Cisco Nexus 9000 Series NX-OS Unicast Routing Configuration Guide, Release 7.x

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New and Changed Information

This chapter provides release-specific information for each new and changed feature in the *Cisco Nexus 9000 Series NX-OS Unicast Routing Configuration Guide, Release 7.x*. The latest version of this document is available at the following Cisco website:
http://www.cisco.com/en/US/docs/switches/datacenter/nexus9000/sw/7.x/unicast/configuration/guide/l3_cli_nxos.html

To check for additional information about Cisco NX-OS Release 7.x, see the *Cisco Nexus 9000 Series NX-OS Release Notes* available at the following Cisco website:
http://www.cisco.com/en/US/docs/switches/datacenter/nexus9000/sw/7.x/release/notes/61-nxos-rn.html

Table 1 summarizes the new and changed features for the *Cisco Nexus 9000 Series NX-OS Unicast Routing Configuration Guide, Release 7.x* and tells you where they are documented.

Table 1 New and Changed Features for Release 7.x

Feature	Description	Changed in Release	Where Documented
DNS	Added IPv6 support.	7.0(3)I5(1)	Chapter 4, "Configuring DNS"
IPv4 and IPv6	Added the LPM dual-host routing mode for Cisco Nexus 9200 and 9300-EX Series switches. Also added support for host to LPM spillover.	7.0(3)I5(1)	Chapter 2, "Configuring IPv4" and Chapter 3, "Configuring IPv6"
OSPFv2 and OSPFv3	Changed the multi-area adjacency configuration such that specifying an instance is now optional.	7.0(3)I5(1)	Chapter 5, "Configuring OSPFv2" and Chapter 6, "Configuring OSPFv3"
Policy-based routing	Added IPv4 and IPv6 support for Cisco Nexus 9200 and 9300-EX Series switches and IPv4 support for Cisco Nexus 9500 Series switches with the X9732C-EX line card.	7.0(3)I5(1)	Chapter 16, "Configuring Policy-Based Routing"
IPv4 and IPv6	Added the LPM heavy routing mode for Cisco Nexus 9200 and 9300-EX Series switches and the Cisco Nexus 9508 switch with an X9732C-EX line card.	7.0(3)I4(4)	Chapter 2, "Configuring IPv4" and Chapter 3, "Configuring IPv6"
Route Policy Manager	Added mask support for IP prefix lists and the **match ospf-area** command.	7.0(3)I4(1)	Chapter 15, "Configuring Route Policy Manager"

Table 1 New and Changed Features for Release 7.x (continued)

Feature	Description	Changed in Release	Where Documented
OSPFv2	Added support for HMAC-SHA authentication and RFC 5709.	7.0(3)I3(1)	Chapter 5, "Configuring OSPFv2" Appendix A, "IETF RFCs Supported by Cisco NX-OS Unicast Features"
OSPFv3	Added support for IPSec authentication and partial support for RFC 4552.	7.0(3)I3(1)	Chapter 6, "Configuring OSPFv3" Appendix A, "IETF RFCs Supported by Cisco NX-OS Unicast Features"
BGP	Added support for RFC 5549.	7.0(3)I2(1)	Chapter 9, "Configuring Basic BGP" Chapter 10, "Configuring Advanced BGP" Appendix A, "IETF RFCs Supported by Cisco NX-OS Unicast Features"
HSRP	Added support for having the same HSRP groups on all nodes in a double-sided vPC.	7.0(3)I2(1)	Chapter 17, "Configuring HSRP"
VRF route leaking	Added route leaking support from a non-default VRF to the default VRF.	7.0(3)I2(1)	Chapter 13, "Configuring Layer 3 Virtualization"
BFD	Added IPv6 support for bidirectional forwarding detection (BFD) for BGP, EIGRP, IS-IS, and OSPFv3.	7.0(3)I1(1)	Chapter 6, "Configuring OSPFv3" Chapter 7, "Configuring EIGRP" Chapter 8, "Configuring IS-IS" Chapter 10, "Configuring Advanced BGP"
EIGRP	Added a command to cause EIGRP to wait for the convergence of redistributed protocols before installing its own routes in the Routing Information Base (RIB) during nonstop forwarding (NSF).	7.0(3)I1(1)	Chapter 7, "Configuring EIGRP"
IPv4 and IPv6	Added the ALPM routing mode for Cisco Nexus 9300 Series switches.	7.0(3)I1(1)	Chapter 2, "Configuring IPv4" and Chapter 3, "Configuring IPv6"
VRRP	Added support for VRRPv3 and VRRS.	7.0(3)I1(1)	Chapter 18, "Configuring VRRP"

Preface

This preface describes the audience, organization, and conventions of the *Cisco Nexus 9000 Series NX-OS Unicast Routing Configuration Guide*. It also provides information on how to obtain related information.

This preface includes the following sections:

Audience

To use this guide, you must be familiar with IP and routing technology.

Document Conventions

Command descriptions use these conventions:

Convention	Description
boldface font	Commands and keywords are in boldface.
italic font	Arguments for which you supply values are in italics.
[ ]	Elements in square brackets are optional.
[x | y | z]	Optional alternative keywords are grouped in brackets and separated by vertical bars.
string	A nonquoted set of characters. Do not use quotation marks around the string or the string will include the quotation marks.

Screen examples use these conventions:

`screen font`	Terminal sessions and information that the switch displays are in screen font.
`boldface screen font`	Information that you must enter is in boldface screen font.
`italic screen font`	Arguments for which you supply values are in italic screen font.
< >	Nonprinting characters, such as passwords, are in angle brackets.
[ ]	Default responses to system prompts are in square brackets.
!, #	An exclamation point (!) or a pound sign (#) at the beginning of a line of code indicates a comment line.

This document uses the following conventions:

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

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

Related Documentation

Cisco NX-OS includes the following documents:

Release Notes

Cisco Nexus 9000 Series NX-OS Release Notes

Cisco Nexus 9000 Series FPGA/EPLD Upgrade Release Notes

Cisco NX-OS Configuration Guides

Cisco Nexus 2000 Series NX-OS Fabric Extender Software Configuration Guide for Cisco Nexus 9000 Series Switches

Cisco Nexus 9000 Series NX-OS Fundamentals Configuration Guide

Cisco Nexus 9000 Series NX-OS High Availability and Redundancy Guide

Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide

Cisco Nexus 9000 Series NX-OS Layer 2 Switching Configuration Guide

Cisco Nexus 9000 Series NX-OS Multicast Routing Configuration Guide

Cisco Nexus 9000 Series NX-OS Quality of Service Configuration Guide

Cisco Nexus 9000 Series NX-OS Security Configuration Guide

Cisco Nexus 9000 Series NX-OS System Management Configuration Guide

Cisco Nexus 9000 Series NX-OS Unicast Routing Configuration Guide

Cisco Nexus 9000 Series NX-OS Verified Scalability Guide

Cisco Nexus 9000 Series Virtual Machine Tracker Configuration Guide

Cisco Nexus 9000 Series NX-OS VXLAN Configuration Guide

Other Software Documents

Cisco Nexus 7000 Series and 9000 Series NX-OS MIB Quick Reference

Cisco Nexus 9000 Series NX-OS Programmability Guide

Cisco Nexus 9000 Series NX-OS Software Upgrade and Downgrade Guide

Cisco Nexus 9000 Series NX-OS System Messages Reference

Cisco Nexus 9000 Series NX-OS Troubleshooting Guide

Cisco NX-OS Licensing Guide

Cisco NX-OS XML Interface User Guide

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Obtaining Documentation and Submitting a Service Request

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Overview

This chapter introduces the underlying concepts for the Layer 3 unicast routing protocols in Cisco NX-OS.

This chapter includes the following sections:

About Layer 3 Unicast Routing

Layer 3 unicast routing involves two basic activities: determining optimal routing paths and packet switching. You can use routing algorithms to calculate the optimal path from the router to a destination. This calculation depends on the algorithm selected, route metrics, and other considerations such as load balancing and alternate path discovery.

This section includes the following topics:

Routing Fundamentals

Routing protocols use a metric to evaluate the best path to the destination. A metric is a standard of measurement, such as a path bandwidth, that routing algorithms use to determine the optimal path to a destination. To aid path determination, routing algorithms initialize and maintain routing tables that contain route information such as the IP destination address, the address of the next router, or the next hop. Destination and next-hop associations tell a router that an IP destination can be reached optimally by sending the packet to a particular router that represents the next hop on the way to the final destination. When a router receives an incoming packet, it checks the destination address and attempts to associate this address with the next hop. See the "Unicast RIB" section on page 1-10 for more information about the route table.

Routing tables can contain other information, such as the data about the desirability of a path. Routers compare metrics to determine optimal routes, and these metrics differ depending on the design of the routing algorithm used. See the "Routing Metrics" section on page 1-3.

Routers communicate with one another and maintain their routing tables by transmitting a variety of messages. The routing update message is one such message that consists of all or a portion of a routing table. By analyzing routing updates from all other routers, a router can build a detailed picture of the network topology. A link-state advertisement, which is another example of a message sent between routers, informs other routers of the link state of the sending router. You can also use link information to enable routers to determine optimal routes to network destinations. For more information, see the "Routing Algorithms" section on page 1-8.

