CHAPTER 35

Configuring IP Unicast Routing

This chapter describes how to configure IP Version 4 (IPv4) unicast routing on the switch. The switch supports basic routing functions, including static routing and the Routing Information Protocol (RIP).

For more detailed IP unicast configuration information, see the *Cisco IOS IP Configuration Guide, Release 12.2* from the Cisco.com page under **Documentation > Cisco IOS Software > 12.2 Mainline > Configuration Guides**. For complete syntax and usage information for the commands used in this chapter, see these command references from the Cisco.com page under **Documentation > Cisco IOS Software > 12.2 Mainline > Command References**:

- *Cisco IOS IP Command Reference, Volume 1 of 3: Addressing and Services, Release 12.2*
- *Cisco IOS IP Command Reference, Volume 2 of 3: Routing Protocols, Release 12.2*
- *Cisco IOS IP Command Reference, Volume 3 of 3: Multicast, Release 12.2*

This chapter consists of these sections:

- Understanding IP Routing, page 35-1
- Steps for Configuring Routing, page 35-3
- Configuring IP Addressing, page 35-3
- Enabling IP Unicast Routing, page 35-17
- Configuring RIP, page 35-17
- Configuring Stub Routing, page 35-23
- Configuring Protocol-Independent Features, page 35-28
- Monitoring and Maintaining the IP Network, page 35-37

Note When configuring routing parameters on the switch and to allocate system resources to maximize the number of unicast routes allowed, you can use the **sdm prefer routing** global configuration command to set the Switch Database Management (sdm) feature to the routing template. For more information on the SDM templates, see Chapter 7, "Configuring SDM Templates" or see the **sdm prefer** command in the command reference for this release.

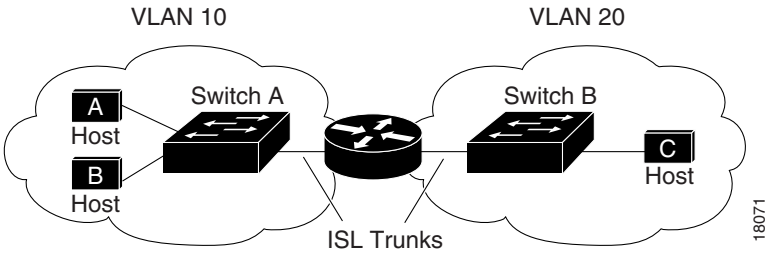
Understanding IP Routing

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 35-1 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.

Figure 35-1 Routing Topology Example



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 three different ways:

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

Default routing refers to sending traffic with a destination unknown to the router to a default outlet or destination.

Static unicast routing forwards packets from predetermined ports through a single path into and out of a network. Static routing is secure and uses little bandwidth, but does not automatically respond to changes in the network, such as link failures, and therefore, might result in unreachable destinations. As networks grow, static routing becomes a labor-intensive liability.

Dynamic routing protocols are used by routers to dynamically calculate the best route for forwarding traffic. Routers using distance-vector protocols maintain routing tables with distance values of networked resources, and periodically pass these tables to their neighbors. Distance-vector protocols use one or a series of metrics for calculating the best routes. These protocols are easy to configure and use.

The switch supports only the Routing Information Protocol (RIP), which uses a single distance metric (cost) to determine the best path. It also supports default routing and static routing.

Steps for Configuring Routing

By default, IP routing is disabled on the switch, and you must enable it before routing can take place. 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 > 12.2 Mainline > Configuration Guides**.

In the following procedures, the specified interface must be one of these Layer 3 interfaces:

- A routed port: a physical port configured as a Layer 3 port by using the **no switchport** interface configuration command.
- A switch virtual interface (SVI): a VLAN interface created by using the **interface vlan** *vlan_id* global configuration command and by default a Layer 3 interface.
- An EtherChannel port channel in Layer 3 mode: a port-channel logical interface created by using the **interface port-channel** *port-channel-number* global configuration command and binding the Ethernet interface into the channel group. For more information, see the "Configuring Layer 3 EtherChannels" section on page 34-13.

Note The switch does not support tunnel interfaces for unicast routed traffic.

All Layer 3 interfaces on which routing will occur must have IP addresses assigned to them. See the "Assigning IP Addresses to Network Interfaces" section on page 35-5.

Note A Layer 3 switch can have an IP address assigned to each routed port and SVI. The number of routed ports and SVIs that you can configure is not limited by software. However, the interrelationship between this number and the number and volume of features being implemented might have an impact on CPU utilization because of hardware limitations. To optimize system memory for routing, use the **sdm prefer routing** global configuration command.

Configuring routing consists of several main procedures:

- To support VLAN interfaces, create and configure VLANs on the switch, and assign VLAN membership to Layer 2 interfaces. For more information, see Chapter 12, "Configuring VLANs."
- Configure Layer 3 interfaces.
- Enable IP routing on the switch.
- Assign IP addresses to the Layer 3 interfaces.
- Enable selected routing protocols on the switch.
- Configure routing protocol parameters (optional).

Configuring IP Addressing

A required task for configuring IP routing is to assign IP addresses to Layer 3 network interfaces to enable the interfaces and allow communication with the hosts on those interfaces that use IP. These sections describe how to configure various IP addressing features. Assigning IP addresses to the interface is required; the other procedures are optional.

- Default Addressing Configuration, page 35-4
- Assigning IP Addresses to Network Interfaces, page 35-5

- Configuring Address Resolution Methods, page 35-7
- Routing Assistance When IP Routing is Disabled, page 35-10
- Configuring Broadcast Packet Handling, page 35-12
- Monitoring and Maintaining IP Addressing, page 35-16

Default Addressing Configuration

Table 35-1 shows the default addressing configuration.

Table 35-1 Default Addressing Configuration

Feature	Default Setting
IP address	None defined.
ARP	No permanent entries in the Address Resolution Protocol (ARP) cache. Encapsulation: Standard Ethernet-style ARP. Timeout: 14400 seconds (4 hours).
IP broadcast address	255.255.255.255 (all ones).
IP classless routing	Enabled.
IP default gateway	Disabled.
IP directed broadcast	Disabled (all IP directed broadcasts are dropped).
IP domain	Domain list: No domain names defined. Domain lookup: Enabled. Domain name: Enabled.
IP forward-protocol	If a helper address is defined or User Datagram Protocol (UDP) flooding is configured, UDP forwarding is enabled on default ports. Any-local-broadcast: Disabled. Spanning Tree Protocol (STP): Disabled. Turbo-flood: Disabled.
IP helper address	Disabled.
IP host	Disabled.
IRDP	Disabled. Defaults when enabled: • Broadcast IRDP advertisements. • Maximum interval between advertisements: 600 seconds. • Minimum interval between advertisements: 0.75 times max interval • Preference: 0.
IP proxy ARP	Enabled.
IP routing	Disabled.
IP subnet-zero	Disabled.

Assigning IP Addresses to Network Interfaces

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.

Beginning in privileged EXEC mode, follow these steps to assign an IP address and a network mask to a Layer 3 interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the Layer 3 interface to configure.
Step 3	**no switchport**	Remove the interface from Layer 2 configuration mode (if it is a physical interface).
Step 4	**ip address** *ip-address subnet-mask*	Configure the IP address and IP subnet mask.
Step 5	**no shutdown**	Enable the interface.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show interfaces** [*interface-id*] **show ip interface** [*interface-id*] **show running-config interface** [*interface-id*]	Verify your entries.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use of Subnet Zero

Subnetting with a subnet address of zero is strongly discouraged because of the problems that can arise if a network and a subnet have the same addresses. For example, if network 131.108.0.0 is subnetted as 255.255.255.0, subnet zero would be written as 131.108.0.0, which is the same as the network address.

You can use the all ones subnet (131.108.255.0) and even though it is discouraged, you can enable the use of subnet zero if you need the entire subnet space for your IP address.

Beginning in privileged EXEC mode, follow these steps to enable subnet zero:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip subnet-zero**	Enable the use of subnet zero for interface addresses and routing updates.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entry.
Step 5	**copy running-config startup-config**	(Optional) Save your entry in the configuration file.

