Configuring IP Unicast Routing

Finding Feature Information

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

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

Information About Configuring IP Unicast Routing

This module describes how to configure IP Version 4 (IPv4) unicast routing on the switch.

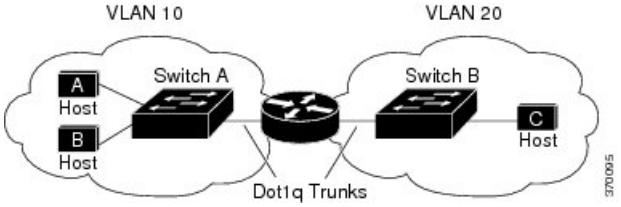
Information About IP Routing

In some network environments, VLANs are associated with individual networks or subnetworks. In an IP network, each subnetwork is mapped to an individual VLAN. Configuring VLANs helps control the size of

the broadcast domain and keeps local traffic local. However, network devices in different VLANs cannot communicate with one another without a Layer 3 device (router) to route traffic between the VLAN, referred to as inter-VLAN routing. You configure one or more routers to route traffic to the appropriate destination VLAN.

Figure 1: Routing Topology Example

This figure shows a basic routing topology. Switch A is in VLAN 10, and Switch B is in VLAN 20. The router has an interface in each VLAN.



When Host A in VLAN 10 needs to communicate with Host B in VLAN 10, it sends a packet addressed to that host. Switch A forwards the packet directly to Host B, without sending it to the router.

When Host A sends a packet to Host C in VLAN 20, Switch A forwards the packet to the router, which receives the traffic on the VLAN 10 interface. The router checks the routing table, finds the correct outgoing interface, and forwards the packet on the VLAN 20 interface to Switch B. Switch B receives the packet and forwards it to Host C.

Types of Routing

Routers and Layer 3 switches can route packets in these ways:

- By using default routing
- By using preprogrammed static routes for the traffic
- By dynamically calculating routes by using a routing protocol

The switch supports static routes and default routes. It does not support routing protocols.

The switch supports static routes and default routes. It supports Routing Information Protocol (RIP) for both IPv4 and IPv6 versions.

Static Unicast Routes

Static unicast routes are user-defined routes that cause packets moving between a source and a destination to take a specified path. Static routes can be important if the router cannot build a route to a particular destination and are useful for specifying a gateway of last resort to which all unroutable packets are sent.

The switch retains static routes until you remove them. However, you can override static routes with dynamic routing information by assigning administrative distance values. Each dynamic routing protocol has a default administrative distance, as listed in Table 41-16. If you want a static route to be overridden by information from a dynamic routing protocol, set the administrative distance of the static route higher than that of the dynamic protocol.

Table 1: Dynamic Routing Protocol Default Administrative Distances

Route Source	Default Distance
Connected interface	0
Static route	1
Enhanced IRGP summary route	5
Internal Enhanced IGRP	90
IGRP	100
OSPF	110
RIP	120
Unknown	225

Static routes that point to an interface are advertised through RIP, IGRP, and other dynamic routing protocols, whether or not static **redistribute** router configuration commands were specified for those routing protocols. These static routes are advertised because static routes that point to an interface are considered in the routing table to be connected and hence lose their static nature. However, if you define a static route to an interface that is not one of the networks defined in a network command, no dynamic routing protocols advertise the route unless a **redistribute** static command is specified for these protocols.

When an interface goes down, all static routes through that interface are removed from the IP routing table. When the software can no longer find a valid next hop for the address specified as the forwarding router's address in a static route, the static route is also removed from the IP routing table.

Default Routes and Networks

A router might not be able to learn the routes to all other networks. To provide complete routing capability, you can use some routers as smart routers and give the remaining routers default routes to the smart router. (Smart routers have routing table information for the entire internetwork.) These default routes can be dynamically learned or can be configured in the individual routers. Most dynamic interior routing protocols include a mechanism for causing a smart router to generate dynamic default information that is then forwarded to other routers.

If a router has a directly connected interface to the specified default network, the dynamic routing protocols running on that device generate a default route. In RIP, it advertises the pseudonetwork 0.0.0.0.