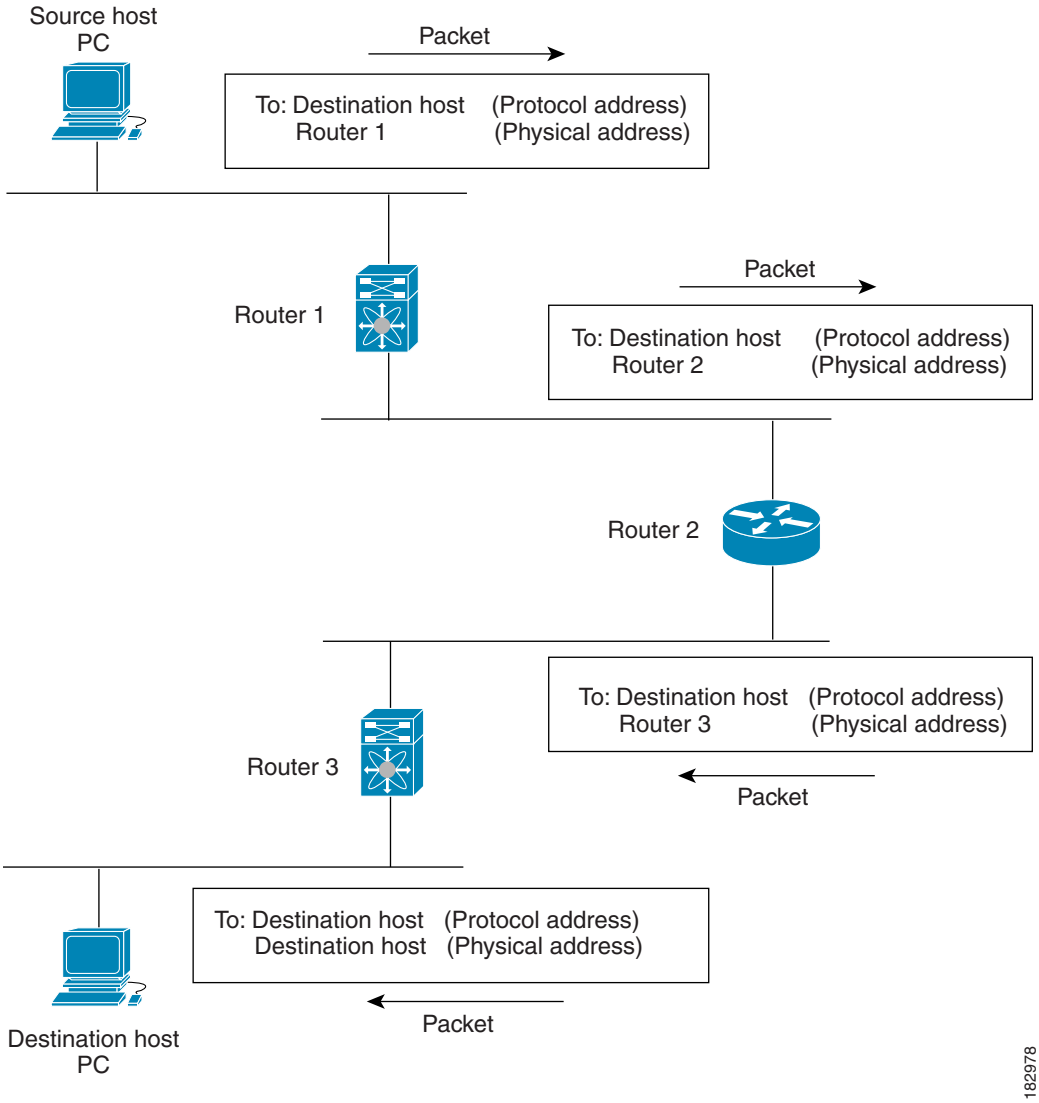
Packet Switching

In packet switching, a host determines that it must send a packet to another host. Having acquired a router address by some means, the source host sends a packet that is addressed specifically to the router physical (Media Access Control [MAC]-layer) address but with the IP (network layer) address of the destination host.

The router examines the destination IP address and tries to find the IP address in the routing table. If the router does not know how to forward the packet, it typically drops the packet. If the router knows how to forward the packet, it changes the destination MAC address to the MAC address of the next-hop router and transmits the packet.

The next hop might be the ultimate destination host or another router that executes the same switching decision process. As the packet moves through the internetwork, its physical address changes, but its protocol address remains constant (see Figure 1-1).

Figure 1-1 Packet Header Updates Through a Network



Routing Metrics

Routing algorithms use many different metrics to determine the best route. Sophisticated routing algorithms can base route selection on multiple metrics.

This section includes the following metrics:

- Path Length, page 1-4
- Reliability, page 1-4
- Routing Delay, page 1-4
- Bandwidth, page 1-4
- Load, page 1-4
- Communication Cost, page 1-4

Path Length

The path length is the most common routing metric. Some routing protocols allow you to assign arbitrary costs to each network link. In this case, the path length is the sum of the costs associated with each link traversed. Other routing protocols define the hop count, which is a metric that specifies the number of passes through internetworking products, such as routers, that a packet must take from a source to a destination.

Reliability

The reliability, in the context of routing algorithms, is the dependability (in terms of the bit-error rate) of each network link. Some network links might go down more often than others. After a network fails, certain network links might be repaired more easily or more quickly than other links. The reliability factors that you can take into account when assigning the reliability rating are arbitrary numeric values that you usually assign to network links.

Routing Delay

The routing delay is the length of time required to move a packet from a source to a destination through the internetwork. The delay depends on many factors, including the bandwidth of intermediate network links, the port queues at each router along the way, the network congestion on all intermediate network links, and the physical distance that the packet must travel. Because the routing delay is a combination of several important variables, it is a common and useful metric.

Bandwidth

The bandwidth is the available traffic capacity of a link. For example, a 10-Gigabit Ethernet link is preferable to a 1-Gigabit Ethernet link. Although the bandwidth is the maximum attainable throughput on a link, routes through links with greater bandwidth do not necessarily provide better routes than routes through slower links. For example, if a faster link is busier, the actual time required to send a packet to the destination could be greater.

Load

The load is the degree to which a network resource, such as a router, is busy. You can calculate the load in a variety of ways, including CPU usage and packets processed per second. Monitoring these parameters on a continual basis can be resource intensive.

Communication Cost

The communication cost is a measure of the operating cost to route over a link. The communication cost is another important metric, especially if you do not care about performance as much as operating expenditures. For example, the line delay for a private line might be longer than a public line, but you can send packets over your private line rather than through the public lines that cost money for usage time.

Router IDs

Each routing process has an associated router ID. You can configure the router ID to any interface in the system. If you do not configure the router ID, Cisco NX-OS selects the router ID based on the following criteria:

- Cisco NX-OS prefers loopback0 over any other interface. If loopback0 does not exist, then Cisco NX-OS prefers the first loopback interface over any other interface type.
- If you have not configured a loopback interface, Cisco NX-OS uses the first interface in the configuration file as the router ID. If you configure any loopback interface after Cisco NX-OS selects the router ID, the loopback interface becomes the router ID. If the loopback interface is not loopback0 and you configure loopback0 with an IP address, the router ID changes to the IP address of loopback0.
- If the interface that the router ID is based on changes, that new IP address becomes the router ID. If any other interface changes its IP address, there is no router ID change.

Autonomous Systems

An autonomous system (AS) is a network controlled by a single technical administration entity. Autonomous systems divide global external networks into individual routing domains, where local routing policies are applied. This organization simplifies routing domain administration and simplifies consistent policy configuration.

Each autonomous system can support multiple interior routing protocols that dynamically exchange routing information through route redistribution. The Regional Internet Registries (RIR) assign a unique number to each public autonomous system that directly connects to the Internet. This autonomous system number (AS number) identifies both the routing process and the autonomous system.

The Border Gateway Protocol (BGP) supports 4-byte AS numbers that can be represented in asplain and asdot notations:

- asplain—A decimal value notation where both 2-byte and 4-byte AS numbers are represented by their decimal value. For example, 65526 is a 2-byte AS number, and 234567 is a 4-byte AS number.
- asdot—An AS dot notation where 2-byte AS numbers are represented by their decimal value and 4-byte AS numbers are represented by a dot notation. For example, 2-byte AS number 65526 is represented as 65526, and 4-byte AS number 65546 is represented as 1.10.

The BGP 4-byte AS number capability is used to propagate 4-byte-based AS path information across BGP speakers that do not support 4-byte AS numbers.

Note RFC 5396 is partially supported. The asplain and asdot notations are supported, but the asdot+ notation is not.

Private autonomous system numbers are used for internal routing domains but must be translated by the router for traffic that is routed out to the Internet. You should not configure routing protocols to advertise private autonomous system numbers to external networks. By default, Cisco NX-OS does not remove private autonomous system numbers from routing updates.

Note The autonomous system number assignment for public and private networks is governed by the Internet Assigned Number Authority (IANA). For information about autonomous system numbers, including the reserved number assignment, or to apply to register an autonomous system number, see this URL: http://www.iana.org/

Convergence

A key aspect to measure for any routing algorithm is how much time a router takes to react to network topology changes. When a part of the network changes for any reason, such as a link failure, the routing information in different routers might not match. Some routers will have updated information about the changed topology, while other routers will still have the old information. The convergence is the amount of time before all routers in the network have updated, matching routing information. The convergence time varies depending on the routing algorithm. Fast convergence minimizes the chance of lost packets caused by inaccurate routing information.

Load Balancing and Equal Cost Multipath

Routing protocols can use load balancing or equal cost multipath (ECMP) to share traffic across multiple paths. When a router learns multiple routes to a specific network, it installs the route with the lowest administrative distance in the routing table. If the router receives and installs multiple paths with the same administrative distance and cost to a destination, load balancing can occur. Load balancing distributes the traffic across all the paths, sharing the load. The number of paths used is limited by the number of entries that the routing protocol puts in the routing table. For the number of ECMP paths supported by each routing protocol, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

Note ECMP does not guarantee equal load-balancing across all links. It guarantees only that a particular flow will choose one particular next hop at any point in time.

Route Redistribution

If you have multiple routing protocols configured in your network, you can configure these protocols to share routing information by configuring route redistribution in each protocol. For example, you can configure the Open Shortest Path First (OSPF) protocol to advertise routes learned from the Border Gateway Protocol (BGP). You can also redistribute static routes into any dynamic routing protocol. The router that is redistributing routes from another protocol sets a fixed route metric for those redistributed routes, which prevents incompatible route metrics between the different routing protocols. For example, routes redistributed from EIGRP into OSPF are assigned a fixed link cost metric that OSPF understands.

Note You are required to use route maps when you configure the redistribution of routing information.

Route redistribution also uses an administrative distance (see the "Administrative Distance" section on page 1-7) to distinguish between routes learned from two different routing protocols. The preferred routing protocol is given a lower administrative distance so that its routes are picked over routes from another protocol with a higher administrative distance assigned.

Administrative Distance

An administrative distance is a rating of the trustworthiness of a routing information source. A higher value indicates a lower trust rating. Typically, a route can be learned through more than one protocol. Administrative distance is used to discriminate between routes learned from more than one protocol. The route with the lowest administrative distance is installed in the IP routing table.