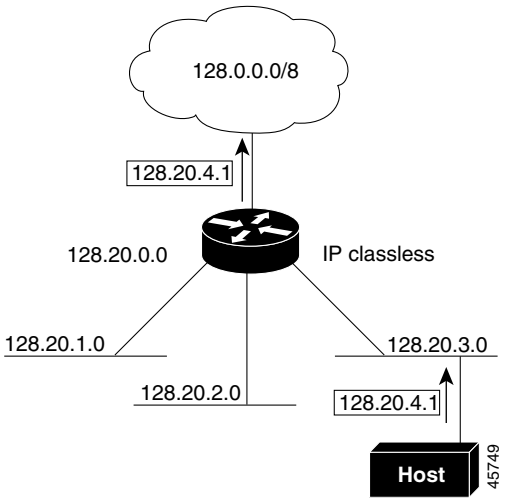
Use the **no ip subnet-zero** global configuration command to restore the default and disable the use of subnet zero.

Classless Routing

By default, classless routing behavior is enabled on the switch when it is configured to route. With classless routing, if a router receives packets for a subnet of a network with no default route, the router forwards the packet to the best supernet route. A *supernet* consists of contiguous blocks of Class C address spaces used to simulate a single, larger address space and is designed to relieve the pressure on the rapidly depleting Class B address space.

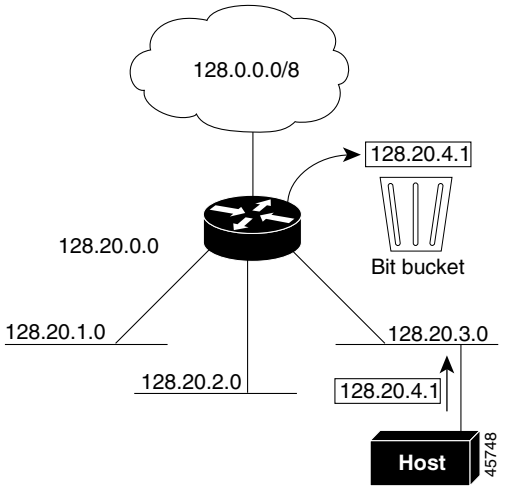
In Figure 35-2, classless routing is enabled. When the host sends a packet to 120.20.4.1, instead of discarding the packet, the router forwards it to the best supernet route. If you disable classless routing and a router receives packets destined for a subnet of a network with no network default route, the router discards the packet.

Figure 35-2 IP Classless Routing



In Figure 35-3, the router in network 128.20.0.0 is connected to subnets 128.20.1.0, 128.20.2.0, and 128.20.3.0. If the host sends a packet to 120.20.4.1, because there is no network default route, the router discards the packet.

Figure 35-3 No IP Classless Routing



To prevent the switch from forwarding packets destined for unrecognized subnets to the best supernet route possible, you can disable classless routing behavior.

Beginning in privileged EXEC mode, follow these steps to disable classless routing:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**no ip classless**	Disable classless routing behavior.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entry.
Step 5	**copy running-config startup-config**	(Optional) Save your entry in the configuration file.

To restore the default and have the switch forward packets destined for a subnet of a network with no network default route to the best supernet route possible, use the **ip classless** global configuration command.

Configuring Address Resolution Methods

You can control interface-specific handling of IP by using address resolution. A device using IP can have both a local address or MAC address, which uniquely defines the device on its local segment or LAN, and a network address, which identifies the network to which the device belongs.

The local address or MAC address is known as a data link address because it is contained in the data link layer (Layer 2) section of the packet header and is read by data link (Layer 2) devices. To communicate with a device on Ethernet, the software must learn the MAC address of the device. The process of learning the MAC address from an IP address is called *address resolution*. The process of learning the IP address from the MAC address is called *reverse address resolution*.

The switch can use these forms of address resolution:

- Address Resolution Protocol (ARP) is used to associate IP address with MAC addresses. Taking an IP address as input, ARP learns the associated MAC address and then stores the IP address/MAC address association in an ARP cache for rapid retrieval. Then the IP datagram is encapsulated in a link-layer frame and sent over the network. Encapsulation of IP datagrams and ARP requests or replies on IEEE 802 networks other than Ethernet is specified by the Subnetwork Access Protocol (SNAP).
- Proxy ARP helps hosts with no routing tables learn the MAC addresses of hosts on other networks or subnets. If the switch (router) receives an ARP request for a host that is not on the same interface as the ARP request sender, and if the router has all of its routes to the host through other interfaces, it generates a proxy ARP packet giving its own local data link address. The host that sent the ARP request then sends its packets to the router, which forwards them to the intended host.

The switch also uses the Reverse Address Resolution Protocol (RARP), which functions the same as ARP does, except that the RARP packets request an IP address instead of a local MAC address. Using RARP requires a RARP server on the same network segment as the router interface. Use the **ip rarp-server** *address* interface configuration command to identify the server.

For more information on RARP, see the *Cisco IOS Configuration Fundamentals Configuration Guide, Release 12.2* under **Documentation > Cisco IOS Software > 12.2 Mainline > Configuration Guides** from the Cisco.com page.

You can perform these tasks to configure address resolution:

- Define a Static ARP Cache, page 35-8
- Set ARP Encapsulation, page 35-9
- Enable Proxy ARP, page 35-9

Define a Static ARP Cache

ARP and other address resolution protocols provide dynamic mapping between IP addresses and MAC addresses. Because most hosts support dynamic address resolution, you usually do not need to specify static ARP cache entries. If you must define a static ARP cache entry, you can do so globally, which installs a permanent entry in the ARP cache that the switch uses to translate IP addresses into MAC addresses. Optionally, you can also specify that the switch respond to ARP requests as if it were the owner of the specified IP address. If you do not want the ARP entry to be permanent, you can specify a timeout period for the ARP entry.

Beginning in privileged EXEC mode, follow these steps to provide static mapping between IP addresses and MAC addresses:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**arp** *ip-address hardware-address type*	Globally associate an IP address with a MAC (hardware) address in the ARP cache, and specify encapsulation type as one of these: • **arpa**—ARP encapsulation for Ethernet interfaces • **snap**—Subnetwork Address Protocol encapsulation for Token Ring and FDDI interfaces • **sap**—HP's ARP type
Step 3	**arp** *ip-address hardware-address type* [*alias*]	(Optional) Specify that the switch respond to ARP requests as if it were the owner of the specified IP address.
Step 4	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to configure.
Step 5	**arp timeout** *seconds*	(Optional) Set the length of time an ARP cache entry will stay in the cache. The default is 14400 seconds (4 hours). The range is 0 to 2147483 seconds.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show interfaces** [*interface-id*]	Verify the type of ARP and the timeout value used on all interfaces or a specific interface.
Step 8	**show arp** or **show ip arp**	View the contents of the ARP cache.
Step 9	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove an entry from the ARP cache, use the **no arp** *ip-address hardware-address type* global configuration command. To remove all nonstatic entries from the ARP cache, use the **clear arp-cache** privileged EXEC command**.**

Set ARP Encapsulation

By default, Ethernet ARP encapsulation (represented by the **arpa** keyword) is enabled on an IP interface. You can change the encapsulation methods to SNAP if required by your network.

Beginning in privileged EXEC mode, follow these steps to specify the ARP encapsulation type:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the Layer 3 interface to configure.
Step 3	**arp** {**arpa** | **snap**}	Specify the ARP encapsulation method: • **arpa**—Address Resolution Protocol • **snap**—Subnetwork Address Protocol
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show interfaces** [*interface-id*]	Verify ARP encapsulation configuration on all interfaces or the specified interface.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable an encapsulation type, use the **no arp arpa** or **no arp snap** interface configuration command.

Enable Proxy ARP

By default, the switch uses proxy ARP to help hosts learn MAC addresses of hosts on other networks or subnets.

Beginning in privileged EXEC mode, follow these steps to enable proxy ARP if it has been disabled:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the Layer 3 interface to configure.
Step 3	**ip proxy-arp**	Enable proxy ARP on the interface.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show ip interface** [*interface-id*]	Verify the configuration on the interface or all interfaces.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable proxy ARP on the interface, use the **no ip proxy-arp** interface configuration command.