A router that is generating the default for a network also might need a default of its own. One way a router can generate its own default is to specify a static route to the network 0.0.0.0 through the appropriate device.

When default information is passed through a dynamic routing protocol, no further configuration is required. The system periodically scans its routing table to choose the optimal default network as its default route. In IGRP networks, there might be several candidate networks for the system default. Cisco routers use administrative distance and metric information to set the default route or the gateway of last resort.

If dynamic default information is not being passed to the system, candidates for the default route are specified with the **ip default-network** global configuration command. If this network appears in the routing table from any source, it is flagged as a possible choice for the default route. If the router has no interface on the default

network, but does have a path to it, the network is considered as a possible candidate, and the gateway to the best default path becomes the gateway of last resort.

Routing Information Protocol

The Routing Information Protocol (RIP) is an interior gateway protocol (IGP) created for use in small, homogeneous networks. It is a distance-vector routing protocol that uses broadcast User Datagram Protocol (UDP) data packets to exchange routing information. The protocol is documented in RFC 1058. You can find detailed information about RIP in *IP Routing Fundamentals,* published by Cisco Press.

Using RIP, the Switch sends routing information updates (advertisements) every 30 seconds. If a router does not receive an update from another router for 180 seconds or more, it marks the routes served by that router as unusable. If there is still no update after 240 seconds, the router removes all routing table entries for the non-updating router.

RIP uses hop counts to rate the value of different routes. The hop count is the number of routers that can be traversed in a route. A directly connected network has a hop count of zero; a network with a hop count of 16 is unreachable. This small range (0 to 15) makes RIP unsuitable for large networks.

If the router has a default network path, RIP advertises a route that links the router to the pseudonetwork 0.0.0.0. The 0.0.0.0 network does not exist; it is treated by RIP as a network to implement the default routing feature. The Switch advertises the default network if a default was learned by RIP or if the router has a gateway of last resort and RIP is configured with a default metric. RIP sends updates to the interfaces in specified networks. If an interface's network is not specified, it is not advertised in any RIP update.

Summary Addresses and Split Horizon

Routers connected to broadcast-type IP networks and using distance-vector routing protocols normally use the split-horizon mechanism to reduce the possibility of routing loops. Split horizon blocks information about routes from being advertised by a router on any interface from which that information originated. This feature usually optimizes communication among multiple routers, especially when links are broken.

Configuring IP Unicast Routing

By default, IP routing is disabled on the switch. For detailed IP routing configuration information, see the *Cisco IOS IP Configuration Guide, Release 12.2* from the *Cisco.com* page under **Documentation** > **Cisco IOS Software Releases** > **12.2 Mainline** > **Configuration Guides**.

In these procedures, the specified interface can be a switch virtual interface (SVI)-a VLAN interface or a physical port interface created by using the **interface vlan** *vlan_id* or **interface** *type number* global configuration commands respectively, and by default a Layer 3 interface. All Layer 3 interfaces on which routing will occur must have IP addresses assigned to them.

Note The switch supports 16 static routes (including user-configured routes and the default route) and any directly connected routes and default routes for the management interface.

Procedures for configuring routing:

- To support VLAN interfaces, create and configure VLANs on the switch, and assign VLAN membership to Layer 2 interfaces. For more information, see chapter: *Configuring VLANs*.

- Configure Layer 3 interfaces.
- Enable IP routing on the switch.
- Assign IP addresses to the Layer 3 interfaces.
- Configure static routes.

Enabling IP Unicast Routing

By default, the Switch is in Layer 2 switching mode and IP routing is disabled. To use the Layer 3 capabilities of the Switch, you must enable IP routing.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip routing** **Example:** `Switch(config)# ip routing`	Enables IP routing.
Step 4	**end** **Example:** `Switch(config)# end`	Returns to privileged EXEC mode.
Step 5	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Switch# copy running-config`	(Optional) Saves your entries in the configuration file.

