot1q800
!

RP/0/# show running interface gigabitEthernet0/0/0/9.250

interface GigabitEthernet0/0/0/9.250 l2transport
  encapsulation dot1q 250
!

RP/0/# show running interface  gigabitEthernet0/0/0/9.800 inheritance detail

interface GigabitEthernet0/0/0/9.250 l2transport
encapsulation dot1q250
## Inherited from group l2tr
mtu 1400
!
```

3. Verify that the correct values from the group do take effect:

```
RP/0/# show interface gigabitEthernet 0/0/0/30

GigabitEthernet0/0/0/30 is down, line protocol is down
  Interface state transitions: 0
  Hardware is GigabitEthernet, address is 0026.9824.ee56 (bia 0026.9824.ee56)
  Internet address is Unknown
  MTU 1500 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 1000Mb/s, link type is force-up
  output flow control is off, input flow control is off
  loopback not set,
  Last input never, output never
  Last clearing of "show interface" counters never
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 0 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
```

```
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 total output drops
     Output 0 broadcast packets, 0 multicast packets
     0 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out

RP/0/# show interface gigabitEthernet 0/0/0/9.801

GigabitEthernet0/0/0/9.801 is up, line protocol is up
  Interface state transitions: 1
  Hardware is VLAN sub-interface(s), address is 0026.9824.ee41
  Internet address is Unknown
  MTU 1400 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation 802.1Q Virtual LAN, VLAN Id 801,  loopback not set,
  Last input never, output never
  Last clearing of "show interface" counters never
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 0 multicast packets
     0 packets output, 0 bytes, 0 total output drops
     Output 0 broadcast packets, 0 multicast packets


RP/0/# show interface gigabitEthernet 0/0/0/9.250

GigabitEthernet0/0/0/9.250 is up, line protocol is up
  Interface state transitions: 1
  Hardware is VLAN sub-interface(s), address is 0026.9824.ee41
  Layer 2 Transport Mode
  MTU 1400 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
     reliability Unknown, txload Unknown, rxload Unknown
  Encapsulation 802.1Q Virtual LAN,
    Outer Match: Dot1Q VLAN 250
    Ethertype Any, MAC Match src any, dest any
  loopback not set,
  Last input never, output never
  Last clearing of "show interface" counters never
     0 packets input, 0 bytes
     0 input drops, 0 queue drops, 0 input errors
     0 packets output, 0 bytes

     0 output drops, 0 queue drops, 0 output errors
```

ACL Referencing: Example

This example shows how to reference access-lists on a number of interfaces using configuration groups.

1. Configure the configuration group and apply-group:

```
RP/0/# show running group acref

group acref
 interface 'GigabitEthernet0/0/0/3.*'
  ipv4 access-group adem ingress
  ipv4 access-group adem egress
```

```
 !
end-group

RP/0/# show running | inc apply-group

Building configuration...

apply-group isis l2tr isis2 mpp bundle1 acref
```

2. Check the concise and inheritance view of the matching configurations:

```
RP/0/# show running interface gigabitEthernet 0/0/0/30

interface GigabitEthernet0/0/0/30
!

RP/0/# show running interface GigabitEthernet 0/0/0/30 inheritance detail

interface GigabitEthernet0/0/0/30
 ## Inherited from group l2tr
 mtu 1500
 ## Inherited from group acref
 ipv4 access-group adem ingress
 ## Inherited from group acref
 ipv4 access-group adem egress
!

RP/0/# show running interface gigabitEthernet 0/0/0/31

interface GigabitEthernet0/0/0/31
!

RP/0/# show running interface GigabitEthernet 0/0/0/31 inheritance detail

interface GigabitEthernet0/0/0/31
 ## Inherited from group l2tr
 mtu 1500
 ## Inherited from group acref
 ipv4 access-group adem ingress
 ## Inherited from group acref
 ipv4 access-group adem egress
```

3. Check that the ACL group configuration actually got configured by using a traffic generator and watching that denied traffic is dropped.

ISIS Hierarchical Configuration: Example

This example illustrates inheritance and priority handling with two ISIS groups using an ISIS configuration.

1. Configure the local ISIS configuration:

```
RP/0/# show running router isis

router isis vink
 net 49.0011.2222.2222.2222.00
 address-family ipv4 unicast
```

```
 mpls traffic-eng level-1-2
 mpls traffic-eng router-id Loopback0
 redistribute connected
!
interface Bundle-Ether1
 address-family ipv4 unicast
 !
!
interface Bundle-Ether2
!
interface Loopback0
!
interface TenGigE0/2/0/0.3521
 address-family ipv4 unicast
 !
!
interface TenGigE0/2/0/0.3522
 address-family ipv4 unicast
 !
!
interface TenGigE0/2/0/0.3523
 address-family ipv4 unicast
 !
!
interface TenGigE0/2/0/0.3524
 address-family ipv4 unicast
 !
!
interface TenGigE0/2/0/0.3525
 address-family ipv4 unicast
 !
!
interface TenGigE0/2/0/0.3526
!
interface TenGigE0/2/0/0.3527
!
interface TenGigE0/2/0/0.3528
!
interface TenGigE0/2/0/1
 address-family ipv4 unicast
 !
!
!
```

2. Configure two ISIS groups and apply these to the configuration:

```
RP/0/# show running group isis

group isis
 router isis '.*'
  address-family ipv4 unicast
   mpls traffic-eng level-1-2
   mpls traffic-eng router-id Loopback0
   redistribute connected
   redistribute ospf 1 level-1-2
  !
  interface 'TenGig.*'
   lsp-interval 40
   hello-interval 15
   address-family ipv4 unicast
    metric 50
   !
```

```
  !
  interface 'Bundle-Ether.*'
   address-family ipv4 unicast
    metric 55
   !
  !
 !
end-group

RP/0/# show running group isis2

group isis2
 router isis '.*'
 !
 router isis '^(vink)'
  address-family ipv4 unicast
  !
  interface '(^Ten)Gig.*'
  !
  interface '^(Ten)Gig.*'
   address-family ipv4 unicast
    metric 66
   !
  !
 !
end-group

RP/0/# show running | inc apply-group

Building configuration...

apply-group isis  l2tr  isis2  mpp  bundle1  acref
```

3. Check the inheritance view of the ISIS configuration:

```
RP/0/# show running router isis inheritance detail

router isis vink
 net 49.0011.2222.2222.2222.00
 address-family ipv4 unicast
  mpls traffic-eng level-1-2
  mpls traffic-eng router-id Loopback0
  redistribute connected
  ## Inherited from group isis
  redistribute ospf 1 level-1-2
 !
 interface Bundle-Ether1
  address-family ipv4 unicast
   ## Inherited from group isis
   metric 55
  !
 !
 interface Bundle-Ether2
  ## Inherited from group isis
  address-family ipv4 unicast
   ## Inherited from group isis
   metric 55
  !
 !
 interface Loopback0
 !
 interface TenGigE0/2/0/0.3521
```