Routing Assistance When IP Routing is Disabled

These mechanisms allow the switch to learn about routes to other networks when it does not have IP routing enabled:

- Proxy ARP, page 35-10
- Default Gateway, page 35-10
- ICMP Router Discovery Protocol (IRDP), page 35-11

Proxy ARP

Proxy ARP, the most common method for learning about other routes, enables an Ethernet host with no routing information to communicate with hosts on other networks or subnets. The host assumes that all hosts are on the same local Ethernet and that they can use ARP to learn their MAC addresses. If a switch receives an ARP request for a host that is not on the same network as the sender, the switch evaluates whether it has the best route to that host. If it does, it sends an ARP reply packet with its own Ethernet MAC address, and the host that sent the request sends the packet to the switch, which forwards it to the intended host. Proxy ARP treats all networks as if they are local and performs ARP requests for every IP address.

Proxy ARP is enabled by default. To enable it after it has been disabled, see the "Enable Proxy ARP" section on page 35-9. Proxy ARP works as long as other routers support it.

Default Gateway

Another method for locating routes is to define a default router or default gateway. All nonlocal packets are sent to this router, which either routes them appropriately or sends an IP Control Message Protocol (ICMP) redirect message back, defining which local router the host should use. The switch caches the redirect messages and forwards each packet as efficiently as possible. A limitation of this method is that there is no means of detecting when the default router has gone down or is unavailable.

Beginning in privileged EXEC mode, follow these steps to define a default gateway (router) when IP routing is disabled:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip default-gateway** *ip-address*	Set up a default gateway (router).
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show ip redirects**	Display the address of the default gateway router to verify the setting.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no ip default-gateway** global configuration command to disable this function.

ICMP Router Discovery Protocol (IRDP)

Router discovery allows the switch to dynamically learn about routes to other networks using IRDP. IRDP allows hosts to locate routers. When operating as a client, the switch generates router discovery packets. When operating as a host, the switch receives router discovery packets. The switch can also listen to Routing Information Protocol (RIP) routing updates and use this information to infer locations of routers. The switch does not actually store the routing tables sent by routing devices; it merely keeps track of which systems are sending the data. The advantage of using IRDP is that it allows each router to specify both a priority and the time after which a device is assumed to be down if no further packets are received.

Each device discovered becomes a candidate for the default router, and a new highest-priority router is selected when a higher priority router is discovered, when the current default router is declared down, or when a TCP connection is about to time out because of excessive retransmissions.

The only required task for IRDP routing on an interface is to enable IRDP processing on that interface. When enabled, the default parameters apply. You can optionally change any of these parameters.

Beginning in privileged EXEC mode, follow these steps to enable and configure IRDP on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the Layer 3 interface to configure.
Step 3	**ip irdp**	Enable IRDP processing on the interface.
Step 4	**ip irdp multicast**	(Optional) Send IRDP advertisements to the multicast address (224.0.0.1) instead of IP broadcasts. **Note** This command allows for compatibility with Sun Microsystems Solaris, which requires IRDP packets to be sent out as multicasts. Many implementations cannot receive these multicasts; ensure end-host ability before using this command.
Step 5	**ip irdp holdtime** *seconds*	(Optional) Set the IRDP period for which advertisements are valid. The default is three times the **maxadvertinterval** value. It must be greater than **maxadvertinterval** and cannot be greater than 9000 seconds. If you change the **maxadvertinterval** value, this value also changes.
Step 6	**ip irdp maxadvertinterval** *seconds*	(Optional) Set the IRDP maximum interval between advertisements. The default is 600 seconds.
Step 7	**ip irdp minadvertinterval** *seconds*	(Optional) Set the IRDP minimum interval between advertisements. The default is 0.75 times the **maxadvertinterval**. If you change the **maxadvertinterval**, this value changes to the new default (0.75 of **maxadvertinterval**).
Step 8	**ip irdp preference** *number*	(Optional) Set a device IRDP preference level. The allowed range is -2^{31} to 2^{31}. The default is 0. A higher value increases the router preference level.
Step 9	**ip irdp address** *address* [*number*]	(Optional) Specify an IRDP address and preference to proxy-advertise.
Step 10	**end**	Return to privileged EXEC mode.
Step 11	**show ip irdp**	Verify settings by displaying IRDP values.
Step 12	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

If you change the **maxadvertinterval** value, the **holdtime** and **minadvertinterval** values also change, so it is important to first change the **maxadvertinterval** value, before manually changing either the **holdtime** or **minadvertinterval** values.

Use the **no ip irdp** interface configuration command to disable IRDP routing.

Configuring Broadcast Packet Handling

After configuring an IP interface address, you can enable routing and configure one or more routing protocols, or you can configure the way the switch responds to network broadcasts. A broadcast is a data packet destined for all hosts on a physical network. The switch supports two kinds of broadcasting:

- A directed broadcast packet is sent to a specific network or series of networks. A directed broadcast address includes the network or subnet fields.
- A flooded broadcast packet is sent to every network.

Note You can also limit broadcast, unicast, and multicast traffic on Layer 2 interfaces by using the **storm-control** interface configuration command to set traffic suppression levels. For more information, see Chapter 24, "Configuring Port-Based Traffic Control."

Routers provide some protection from broadcast storms by limiting their extent to the local cable. Bridges (including intelligent bridges), because they are Layer 2 devices, forward broadcasts to all network segments, thus propagating broadcast storms. The best solution to the broadcast storm problem is to use a single broadcast address scheme on a network. In most modern IP implementations, you can set the address to be used as the broadcast address. Many implementations, including the one in the switch, support several addressing schemes for forwarding broadcast messages.

Perform the tasks in these sections to enable these schemes:

- Enabling Directed Broadcast-to-Physical Broadcast Translation, page 35-12
- Forwarding UDP Broadcast Packets and Protocols, page 35-13
- Establishing an IP Broadcast Address, page 35-14
- Flooding IP Broadcasts, page 35-15

Enabling Directed Broadcast-to-Physical Broadcast Translation

By default, IP directed broadcasts are dropped; they are not forwarded. Dropping IP-directed broadcasts makes routers less susceptible to denial-of-service attacks.

You can enable forwarding of IP-directed broadcasts on an interface where the broadcast becomes a physical (MAC-layer) broadcast. Only those protocols configured by using the **ip forward-protocol** global configuration command are forwarded.

You can specify an access list to control which broadcasts are forwarded. When an access list is specified, only those IP packets permitted by the access list are eligible to be translated from directed broadcasts to physical broadcasts. For more information on access lists, see Chapter 32, "Configuring Network Security with ACLs."

Beginning in privileged EXEC mode, follow these steps to enable forwarding of IP-directed broadcasts on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to configure.
Step 3	**ip directed-broadcast** [*access-list-number*]	Enable directed broadcast-to-physical broadcast translation on the interface. You can include an access list to control which broadcasts are forwarded. When an access list, only IP packets permitted by the access list can be translated **Note** The **ip directed-broadcast** interface configuration command can be configured on a VPN routing/forwarding(VRF) interface and is VRF-aware. Directed broadcast traffic is routed only within the VRF.
Step 4	**exit**	Return to global configuration mode.
Step 5	**ip forward-protocol** {**udp** [*port*] | **nd** | **sdns**}	Specify which protocols and ports the router forwards when forwarding broadcast packets. • **udp**—Forward UPD datagrams. *port*: (Optional) Destination port that controls which UDP services are forwarded. • **nd**—Forward ND datagrams. • **sdns**—Forward SDNS datagrams
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show ip interface** [*interface-id*] or **show running-config**	Verify the configuration on the interface or all interfaces.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no ip directed-broadcast** interface configuration command to disable translation of directed broadcast to physical broadcasts. Use the **no ip forward-protocol** global configuration command to remove a protocol or port.

Forwarding UDP Broadcast Packets and Protocols

User Datagram Protocol (UDP) is an IP host-to-host layer protocol, as is TCP. UDP provides a low-overhead, connectionless session between two end systems and does not provide for acknowledgment of received datagrams. Network hosts occasionally use UDP broadcasts to find address, configuration, and name information. If such a host is on a network segment that does not include a server, UDP broadcasts are normally not forwarded. You can remedy this situation by configuring an interface on a router to forward certain classes of broadcasts to a helper address. You can use more than one helper address per interface.