Stub Routing

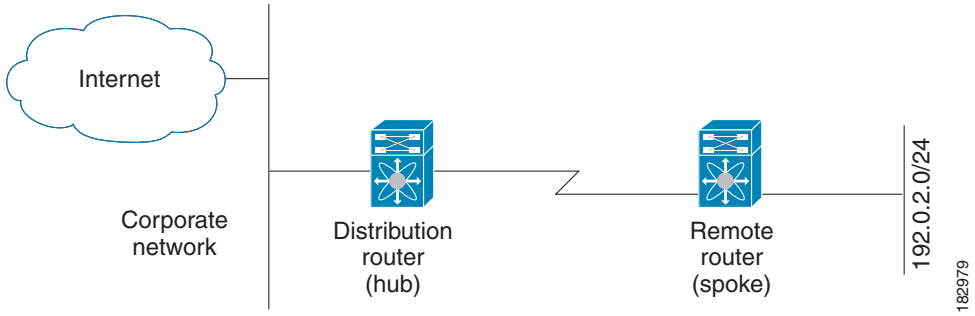
You can use stub routing in a hub-and-spoke network topology, where one or more end (stub) networks are connected to a remote router (the spoke) that is connected to one or more distribution routers (the hub). The remote router is adjacent only to one or more distribution routers. The only route for IP traffic to follow into the remote router is through a distribution router. This type of configuration is commonly used in WAN topologies in which the distribution router is directly connected to a WAN. The distribution router can be connected to many more remote routers. Often, the distribution router is connected to 100 or more remote routers. In a hub-and-spoke topology, the remote router must forward all nonlocal traffic to a distribution router, so it becomes unnecessary for the remote router to hold a complete routing table. Generally, the distribution router sends only a default route to the remote router.

Only specified routes are propagated from the remote (stub) router. The stub router responds to all queries for summaries, connected routes, redistributed static routes, external routes, and internal routes with the message “inaccessible.” A router that is configured as a stub sends a special peer information packet to all neighboring routers to report its status as a stub router.

Any neighbor that receives a packet that informs 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.

Figure 1-2 shows a simple hub-and-spoke configuration.

Figure 1-2 Simple Hub-and-Spoke Network



Stub routing does not prevent routes from being advertised to the remote router. Figure 1-2 shows that the remote router can access the corporate network and the Internet through the distribution router only. A full route table on the remote router, in this example, serves no functional purpose because the path to the corporate network and the Internet is always through the distribution router. A larger route table reduces only the amount of memory required by the remote router. The bandwidth and memory used can be lessened by summarizing and filtering routes in the distribution router. In this network topology, the remote router does not need to receive routes that have been learned from other networks because the

remote router must send all nonlocal traffic, regardless of its destination, to the distribution router. To configure a true stub network, you should configure the distribution router to send only a default route to the remote router.

OSPF supports stub areas, and the Enhanced Interior Gateway Routing Protocol (EIGRP) supports stub routers.

Routing Algorithms

Routing algorithms determine how a router gathers and reports reachability information, how it deals with topology changes, and how it determines the optimal route to a destination. Various types of routing algorithms exist, and each algorithm has a different impact on network and router resources. Routing algorithms use a variety of metrics that affect calculation of optimal routes. You can classify routing algorithms by type, such as static or dynamic, and interior or exterior.

This section includes the following topics:

Static Routes and Dynamic Routing Protocols

Static routes are route table entries that you manually configure. These static routes do not change unless you reconfigure them. Static routes are simple to design and work well in environments where network traffic is relatively predictable and where network design is relatively simple.

Because static routing systems cannot react to network changes, you should not use them for large, constantly changing networks. Most routing protocols today use dynamic routing algorithms that adjust to changing network circumstances by analyzing incoming routing update messages. If the message indicates that a network change has occurred, the routing software recalculates routes and sends out new routing update messages. These messages permeate the network, triggering routers to rerun their algorithms and change their routing tables accordingly.

You can supplement dynamic routing algorithms with static routes where appropriate. For example, you should configure each subnetwork with a static route to the IP default gateway or router of last resort (a router to which all unrouteable packets are sent).

Interior and Exterior Gateway Protocols

You can separate networks into unique routing domains or autonomous systems. An autonomous system is a portion of an internetwork under common administrative authority that is regulated by a particular set of administrative guidelines. Routing protocols that route between autonomous systems are called exterior gateway protocols or interdomain protocols. The Border Gateway Protocol (BGP) is an example of an exterior gateway protocol. Routing protocols used within an autonomous system are called interior gateway protocols or intradomain protocols. EIGRP and OSPF are examples of interior gateway protocols.

Distance Vector Protocols

Distance vector protocols use distance vector algorithms (also known as Bellman-Ford algorithms) that call for each router to send all or some portion of its routing table to its neighbors. Distance vector algorithms define routes by distance (for example, the number of hops to the destination) and direction (for example, the next-hop router). These routes are then broadcast to the directly connected neighbor routers. Each router uses these updates to verify and update the routing tables.

To prevent routing loops, most distance vector algorithms use split horizon with poison reverse which means that the routes learned from an interface are set as unreachable and advertised back along the interface that they were learned on during the next periodic update. This process prevents the router from seeing its own route updates coming back.

Distance vector algorithms send updates at fixed intervals but can also send updates in response to changes in route metric values. These triggered updates can speed up the route convergence time. The Routing Information Protocol (RIP) is a distance vector protocol.

Link-State Protocols

The link-state protocols, also known as shortest path first (SPF), share information with neighboring routers. Each router builds a link-state advertisement (LSA) that contains information about each link and directly connected neighbor router.

Each LSA has a sequence number. When a router receives an LSA and updates its link-state database, the LSA is flooded to all adjacent neighbors. If a router receives two LSAs with the same sequence number (from the same router), the router does not flood the last LSA that it received to its neighbors because it wants to prevent an LSA update loop. Because the router floods the LSAs immediately after it receives them, the convergence time for link-state protocols is minimized.

Discovering neighbors and establishing adjacency is an important part of a link state protocol. Neighbors are discovered using special Hello packets that also serve as keepalive notifications to each neighbor router. Adjacency is the establishment of a common set of operating parameters for the link-state protocol between neighbor routers.

The LSAs received by a router are added to the router's link-state database. Each entry consists of the following parameters:

- Router ID (for the router that originated the LSA)
- Neighbor ID
- Link cost
- Sequence number of the LSA
- Age of the LSA entry

The router runs the SPF algorithm on the link-state database, building the shortest path tree for that router. This SPF tree is used to populate the routing table.

In link-state algorithms, each router builds a picture of the entire network in its routing tables. The link-state algorithms send small updates everywhere, while distance vector algorithms send larger updates only to neighboring routers.

Because they converge more quickly, link-state algorithms are less likely to cause routing loops than distance vector algorithms. However, link-state algorithms require more CPU power and memory than distance vector algorithms and they can be more expensive to implement and support. Link-state protocols are generally more scalable than distance vector protocols.

OSPF is an example of a link-state protocol.

Layer 3 Virtualization

Cisco NX-OS supports multiple virtual routing and forwarding (VRF) instances and multiple Routing Information Bases (RIBs) to support multiple address domains. Each VRF is associated with a RIB, and this information is collected by the Forwarding Information Base (FIB). A VRF represents a Layer 3 addressing domain. Each Layer 3 interface (logical or physical) belongs to one VRF. For more information, see Chapter 13, “Configuring Layer 3 Virtualization.”

Cisco NX-OS can segment operating system and hardware resources into virtual device contexts (VDCs) that emulate virtual devices. The Cisco Nexus 9000 Series switch currently does not support multiple VDCs. All switch resources are managed in the default VDC.

Cisco NX-OS Fowarding Architecture

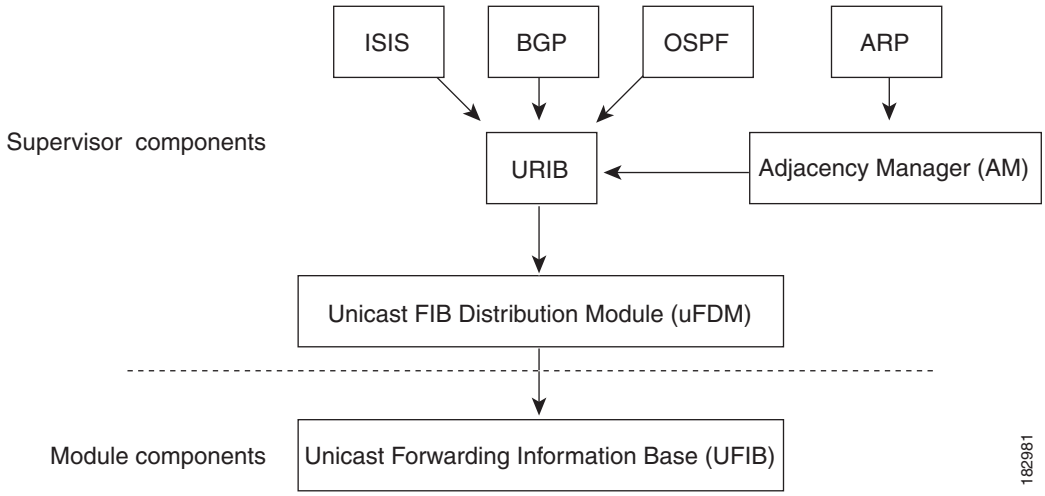
The Cisco NX-OS forwarding architecture is responsible for processing all routing updates and populating the forwarding information to all modules in the chassis.

This section includes the following topics:

Unicast RIB

The Cisco NX-OS forwarding architecture consists of multiple components, as shown in Figure 1-3.

Figure 1-3 Cisco NX-OS Forwarding Architecture



The unicast RIB exists on the active supervisor. It maintains the routing table with directly connected routes, static routes, and routes learned from dynamic unicast routing protocols. The unicast RIB also collects adjacency information from sources such as the Address Resolution Protocol (ARP). The unicast RIB determines the best next hop for a given route and populates the unicast FIB on the modules by using the services of the unicast FIB Distribution Module (FDM).

Each dynamic routing protocol must update the unicast RIB for any route that has timed out. The unicast RIB then deletes that route and recalculates the best next hop for that route (if an alternate path is available).

Adjacency Manager

The adjacency manager exists on the active supervisor and maintains adjacency information for different protocols including ARP, Neighbor Discovery Protocol (NDP), and static configuration. The most basic adjacency information is the Layer 3 to Layer 2 address mapping discovered by these protocols. Outgoing Layer 2 packets use the adjacency information to complete the Layer 2 header.

The adjacency manager can trigger ARP requests to find a particular Layer 3 to Layer 2 mapping. The new mapping becomes available when the corresponding ARP reply is received and processed. For IPv6, the adjacency manager finds the Layer 3 to Layer 2 mapping information from NDP. For more information, see Chapter 3, “Configuring IPv6.”

Unicast Forwarding Distribution Module

The unicast Forwarding Distribution Module (FDM) exists on the active supervisor and distributes the forwarding path information from the unicast RIB and other sources. The unicast RIB generates forwarding information that the unicast FIB programs into the hardware forwarding tables on the standby supervisor and the modules. The unicast FDM also downloads the FIB information to newly inserted modules.

The unicast FDM gathers adjacency information, rewrite information, and other platform-dependent information when updating routes in the unicast FIB. The adjacency and rewrite information consists of interface, next hop, and Layer 3 to Layer 2 mapping information. The interface and next-hop information is received in route updates from the unicast RIB. The Layer 3 to Layer 2 mapping is received from the adjacency manager.