```
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/2/0/0.3522
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/2/0/0.3523
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/2/0/0.3524
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/2/0/0.3525
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/2/0/0.3526
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 ## Inherited from group isis
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/2/0/0.3527
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
```

```
 hello-interval 15
 ## Inherited from group isis
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/2/0/0.3528
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 ## Inherited from group isis
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/2/0/1
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
!
```

4. Verify the actual functionality:

```
RP/0/# show isis interface TenGigE0/2/0/0.3528 | inc Metric

Metric (L1/L2):         50/50
```

OSPF Hierarchy: Example

This example illustrates hierarchical inheritance and priority. The configuration that is lower in hierarchy gets the highest priority.

1. Configure a local OSPF configuration:

```
RP/0/# show running router ospf

router ospf 1
 apply-group go-c
 nsr
 router-id 121.121.121.121
 nsf cisco
 redistribute connected
 address-family ipv4 unicast
 area 0
  apply-group go-b
  interface GigabitEthernet0/0/0/0
   apply-group go-a
  !
  interface GigabitEthernet0/0/0/1
```

```
  !
  interface GigabitEthernet0/0/0/3
  !
  interface GigabitEthernet0/0/0/4
  !
  interface GigabitEthernet0/0/0/21
   bfd minimum-interval 100
   bfd fast-detect
   bfd multiplier 3
  !
  interface TenGigE0/2/0/0.3891
  !
  interface TenGigE0/2/0/0.3892
  !
  interface TenGigE0/2/0/0.3893
  !
  interface TenGigE0/2/0/0.3894
  !
 !
!
router ospf 100
!
router ospf 1000
!
router ospf 1001
!
```

2. Configure a configuration group and apply it in a configuration submode:

```
RP/0/# show running group go-a

group go-a
 router ospf '.*'
  area '.*'
   interface 'Gig.*'
    cost 200
   !
  !
 !
end-group

RP/0/# show running group go-b

group go-b
 router ospf '.*'
  area '.*'
   interface 'Gig.*'
    cost 250
   !
  !
 !
end-group

RP/0/# show running group go-c

group go-c
 router ospf '.*'
  area '.*'
   interface 'Gig.*'
    cost 300
   !
  !
 !
```

```
end-group
```

3. Check the inheritance view and verify that the apply-group in the lowest configuration submode gets the highest priority:

```
RP/0/# show running router ospf 1 inheritance detail

router ospf 1
 nsr
 router-id 121.121.121.121
 nsf cisco
 redistribute connected
 address-family ipv4 unicast
 area 0
  interface GigabitEthernet0/0/0/0
   ## Inherited from group go-a
   cost 200                    << apply-group in lowest submode  gets highest priority

  !
  interface GigabitEthernet0/0/0/1
   ## Inherited from group go-b
   cost 250
  !
  interface GigabitEthernet0/0/0/3
   ## Inherited from group go-b
   cost 250
  !
  interface GigabitEthernet0/0/0/4
   ## Inherited from group go-b
   cost 250
  !
  interface GigabitEthernet0/0/0/21
   bfd minimum-interval 100
   bfd fast-detect
   bfd multiplier 3
   ## Inherited from group go-b
   cost 250
  !
  interface TenGigE0/2/0/0.3891
  !
  interface TenGigE0/2/0/0.3892
  !
  interface TenGigE0/2/0/0.3893
  !
  interface TenGigE0/2/0/0.3894
  !
 !
!
```

4. Check the functionality of the cost inheritance through the groups:

```
RP/0/# show ospf 1 interface GigabitEthernet 0/0/0/0

GigabitEthernet0/0/0/0 is up, line protocol is up
  Internet Address 1.0.1.1/30, Area 0
  Process ID 1, Router ID 121.121.121.121, Network Type BROADCAST, Cost: 200
  Transmit Delay is 1 sec, State DR, Priority 1, MTU 1500, MaxPktSz 1500
  Designated Router (ID) 121.121.121.121, Interface address 1.0.1.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  Non-Stop Forwarding (NSF) enabled
    Hello due in 00:00:02
```

```
 Index 5/5, flood queue length 0
 Next 0(0)/0(0)
 Last flood scan length is 1, maximum is 40
 Last flood scan time is 0 msec, maximum is 7 msec
 LS Ack List: current length 0, high water mark 0
 Neighbor Count is 1, Adjacent neighbor count is 0
 Suppress hello for 0 neighbor(s)
 Multi-area interface Count is 0
```

Link Bundling Usage: Example

This example shows how to configure interface membership in a bundle link:

1. Configure the configuration groups:

```
RP/0/# show running group bundle1

group bundle1
 interface 'GigabitEthernet0/1/0/1[1-6]'
  bundle id 1 mode active
 !
end-group

RP/0/# show running | inc apply-group

Building configuration...

apply-group isis l2tr  isis2  mpp  bundle1
```

2. Check the local configuration:

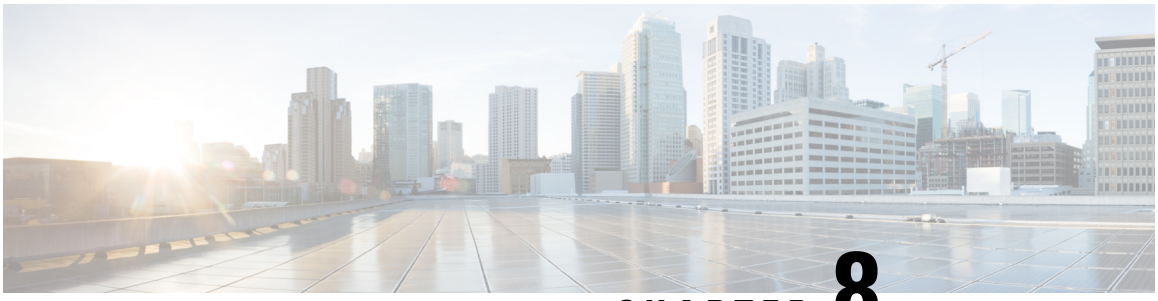
```
RP/0/# show running interface gigabitEthernet 0/1/0/11

interface GigabitEthernet0/1/0/11
!