You can specify a UDP destination port to control which UDP services are forwarded. You can specify multiple UDP protocols. You can also specify the Network Disk (ND) protocol, which is used by older diskless Sun workstations and the network security protocol SDNS.

By default, both UDP and ND forwarding are enabled if a helper address has been defined for an interface. The description for the **ip forward-protocol** interface configuration command in the *Cisco IOS IP Command Reference, Volume 1 of 3: Addressing and Services, Release 12.2* lists the ports that are forwarded by default if you do not specify any UDP ports.

If you do not specify any UDP ports when you configure the forwarding of UDP broadcasts, you are configuring the router to act as a BOOTP forwarding agent. BOOTP packets carry DHCP information.

Beginning in privileged EXEC mode, follow these steps to enable forwarding UDP broadcast packets on an interface and specify the destination address:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the Layer 3 interface to configure.
Step 3	**ip helper-address** *address*	Enable forwarding and specify the destination address for forwarding UDP broadcast packets, including BOOTP.
Step 4	**exit**	Return to global configuration mode.
Step 5	**ip forward-protocol** {**udp** [*port*] | **nd** | **sdns**}	Specify which protocols the router forwards when forwarding broadcast packets.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show ip interface** [*interface-id*] or **show running-config**	Verify the configuration on the interface or all interfaces.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no ip helper-address** interface configuration command to disable the forwarding of broadcast packets to specific addresses. Use the **no ip forward-protocol** global configuration command to remove a protocol or port.

Establishing an IP Broadcast Address

The most popular IP broadcast address (and the default) is an address consisting of all ones (255.255.255.255). However, the switch can be configured to generate any form of IP broadcast address.

Beginning in privileged EXEC mode, follow these steps to set the IP broadcast address on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to configure.
Step 3	**ip broadcast-address** *ip-address*	Enter a broadcast address different from the default, for example 128.1.255.255.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show ip interface** [*interface-id*]	Verify the broadcast address on the interface or all interfaces.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To restore the default IP broadcast address, use the **no ip broadcast-address** interface configuration command.

Flooding IP Broadcasts

You can allow IP broadcasts to be flooded throughout your internetwork in a controlled fashion by using the database created by the bridging STP. Using this feature also prevents loops. To support this capability, bridging must be configured on each interface that is to participate in the flooding. If bridging is not configured on an interface, it still can receive broadcasts. However, the interface never forwards broadcasts it receives, and the router never uses that interface to send broadcasts received on a different interface.

Packets that are forwarded to a single network address using the IP helper-address mechanism can be flooded. Only one copy of the packet is sent on each network segment.

To be considered for flooding, packets must meet these criteria. (Note that these are the same conditions used to consider packet forwarding using IP helper addresses.)

- The packet must be a MAC-level broadcast.
- The packet must be an IP-level broadcast.
- The packet must be a TFTP, DNS, Time, NetBIOS, ND, or BOOTP packet, or a UDP specified by the **ip forward-protocol udp** global configuration command.
- The time-to-live (TTL) value of the packet must be at least two.

A flooded UDP datagram is given the destination address specified with the **ip broadcast-address** interface configuration command on the output interface. The destination address can be set to any address. Thus, the destination address might change as the datagram propagates through the network. The source address is never changed. The TTL value is decremented.

When a flooded UDP datagram is sent out an interface (and the destination address possibly changed), the datagram is handed to the normal IP output routines and is, therefore, subject to access lists, if they are present on the output interface.

Beginning in privileged EXEC mode, follow these steps to use the bridging spanning-tree database to flood UDP datagrams:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip forward-protocol spanning-tree**	Use the bridging spanning-tree database to flood UDP datagrams.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entry.
Step 5	**copy running-config startup-config**	(Optional) Save your entry in the configuration file.

Use the **no ip forward-protocol spanning-tree** global configuration command to disable the flooding of IP broadcasts.

In the switch, the majority of packets are forwarded in hardware; most packets do not go through the switch CPU. For those packets that do go to the CPU, you can speed up spanning tree-based UDP flooding by a factor of about four to five times by using turbo-flooding. This feature is supported over Ethernet interfaces configured for ARP encapsulation.

Beginning in privileged EXEC mode, follow these steps to increase spanning-tree-based flooding:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode
Step 2	**ip forward-protocol turbo-flood**	Use the spanning-tree database to speed up flooding of UDP datagrams.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show running-config**	Verify your entry.
Step 5	**copy running-config startup-config**	(Optional) Save your entry in the configuration file.

To disable this feature, use the **no ip forward-protocol turbo-flood** global configuration command.

Monitoring and Maintaining IP Addressing

When the contents of a particular cache, table, or database have become or are suspected to be invalid, you can remove all its contents by using the **clear** privileged EXEC commands. Table 35-2 lists the commands for clearing contents.

Table 35-2 Commands to Clear Caches, Tables, and Databases

Command	Purpose
clear arp-cache	Clear the IP ARP cache and the fast-switching cache.
clear host {*name* | *}}	Remove one or all entries from the hostname and the address cache.
clear ip route {*network* [*mask*] |*}	Remove one or more routes from the IP routing table.

You can display specific statistics, such as the contents of IP routing tables, caches, and databases; the reachability of nodes; and the routing path that packets are taking through the network. Table 35-3 lists the privileged EXEC commands for displaying IP statistics.

Table 35-3 Commands to Display Caches, Tables, and Databases

Command	Purpose
show arp	Display the entries in the ARP table.
show hosts	Display the default domain name, style of lookup service, name server hosts, and the cached list of hostnames and addresses.
show ip aliases	Display IP addresses mapped to TCP ports (aliases).
show ip arp	Display the IP ARP cache.
show ip interface [*interface-id*]	Display the IP status of interfaces.
show ip irdp	Display IRDP values.
show ip masks *address*	Display the masks used for network addresses and the number of subnets using each mask.
show ip redirects	Display the address of a default gateway.
show ip route [*address* [*mask*]] | [*protocol*]	Display the current state of the routing table.
show ip route summary	Display the current state of the routing table in summary form.

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.

Beginning in privileged EXEC mode, follow these steps to enable IP routing:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip routing**	Enable IP routing.
Step 3	**router** *ip_routing_protocol*	Specify an IP routing protocol. This step might include other commands, such as specifying the networks to route with the **network** (RIP) router configuration command. For information on specific protocols, see sections later in this chapter and the *Cisco IOS IP Configuration Guide, Release 12.2.* **Note** The IP base image supports only RIP as a routing protocol
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show running-config**	Verify your entries.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no ip routing** global configuration command to disable routing.

This example shows how to enable IP routing using RIP as the routing protocol:

```
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# ip routing
Switch(config)# router rip
Switch(config-router)# network 10.0.0.0
Switch(config-router)# end
```

Configuring RIP

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.

Note RIP is the only routing protocol supported by the switch.

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.

These sections contain this configuration information:

- Default RIP Configuration, page 35-18
- Configuring Basic RIP Parameters, page 35-19
- Configuring RIP Authentication, page 35-20
- Configuring Summary Addresses and Split Horizon, page 35-21

Default RIP Configuration

Table 35-4 shows the default RIP configuration.

Table 35-4 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 receive version	According to the **version** router configuration command.
IP RIP send version	According to the **version** router configuration command.
IP RIP triggered	According to the **version** router configuration command.
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. RIP configuration commands are ignored on the switch until you configure the network number.

Beginning in privileged EXEC mode, follow these steps to enable and configure RIP:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip routing**	Enable IP routing. (Required only if IP routing is disabled.)
Step 3	**router rip**	Enable a RIP routing process, and enter router configuration mode.
Step 4	**network** *network number*	Associate 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 RIP commands to take effect.
Step 5	**neighbor** *ip-address*	(Optional) Define 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 6	**offset list** [*access-list number* | *name*] {**in** | **out**} *offset* [*type number*]	(Optional) Apply an offset list to routing metrics to increase incoming and outgoing metrics to routes learned through RIP. You can limit the offset list with an access list or an interface.
Step 7	**timers basic** *update invalid holddown flush*	(Optional) Adjust 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 8	**version** {**1** | **2**}	(Optional) Configure 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 9	**no auto summary**	(Optional) Disable 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.