FIB

The unicast FIB exists on supervisors and switching modules and builds the information used for the hardware forwarding engine. The unicast FIB receives route updates from the unicast FDM and sends the information to be programmed in the hardware forwarding engine. The unicast FIB controls the addition, deletion, and modification of routes, paths, and adjacencies.

The unicast FIBs are maintained on a per-VRF and per-address-family basis, that is, one for IPv4 and one for IPv6 for each configured VRF. Based on route update messages, the unicast FIB maintains a per-VRF prefix and next-hop adjacency information database. The next-hop adjacency data structure contains the next-hop IP address and the Layer 2 rewrite information. Multiple prefixes could share a next-hop adjacency information structure.

Hardware Forwarding

Cisco NX-OS supports distributed packet forwarding. The ingress port takes relevant information from the packet header and passes the information to the local switching engine. The local switching engine does the Layer 3 lookup and uses this information to rewrite the packet header. The ingress module forwards the packet to the egress port. If the egress port is on a different module, the packet is forwarded using the switch fabric to the egress module. The egress module does not participate in the Layer 3 forwarding decision.

You also use the **show platform fib** or **show platform forwarding** commands to display details on hardware forwarding.

Software Forwarding

The software forwarding path in Cisco NX-OS is used mainly to handle features that are not supported in the hardware or to handle errors encountered during the hardware processing. Typically, packets with IP options or packets that need fragmentation are passed to the CPU on the active supervisor. All packets that should be switched in the software or terminated go to the supervisor. The supervisor uses the information provided by the unicast RIB and the adjacency manager to make the forwarding decisions. The module is not involved in the software forwarding path.

Software forwarding is controlled by control plane policies. For more information, see the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide*.

Summary of Layer 3 Unicast Routing Features

This section provides a brief introduction to the Layer 3 unicast features and protocols supported in Cisco NX-OS.

This section includes the following topics:

IPv4 and IPv6

Layer 3 uses either the IPv4 or IPv6 protocol. IPv6 increases the number of network address bits from 32 bits (in IPv4) to 128 bits. For more information, see Chapter 2, “Configuring IPv4” or Chapter 3, “Configuring IPv6.”

IP Services

IP Services includes Dynamic Host Configuration Protocol (DHCP) and Domain Name System (DNS Client) clients. For more information, see Chapter 4, “Configuring DNS.”

OSPF

The Open Shortest Path First (OSPF) protocol is a link-state routing protocol used to exchange network reachability information within an autonomous system. Each OSPF router advertises information about its active links to its neighbor routers. Link information consists of the link type, the link metric, and the neighbor router that is connected to the link. The advertisements that contain this link information are called link-state advertisements. For more information, see Chapter 5, “Configuring OSPFv2.”

EIGRP

The Enhanced Interior Gateway Routing Protocol (EIGRP) is a unicast routing protocol that has the characteristics of both distance vector and link-state routing protocols. It is an improved version of IGRP, which is a Cisco proprietary routing protocol. EIGRP relies on its neighbors to provide the routes. It constructs the network topology from the routes advertised by its neighbors, similar to a link-state protocol, and uses this information to select loop-free paths to destinations. For more information, see Chapter 7, “Configuring EIGRP.”

IS-IS

The Intermediate System-to-Intermediate System (IS-IS) protocol is an intradomain Open System Interconnection (OSI) dynamic routing protocol specified in the International Organization for Standardization (ISO) 10589. The IS-IS routing protocol is a link-state protocol. IS-IS features are as follows:

- Hierarchical routing
- Classless behavior
- Rapid flooding of new information
- Fast Convergence
- Very scalable

For more information, see Chapter 8, "Configuring IS-IS."

BGP

The Border Gateway Protocol (BGP) is an inter-autonomous system routing protocol. A BGP router advertises network reachability information to other BGP routers using Transmission Control Protocol (TCP) as its reliable transport mechanism. The network reachability information includes the destination network prefix, a list of autonomous systems that needs to be traversed to reach the destination, and the next-hop router. Reachability information contains additional path attributes such as preference to a route, origin of the route, community and others. For more information, see Chapter 9, "Configuring Basic BGP" and Chapter 10, "Configuring Advanced BGP."

RIP

The Routing Information Protocol (RIP) is a distance-vector protocol that uses a hop count as its metric. RIP is widely used for routing traffic in the global Internet and is an Interior Gateway Protocol (IGP), which means that it performs routing within a single autonomous system. For more information, see Chapter 11, "Configuring RIP."

Static Routing

Static routing allows you to enter a fixed route to a destination. This feature is useful for small networks where the topology is simple. Static routing is also used with other routing protocols to control default routes and route distribution. For more information, see Chapter 12, "Configuring Static Routing."

Layer 3 Virtualization

Virtualization allows you to share physical resources across separate management domains. Cisco NX-OS supports Layer 3 virtualization with virtual routing and forwarding (VRF). VRF provides a separate address domain for configuring Layer 3 routing protocols. For more information, see Chapter 13, "Configuring Layer 3 Virtualization."

Route Policy Manager

The Route Policy Manager provides a route filtering capability in Cisco NX-OS. It uses route maps to filter routes distributed across various routing protocols and between different entities within a given routing protocol. Filtering is based on specific match criteria, which is similar to packet filtering by

access control lists. For more information, see Chapter 15, “Configuring Route Policy Manager.”

Policy-Based Routing

Policy-based routing uses the Route Policy Manager to create policy route filters. These policy route filters can forward a packet to a specified next hop based on the source of the packet or other fields in the packet header. Policy routes can be linked to extended IP access lists so that routing might be based on protocol types and port numbers. For more information, see Chapter 16, “Configuring Policy-Based Routing.”

First Hop Redundancy Protocols

First hop redundancy protocols (FHRP), such as the Hot Standby Router Protocol (HSRP) and the Virtual Router Redundancy Protocol (VRRP), allow you to provide redundant connections to your hosts. If an active first-hop router fails, the FHRP automatically selects a standby router to take over. You do not need to update the hosts with new IP addresses because the address is virtual and shared between each router in the FHRP group. For more information on HSRP, see Chapter 17, “Configuring HSRP.” For more information on VRRP, see Chapter 18, “Configuring VRRP.”

Object Tracking

Object tracking allows you to track specific objects on the network, such as the interface line protocol state, IP routing, and route reachability, and take action when the tracked object’s state changes. This feature allows you to increase the availability of the network and shorten the recovery time if an object state goes down. For more information, see Chapter 19, “Configuring Object Tracking.”

Related Topics

The following Cisco documents are related to the Layer 3 features:

- *Cisco Nexus 9000 Series NX-OS Multicast Routing Configuration Guide*
- *Cisco Nexus 9000 Series NX-OS High Availability and Redundancy Guide*
- Exploring Autonomous System Numbers: http://www.cisco.com/web/about/ac123/ac147/archived_issues/ipj_9-1/autonomous_system_numbers.html

Configuring IPv4

This chapter describes how to configure Internet Protocol version 4 (IPv4), which includes addressing, Address Resolution Protocol (ARP), and Internet Control Message Protocol (ICMP), on the Cisco NX-OS device.

This chapter includes the following sections:

About IPv4

You can configure IP on the device to assign IP addresses to network interfaces. When you assign IP addresses, you enable the interfaces and allow communication with the hosts on those interfaces.

You can configure an IP address as primary or secondary on a device. An interface can have one primary IP address and multiple secondary addresses. All networking devices on an interface should share the same primary IP address because the packets that are generated by the device always use the primary IPv4 address. Each IPv4 packet is based on the information from a source or destination IP address. For more information, see the "Multiple IPv4 Addresses" section on page 2-2.

You can use a subnet to mask the IP addresses. A mask is used to determine what subnet an IP address belongs to. An IP address contains the network address and the host 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 then referred to as a subnet mask. Subnet masks are 32-bit values that allow the recipient of IP packets to distinguish the network ID portion of the IP address from the host ID portion of the IP address.

The IP feature is responsible for handling IPv4 packets that terminate in the supervisor module, as well as forwarding of IPv4 packets, which includes IPv4 unicast/multicast route lookup and software access control list (ACL) forwarding. The IP feature also manages the network interface IP address configuration, duplicate address checks, static routes, and packet send/receive interface for IP clients.

This section includes the following topics:

Multiple IPv4 Addresses

Cisco NX-OS supports multiple IP addresses per interface. You can specify an unlimited number of secondary addresses for a variety of situations. The most common are as follows:

- When there are not enough host IP addresses for a particular network interface. For example, if your subnetting allows up to 254 hosts per logical subnet, but on one physical subnet you must have 300 host addresses, then you can use secondary IP addresses on the routers or access servers to allow you to have two logical subnets that use one physical subnet.
- Two subnets of a single network might otherwise be separated by another network. You can create a single network from subnets that are physically separated by another network by using a secondary address. In these instances, the first network is extended, or layered on top of the second network. A subnet cannot appear on more than one active interface of the router at a time.

Note If any device on a network segment uses a secondary IPv4 address, all other devices on that same network interface must also use a secondary address from the same network or subnet. The inconsistent use of secondary addresses on a network segment can quickly cause routing loops.

LPM Routing Modes

By default, Cisco NX-OS programs routes in a hierarchical fashion to allow for the longest prefix match (LPM) on the device. However, you can configure the device for different routing modes to support significantly more LPM route entries.

The following tables list the LPM routing modes that are supported on Cisco Nexus 9000 Series switches.

Table 2-1 LPM Routing Modes for Cisco Nexus 9200 and 9300-EX Series Switches

LPM Routing Mode	CLI Command
Default system routing mode	
LPM heavy routing mode[1]	**system routing template-lpm-heavy**
LPM dual-host routing mode	**system routing template-dual-stack-host-scale**

1. This mode is also supported for Cisco Nexus 9508 switches with the X9732C-EX line card.

Table 2-2 LPM Routing Modes for Cisco Nexus 9300 Series Switches

LPM Routing Mode	Broadcom T2 Mode	CLI Command
Default system routing mode	3	
ALPM routing mode	4	**system routing max-mode l3**

Table 2-3 LPM Routing Modes for Cisco Nexus 9500 Series Switches

LPM Routing Mode	Broadcom T2 Mode	CLI Command
Default system routing mode	3 (for line cards); 4 (for fabric modules)	
Max-host routing mode	2 (for line cards); 3 (for fabric modules)	**system routing max-mode host**
Nonhierarchical routing mode	3 (for line cards); 4 with **max-l3-mode** option (for line cards)	**system routing non-hierarchical-routing** [**max-l3-mode**]
64-bit ALPM routing mode	Submode of mode 4 (for fabric modules)	**system routing mode hierarchical 64b-alpm**

For detailed configuration information, see the "Configuring IPv4" section on page 2-8.