	Command or Action	Purpose
	`startup-config`	

Example: Enabling IP Unicast Routing

This example shows how to enable IP unicast routing.

```
Device(config)# ip routing
Device(config)# end
Device# show running-config
Device# copy running-config startup-config
```

Assigning IP Addresses to SVIs

To configure IP routing, you need to assign IP addresses to Layer 3 network interfaces. This enables communication with the hosts of those interfaces that use IP. IP routing is disabled by default, and no IP addresses are assigned to SVIs.

An IP address identifies a location to which IP packets can be sent. Some IP addresses are reserved for special uses and cannot be used for host, subnet, or network addresses. RFC 1166, “Internet Numbers,” contains the official description of IP addresses.

An interface can have one primary IP address. A mask identifies the bits that denote the network number in an IP address. When you use the mask to subnet a network, the mask is referred to as a subnet mask. To receive an assigned network number, contact your Internet service provider.

Follow these steps to assign an IP address and a network mask to an SVI:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface vlan** *vlan-id*	Enters interface configuration mode, and specifies the Layer 3 VLAN to configure.
Step 4	**ip address** *ip-address subnet-mask* **Example:**	Configures the IP address and IP subnet mask.

	Command or Action	Purpose
	`Switch(config-if)# ip address 10.1.5.1 255.255.255.0`	
Step 5	**end** **Example:** `Switch(config)# end`	Returns to privileged EXEC mode.
Step 6	**show interfaces** [*interface-id*] **Example:** `Switch# show interfaces gigabitethernet 0/1`	Verifies your entries.
Step 7	**show interfaces vlan** [*vlan-id*] **Example:** `Switch# show interfaces vlan 4`	Verifies your entries.
Step 8	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 9	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Example: Assigning IP Addresses to SVIs

This example shows how to assign an IP address and a network mask to an SVI.

```
Device(config)# interface vlan 4
Device(config-if)# ip address 10.1.5.1 255.255.255.0
Device(config-if)# exit
Device# show interfaces vlan 4
Device# show running-config
Device# copy running-config startup-config
```

Configuring Static Unicast Routes

Static unicast routes are user-defined routes that cause packets moving between a source and a destination to take a specified path. Static routes can be important if the router cannot build a route to a particular destination and are useful for specifying a gateway of last resort to which all unroutable packets are sent.

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

Follow these steps to configure a static route:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip route prefix mask** {*address* | *interface*} [*distance*] **Example:** `Device(config)# ip route prefix mask gigabitethernet 1/0/4gigabitethernet 0/4`	Establish a static route.
Step 4	**end** **Example:** `Switch(config)# end`	Returns to privileged EXEC mode.
Step 5	**show ip route** **Example:** `Switch# show ip route`	Displays the current state of the routing table to verify the configuration.
Step 6	**copy running-config startup-config** **Example:**	(Optional) Saves your entries in the configuration file.

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

What to do next

Use the **no ip route** *prefix mask* {*address*| *interface*} global configuration command to remove a static route. The switch retains static routes until you remove them.

Example: Configuring Static Unicast Routes

This example shows how to configure static unicast routes.

```
Device(config)# ip route prefix mask gigabitethernet 0/4
Device(config)# end
Device# show ip route
Device# copy running-config startup-config
```

Configuring Default Routes and Networks

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 2	**ip route** *network number* **Example:** `Switch(config)# ip route 0.0.0.0 0.0.0.0 10.10.10.2`	Specifies a default network.
Step 3	**end** **Example:** `Switch(config)# end`	Returns to privileged EXEC mode.
Step 4	**show ip route** **Example:** `Switch# show ip route`	Displays the selected default route in the gateway of last resort display.

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

How to Configure RIP

Default RIP Configuration

Table 2: Default RIP Configuration

Feature	Default Setting
Auto summary	Enabled.
Default-information originate	Disabled.
Default metric	Built-in; automatic metric translations.
IP RIP authentication key-chain	No authentication. Authentication mode: clear text.
IP RIP triggered	Disabled
IP split horizon	Varies with media.
Neighbor	None defined.
Network	None specified.
Offset list	Disabled.
Output delay	0 milliseconds.
Timers basic	• Update: 30 seconds. • Invalid: 180 seconds. • Hold-down: 180 seconds. • Flush: 240 seconds.
Validate-update-source	Enabled.
Version	Receives RIP Version 1 and 2 packets; sends Version 1 packets.