	Command	Purpose
Step 10	**no validate-update-source**	(Optional) Disable validation of the source IP address of incoming RIP routing updates. By default, the switch validates the source IP address of incoming RIP routing updates and discards the update if the source address is not valid. Under normal circumstances, disabling this feature is not recommended. However, if you have a router that is off-network and you want to receive its updates, you can use this command.
Step 11	**output-delay** *delay*	(Optional) Add interpacket delay for RIP updates sent. By default, packets in a multiple-packet RIP update have no delay added between packets. If you are sending packets to a lower-speed device, you can add an interpacket delay in the range of 8 to 50 milliseconds.
Step 12	**end**	Return to privileged EXEC mode.
Step 13	**show ip protocols**	Verify your entries.
Step 14	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To turn off the RIP routing process, use the **no router rip** global configuration command.

To display the parameters and current state of the active routing protocol process, use the **show ip protocols** privileged EXEC command. Use the **show ip rip database** privileged EXEC command to display summary address entries in the RIP database.

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. Therefore, you must also perform the tasks in the "Managing Authentication Keys" section on page 35-36.

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

Beginning in privileged EXEC mode, follow these steps to configure RIP authentication on an interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to configure.
Step 3	**ip rip authentication key-chain** *name-of-chain*	Enable RIP authentication.
Step 4	**ip rip authentication mode** [**text** | **md5**}	Configure the interface to use plain text authentication (the default) or MD5 digest authentication.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show running-config interface** [*interface-id*]	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To restore clear text authentication, use the **no ip rip authentication mode** interface configuration command. To prevent authentication, use the **no ip rip authentication key-chain** interface configuration command.

Configuring 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.

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.

Beginning in privileged EXEC mode, follow these steps to set an interface to advertise a summarized local IP address and to disable split horizon on the interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the Layer 3 interface to configure.
Step 3	**ip address** *ip-address subnet-mask*	Configure the IP address and IP subnet.
Step 4	**ip summary-address rip** *ip address ip-network mask*	Configure the IP address to be summarized and the IP network mask.
Step 5	**no ip split horizon**	Disable split horizon on the interface.
Step 6	**end**	Return to privileged EXEC mode.
Step 7	**show ip interface** *interface-id*	Verify your entries.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable IP summarization, use the **no ip summary-address rip** router configuration command.

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 gi0/2
Switch(config-if)# ip address 10.1.5.1 255.255.255.0
Switch(config-if)# ip summary-address rip 10.2.0.0 255.255.0.0
Switch(config-if)# no ip split-horizon
Switch(config-if)# exit
Switch(config)# router rip
Switch(config-router)# network 10.0.0.0
Switch(config-router)# neighbor 2.2.2.2 peer-group mygroup
Switch(config-router)# end
```

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.

Beginning in privileged EXEC mode, follow these steps to disable split horizon on the interface:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Enter interface configuration mode, and specify the interface to configure.
Step 3	**ip address** *ip-address subnet-mask*	Configure the IP address and IP subnet.
Step 4	**no ip split-horizon**	Disable split horizon on the interface.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show ip interface** *interface-id*	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To enable the split horizon mechanism, use the **ip split-horizon** interface configuration command.

Configuring Stub Routing

The stub routing feature reduces resource usage by moving routed traffic closer to the end user. The switch supports Protocol-Independent Multicast (PIM) stub routing and Enhanced Interior Gateway Routing Protocol (EIGRP) stub routing.

Stub routing is explained in these sections:

- Understanding PIM Stub Routing, page 35-23
- Configuring PIM Stub Routing, page 35-24
- Understanding EIGRP Stub Routing, page 35-26
- Configuring EIGRP Stub Routing, page 35-27

Understanding PIM Stub Routing

The PIM stub routing feature reduces resource usage by moving routed traffic closer to the end user. In a network using PIM stub routing, the only allowable route for IP traffic to the user is through a switch that is configured with PIM stub routing. PIM passive interfaces are connected to Layer 2 access domains, such as VLANs, or to interfaces that are connected to other Layer 2 devices. Only directly connected multicast (IGMP) receivers and sources are allowed in the Layer 2 access domains. The PIM passive interfaces do not send or process any received PIM control packets.

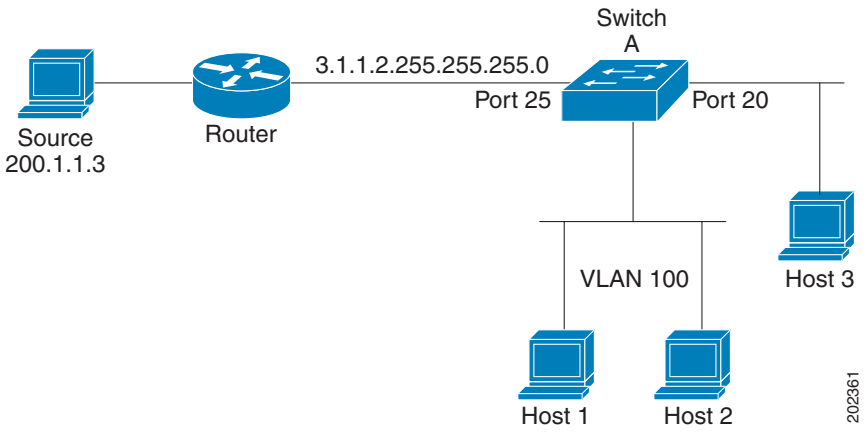
When using PIM stub routing, you should configure the distribution and remote routers to use IP multicast routing and configure only the switch as a PIM stub router. The switch does not route transit traffic between distribution routers. You also need to configure a routed uplink port on the switch. The switch uplink port cannot be used with SVIs.

You must also configure EIGRP stub routing when configuring PIM stub routing on the switch. For more information, see the "Understanding EIGRP Stub Routing" section on page 35-26 and the "Configuring EIGRP Stub Routing" section on page 35-27.

The redundant PIM stub router topology is not supported. The redundant topology exists when there is more than one PIM router forwarding multicast traffic to a single access domain. PIM messages are blocked, and the PIM assert and designated router election mechanisms are not supported on the PIM passive interfaces. Only the nonredundant access router topology is supported by the PIM stub feature. By using a nonredundant topology, the PIM passive interface assumes that it is the only interface and designated router on that access domain.

In Figure 35-4, Switch A routed uplink port 25 is connected to the router and PIM stub routing is enabled on the VLAN 100 interfaces and on Host 3. This configuration allows the directly connected hosts to receive traffic from multicast source 200.1.1.3. See the "Configuring PIM Stub Routing" section on page 35-24 for more information.

Figure 35-4 PIM Stub Router Configuration



Configuring PIM Stub Routing

The PIM stub routing feature supports multicast routing between the distribution layer and the access layer. It supports two types of PIM interfaces, uplink PIM interfaces, and PIM passive interfaces. A routed interface configured with the PIM passive mode does not pass or forward PIM control traffic, it only passes and forwards IGMP traffic.

PIM Stub Routing Configuration Guidelines

Follow these guidelines when enabling PIM stub routing on an interface:

- Before configuring PIM stub routing, you must have IP multicast routing configured on both the stub router and the central router. You must also have PIM mode (dense-mode, sparse-mode, or dense-sparse-mode) configured on the uplink interface of the stub router.
- The PIM stub router does not route the transit traffic between the distribution routers. Unicast (EIGRP) stub routing enforces this behavior. You must configure unicast stub routing to assist the PIM stub router behavior. For more information, see the "Configuring EIGRP Stub Routing" section on page 35-27.
- Only directly connected multicast (IGMP) receivers and sources are allowed in the Layer 2 access domains. The PIM protocol is not supported in access domains.
- The redundant PIM stub router topology is not supported.

Enabling PIM Stub Routing

Beginning in privileged EXEC mode, follow these steps to enable PIM stub routing on an interface. This procedure is optional.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *interface-id*	Specify the interface on which you want to enable PIM stub routing, and enter interface configuration mode.
Step 3	**ip pim passive**	Configure the PIM stub feature on the interface.

	Command	Purpose
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show ip pim interface**	Display the PIM stub that is enabled on each interface.
Step 6	**show running-config**	Verify your entries.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable PIM stub routing on an interface, use the **no ip pim passive** interface configuration command.

In this example, IP multicast routing is enabled, Switch A PIM uplink port 25 is configured as a routed uplink port with **spare-dense-mode** enabled. PIM stub routing is enabled on the VLAN 100 interfaces and on Gigabit Ethernet port 20 in Figure 35-4:

```
Switch(config)# ip multicast-routing distributed
Switch(config)# interface GigabitEthernet0/25
Switch(config-if)# no switchport
Switch(config-if)# ip address 3.1.1.2 255.255.255.0
Switch(config-if)# ip pim sparse-dense-mode
Switch(config-if)# exit
Switch(config)# interface vlan100
Switch(config-if)# ip pim passive
Switch(config-if)# exit
Switch(config)# interface GigabitEthernet0/20
Switch(config-if)# ip pim passive
Switch(config-if)# exit
Switch(config)# interface vlan100
Switch(config-if)# ip address 100.1.1.1 255.255.255.0
Switch(config-if)# ip pim passive
Switch(config-if)# exit
Switch(config)# interface GigabitEthernet0/20
Switch(config-if)# no switchport
Switch(config-if)# ip address 10.1.1.1 255.255.255.0
Switch(config-if)# ip pim passive
Switch(config-if)# end
```

To verify that PIM stub is enabled for each interface, use the **show ip pim interface** privileged EXEC command:

```
Switch#show ip pim interface
Address Interface Ver/ Nbr Query DR DR
Mode Count Intvl Prior
3.1.1.2 GigabitEthernet0/25 v2/SD 1 30 1 3.1.1.2
100.1.1.1 Vlan100 v2/P 0 30 1 100.1.1.1
10.1.1.1 GigabitEthernet0/20 v2/P 0 30 1 10.1.1.1
```

Use these privileged EXEC commands to display information about PIM stub configuration and status:

- **show ip pim interface** displays the PIM stub that is enabled on each interface.
- **show ip igmp detail** displays the interested clients that have joined the specific multicast source group.
- **show ip igmp mroute** verifies that the multicast stream forwards from the source to the interested clients.

Understanding EIGRP Stub Routing

The EIGRP stub routing feature reduces resource utilization by moving routed traffic closer to the end user. In a network using EIGRP stub routing, the only allowable route for IP traffic to the user is through a switch that is configured with EIGRP stub routing. The switch sends the routed traffic to interfaces that are configured as user interfaces or are connected to other devices.

Note The switch does not support complete EIGRP routing. It contains EIGRP stub routing capability, which only advertises connected or summary routes from the routing tables to other switches in the network. The switch uses EIGRP stub routing at the access layer to eliminate the need for other types of routing advertisements. If you try to configure multi-VRF-CE and EIGRP stub routing at the same time, the configuration is not allowed.

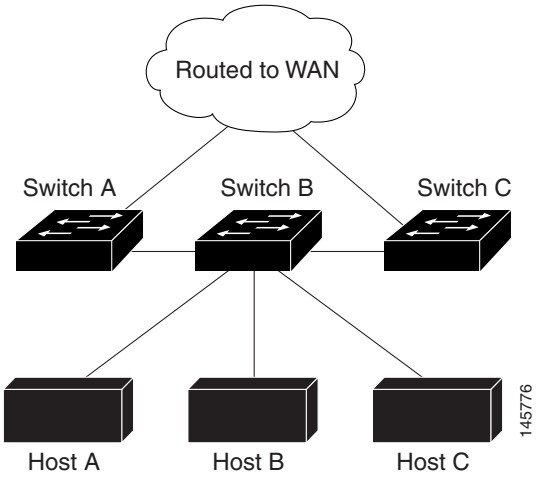
After you have entered the **eigrp stub** router configuration command, only the **eigrp stub connected summary** command takes effect. Although the CLI help might show the **receive-only** and **static** keywords and you can enter these keywords, the switch always behaves as if the **connected** and **summary** keywords were configured.

When using EIGRP stub routing, you need to configure the distribution and remote routers to use EIGRP and to configure only the switch as a stub. Only specified routes are propagated from the switch. The switch responds to all queries for summaries, connected routes, and routing updates.

Any neighbor that receives a packet informing it of the stub status does not query the stub router for any routes, and a router that has a stub peer does not query that peer. The stub router depends on the distribution router to send the proper updates to all peers.

In Figure 35-5, switch B is configured as an EIGRP stub router. Switches A and C are connected to the rest of the WAN. Switch B advertises connected, static, redistribution, and summary routes to switch A and C. Switch B does not advertise any routes learned from switch A (and the reverse).

Figure 35-5 EIGRP Stub Router Configuration



When configuring the distribution router to send only a default route to the remote router, you must use the **ip classless** global configuration command on the remote router. By default, the **ip classless** command is enabled in all Cisco IOS images that support the EIGRP stub routing feature.

Without the stub feature, even after the routes that are sent from the distribution router to the remote router have been filtered or summarized, a problem might occur. If a route is lost somewhere in the corporate network, EIGRP could send a query to the distribution router, which in turn will send a query to the remote router even if routes are being summarized. The EIGRP Stub Routing feature allows a network administrator to prevent queries from being sent to the remote router.

Note You should configure EIGRP stub routing only on stub routers. A stub router is defined as a router connected to the network core or distribution layer through which core transit traffic should not flow. A stub router should not have any EIGRP neighbors other than distribution routers. Ignoring this restriction will cause undesirable behavior.

For more information about EIGRP stub routing, see "Configuring EIGRP Stub Routing" part of the *Cisco IOS IP Configuration Guide, Volume 2 of 3: Routing Protocols, Release 12.2* from the Cisco.com page under **Documentation > Cisco IOS Software > 12.2 Mainline > Configuration Guides**.

Configuring EIGRP Stub Routing

Beginning in privileged EXEC mode, follow these steps to configure a remote or spoke router for EIGRP stub routing:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**router eigrp 1**	Configure a remote or distribution router to run an EIGRP process and enter router configuration mode.
Step 3	**network** *network-number*	Associate networks with an EIGRP routing process.
Step 4	**eigrp stub** [**receive-only** | **connected** | **static** | **summary**]	Configure a remote router as an EIGRP stub router. The keywords have these meanings: • Enter **receive-only** to set the router as a receive-only neighbor. • Enter **connected** to advertise connected routes. • Enter **static** to advertise static routes. • Enter **summary** to advertise summary routes.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show ip eigrp neighbor detail**	Verify that a remote router has been configured as a stub router with EIGRP. The last line of the output shows the stub status of the remote or spoke router.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Enter the **show ip eigrp neighbor detail** privileged EXEC command from the distribution router to verify the configuration.

Configuring Protocol-Independent Features

This section describes how to configure IP routing protocol-independent features. These features are available on switches running the IP base image or the IP services image; except that with the IP base image, protocol-related features are available only for RIP. For a complete description of the IP routing protocol-independent commands in this chapter, see the "IP Routing Protocol-Independent Commands" chapter of the *Cisco IOS IP Command Reference, Volume 2 of 3: Routing Protocols, Release 12.2* from the Cisco.com page under **Documentation > Cisco IOS Software > 12.2 Mainline > Command References**.

These sections contain this configuration information:

- Configuring Cisco Express Forwarding, page 35-28
- Configuring the Number of Equal-Cost Routing Paths, page 35-29
- Configuring Static Unicast Routes, page 35-30
- Specifying Default Routes and Networks, page 35-31
- Using Route Maps to Redistribute Routing Information, page 35-32
- Filtering Routing Information, page 35-34
- Managing Authentication Keys, page 35-36

Configuring Cisco Express Forwarding

Cisco Express Forwarding (CEF) is a Layer 3 IP switching technology used to optimize network performance. CEF implements an advanced IP look-up and forwarding algorithm to deliver maximum Layer 3 switching performance. CEF is less CPU-intensive than fast switching route caching, allowing more CPU processing power to be dedicated to packet forwarding. In dynamic networks, fast switching cache entries are frequently invalidated because of routing changes, which can cause traffic to be process switched using the routing table, instead of fast switched using the route cache. CEF use the Forwarding Information Base (FIB) lookup table to perform destination-based switching of IP packets.

The two main components in CEF are the distributed FIB and the distributed adjacency tables.

- The FIB is similar to a routing table or information base and maintains a mirror image of the forwarding information in the IP routing table. When routing or topology changes occur in the network, the IP routing table is updated, and those changes are reflected in the FIB. The FIB maintains next-hop address information based on the information in the IP routing table. Because the FIB contains all known routes that exist in the routing table, CEF eliminates route cache maintenance, is more efficient for switching traffic, and is not affected by traffic patterns.
- Nodes in the network are said to be adjacent if they can reach each other with a single hop across a link layer. CEF uses adjacency tables to prepend Layer 2 addressing information. The adjacency table maintains Layer 2 next-hop addresses for all FIB entries.

Because the switch uses Application Specific Integrated Circuits (ASICs) to achieve Gigabit-speed line rate IP traffic, CEF forwarding applies only to the software-forwarding path, that is, traffic that is forwarded by the CPU.

CEF is enabled globally by default. If for some reason it is disabled, you can re-enable it by using the **ip cef** global configuration command.

The default configuration is CEF enabled on all Layer 3 interfaces. Entering the **no ip route-cache cef** interface configuration command disables CEF for traffic that is being forwarded by software. This command does not affect the hardware forwarding path. Disabling CEF and using the **debug ip packet**

detail privileged EXEC command can be useful to debug software-forwarded traffic. To enable CEF on an interface for the software-forwarding path, use the **ip route-cache cef** interface configuration command.