RP/0/# show running interface Bundle-Ether1

interface Bundle-Ether1
 ipv4 address 108.108.1.1 255.255.255.0
 bundle maximum-active links 10
 bundle minimum-active links 5
!
```

3. Check the inheritance configuration view:

```
RP/0/# show running interface GigabitEthernet 0/1/0/11  inheritance detail

interface GigabitEthernet0/1/0/11
 ## Inherited from group bundle1
 bundle id 1 mode active
!
```

4. Check that the inheritance configuration took effect:

```
RP/0/# show interface Bundle-Ether1

Bundle-Ether1 is up, line protocol is up
  Interface state transitions: 1
  Hardware is Aggregated Ethernet interface(s), address is 0024.f71f.4bc3
  Internet address is 108.108.1.1/24
  MTU 1514 bytes, BW 6000000 Kbit (Max: 6000000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 6000Mb/s
  loopback not set,
  ARP type ARPA, ARP timeout 04:00:00
    No. of members in this bundle: 6
      GigabitEthernet0/1/0/11      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/12      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/13      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/14      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/15      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/16      Full-duplex  1000Mb/s     Active
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters never
  5 minute input rate 8000 bits/sec, 1 packets/sec
  5 minute output rate 3000 bits/sec, 1 packets/sec
     2058 packets input, 1999803 bytes, 426 total input drops
     0 drops for unrecognized upper-level protocol
     Received 1 broadcast packets, 2057 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     1204 packets output, 717972 bytes, 0 total output drops
     Output 2 broadcast packets, 1202 multicast packets
     0 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
```



CHAPTER 8

Configure Licenses Using the Smart Licensing Solution

What Is Smart Licensing

Smart Licensing is a cloud-based, flexible software licensing model that enables you to activate and manage Cisco software licenses across their organization. Smart Licensing solution allows you to easily track the status of your license and software usage trends. Cisco Smart Licensing establishes a pool of licenses or entitlements that can be used across the entire organization in a flexible and automated manner. Smart Licensing helps simplify four core functions:

- **Purchase—**Creates a Smart Account (and optionally, your Virtual Account). Licenses are added to your Smart Account and are immediately available for use.
- **Install—**Register your product with your Smart Account using an account-based Registration Token. Thereafter, the entire process is automatic. Product Activation Keys (PAKs) and license files are no longer needed.
- **Management—**Make changes to license consumption by updating your configuration; any license change is automatically reflected in your Smart Account. You can share licenses in your Virtual Account through the license pooling option. License pools (logical grouping of licenses) can reflect your organization structure. Smart Licensing solution also offers Cisco Smart Software Manager, a centralized portal that enables you to manage all your Cisco software licenses from one centralized website.
- **Visibility and Asset Management—**Cisco Smart Software Manager (CSSM) portal offers an integrated view of the licenses you own and have deployed. You can use this data to make better purchase decisions, based on your consumption.

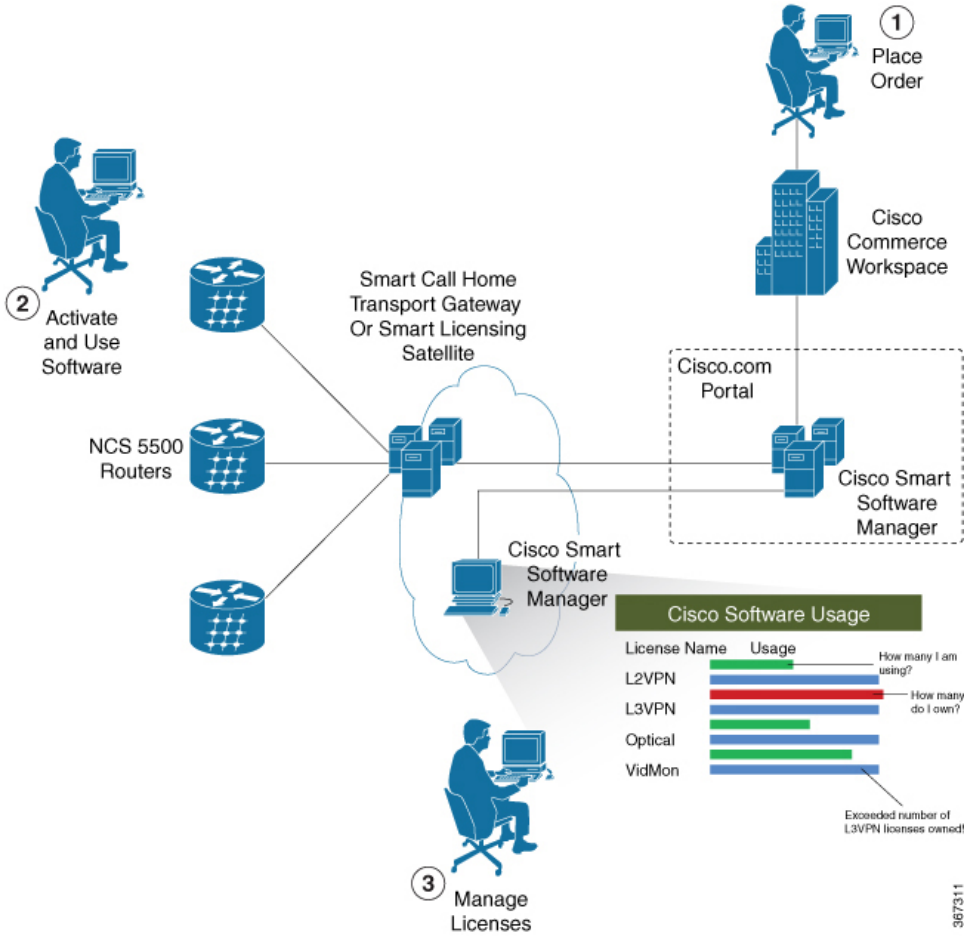
Note

- By default Smart Licensing is enabled.

How Does Smart Licensing Work?

Smart Licensing consists of three steps as depicted in the following illustration.

Figure 4: Smart Licensing - Example



1. **Setting up Smart Licensing—**You can place the order for Smart Licensing to manage licenses on Cisco.com portal. You can agree to the terms and conditions governing the use and access of Smart Licensing in the Smart Software Manager portal.

2. **Activate and Use Smart Licensing—** Follow the steps to enable Smart Licensing as shown in the illustration in the Smart Licensing Workflow, on page 112 section.

   After you enable Smart Licensing, you can use either of the following options to communicate:

   - **Smart Call Home—**The Smart Call Home feature is automatically configured after the Smart Licensing is enabled. Smart Call Home is used by Smart Licensing as a medium for communication

with the Cisco license service. Call Home feature allows Cisco products to periodically call-home and perform an audit and reconciliation of your software usage information. This information helps Cisco efficiently track your install base, keep them up and running, and more effectively pursue service and support contract renewals, without much intervention from your end. For more information on Smart Call Home feature, see the Smart Call Home Deployment Guide.

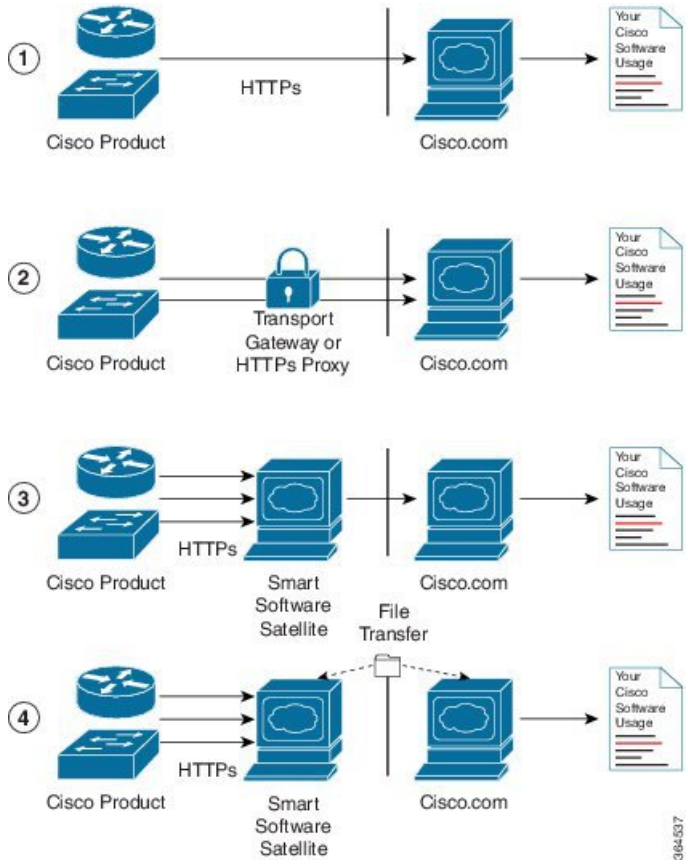
- **Smart Licensing Satellite—**The Smart licensing satellite option provides an on-premises collector that can be used to consolidate and manage Smart license usage, as well facilitate communications back to Cisco License Service at Cisco.com.

3. **Manage and Report Licenses—**You can manage and view reports about your overall software usage in the Smart Software Manager portal.

Deployment Options for Smart Licensing

The following illustration shows the various options available for deploying Smart Licensing:

Figure 5: Smart Licensing Deployment Options



1. **Direct cloud access—**In direct cloud access deployment method, Cisco products send usage information directly over the internet to Cisco License Service on http://www.cisco.com; no additional components are needed for deployment.

2. **Direct cloud access through an HTTPs proxy—**In direct cloud access through an HTTPs proxy deployment method, Cisco products send usage information over the internet through a proxy server - either a Smart Call Home Transport Gateway or off-the-shelf Proxy (such as Apache) to Cisco License Service on http://www.cisco.com.
3. **Mediated access through an on-premises collector-connected—**In mediated access through an on-premises collector-connected deployment method, Cisco products send usage information to a locally-connected collector, which acts as a local license authority. Periodically, the information is exchanged to keep the databases in synchronization.