For additional information on the supported routing modes, see Layer 3 Forwarding Modes on Cisco Nexus 9500, 9300, 3164, and 3200 Platform Switches.

Host to LPM Spillover

Beginning with Cisco NX-OS Release 7.0(3)I5(1), host routes can be stored in the LPM table in order to achieve a larger host scale. In ALPM mode, the switch allows fewer host routes. If you add more host routes than the supported scale, the routes that are spilled over from the host table take the space of the LPM routes in the LPM table. The total number of LPM routes allowed in that mode is reduced by the number of host routes stored. This feature is supported on Cisco Nexus 9300 and 9500 Series switches.

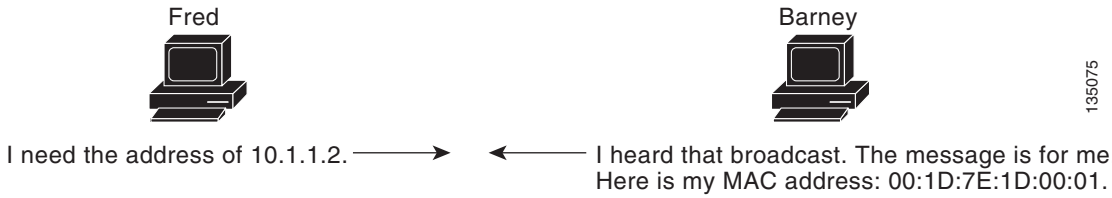
In the default system routing mode, Cisco Nexus 9300 Series switches are configured for higher host scale and fewer LPM routes, and the LPM space can be used to store additional host routes. For Cisco Nexus 9500 Series switches, only the default system routing and nonhierarchical routing modes support this feature on line cards. Fabric modules do not support this feature.

Address Resolution Protocol

Networking devices and Layer 3 switches use Address Resolution Protocol (ARP) to map IP (network layer) addresses to (Media Access Control [MAC]-layer) addresses to enable IP packets to be sent across networks. Before a device sends a packet to another device, it looks in its own ARP cache to see if there is a MAC address and corresponding IP address for the destination device. If there is no entry, the source device sends a broadcast message to every device on the network.

Each device compares the IP address to its own. Only the device with the matching IP address replies to the device that sends the data with a packet that contains the MAC address for the device. The source device adds the destination device MAC address to its ARP table for future reference, creates a data-link header and trailer that encapsulates the packet, and proceeds to transfer the data. Figure 2-1 shows the ARP broadcast and response process.

Figure 2-1 ARP Process



When the destination device lies on a remote network that is beyond another device, the process is the same except that the device that sends the data sends an ARP request for the MAC address of the default gateway. After the address is resolved and the default gateway receives the packet, the default gateway broadcasts the destination IP address over the networks connected to it. The device on the destination device network uses ARP to obtain the MAC address of the destination device and delivers the packet. ARP is enabled by default.

The default system-defined CoPP policy rate limits ARP broadcast packets bound for the supervisor module. The default system-defined CoPP policy prevents an ARP broadcast storm from affecting the control plane traffic but does not affect bridged packets.

ARP Caching

ARP caching minimizes broadcasts and limits wasteful use of network resources. The mapping of IP addresses to MAC addresses occurs at each hop (device) on the network for every packet sent over an internetwork, which may affect network performance.

ARP caching stores network addresses and the associated data-link addresses in the memory for a period of time, which minimizes the use of valuable network resources to broadcast for the same address each time that a packet is sent. You must maintain the cache entries that are set to expire periodically because the information might become outdated. Every device on a network updates its tables as addresses are broadcast.

Static and Dynamic Entries in the ARP Cache

Static routing requires that you manually configure the IP addresses, subnet masks, gateways, and corresponding MAC addresses for each interface of each device. Static routing requires more work to maintain the route table. You must update the table each time you add or change routes.

Dynamic routing uses protocols that enable the devices in a network to exchange routing table information with each other. Dynamic routing is more efficient than static routing because the route table is automatically updated unless you add a time limit to the cache. The default time limit is 25 minutes but you can modify the time limit if the network has many routes that are added and deleted from the cache.

Devices That Do Not Use ARP

When a network is divided into two segments, a bridge joins the segments and filters traffic to each segment based on MAC addresses. The bridge builds its own address table, which uses MAC addresses only. A device has an ARP cache that contains both IP addresses and the corresponding MAC addresses.

Passive hubs are central-connection devices that physically connect other devices in a network. They send messages out on all their ports to the devices and operate at Layer 1 but do not maintain an address table.

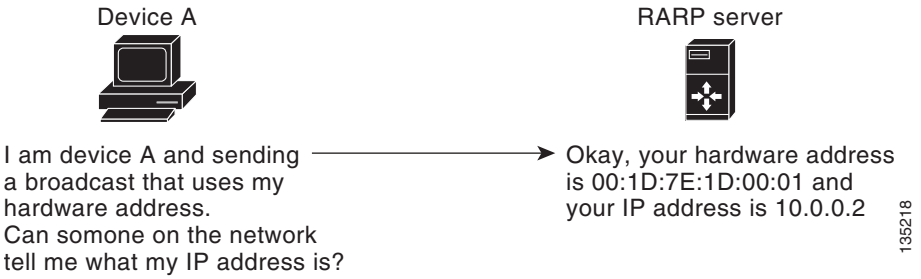
Layer 2 switches determine which port of a device receives a message that is sent only to that port. However, Layer 3 switches are devices that build an ARP cache (table).

Reverse ARP

Reverse ARP (RARP) as defined by RFC 903 works the same way as ARP, except that the RARP request packet requests an IP address instead of a MAC address. RARP often is used by diskless workstations because this type of device has no way to store IP addresses to use when they boot. The only address that is known is the MAC address because it is burned into the hardware.

Use of RARP requires an RARP server on the same network segment as the router interface. Figure 2-2 shows how RARP works.

Figure 2-2 Reverse ARP



RARP has several limitations. Because of these limitations, most businesses use DHCP to assign IP addresses dynamically. DHCP is cost effective and requires less maintenance than RARP. The following are the most important limitations:

- Because RARP uses hardware addresses, if the internetwork is large with many physical networks, a RARP server must be on every segment with an additional server for redundancy. Maintaining two servers for every segment is costly.
- Each server must be configured with a table of static mappings between the hardware addresses and IP addresses. Maintenance of the IP addresses is difficult.
- RARP only provides IP addresses of the hosts and not subnet masks or default gateways.

Proxy ARP

Proxy ARP enables a device that is physically located on one network appear to be logically part of a different physical network connected to the same device or firewall. Proxy ARP allows you to hide a device with a public IP address on a private network behind a router and still have the device appear to be on the public network in front of the router. By hiding its identity, the router accepts responsibility for routing packets to the real destination. Proxy ARP can help devices on a subnet reach remote subnets without configuring routing or a default gateway.

When devices are not in the same data link layer network but in the same IP network, they try to transmit data to each other as if they are on the local network. However, the router that separates the devices does not send a broadcast message because routers do not pass hardware-layer broadcasts and the addresses cannot be resolved.

When you enable Proxy ARP on the device and it receives an ARP request, it identifies the request as a request for a system that is not on the local LAN. The device responds as if it is the remote destination for which the broadcast is addressed, with an ARP response that associates the device's MAC address with the remote destination's IP address. The local device believes that it is directly connected to the destination, while in reality its packets are being forwarded from the local subnetwork toward the destination subnetwork by their local device. By default, Proxy ARP is disabled.

Local Proxy ARP

You can use local Proxy ARP to enable a device to respond to ARP requests for IP addresses within a subnet where normally no routing is required. When you enable local Proxy ARP, ARP responds to all ARP requests for IP addresses within the subnet and forwards all traffic between hosts in the subnet. Use this feature only on subnets where hosts are intentionally prevented from communicating directly by the configuration on the device to which they are connected.

Gratuitous ARP

Gratuitous ARP sends a request with an identical source IP address and a destination IP address to detect duplicate IP addresses. Cisco NX-OS supports enabling or disabling gratuitous ARP requests or ARP cache updates.

Glean Throttling

If the Address Resolution Protocol (ARP) request for the next hop is not resolved when incoming IP packets are forwarded in a line card, the line card forwards the packets to the supervisor (glean throttling). The supervisor resolves the MAC address for the next hop and programs the hardware.

When an ARP request is sent, the software adds a /32 drop adjacency in the hardware to prevent the packets to the same next-hop IP address to be forwarded to the supervisor. When the ARP is resolved, the hardware entry is updated with the correct MAC address. If the ARP entry is not resolved before a timeout period, the entry is removed from the hardware.

Path MTU Discovery

Path maximum transmission unit (MTU) discovery is a method for maximizing the use of available bandwidth in the network between the endpoints of a TCP connection. It is described in RFC 1191. Existing connections are not affected when this feature is turned on or off.

ICMP

You can use the Internet Control Message Protocol (ICMP) to provide message packets that report errors and other information that is relevant to IP processing. ICMP generates error messages, such as ICMP destination unreachable messages, ICMP Echo Requests (which send a packet on a round trip between two hosts) and Echo Reply messages. ICMP also provides many diagnostic functions and can send and redirect error packets to the host. By default, ICMP is enabled.

Some of the ICMP message types are as follows:

- Network error messages
- Network congestion messages
- Troubleshooting information
- Timeout announcements

Note ICMP redirects are disabled on interfaces where the local proxy ARP feature is enabled.

Virtualization Support

IPv4 supports virtual routing and forwarding (VRF) instances.

Licensing Requirements for IPv4

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	IP requires no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for IPv4

IPv4 has the following prerequisites:

- IPv4 can only be configured on Layer 3 interfaces.

Guidelines and Limitations for IPv4

IPv4 has the following configuration guidelines and limitations:

- You can configure a secondary IP address only after you configure the primary IP address.

Default Settings

Table 2-4 lists the default settings for IP parameters.

Table 2-4 Default IP Parameters

Parameters	Default
ARP timeout	1500 seconds
Proxy ARP	Disabled

Configuring IPv4

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Configuring IPv4 Addressing

You can assign a primary IP address for a network interface.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *number*
3. **ip address** *ip-address/length*
4. (Optional) **show ip interface**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface ethernet** *number* **Example:** `switch(config)# interface ethernet 2/3` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip address** *ip-address/length* [secondary] **Example:** `switch(config-if)# ip address 192.168.1.1 255.0.0.0`	Specifies a primary or secondary IPv4 address for an interface. • The network mask can be a four-part dotted decimal address. For example, 255.0.0.0 indicates that each bit equal to 1 means the corresponding address bit belongs to the network address. • The network mask can be indicated as a slash (/) and a number, which is the prefix length. The prefix length is a decimal value that indicates how many of the high-order contiguous bits of the address comprise the prefix (the network portion of the address). A slash must precede the decimal value and there is no space between the IP address and the slash.