Caution Although the **no ip route-cache cef** interface configuration command to disable CEF on an interface is visible in the CLI, we strongly recommend that you do not disable CEF on interfaces except for debugging purposes.

Beginning in privileged EXEC mode, follow these steps to enable CEF globally and on an interface for software-forwarded traffic if it has been disabled:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip cef**	Enable CEF operation.
Step 3	**interface** *interface-id*	Enter interface configuration mode, and specify the Layer 3 interface to configure.
Step 4	**ip route**-cache cef	Enable CEF on the interface for software-forwarded traffic.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show ip cef**	Display the CEF status on all interfaces.
Step 7	**show cef linecard**[**detail**]	Display CEF-related interface information
Step 8	**show cef interface** [*interface-id*]	Display detailed CEF information for all interfaces or the specified interface.
Step 9	**show adjacency**	Display CEF adjacency table information.
Step 10	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Configuring the Number of Equal-Cost Routing Paths

When a router has two or more routes to the same network with the same metrics, these routes can be thought of as having an equal cost. The term *parallel path* is another way to see occurrences of equal-cost routes in a routing table. If a router has two or more equal-cost paths to a network, it can use them concurrently. Parallel paths provide redundancy in case of a circuit failure and also enable a router to load balance packets over the available paths for more efficient use of available bandwidth.

Even though the router automatically learns about and configures equal-cost routes, you can control the maximum number of parallel paths supported by an IP routing protocol in its routing table. Although the switch software allows a maximum of 32 equal-cost routes, the switch hardware will never use more than 16 paths per route.

Beginning in privileged EXEC mode, follow these steps to change the maximum number of parallel paths installed in a routing table from the default:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**router rip**	Enter router configuration mode.

	Command	Purpose
Step 3	**maximum-paths** *maximum*	Set the maximum number of parallel paths for the protocol routing table. The range is from 1 to 16; the default is 4.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show ip protocols**	Verify the setting in the *Maximum path* field.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no maximum-paths** router configuration command to restore the default value.

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.

Beginning in privileged EXEC mode, follow these steps to configure a static route:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip route** *prefix mask* {*address* | *interface*} [*distance*]	Establish a static route.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show ip route**	Display the current state of the routing table to verify the configuration.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

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. 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 35-5. 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 35-5 Dynamic Routing Protocol Default Administrative Distances

Route Source	Default Distance
Connected interface	0
Static route	1
Unknown	225

Static routes that point to an interface are advertised through RIP, 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.

Specifying 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.s

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.

Beginning in privileged EXEC mode, follow these steps to define a static route to a network as the static default route:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**ip default-network** *network number*	Specify a default network.
Step 3	**end**	Return to privileged EXEC mode.
Step 4	**show ip route**	Display the selected default route in the gateway of last resort display.
Step 5	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no ip default-network** *network number* global configuration command to remove the route.

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. 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.

Using Route Maps to Redistribute Routing Information

The switch can run multiple routing protocols simultaneously, and it can redistribute information from one routing protocol to another. Redistributing information from one routing protocol to another applies to all supported IP-based routing protocols.

You can also conditionally control the redistribution of routes between routing domains by defining enhanced packet filters or route maps between the two domains. The **match** and **set** route-map configuration commands define the condition portion of a route map. The **match** command specifies that a criterion must be matched. The **set** command specifies an action to be taken if the routing update meets the conditions defined by the match command. Although redistribution is a protocol-independent feature, some of the **match** and **set** route-map configuration commands are specific to a particular protocol.

One or more **match** commands and one or more **set** commands follow a **route-map** command. If there are no **match** commands, everything matches. If there are no **set** commands, nothing is done, other than the match. Therefore, you need at least one **match** or **set** command.

Note A route map with no **set** route-map configuration commands is sent to the CPU, which causes high CPU utilization.

You can also identify route-map statements as **permit** or **deny**. If the statement is marked as a deny, the packets meeting the match criteria are sent back through the normal forwarding channels (destination-based routing). If the statement is marked as permit, set clauses are applied to packets meeting the match criteria. Packets that do not meet the match criteria are forwarded through the normal routing channel.

Note Although the steps following Step 3 are optional, you must enter at least one **match** route-map configuration command and one **set** route-map configuration command.

Beginning in privileged EXEC mode, follow these steps to configure a route map for redistribution:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**route-map** *map-tag* [**permit** | **deny**] [*sequence number*]	Define any route maps used to control redistribution and enter route-map configuration mode. *map-tag*—A meaningful name for the route map. The **redistribute** router configuration command uses this name to reference this route map. Multiple route maps might share the same map tag name. (Optional) If **permit** is specified and the match criteria are met for this route map, the route is redistributed as controlled by the set actions. If **deny** is specified, the route is not redistributed. *sequence number* (Optional)— Number that indicates the position a new route map is to have in the list of route maps already configured with the same name.

	Command	Purpose
Step 3	**match ip address** {*access-list-number* | *access-list-name*} [*...access-list-number* | *...access-list-name*]	Match a standard access list by specifying the name or number. It can be an integer from 1 to 199.
Step 4	**match metric** *metric-value*	Match the specified route metric. The *metric-valu*e can be a specified value from 0 to 4294967295.
Step 5	**match ip next-hop** {*access-list-number* | *access-list-name*} [*...access-list-number* | *...access-list-name*]	Match a next-hop router address passed by one of the access lists specified (numbered from 1 to 199).
Step 6	**match tag** *tag value* [*...tag-value*]	Match the specified tag value in a list of one or more route tag values. Each can be an integer from 0 to 4294967295.
Step 7	**match interface** *type number* [*...type number*]	Match the specified next hop route out one of the specified interfaces.
Step 8	**match ip route-source** {*access-list-number* | *access-list-name*} [*...access-list-number* | *...access-list-name*]	Match the address specified by the specified advertised access lists.
Step 9	**set level** {**level-1** | **level-2** | **level-1-2**}	Set the level for routes that are advertised into the specified area of the routing domain.
Step 10	**end**	Return to privileged EXEC mode.
Step 11	**show route-map**	Display all route maps configured or only the one specified to verify configuration.
Step 12	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To delete an entry, use the **no route-map** *map tag* global configuration command or the **no match** or **no set** route-map configuration commands.

You can distribute routes from one routing domain into another and control route distribution.

Beginning in privileged EXEC mode, follow these steps to control route redistribution. Note that the keywords are the same as defined in the previous procedure.

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**router rip**	Enter router configuration mode.
Step 3	**redistribute** *protocol* [*process-id*] {**level-1** | **level-1-2** | **level-2**} [**metric** *metric-value*] [**metric-type** *type-value*] [**match internal** | **external** t*ype-value*] [**tag** *tag-value*] [**route-map** *map-tag*] [**weight** *weight*] [**subnets**]	Redistribute routes from one routing protocol to another routing protocol. If no route-maps are specified, all routes are redistributed. If the keyword **route-map** is specified with no *map-tag*, no routes are distributed.
Step 4	**default-metric** *number*	Cause the current routing protocol to use the same metric value for all redistributed routes (RIP).
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**show route-map**	Display all route maps configured or only the one specified to verify configuration.