Configuring Basic RIP Parameters

To configure RIP, you enable RIP routing for a network and optionally configure other parameters. On the Switch, RIP configuration commands are ignored until you configure the network number.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**ip routing** **Example:** `Switch(config)# ip routing`	Enables IP routing. (Required only if IP routing is disabled.)
Step 4	**router rip** **Example:** `Switch(config)# router rip`	Enables a RIP routing process, and enter router configuration mode.
Step 5	**network** *network number* **Example:** `Switch(config-router)# network 12.0.0.0`	Associates a network with a RIP routing process. You can specify multiple **network** commands. RIP routing updates are sent and received through interfaces only on these networks. **Note** You must configure a network number for the RIP commands to take effect.
Step 6	**neighbor** *ip-address* **Example:** `Switch(config-router)# neighbor 10.2.5.1`	(Optional) Defines a neighboring router with which to exchange routing information. This step allows routing updates from RIP (normally a broadcast protocol) to reach nonbroadcast networks.
Step 7	**offset-list** [*access-list number* | *name*] {**in** | **out**} *offset* [*type number*] **Example:**	(Optional) Applies an offset list to routing metrics to increase incoming and outgoing metrics to routes learned through RIP. You

	Command or Action	Purpose
	`Switch(config-router)# offset-list 103 in 10`	can limit the offset list with an access list or an interface.
Step 8	**timers basic** *update invalid holddown flush* **Example:** `Switch(config-router)# timers basic 45 360 400 300`	(Optional) Adjusts routing protocol timers. Valid ranges for all timers are 0 to 4294967295 seconds. • *update*—The time between sending routing updates. The default is 30 seconds. • *invalid*—The timer after which a route is declared invalid. The default is 180 seconds. • *holddown*—The time before a route is removed from the routing table. The default is 180 seconds. • *flush*—The amount of time for which routing updates are postponed. The default is 240 seconds.
Step 9	**version** {**1** | **2**} **Example:** `Switch(config-router)# version 2`	(Optional) Configures the switch to receive and send only RIP Version 1 or RIP Version 2 packets. By default, the switch receives Version 1 and 2 but sends only Version 1. You can also use the interface commands **ip rip** {**send** | **receive**} **version 1** | **2** | **1 2**} to control what versions are used for sending and receiving on interfaces.
Step 10	**no auto-summary** **Example:** `Switch(config-router)# no auto-summary`	(Optional) Disables automatic summarization. By default, the switch summarizes subprefixes when crossing classful network boundaries. Disable summarization (RIP Version 2 only) to advertise subnet and host routing information to classful network boundaries.
Step 11	**end** **Example:** `Switch(config-router)# end`	Returns to privileged EXEC mode.
Step 12	**show ip protocols** **Example:** `Switch# show ip protocols`	Verifies your entries.

	Command or Action	Purpose
Step 13	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring RIP Authentication

RIP Version 1 does not support authentication. If you are sending and receiving RIP Version 2 packets, you can enable RIP authentication on an interface. The key chain specifies the set of keys that can be used on the interface. If a key chain is not configured, no authentication is performed, not even the default.

The Switch supports two modes of authentication on interfaces for which RIP authentication is enabled: plain text and MD5. The default is plain text.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Enters interface configuration mode, and specifies the interface to configure.
Step 4	**ip rip authentication key-chain** *name-of-chain* **Example:** `Switch(config-if)# ip rip authentication key-chain trees`	Enables RIP authentication.
Step 5	**ip rip authentication mode** {**text** | **md5**} **Example:** `Switch(config-if)# ip rip authentication mode md5`	Configures the interface to use plain text authentication (the default) or MD5 digest authentication.