4. **Mediated access through an on-premises collector-disconnected—**In the mediated access through an on-premises collector-disconnected deployment method, Cisco products send usage information to a local disconnected collector, which acts as a local license authority. Exchange of human-readable information is performed occasionally (once a month) to keep the databases in synchronization.

Options **1** and **2** provide an easy deployment option, and options **3** and **4** provide a secure environment deployment option. Smart Software Satellite provides support for options **3** and **4**.

The communication between Cisco products and Cisco license service is facilitated by the Smart Call Home software.

About Call Home

Call Home provides an email and http/https based notification for critical system policies. A range of message formats are available for compatibility with pager services or XML-based automated parsing applications. You can use this feature to page a network support engineer, email a Network Operations Center, or use Cisco Smart Call Home services to generate a case with the Technical Assistance Center. The Call Home feature can deliver alert messages containing information about diagnostics and environmental faults and events.

The Call Home feature can deliver alerts to multiple recipients, referred to as Call Home destination profiles. Each profile includes configurable message formats and content categories. A predefined destination is provided for sending alerts to the Cisco TAC, but you also can define your own destination profiles. When you configure Call Home to send messages, the appropriate CLI show command is executed and the command output is attached to the message. Call Home messages are delivered in the following formats:

- Short text format which provides a one or two line description of the fault that is suitable for pagers or printed reports.
- Full text format which provides fully formatted message with detailed information that is suitable for human reading.
- XML machine readable format that uses Extensible Markup Language (XML) and Adaptive Messaging Language (AML) XML schema definition (XSD). The AML XSD is published on the Cisco.com website at http://www.cisco.com/. The XML format enables communication with the Cisco Systems Technical Assistance Center.

Supported Flexible Consumption Model Licenses

Smart Licensing uses Flexible Consumption licensing model. Flexible Consumption model licensing is based on the capacity of the ports configured. If you purchase a chassis that supports Flexible Consumption model licensing, you need to configure Flexible Consumption model licensing to enable the licensing features.

Flexible Consumption model licensing checks usage across all ports of a system on a daily basis and reports license usage results to the Smart Licensing Manager at Cisco.com.

To enable Flexible Consumption model licensing for your hardware or software, use **license smart flexible-consumption enable** command in the global configuration mode. To disable Flexible Consumption model licensing for your hardware or software, use the **no license smart flexible-consumption enable** command in the global configuration mode.

There are three types of licenses in this model:

- Essential licenses are the licenses that are required by every active port, for example ESS-100G-RTU-1. These licenses support the pay as you grow model of flexible consumption model of licensing.
- Advanced licenses are the licenses that are required for ports that use advanced features like L3VPN. Example of an advanced license is ADV-100G-RTU-1. These licenses support the pay as you grow model of flexible consumption model of licensing.
- Tracking licenses. These licenses support systems and line cards and help you to understand the number of systems or line cards in use in a network.

The following table provides the consumption pattern of different Flexible Consumption model licenses for Cisco NCS 540 Series Routers:

Table 5: Flexible Consumption Licensing Model Usage Pattern

Flexible Consumption Model Licenses	Consumption Pattern
ESS-AC-10G-RTU-1	If the router has a fixed chassis (N540-24Z8Q2C-M, N540-X-24Z8Q2C-M), the license consumption checks are performed on the chassis.
ESS-AC-10G-SIA-3	Access Network Essentials Software Innovation Access per 10Gb: 3-year
ESS-AC-10G-SIA-4	Access Network Essentials Software Innovation Access per 10Gb: 4-yearW
ESS-AC-10G-SIA-5	Access Network Essentials Software Innovation Access per 10Gb: 5-year
ESS-AC-10G-SIA-7	Access Network Essentials Software Innovation Access per 10Gb: 7-year
ESS-AC-10G-SIA-10	Access Network Essentials Software Innovation Access per 10Gb: 10-year
ADV-AC-10G-RTU-1	Access Network Advanced Software RTU per 10Gb
ADV-AC-10G-SIA-3	Access Network Advanced Software Innovation Access per 10Gb: 3-year
ADV-AC-10G-SIA-4	Access Network Advanced Software Innovation Access per 10Gb: 4-year
ADV-AC-10G-SIA-5	Access Network Advanced Software Innovation Access per 10Gb: 5-year

Flexible Consumption Model Licenses	Consumption Pattern
ADV-AC-10G-SIA-7	Access Network Advanced Software Innovation Access per 10Gb: 7-year
ADV-AC-10G-SIA-10	Access Network Advanced Software Innovation Access per 10Gb: 10-year
N540-24Z8Q2C-FC-SW	NCS 540 Series additional Software Licenses (RTU, SIA)

Configure Licenses Using the Smart Licensing Solution

Register and Activate Your Device

Smart Licensing components are packaged into the *ncs5500-mini-x.iso*. The https client that is required for configuring the Smart Call Home is packaged into the *ncs5500-k9sec RPM*. Use the steps described here to register and activate your device, and associate the device with your virtual account.

To register and activate your device, you must:

- Generate registration token from the Cisco Smart Software Manager portal.
- Use the registration token to register your device using the command line interface.

Generate Product Registration Token from the Portal

You must have purchased the product for which you are adding the license. When you purchase the product, you are provided with a username and password to the Cisco Smart Software Manager portal, from where you can generate the product instance registration tokens.

1. Log in to Cisco Smart Software Manager at Smart Software Licensing.
2. Under **Inventory** menu, click **General** tab.
3. Click **New Token** to generate a product registration token.
4. Copy the new token value, which is used to register and activate your device, and associate the device to your virtual account.

Note This token is valid for 290 days.

Register New Product in CLI

On the command prompt, use the registration token to activate the device.