	Command	Purpose
Step 4	**show ip interface** **Example:** `switch(config-if)# show ip interface`	(Optional) Displays interfaces configured for IPv4.
Step 5	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring Multiple IP Addresses

You can only add secondary IP addresses after you configure primary IP addresses.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *number*
3. **ip address** *ip-address/length*
4. (Optional) **show ip interface**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface ethernet** *number* **Example:** `switch(config)# interface ethernet 2/3` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip address** *ip-address/length* [secondary] **Example:** `switch(config-if)# ip address 192.168.1.1 255.0.0.0 secondary`	Specifies the configured address as a secondary IPv4 address.
Step 4	**show ip interface** **Example:** `switch(config-if)# show ip interface`	(Optional) Displays interfaces configured for IPv4.
Step 5	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring Max-Host Routing Mode (Cisco Nexus 9500 Series Switches Only)

By default, Cisco NX-OS programs routes in a hierarchical fashion (with fabric modules configured to be in mode 4 and line card modules configured to be in mode 3), which allows for longest prefix match (LPM) and host scale on the device.

You can modify the default LPM and host scale to program more hosts in the system, as might be required when the node is positioned as a Layer-2 to Layer-3 boundary node.

Note If you want to further scale the entries in the LPM table, see the "Configuring Nonhierarchical Routing Mode (Cisco Nexus 9500 Series Switches Only)" section on page 2-12 to configure the device to program all of the Layer 3 IPv4 and IPv6 routes on the line cards and none of the routes on the fabric modules.

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For the max-host routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. **[no] system routing max-mode host**
3. (Optional) **show forwarding route summary**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**[no] system routing max-mode host** **Example:** `switch(config)# system routing max-mode host`	Puts the line cards in Broadcom T2 mode 2 and the fabric modules in Broadcom T2 mode 3 to increase the number of supported hosts.
Step 3	**show forwarding route summary** **Example:** `switch(config)# show forwarding route summary`	(Optional) Displays the LPM routing mode.

	Command	Purpose
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	Saves this configuration change.
Step 5	**reload** **Example:** switch(config)# reload	Reboots the entire device.

Configuring Nonhierarchical Routing Mode (Cisco Nexus 9500 Series Switches Only)

If the host scale is small (as in a pure Layer 3 deployment), we recommend programming the longest prefix match (LPM) routes in the line cards to improve convergence performance. Doing so programs routes and hosts in the line cards and does not program any routes in the fabric modules.

Note This configuration impacts both the IPv4 and IPv6 address families.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system routing non-hierarchical-routing** [**max-l3-mode**]
3. (Optional) **show forwarding route summary**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[**no**] **system routing non-hierarchical-routing** [**max-l3-mode**] **Example:** switch(config)# system routing non-hierarchical-routing max-l3-mode	Puts the line cards in Broadcom T2 mode 3 (or Broadcom T2 mode 4 if you use the **max-l3-mode** option) to support a larger LPM scale. As a result, all of the IPv4 and IPv6 routes will be programmed on the line cards rather than on the fabric modules.

	Command	Purpose
Step 3	**show forwarding route summary** **Example:** switch(config)# show forwarding route summary Mode 3: 120K IPv4 Host table 16k LPM table (> 65 < 127 1k entry reserved) Mode 4: 16k V4 host/4k V6 host 128k v4 LPM/20K V6 LPM	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	Saves this configuration change.
Step 5	**reload** **Example:** switch(config)# reload	Reboots the entire device.

Configuring 64-Bit ALPM Routing Mode (Cisco Nexus 9500 Series Switches Only)

You can use the 64-bit algorithmic longest prefix match (ALPM) feature to manage IPv4 and IPv6 route table entries. In 64-bit ALPM routing mode, the device can store significantly more route entries. In this mode, you can program one of the following:

- 80,000 IPv6 entries and no IPv4 entries
- No IPv6 entries and 128,000 IPv4 entries
- *x* IPv6 entries and *y* IPv4 entries, where $2x + y <= 128,000$

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For the 64-bit ALPM routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system routing mode hierarchical 64b-alpm**
3. (Optional) **show system routing mode**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	[**no**] **system routing mode hierarchical 64b-alpm** **Example:** `switch(config)# system routing mode hierarchical 64b-alpm`	Causes all IPv4 and IPv6 LPM routes with a mask length that is less than or equal to 64 to be programmed in the fabric module. All host routes for IPv4 and IPv6 and all LPM routes with a mask length of 65 through 127 are programmed in the line card.
Step 3	**show system routing mode** **Example:** `switch(config)# show system routing mode`	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	Saves this configuration change.
Step 5	**reload** **Example:** `switch(config)# reload`	Reboots the entire device.

Configuring ALPM Routing Mode (Cisco Nexus 9300 Series Switches Only)

You can configure Cisco Nexus 9300 Series switches to support significantly more LPM route entries.

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For ALPM routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system routing max-mode l3**
3. (Optional) **show system routing mode**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	[**no**] **system routing max-mode l3** **Example:** `switch(config)# system routing max-mode l3`	Puts the device in Broadcom T2 mode 4 to support a larger LPM scale.
Step 3	**show system routing mode** **Example:** `switch(config)# show system routing mode`	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	Saves this configuration change.
Step 5	**reload** **Example:** `switch(config)# reload`	Reboots the entire device.

Configuring LPM Heavy Routing Mode (Cisco Nexus 9200 and 9300-EX Series Switches and X9732C-EX Line Card Only)

Beginning with Cisco NX-OS Release 7.0(3)I4(4), you can configure LPM heavy routing mode in order to support significantly more LPM route entries. Only the Cisco Nexus 9200 and 9300-EX Series switches and the Cisco Nexus 9508 switch with an X9732C-EX line card support this routing mode.

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For LPM heavy routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] s**ystem routing template-lpm-heav**y
3. (Optional) **show system routing mode**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[**no**] **system routing template-lpm-heavy** **Example:** switch(config)# system routing template-lpm-heavy	Puts the device in LPM heavy routing mode to support a larger LPM scale.
Step 3	**show system routing mode** **Example:** switch(config)# show system routing mode Configured System Routing Mode: LPM Heavy Applied System Routing Mode: LPM Heavy	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	Saves this configuration change.
Step 5	**reload** **Example:** switch(config)# reload	Reboots the entire device.

Configuring LPM Dual-Host Routing Mode (Cisco Nexus 9200 and 9300-EX Series Switches)

Beginning with Cisco NX-OS Release 7.0(3)I5(1), you can configure LPM dual-host routing mode in order to increase the ARP/ND scale to double the default mode value. Only the Cisco Nexus 9200 and 9300-EX Series switches support this routing mode.

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For LPM dual-host routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system routing template-dual-stack-host-scale**
3. (Optional) **show system routing mode**
4. **copy running-config startup-config**

5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[**no**] **system routing template-dual-stack-host-scale** **Example:** switch(config)# system routing template-dual-stack-host-scale Warning: The command will take effect after next reload. Multicast is not supported in this profile Note: This requires copy running-config to startup-config before switch reload	Puts the device in LPM dual-host routing mode to support a larger ARP/ND scale.
Step 3	**show system routing mode** **Example:** switch(config)# show system routing mode	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	Saves this configuration change.
Step 5	**reload** **Example:** switch(config)# reload	Reboots the entire device.

Configuring a Static ARP Entry

You can configure a static ARP entry on the device to map IP addresses to MAC hardware addresses, including static multicast MAC addresses.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *number*
3. **ip arp** *ipaddr mac_addr*
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface ethernet** *number* **Example:** `switch(config)# interface ethernet 2/3` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip arp** *ipaddr mac_addr* **Example:** `switch(config-if)# ip arp 192.168.1.1 0019.076c.1a78`	Associates an IP address with a MAC address as a static entry.
Step 4	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring Proxy ARP

You can configure Proxy ARP on the device to determine the media addresses of hosts on other networks or subnets.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *number*
3. **ip proxy-arp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface ethernet** *number* **Example:** `switch(config)# interface ethernet 2/3` `switch(config-if)#`	Enters interface configuration mode.

	Command	Purpose
Step 3	**ip proxy-arp** **Example:** `switch(config-if)# ip proxy-arp`	Enables Proxy ARP on the interface.
Step 4	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring Local Proxy ARP

You can configure Local Proxy ARP on the device.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *number*
3. **ip local-proxy-arp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface ethernet** *number* **Example:** `switch(config)# interface ethernet 2/3` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip local-proxy-arp** **Example:** `switch(config-if)# ip local-proxy-arp`	Enables Local Proxy ARP on the interface.
Step 4	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring Gratuitous ARP

You can configure gratuitous ARP on an interface.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *number*
3. **ip arp gratuitous** {**request** | **update**}
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface ethernet** *number* **Example:** `switch(config)# interface ethernet 2/3` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip arp gratuitous** {**request** | **update**} **Example:** `switch(config-if)# ip arp gratuitous request`	Enables gratuitous ARP on the interface. The default is enabled.
Step 4	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring Path MTU Discovery

You can configure path MTU discovery.

SUMMARY STEPS

1. **configure terminal**
2. **ip tcp path-mtu-discovery**
3. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**ip tcp path-mtu-discovery** **Example:** `switch(config)# ip tcp path-mtu-discovery`	Enables path MTU discovery.
Step 3	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring IP Directed Broadcasts

An IP directed broadcast is an IP packet whose destination address is a valid broadcast address for some IP subnet but which originates from a node that is not itself part of that destination subnet.

A device that is not directly connected to its destination subnet forwards an IP directed broadcast in the same way it forwards unicast IP packets destined to a host on that subnet. When a directed broadcast packet reaches a device that is directly connected to its destination subnet, that packet is broadcast on the destination subnet. The destination address in the IP header of the packet is rewritten to the configured IP broadcast address for the subnet, and the packet is sent as a link-layer broadcast.

If directed broadcast is enabled for an interface, incoming IP packets whose addresses identify them as directed broadcasts intended for the subnet to which that interface is attached are broadcasted on that subnet. You can optionally filter those broadcasts through an IP access list such that only those packets that pass through the access list are broadcasted on the subnet.

To enable IP directed broadcasts, use the following command in interface configuration mode:

Command	Purpose
ip directed-broadcast [*acl*]	Enables the translation of a directed broadcast to physical broadcasts. You can optionally filter those broadcasts through an IP access list.