	Command or Action	Purpose
Step 6	**end** **Example:** `Switch(config)# end`	Returns to privileged EXEC mode.
Step 7	**show running-config** **Example:** `Switch# show running-config`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Summary Addresses and Split Horizon

Note In general, disabling split horizon is not recommended unless you are certain that your application requires it to properly advertise routes.

If you want to configure an interface running RIP to advertise a summarized local IP address pool on a network access server for dial-up clients, use the **ip summary-address rip** interface configuration command.

Note If split horizon is enabled, neither autosummary nor interface IP summary addresses are advertised.

Procedure

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

	Command or Action	Purpose
	`Switch# configure terminal`	
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Enters interface configuration mode, and specifies the Layer 3 interface to configure.
Step 4	**ip address** *ip-address subnet-mask* **Example:** `Switch(config-if)# ip address 10.1.1.10 255.255.255.0`	Configures the IP address and IP subnet.
Step 5	**end** **Example:** `Switch(config)# end`	Returns to privileged EXEC mode.
Step 6	**show ip interface** *interface-id* **Example:** `Switch# show ip interface gigabitethernet 0/1`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configuring Split Horizon

Routers connected to broadcast-type IP networks and using distance-vector routing protocols normally use the split-horizon mechanism to reduce the possibility of routing loops. Split horizon blocks information about routes from being advertised by a router on any interface from which that information originated. This feature can optimize communication among multiple routers, especially when links are broken.

Note In general, we do not recommend disabling split horizon unless you are certain that your application requires it to properly advertise routes.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Switch> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Switch# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Switch(config)# interface gigabitethernet 0/1`	Enters interface configuration mode, and specifies the interface to configure.
Step 4	**ip address** *ip-address subnet-mask* **Example:** `Switch(config-if)# ip address 10.1.1.10 255.255.255.0`	Configures the IP address and IP subnet.
Step 5	**end** **Example:** `Switch(config)# end`	Returns to privileged EXEC mode.
Step 6	**show ip interface** *interface-id* **Example:** `Switch# show ip interface gigabitethernet 0/1`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Switch# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Example: Configuring Summary Addresses and Split Horizon

In this example, the major net is 10.0.0.0. The summary address 10.2.0.0 overrides the autosummary address of 10.0.0.0 so that 10.2.0.0 is advertised out interface Gigabit Ethernet port 2, and 10.0.0.0 is not advertised. In the example, if the interface is still in Layer 2 mode (the default), you must enter a **no switchport** interface configuration command before entering the **ip address** interface configuration command.

Note If split horizon is enabled, neither autosummary nor interface summary addresses (those configured with the **ip summary-address rip** router configuration command) are advertised.

```
Switch(config)# router rip
Switch(config-router)# interface gigabitethernet0/2
Switch(config-if)# ip address 10.1.5.1 255.255.255.0
Switch(config-if)# exit
Switch(config)# router rip
Switch(config-router)# network 10.0.0.0
Switch(config-router)# end
```

Example: Displaying Current Status of Routing Table

This is an example of the output from the **show ip route** privileged EXEC command:

```
Device# show ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
a - application route
+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is 192.0.2.5 to network 0.0.0.0

S* 0.0.0.0/0 [0/0] via 192.0.2.5
3.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C 3.3.3.0/24 is directly connected, GigabitEthernet0/23
L 3.3.3.2/32 is directly connected, GigabitEthernet0/23
6.0.0.0/24 is subnetted, 1 subnets
S 6.6.6.0 [1/0] via 192.0.2.5
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C 192.0.2.4/24 is directly connected, Vlan1
L 192.0.2.10/24 is directly connected, Vlan1
40.0.0.0/24 is subnetted, 1 subnets
S 40.40.40.0 [1/0] via 192.0.2.5
Device#


S -- Stand for static route.
```

Monitoring and Maintaining the IP Network

You can remove all contents of a particular cache, table, or database. You can also display specific statistics.

Table 3: Commands to Clear IP Routes or Display Route Status

Command	Purpose
show ip route [*address* [*mask*] [**longer-prefixes**]]	Displays the current state of the routing table.
show ip route summary	Displays the current state of the routing table in summary form.