```
RP/0/#license smart register idtoken token_ID
RP/0/#commit
```

On successful registration, the device receives an identity certificate. This certificate is saved on your device and automatically used for all future communications with Cisco. Every 290 days, Smart Licensing automatically renews the registration information with Cisco. If registration fails, an error is logged. Also, license usage data is collected and a report is sent to you every month. If necessary, you can configure your Smart Call Home settings such that sensitive information (like hostname, username and password) are filtered out from the usage report.

Verify Smart Licensing Configuration

After enabling Smart Licensing, you can use the **show** commands to verify the default Smart Licensing configuration. If any issue is detected, take corrective action before making further configurations.

Procedure

Step 1 **show license status**

Example:

```
router#show license status
```

Displays the compliance status of Smart Licensing. Following are the possible status:

- **Waiting**—Indicates the initial state after your device has made a license entitlement request. The device establishes communication with Cisco and successfully registers itself with the Cisco Smart Software Manager.
- **Authorized**—Indicates that your device is able to communicate with the Cisco Smart Software Manager, and is authorised to initiate requests for license entitlements.
- **Out-Of-Compliance**—Indicates that one or more of your licenses are out-of-compliance. You must buy additional licenses.
- **Eval Period**—Indicates that Smart Licencing is consuming the evaluation period. You must register the device with the Cisco Smart Software Manager, else your license expires.
- **Disabled**—Indicates that Smart Licensing is disabled.
- **Invalid**—Indicates that Cisco does not recognize the entitlement tag as it is not in the database.

Step 2 **show license all**

Example:

```
router# show license all
```

Displays all entitlements in use. Additionally, it shows associated licensing certificates, compliance status, UDI, and other details.

Step 3 **show license status**

Example:

```
router# show license status
```

Displays the status of all entitlements in use.

Step 4 **show license udi**

Example:

```
router# show license udi
```

Displays UDI information.

Step 5 **show license summary**

Example:

```
router# show license summary
```

Displays a summary of all entitlements in use.

Step 6 **show license platform summary**

Example:

```
router# show license platform summary
```

Displays the registration status and provides detailed information regarding the number of essential, advanced and tracking license consumption in generic or Flexible Consumption License Model.

Step 7 **show license platform detail**

Example:

```
router# show license platform detail
```

Displays the detailed licenses that can be consumed in particular platform in both generic and Flexible Consumption model. Also displays the current and the next consumption count of a particular license. Displays information of the active model,whether is it generic or Flexible Consumption License Model.

Step 8 **show call-home smart-licensing statistics**

Example:

The following example shows sample output from the **show call-home smart-licensing statistics** command:

```
router# show call-home smart-licensing statistics
Success: Successfully sent and response received.
Failed : Failed to send or response indicated error occurred.
Inqueue: In queue waiting to be sent.
Dropped: Dropped due to incorrect call-home configuration.

Msg Subtype      Success Failed  Inqueue Dropped Last-sent (GMT-07:00)
-------------------------------------------------------------------------
ENTITLEMENT      2       0       0       0       2014-04-24 18:24:34
REGISTRATION     1       0       0       0       2014-04-25 03:53:57
ACKNOWLEDGEMENT  1       0       0       0       2014-04-23 19:21:21
RENEW            1       0       0       0       2014-04-23 19:21:11
DEREGISTRATION   1       0       0       0       2014-04-25 03:31:35
```

Displays the statistics of communication between the Smart Licensing manager and the Cisco back-end using Smart Call Home. In case communication fails or drops, check your call home configuration for any errors.

Renew Smart Licensing Registration

In general, your registration is automatically renewed every six months. Use this option to make an on-demand manual update of your registration. Thus, instead of waiting six months for the next registration renewal cycle, you can issue this command to instantly find out the status of your license.

Before you begin

You must ensure that the following conditions are met to renew your smart license:

- Smart licensing is enabled.
- The device is registered.

Procedure

license smart renew {**auth** | **id**}

Example:

```
RP/0/RP0/CPU0:#license smart renew auth
Tue  Apr 22 09:12:37.086 PST

license smart renew auth: Authorization process is in progress.
Please check the syslog for the authorization status and result.
```

Renew your ID or authorization with Cisco smart licensing. If ID certification renewal fails, then the product instance goes to an unidentified state and starts consuming the evaluation period.

Authorization periods are renewed by the Smart Licensing system every 30 days. As long as the license is in an 'Authorized' or 'Out-of-compliance' (OOC), the authorization period is renewed. Grace period starts when an authorization period expires. During the grace period or when the grace period is in the 'Expired' state, the system continues to try renew the authorization period. If a retry is successful, a new authorization period starts.

De-register Smart Licensing

When your device is taken off the inventory, shipped elsewhere for redeployment or returned to Cisco for replacement using the return merchandise authorization (RMA) process, you can use the de-register option to cancel the registration on your device. Use the following steps to cancel device registration:

Procedure

license smart deregister

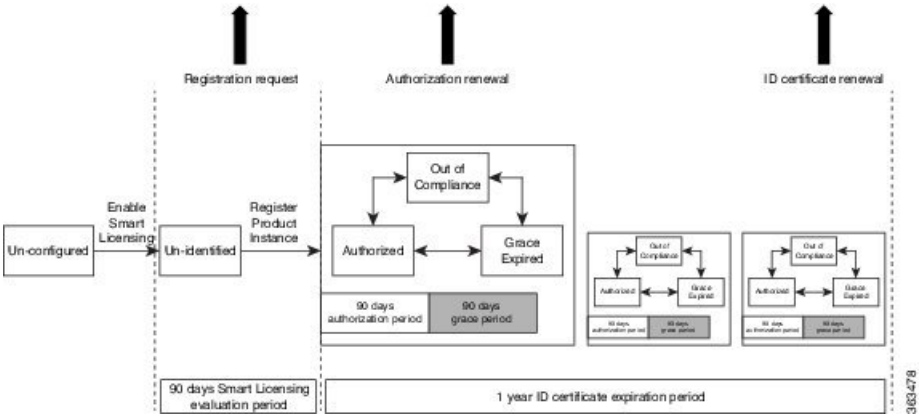
Example:

```
RP/0//CPU0 #license smart deregister

license smart deregister: Success

License command "license smart deregister " completed successfully.
```

Cancels the device registration and sends it into a 30-day evaluation mode. All Smart Licensing entitlements and certificates on the platform are removed. Though the product instance has been de-registered from the Cisco license cloud service, Smart Licensing is still enabled.

Smart Licensing Workflow

The Smart Licensing workflow is depicted in this flowchart.



Licenses, Product Instances, and Registration Tokens

Licenses

Depending on the product, all Cisco products licenses are any one of the following two types:

- Perpetual licenses—Licenses that do not expire.
- Term licenses—Licenses that automatically expire after a set amount of time: one year, three years, or whatever term was purchased.

All product licenses reside in a virtual account.

Product Instances

A product instance is an individual device with a unique device identifier (UDI) that is registered using a product instance registration token (or registration token). You can register any number of instances of a product with a single registration token. Each product instance can have one or more licenses residing in the same virtual account. Product instances must periodically connect to the Cisco Smart Software Manager servers during a specific renewal period. If a product instance fails to connect, it is marked as having a license shortage, but continues to use the license. If you remove the product instance, its licenses are released and made available within the virtual account.

Product Instance Registration Tokens

A product requires a registration token until you have registered the product. Registration tokens are stored in the Product Instance Registration Token Table associated with your enterprise account. Once the product

is registered the registration token is no longer necessary and can be revoked and removed from the table without effect. Registration tokens can be valid from 1 to 365 days.

Virtual Accounts

Smart Licencing allows you to create multiple license pools or virtual accounts within the Smart Software Manager portal. Using the **Virtual Accounts** option you can aggregate licenses into discrete bundles associated with a cost center so that one section of an organization cannot use the licenses of another section of the organization. For example, if you segregate your company into different geographic regions, you can create a virtual account for each region to hold the licenses and product instances for that region.

All new licenses and product instances are placed in the default virtual account in the Smart Software Manager, unless you specify a different one during the order process. Once in the default account, you may choose to transfer them to any other account as desired, provided you have the required access permissions.

Use the Smart Software Manager portal at https://tools.cisco.com/rhodui/index to create license pools or transfer licenses.

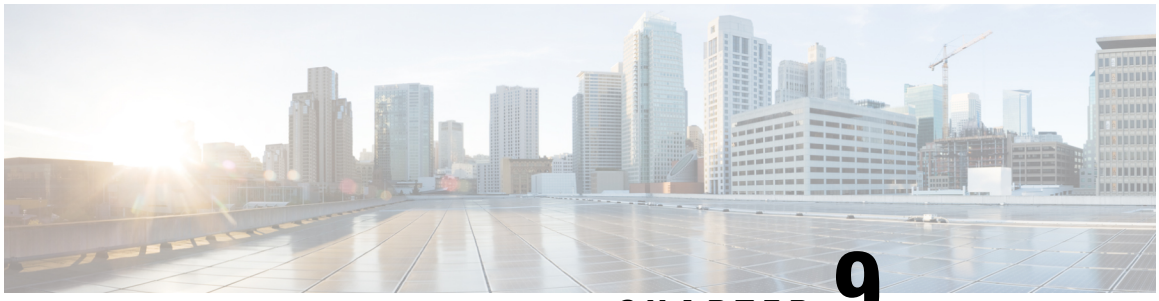
Compliance reporting

On a periodic basis, as described by the terms of the Smart Licensing contract, reports are automatically sent to you containing inventory and license compliance data. These reports will take one of three forms:

- **Periodic Record—**This record is generated on a periodic (configurable) basis with relevant inventory data saved at a given point of time. This report is saved within the Cisco cloud for archival.
- **Manual Record—**You can manually generate this record with relevant inventory data saved at any given point of time. This report will be saved within the Cisco cloud for archival.
- **Compliance Warning Report—**This report is automatically or manually generated when a license compliance event occurs. This report does not contain a full inventory data, but only any shortfalls in entitlements for a given software license.

Note A warning message appears when a license is out-of-compliance. A log message is also saved in the syslog.

You can view these reports from the Smart Software Manager portal at https://tools.cisco.com/rhodui/index.



CHAPTER 9

Configuring Zero Touch Provisioning

Zero Touch Provisioning (ZTP) works as a Third Party App (TPA) in Route-Switch Processor (RSP) and Route Processor (RP). ZTP was designed to perform two different operations:

- Download and apply an initial configuration.
- Download and execute a shell script.

If the downloaded file content starts with **!! IOS XR** it is considered as a configuration file, and ZTP performs **apply_config** action on the configuration file.

If the downloaded file content starts with **#! /bin/bash**, **#! /bin/sh** or **#!/usr/bin/python** it is considered as a script file, and ZTP executes the script.

ZTP works as following:

1. XR scripts that run on boot, invoke DHCP request.
2. DHCP server returns either a user script or configuration file.
3. Download the user script or configuration file.
4. Execute the downloaded user script or apply the downloaded configuration.

Prior to Cisco IOS XR Release 6.3.1, ZTP was executed within the default network namespace and could not access the data interfaces directly. Starting with Cisco IOS XR Release 6.3.1, ZTP is executed inside the global Virtual Routing and Forwarding (VRF) network namespace with full access to all the data interfaces.

When ZTP process encounters any error, or when ZTP quits or terminates, it revert to the initial configuration that exists before starting of ZTP process.

Note

- When initiated, ZTP checks if the system start-up configuration is applied. If startup configuration is not applied, ZTP waits for 10 minutes before proceeding.
- To boot an image through ZTP, configure the ROMMON reboot mode option to 3.

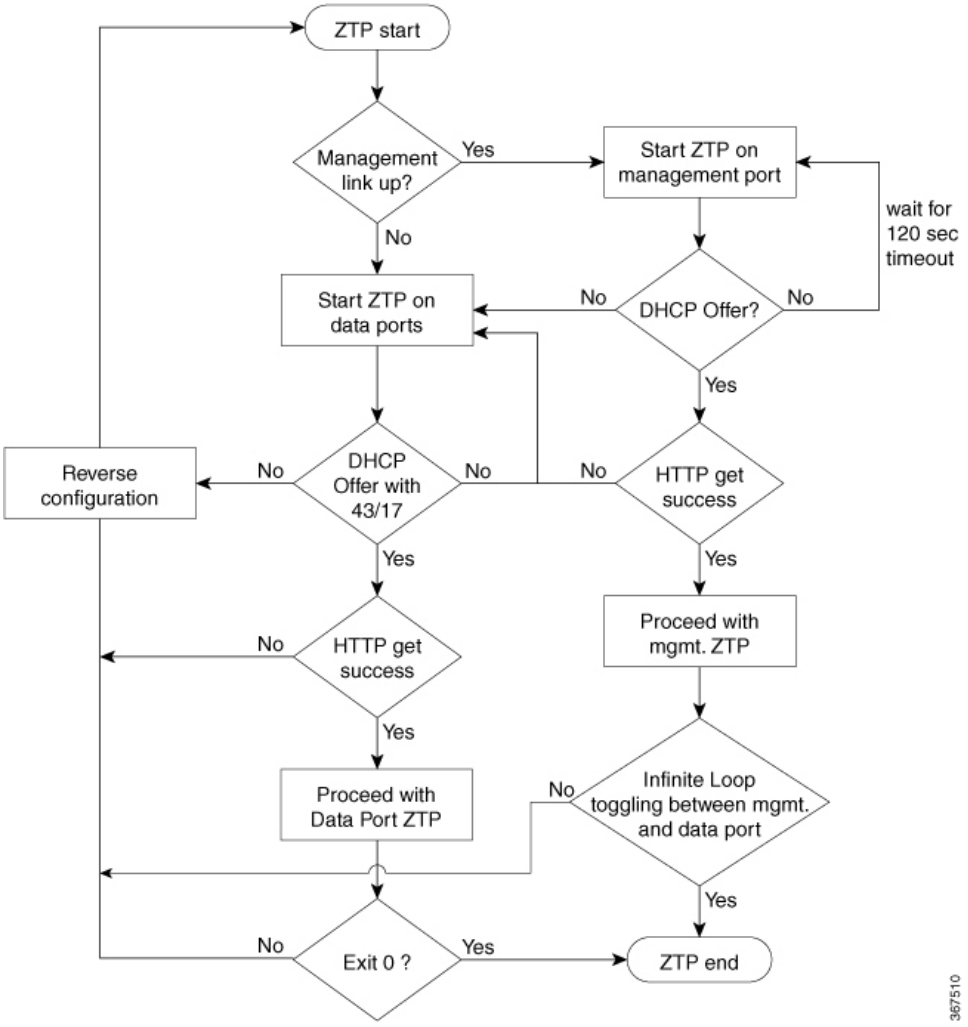
ZTP Switches between Management and Data Port

From Cisco IOS XR Release 6.5.1, during the fresh boot of a router, auto ZTP process is initiated from the management port and switches to data port. The following events cause the ZTP process to switch between management and data port:

- When ZTP does not find an active interface.
- When ZTP does not receive DHCP response and time elapsed since dhclient started is greater than 128 seconds.
- When ZTP encounters an error.

The below flow diagram illustrates the ZTP process.

Figure 6: ZTP Process Flow Sequence



Note

- During fresh boot or manual invocation, ZTP enables IPv6 on all data port interfaces in the dataport mode.
- The auto breakout mode is not supported.
- Starting from Cisco IOS XR Release 6.5.1, auto data port is supported.

Manual ZTP Invocation

Manual Zero Touch Provisioning (ZTP) can be invoked manually via CLI commands. This manual way helps you to provision the router in stages. Ideal for testing out ZTP configuration without a reboot. If you would like to invoke a ZTP on an interfaces(data ports or management port), you don't have to bring up and configure the interface first. You can execute the **ztp initiate** command, even if the interface is down, ZTP script will bring it up and invoke dhclient. So ZTP could run over all interfaces no matter it is up or down.

Use the **ztp initiate**, **ztp breakout**, **ztp terminate**, and **ztp clean** commands to force ZTP to run over more interfaces.

- **ztp initiate**— Invokes a new ZTP session. Logs can be found in **/var/log/ztp.log**.
- **ztp terminate**—Terminates any ZTP session in progress.
- **ztp clean**—Removes only the ZTP state files.

  From release 6.2.3, the log file ztp.log is saved in **/var/log** folder, and a copy of log file is available at **/disk0:/ztp/ztp.log** location using a soft link. However, executing **ztp clean** clears files saved on disk and not on **/var/log** folder where current ZTP logs are saved. In order to have a log from current ZTP run, you must manually clear the ZTP log file from **/var/log/** folder.

For more information of the commands, see the ZTP command chapter in the .

This task shows the most common use case of manual ZTP invocation: invoke 4x10 breakout discovery and ZTP.

Procedure

	Command or Action	Purpose
Step 1	**ztp breakout** **Example:** `RP/0/# ztp breakout`	Tries the 4x10 breakout on 100 GE interfaces that supports breakout and are operationally down after no-shut. If the 10x10 breakout configure brings any 10GE interface operationally up, the breakout configuration is retained; if not, the breakout configuration is reverted.

	Command or Action	Purpose

Step 2	**ztp initiate dataport**
	Example:
	`RP/0/# ztp initiate dataport`
	
	`Wed Apr 22 10:52:24.417 UTC`
	`Invoke ZTP? (this may change your configuration) [confirm] [y/n] :y`
	`ZTP will now run in the background.`
	`ZTP might bring up the interfaces if they are in shutdown state.`
	`Please use "show logging" or look at /disk0:/ztp/ztp.log to check progress.`
		Invokes DHCP sessions on all data ports that are either up or could be brought up. ZTP runs in the background.

ZTP Bootscript

If you want to hard code a script to be executed every boot, configure the following.