Configuring IP Glean Throttling

We recommend that you configure IP glean throttling to filter the unnecessary glean packets that are sent to the supervisor for ARP resolution for the next hops that are not reachable or do not exist. IP glean throttling boosts software performance and helps to manage traffic more efficiently.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **hardware ip glean throttle**
3. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	[**no**] **hardware ip glean throttle** **Example:** `switch(config)# hardware ip glean throttle`	Enables IP glean throttling.
Step 3	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring the Hardware IP Glean Throttle Maximum

You can limit the maximum number of drop adjacencies that are installed in the Forwarding Information Base (FIB).

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **hardware ip glean throttle maximum** *count*
3. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.

	Command	Purpose
Step 2	[**no**] **hardware ip glean throttle maximum** *count* **Example:** `switch(config)# hardware ip glean throttle maximum 2134`	Configures the number of drop adjacencies that are installed in the FIB.
Step 3	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring a Hardware IP Glean Throttle Timeout

You can configure a timeout for the installed drop adjacencies to remain in the FIB.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **hardware ip glean throttle maximum timeout** *timeout*
3. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	[**no**] **hardware ip glean throttle maximum timeout** *timeout* **Example:** `switch(config)# hardware ip glean throttle maximum timeout 300`	Configures the timeout for the installed drop adjacencies to remain in the FIB. The range is from 300 seconds (5 minutes) to 1800 seconds (30 minutes). **Note** After the timeout period is exceeded, the drop adjacencies are removed from the FIB.
Step 3	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring the Interface IP Address for the ICMP Source IP Field

You can configure an interface IP address for the ICMP source IP field to handle ICMP error messages.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **ip source** {**ethernet** *slot/port* | **loopback** *number* | **port-channel** *number*} **icmp-errors**
3. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	[**no**] **ip source** {**ethernet** *slot/port* | **loopback** *number* | **port-channel** *number*} **icmp-errors** **Example:** `switch(config)# ip source loopback 0 icmp-errors`	Configures an interface IP address for the ICMP source IP field to route ICMP error messages.
Step 3	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Verifying the IPv4 Configuration

To display the IPv4 configuration information, perform one of the following tasks:

Command	Purpose
show ip adjacency	Displays the adjacency table.
show ip adjacency summary	Displays a summary of throttle adjacencies.
show ip arp	Displays the ARP table.
show ip arp summary	Displays a summary of the number of throttle adjacencies.
show ip interface	Displays IP-related interface information.
show ip arp statistics [**vrf** *vrf-name*]	Displays the ARP statistics.
show system routing mode	Displays the LPM routing mode.

Configuring IPv6

This chapter describes how to configure Internet Protocol version 6 (IPv6), which includes addressing, on the Cisco NX-OS device.

This chapter includes the following sections:

About IPv6

IPv6, which is designed to replace IPv4, increases the number of network address bits from 32 bits (in IPv4) to 128 bits. IPv6 is based on IPv4 but it includes a much larger address space and other improvements such as a simplified main header and extension headers.

The larger IPv6 address space allows networks to scale and provide global reachability. The simplified IPv6 packet header format handles packets more efficiently. The flexibility of the IPv6 address space reduces the need for private addresses and the use of Network Address Translation (NAT), which translates private (not globally unique) addresses into a limited number of public addresses. IPv6 enables new application protocols that do not require special processing by border routers at the edge of networks.

IPv6 functionality, such as prefix aggregation, simplified network renumbering, and IPv6 site multihoming capabilities, enable more efficient routing. IPv6 supports Routing Information Protocol (RIP), Integrated Intermediate System-to-Intermediate System (IS-IS), Open Shortest Path First (OSPF) for IPv6, and multiprotocol Border Gateway Protocol (BGP).

This section includes the following topics:

IPv6 Address Formats

An IPv6 address has 128 bits or 16 bytes. The address is divided into eight, 16-bit hexadecimal blocks separated by colons (:) in the format: x:x:x:x:x:x:x:x. Two examples of IPv6 addresses are as follows:

```
2001:0DB8:7654:3210:FEDC:BA98:7654:3210
2001:0DB8:0:0:8:800:200C:417A
```

IPv6 addresses contain consecutive zeros within the address. You can use two colons (::) at the beginning, middle, or end of an IPv6 address to replace the consecutive zeros. Table 3-1 shows a list of compressed IPv6 address formats.

Note You can use two colons (::) only once in an IPv6 address to replace the longest string of consecutive zeros within the address.

You can use a double colon as part of the IPv6 address when consecutive 16-bit values are denoted as zero. You can configure multiple IPv6 addresses per interface but only one link-local address.

The hexadecimal letters in IPv6 addresses are not case sensitive.

Table 3-1 Compressed IPv6 Address Formats

IPv6 Address Type	Preferred Format	Compressed Format
Unicast	2001:0:0:0:0DB8:800:200C:417A	2001::0DB8:800:200C:417A
Multicast	FF01:0:0:0:0:0:0:101	FF01::101
Loopback	0:0:0:0:0:0:0:1	::1
Unspecified	0:0:0:0:0:0:0:0	::

A node may use the loopback address listed in Table 3-1 to send an IPv6 packet to itself. The loopback address in IPv6 is the same as the loopback address in IPv4. For more information, see Chapter 1, "Overview."

Note You cannot assign the IPv6 loopback address to a physical interface. A packet that contains the IPv6 loopback address as its source or destination address must remain within the node that created the packet. IPv6 routers do not forward packets that have the IPv6 loopback address as their source or destination address.

Note You cannot assign an IPv6 unspecified address to an interface. You should not use the unspecified IPv6 addresses as destination addresses in IPv6 packets or the IPv6 routing header.

The IPv6-prefix is in the form documented in RFC 2373 where the IPv6 address is specified in hexadecimal using 16-bit values between colons. The prefix length is a decimal value that indicates how many of the high-order contiguous bits of the address comprise the prefix (the network portion of the address). For example, 2001:0DB8:8086:6502::/32 is a valid IPv6 prefix.

IPv6 Unicast Addresses

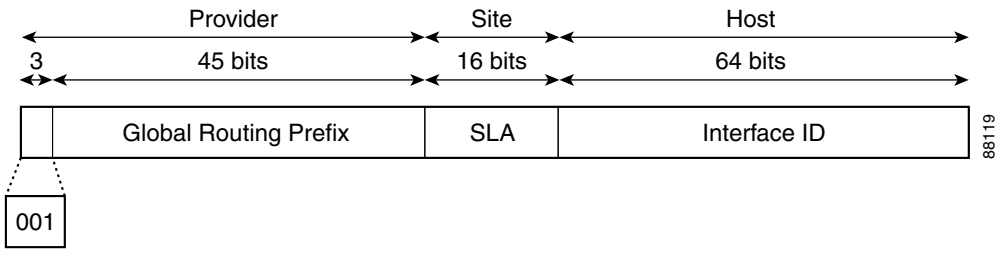
An IPv6 unicast address is an identifier for a single interface on a single node. A packet that is sent to a unicast address is delivered to the interface identified by that address. This section includes the following topics:

Aggregatable Global Addresses

An aggregatable global address is an IPv6 address from the aggregatable global unicast prefix. The structure of aggregatable global unicast addresses enables strict aggregation of routing prefixes that limits the number of routing table entries in the global routing table. Aggregatable global addresses are used on links that are aggregated upward through organizations and eventually to the Internet service providers (ISPs).

Aggregatable global IPv6 addresses are defined by a global routing prefix, a subnet ID, and an interface ID. Except for addresses that start with binary 000, all global unicast addresses have a 64-bit interface ID. The IPv6 global unicast address allocation uses the range of addresses that start with binary value 001 (2000::/3). Figure 3-1 shows the structure of an aggregatable global address.

Figure 3-1 Aggregatable Global Address Format



Addresses with a prefix of 2000::/3 (001) through E000::/3 (111) are required to have 64-bit interface identifiers in the extended universal identifier (EUI)-64 format. The Internet Assigned Numbers Authority (IANA) allocates the IPv6 address space in the range of 2000::/16 to regional registries.

The aggregatable global address consists of a 48-bit global routing prefix and a 16-bit subnet ID or Site-Level Aggregator (SLA). In the IPv6 aggregatable global unicast address format document (RFC 2374), the global routing prefix included two other hierarchically structured fields called Top-Level Aggregator (TLA) and Next-Level Aggregator (NLA). The IETF decided to remove the TLS and NLA fields from the RFCs because these fields are policy based. Some existing IPv6 networks deployed before the change might still use networks that are on the older architecture.

A subnet ID, which is a 16-bit subnet field, can be used by individual organizations to create a local addressing hierarchy and to identify subnets. A subnet ID is similar to a subnet in IPv4, except that an organization with an IPv6 subnet ID can support up to 65,535 individual subnets.

An interface ID identifies interfaces on a link. The interface ID is unique to the link. In many cases, an interface ID is the same as or based on the link-layer address of an interface. Interface IDs used in aggregatable global unicast and other IPv6 address types have 64 bits and are in the modified EUI-64 format.

Interface IDs are in the modified EUI-64 format in one of the following ways:

- For all IEEE 802 interface types (for example, Ethernet and Fiber Distributed Data interfaces), the first three octets (24 bits) are the Organizationally Unique Identifier (OUI) of the 48-bit link-layer address (MAC address) of the interface, the fourth and fifth octets (16 bits) are a fixed hexadecimal value of FFFE, and the last three octets (24 bits) are the last three octets of the MAC address. The Universal/Local (U/L) bit, which is the seventh bit of the first octet, has a value of 0 or 1. Zero indicates a locally administered identifier; 1 indicates a globally unique IPv6 interface identifier.
- For all other interface types (for example, serial, loopback, ATM, and Frame Relay types), the interface ID is similar to the interface ID for IEEE 802 interface types; however, the first MAC address from the pool of MAC addresses in the router is used as the identifier (because the interface does not have a MAC address).

Note For interfaces that use the Point-to-Point Protocol (PPP), where the interfaces at both ends of the connection might have the same MAC address, the interface identifiers at both ends of the connection are negotiated (picked randomly and, if necessary, reconstructed) until both identifiers are unique. The first MAC address in the router is used as the identifier for interfaces using PPP.