Step 7	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To disable redistribution, use the **no** form of the commands.

The metrics of one routing protocol do not necessarily translate into the metrics of another. For example, the RIP metric is a hop count, and the IGRP metric is a combination of five qualities. In these situations, an artificial metric is assigned to the redistributed route. Uncontrolled exchanging of routing information between different routing protocols can create routing loops and seriously degrade network operation.

If you have not defined a default redistribution metric that replaces metric conversion, some automatic metric translations occur between routing protocols:

- RIP can automatically redistribute static routes. It assigns static routes a metric of 1 (directly connected).
- Any protocol can redistribute other routing protocols if a default mode is in effect.

Filtering Routing Information

You can filter routing protocol information by performing the tasks described in this section.

Setting Passive Interfaces

To prevent other routers on a local network from dynamically learning about routes, you can use the **passive-interface** router configuration command to keep routing update messages from being sent through a router interface.

In networks with many interfaces, to avoid having to manually set them as passive, you can set all interfaces to be passive by default by using the **passive-interface default** router configuration command and manually setting interfaces where adjacencies are desired.

Beginning in privileged EXEC mode, follow these steps to configure passive interfaces:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**router rip**	Enter router configuration mode.
Step 3	**passive-interface** *interface-id*	Suppress sending routing updates through the specified Layer 3 interface.
Step 4	**passive-interface default**	(Optional) Set all interfaces as passive by default.
Step 5	**no passive-interface** *interface type*	(Optional) Activate only those interfaces that need to have adjacencies sent.
Step 6	**network** *network-address*	(Optional) Specify the list of networks for the routing process. The *network-address* is an IP address.
Step 7	**end**	Return to privileged EXEC mode.
Step 8	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **show ip interface** privileged EXEC command to verify the interfaces that you enabled as active.

To re-enable the sending of routing updates, use the **no passive-interface** *interface-id* router configuration command. The **default** keyword sets all interfaces as passive by default. You can then configure individual interfaces where you want adjacencies by using the **no passive-interface** router configuration command. The **default** keyword is useful in Internet service provider and large enterprise networks where many of the distribution routers have more than 200 interfaces.

Controlling Advertising and Processing in Routing Updates

You can use the **distribute-list** router configuration command with access control lists to suppress routes from being advertised in routing updates and to prevent other routers from learning one or more routes. You can also use a **distribute-list** router configuration command to avoid processing certain routes listed in incoming updates.

Beginning in privileged EXEC mode, follow these steps to control the advertising or processing of routing updates:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**router rip**	Enter router configuration mode.
Step 3	**distribute-list** {*access-list-number* | *access-list-name*} **out** [*interface-name* | *routing process* | *autonomous-system-number*]	Permit or deny routes from being advertised in routing updates, depending upon the action listed in the access list.
Step 4	**distribute-list** {*access-list-number* | *access-list-name*} **in** [*type-number*]	Suppress processing in routes listed in updates.
Step 5	**end**	Return to privileged EXEC mode.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

Use the **no distribute-list in** router configuration command to change or cancel a filter. To cancel suppression of network advertisements in updates, use the **no distribute-list out** router configuration command.

Filtering Sources of Routing Information

Because some routing information might be more accurate than others, you can use filtering to prioritize information coming from different sources. An *administrative distance* is a rating of the trustworthiness of a routing information source, such as a router or group of routers. In a large network, some routing protocols can be more reliable than others. By specifying administrative distance values, you enable the router to intelligently discriminate between sources of routing information. The router always picks the route whose routing protocol has the lowest administrative distance. Table 35-5 on page 35-30 shows the default administrative distances for various routing information sources.

Because each network has its own requirements, there are no general guidelines for assigning administrative distances.

Beginning in privileged EXEC mode, follow these steps to filter sources of routing information:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**router rip**	Enter router configuration mode.

	Command	Purpose
Step 3	**distance** *weight* {*ip-address* {*ip-address mask*}} [*ip access list*]	Define an administrative distance. *weight*—The administrative distance as an integer from 10 to 255. Used alone, *weight* specifies a default administrative distance that is used when no other specification exists for a routing information source. Routes with a distance of 255 are not installed in the routing table. (Optional) *ip access list*—An IP standard or extended access list to be applied to incoming routing updates.
Step 4	**end**	Return to privileged EXEC mode.
Step 5	**show ip protocols**	Display the default administrative distance for a specified routing process.
Step 6	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove a distance definition, use the **no distance** router configuration command.

Managing Authentication Keys

Key management is a method of controlling authentication keys used by routing protocols. Not all protocols can use key management. Authentication keys are available for RIP Version 2.

Before you manage authentication keys, you must enable authentication. See the appropriate protocol section to see how to enable authentication for that protocol. To manage authentication keys, define a key chain, identify the keys that belong to the key chain, and specify how long each key is valid. Each key has its own key identifier (specified with the **key** *number* key chain configuration command), which is stored locally. The combination of the key identifier and the interface associated with the message uniquely identifies the authentication algorithm and Message Digest 5 (MD5) authentication key in use.

You can configure multiple keys with life times. Only one authentication packet is sent, regardless of how many valid keys exist. The software examines the key numbers in order from lowest to highest, and uses the first valid key it encounters. The lifetimes allow for overlap during key changes. Note that the router must know these lifetimes.

Beginning in privileged EXEC mode, follow these steps to manage authentication keys:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**key chain** *name-of-chain*	Identify a key chain, and enter key chain configuration mode.
Step 3	**key** *number*	Identify the key number. The range is 0 to 2147483647.
Step 4	**key-string** *text*	Identify the key string. The string can contain from 1 to 80 uppercase and lowercase alphanumeric characters, but the first character cannot be a number.

	Command	Purpose
Step 5	**accept-lifetime** *start-time* {**infinite** | *end-time* | **duration** *seconds*}	(Optional) Specify the time period during which the key can be received. The *start-time* and *end-time* syntax can be either *hh*:*mm*:*ss Month date year* or *hh*:*mm*:*ss date Month year*. The default is forever with the default *start-time* and the earliest acceptable date as January 1, 1993. The default *end-time* and **duration** is **infinite**.
Step 6	**send-lifetime** *start-time* {**infinite** | *end-time* | **duration** *seconds*}	(Optional) Specify the time period during which the key can be sent. The *start-time* and *end-time* syntax can be either *hh*:*mm*:*ss Month date year* or *hh*:*mm*:*ss date Month year*. The default is forever with the default *start-time* and the earliest acceptable date as January 1, 1993. The default *end-time* and **duration** is infinite.
Step 7	**end**	Return to privileged EXEC mode.
Step 8	**show key chain**	Display authentication key information.
Step 9	**copy running-config startup-config**	(Optional) Save your entries in the configuration file.

To remove the key chain, use the **no key chain** *name-of-chain* global configuration command.

Monitoring and Maintaining the IP Network

You can remove all contents of a particular cache, table, or database. You can also display specific statistics. Use the privileged EXEC commands in Table 35-6 to clear routes or display status:

Table 35-6 Commands to Clear IP Routes or Display Route Status

Command	Purpose
clear ip route {*network* [*mask* | *]}	Clear one or more routes from the IP routing table.
show ip protocols	Display the parameters and state of the active routing protocol process.
show ip route [*address* [*mask*] [**longer-prefixes**]] | [*protocol* [*process-id*]]	Display the current state of the routing table.
show ip route summary	Display the current state of the routing table in summary form.
show ip route supernets-only	Display supernets.
show ip cache	Display the routing table used to switch IP traffic.
show route-map [*map-name*]	Display all route maps configured or only the one specified.