```
conf t
    ztp bootscript /disk0:/myscript
commit
```

The above configuration will wait for the first data-plane interface to be configured and then wait an additional minute for the management interface to be configured with an IP address, to ensure that we have connectivity in the third party namespace for applications to use. If the delay is not desired, use:

```
conf t
    ztp bootscript preip /disk0:/myscript
commit
```

Note When the above command is first configured, you will be prompted if you wish to invoke it now. The prompt helps with testing.

This is the example content of **/disk0:/myscript**:

```
#!/bin/bash
exec &> /dev/console # send logs to console
source /pkg/bin/ztp_helper.sh

# If we want to only run one time:
xrcmd "show running" | grep -q myhostname
if [[ $? -eq 0 ]]; then
    echo Already configured
fi

# Set the hostname
cat >/tmp/config <<%%
!! XR config example
hostname myhostname
%%
xrapply /tmp/config
```

```
#
# Force an invoke of ZTP again. If there was a username normally it would not run. This
forces it.
# Kill off ztp if it is running already and suppress errors to the console when ztp runs
below and
# cleans up xrcmd that invokes it. ztp will continue to run however.
#
xrcmd "ztp terminate noprompt" 2>/dev/null
xrcmd "ztp initiate noprompt" 2>/dev/null
```

ZTP Utilities

ZTP includes a set of shell utilities that can be sourced within the user script. **ztp_helper.sh** is a shell script that can be sourced by the user script. **ztp_helper.sh** provides simple utilities to access some XR functionalities. Following are the bash functions that can be invoked:

- **xrcmd**—Used to run a single XR exec command:

  ```
  xrcmd "show running"
  ```

- **xrapply**—Applies the block of configuration, specified in a file:

  ```
  cat >/tmp/config <<%%
  !! XR config example
  hostname node1-mgmt-via-xrapply
  %%
  xrapply /tmp/config
  ```

- **xrapply_with_reason**—Used to apply a block of XR configuration along with a reason for logging purpose:

  ```
  cat >/tmp/config <<%%
  !! XR config example
  hostname node1-mgmt-via-xrapply
  %%
  xrapply_with_reason "this is a system upgrade" /tmp/config
  ```

- **xrapply_string**—Used to apply a block of XR configuration in one line:

  ```
  xrapply_string "hostname foo\ninterface GigabitEthernet0/0/0/0\nipv4 address 1.2.3.44
  255.255.255.0\n"
  ```

- **xrapply_string_with_reason**—Used to apply a block of XR configuration in one line along with a reason for logging purposes:

  ```
  xrapply_string_with_reason "system renamed again" "hostname venus\n interface
  TenGigE0/0/0/0\n ipv4 address 172.30.0.144/24\n"
  ```

- **xrreplace**—Used to apply XR configuration replace in XR namespace via a file.

  ```
  cat rtr.cfg <<%%
  !! XR config example
  hostname node1-mgmt-via-xrreplace
  %%
  xrreplace rtr.cfg
  ```

- **admincmd**—Used to run an admin CLI command in XR namespace. Logs can be found in **/disk0:/ztp/ztp_admincmd.log**
- **xrapply_with_extra_auth**—Used to apply XR configuration that requires authentication, in XR namespace via a file. The **xrapply_with_extra_auth** API is used when configurations that require additional authentication to be applied such as alias, flex groups.

```
cat >/tmp/config <<%%
!! XR config example
alias exec alarms show alarms brief system active
alias exec version run cat /etc/show_version.txt
%%
xrapply_with_extra_auth >/tmp/config
```

- **xrreplace_with_extra_auth**—Used to apply XR configuration replace in XR namespace via a file The **xrreplace_with_extra_auth** API is used when configurations that require additional authentication to be applied such as alias, flex groups

```
cat >/tmp/config <<%%
!! XR config example
alias exec alarms show alarms brief system active
alias exec version run cat /etc/show_version.txt
%%
xrreplace_with_extra_auth >/tmp/config
```

Examples

ZTP logs its operation on the flash file system in the directory **/disk0:/ztp/**. ZTP logs all the transaction with the DHCP server and all the state transition. Prior executions of ZTP are also logged in **/disk0:/ztp/old_logs/**.

The following example displays the execution of a simple configuration script downloaded from a data interface using the command **ztp initiate interface Ten 0/0/0/0 verbose**, this script will unshut all the interfaces of the system and configure a load interval of 30 seconds on all of them.

```
#!/bin/bash
##############################################################################
# *** Be careful this is powerful and can potentially destroy your system ***
#                *** !!! Use at your own risk !!! ***
#
# Script file should be saved on the backend HTTP server
##############################################################################

source ztp_helper.sh
config_file="/tmp/config.txt"
interfaces=$(xrcmd "show interfaces brief")

function activate_all_if(){
  arInt=($(echo $interfaces | grep -oE '(Te|Fo|Hu)[0-9]*/[0-9]*/[0-9]*/[0-9]*'))
  for int in ${arInt[*]}; do
    echo -ne "interface $int\n no shutdown\n load-interval 30\n" >> $config_file
  done
  xrapply_with_reason "Initial ZTP configuration" $config_file
}

### Script entry point
if [ -f $config_file ]; then
```

```
  /bin/rm -f $config_file
else
  /bin/touch $config_file
fi
activate_all_if;
exit 0
```

The following example displays the ZTP logging output:

```
Oct 11 11:05:38 172.30.0.54 ztp-script: Hello from ncs-5001-c !!!
Oct 11 11:05:40 172.30.0.54 ztp-script: current=6.1.1, desired=6.1.1
Oct 11 11:05:40 172.30.0.54 ztp-script: Version match, proceeding to configuration
Oct 11 11:05:41 172.30.0.54 ztp-script: Starting autoprovision process...
Oct 11 11:05:42 172.30.0.54 ztp-script: ### XR K9SEC INSTALL ###
Oct 11 11:05:44 172.30.0.54 ztp-script: ### Downloading complete ###
Oct 11 11:05:55 172.30.0.54 ztp-script: Waiting for k9sec package to be activated
Oct 11 11:06:01 172.30.0.54 ztp-script: ### XR K9SEC INSTALL COMPLETE ###
Oct 11 11:06:03 172.30.0.54 ztp-script: ### Installing midnight commander ###
Oct 11 11:06:04 172.30.0.54 ztp-script: ### Downloading system configuration ###
Oct 11 11:06:05 172.30.0.54 ztp-script: ### Downloading system configuration complete ###
Oct 11 11:06:06 172.30.0.54 ztp-script: ### Applying initial system configuration ###
Oct 11 11:06:11 172.30.0.54 ztp-script: !!! Checking for errors !!!
Oct 11 11:06:14 172.30.0.54 ztp-script: ### Applying system configuration complete ###
Oct 11 11:06:15 172.30.0.54 ztp-script: Autoprovision complete...
```