If no IEEE 802 interface types are in the router, link-local IPv6 addresses are generated on the interfaces in the router in the following sequence:

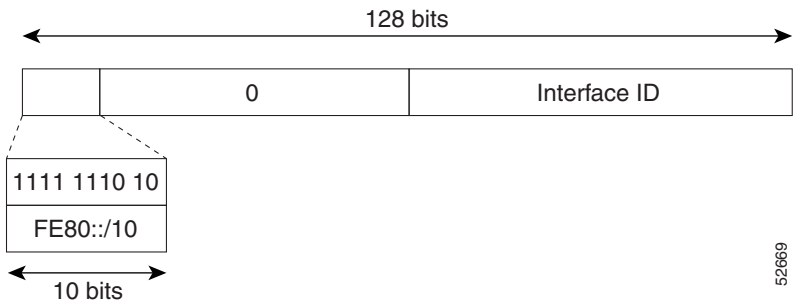
1. The router is queried for MAC addresses (from the pool of MAC addresses in the router).
2. If no MAC addresses are available in the router, the serial number of the router is used to form the link-local addresses.
3. If the serial number of the router cannot be used to form the link-local addresses, the router uses a Message Digest 5 (MD5) hash to determine the MAC address of the router from the hostname of the router.

Link-Local Addresses

A link-local address is an IPv6 unicast address that can be automatically configured on any interface using the link-local prefix FE80::/10 (1111 1110 10) and the interface identifier in the modified EUI-64 format. Link-local addresses are used in the Neighbor Discovery Protocol (NDP) and the stateless autoconfiguration process. Nodes on a local link can use link-local addresses to communicate; the nodes do not need globally unique addresses to communicate. Figure 3-2 shows the structure of a link-local address.

IPv6 routers cannot forward packets that have link-local source or destination addresses to other links.

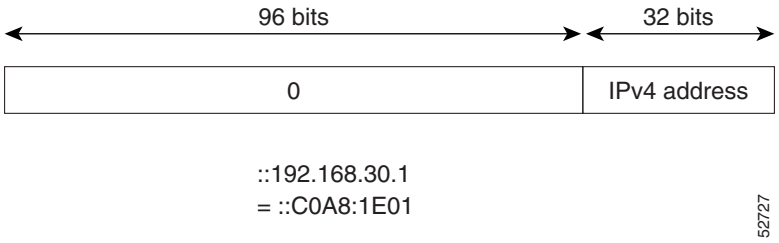
Figure 3-2 Link-Local Address Format



IPv4-Compatible IPv6 Addresses

An IPv4-compatible IPv6 address is an IPv6 unicast address that has zeros in the high-order 96 bits of the address and an IPv4 address in the low-order 32 bits of the address. The format of an IPv4-compatible IPv6 address is 0:0:0:0:0:0:A.B.C.D or ::A.B.C.D. The entire 128-bit IPv4-compatible IPv6 address is used as the IPv6 address of a node and the IPv4 address embedded in the low-order 32 bits is used as the IPv4 address of the node. IPv4-compatible IPv6 addresses are assigned to nodes that support both the IPv4 and IPv6 protocol stacks and are used in automatic tunnels. Figure 3-3 shows the structure of an IPv4-compatible IPv6 address and a few acceptable formats for the address.

Figure 3-3 IPv4-Compatible IPv6 Address Format



Unique Local Addresses

A unique local address is an IPv6 unicast address that is globally unique and is intended for local communications. It is not expected to be routable on the global Internet and is routable inside of a limited area, such as a site, and it may be routed between a limited set of sites. Applications may treat unique local addresses like global scoped addresses.

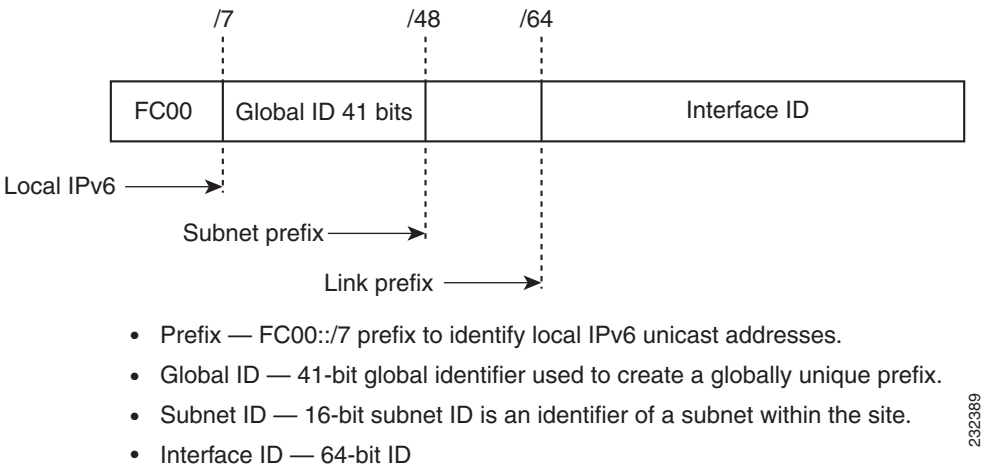
A unique local address has the following characteristics:

- It has a globally unique prefix (it has a high probability of uniqueness).
- It has a well-known prefix to allow for easy filtering at site boundaries.
- It allows sites to be combined or privately interconnected without creating any address conflicts or requiring renumbering of interfaces that use these prefixes.
- It is ISP-independent and can be used for communications inside of a site without having any permanent or intermittent Internet connectivity.

- If it is accidentally leaked outside of a site through routing or the Domain Name Server (DNS), there is no conflict with any other addresses.

Figure 3-4 shows the structure of a unique local address.

Figure 3-4 Unique Local Address Structure



- Prefix — FC00::/7 prefix to identify local IPv6 unicast addresses.
- Global ID — 41-bit global identifier used to create a globally unique prefix.
- Subnet ID — 16-bit subnet ID is an identifier of a subnet within the site.
- Interface ID — 64-bit ID

Site-Local Address

Because RFC 3879 deprecates the use of site-local addresses, you should follow the recommendations of unique local addressing (ULA) in RFC 4193 when you configure private IPv6 addresses.

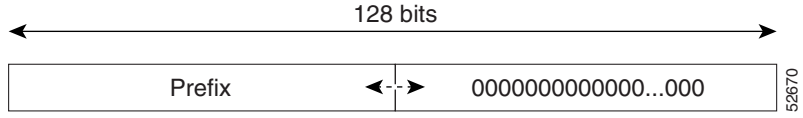
IPv6 Anycast Addresses

An anycast address is an address that is assigned to a set of interfaces that belong to different nodes. A packet sent to an anycast address is delivered to the closest interface—as defined by the routing protocols in use—identified by the anycast address. Anycast addresses are syntactically indistinguishable from unicast addresses because anycast addresses are allocated from the unicast address space. Assigning a unicast address to more than one interface turns a unicast address into an anycast address. You must configure the nodes to which the anycast address to recognize that the address is an anycast address.

Note Anycast addresses can be used only by a router, not a host. Anycast addresses cannot be used as the source address of an IPv6 packet.

Figure 3-5 shows the format of the subnet router anycast address; the address has a prefix concatenated by a series of zeros (the interface ID). The subnet router anycast address can be used to reach a router on the link that is identified by the prefix in the subnet router anycast address.

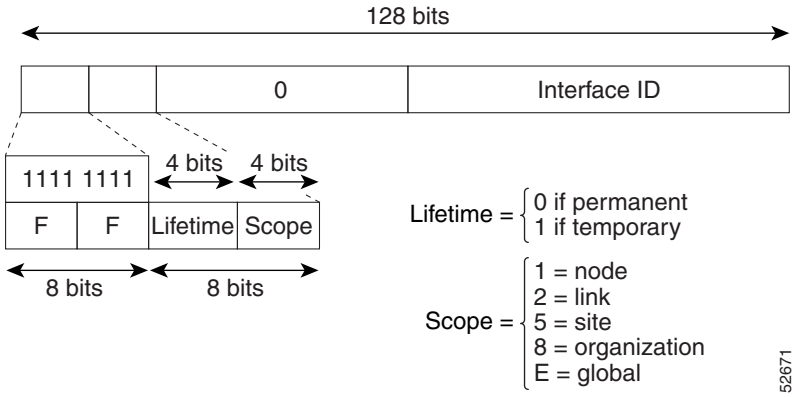
Figure 3-5 Subnet Router Anycast Address Format



IPv6 Multicast Addresses

An IPv6 multicast address is an IPv6 address that has a prefix of FF00::/8 (1111 1111). An IPv6 multicast address is an identifier for a set of interfaces that belong to different nodes. A packet sent to a multicast address is delivered to all interfaces identified by the multicast address. The second octet following the prefix defines the lifetime and scope of the multicast address. A permanent multicast address has a lifetime parameter equal to 0; a temporary multicast address has a lifetime parameter equal to 1. A multicast address that has the scope of a node, link, site, or organization, or a global scope, has a scope parameter of 1, 2, 5, 8, or E, respectively. For example, a multicast address with the prefix FF02::/16 is a permanent multicast address with a link scope. Figure 3-6 shows the format of the IPv6 multicast address.

Figure 3-6 IPv6 Multicast Address Format



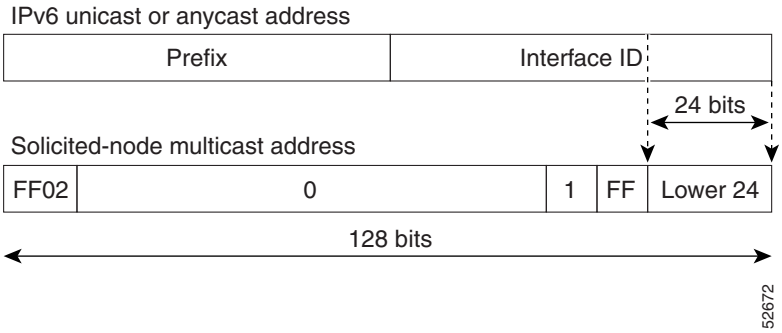
IPv6 nodes (hosts and routers) are required to join (where received packets are destined for) the following multicast groups:

- All-nodes multicast group FF02:0:0:0:0:0:0:1 (the scope is link-local)
- Solicited-node multicast group FF02:0:0:0:0:1:FF00:0000/104 for each of its assigned unicast and anycast addresses

IPv6 routers must also join the all-routers multicast group FF02:0:0:0:0:0:0:2 (the scope is link-local).

The solicited-node multicast address is a multicast group that corresponds to an IPv6 unicast or anycast address. IPv6 nodes must join the associated solicited-node multicast group for every unicast and anycast address to which it is assigned. The IPv6 solicited-node multicast address has the prefix FF02:0:0:0:0:1:FF00:0000/104 concatenated with the 24 low-order bits of a corresponding IPv6 unicast or anycast address (see Figure 3-7). For example, the solicited-node multicast address that corresponds to the IPv6 address 2037::01:800:200E:8C6C is FF02::1:FF0E:8C6C. Solicited-node addresses are used in neighbor solicitation messages.

Figure 3-7 IPv6 Solicited-Node Multicast Address Format

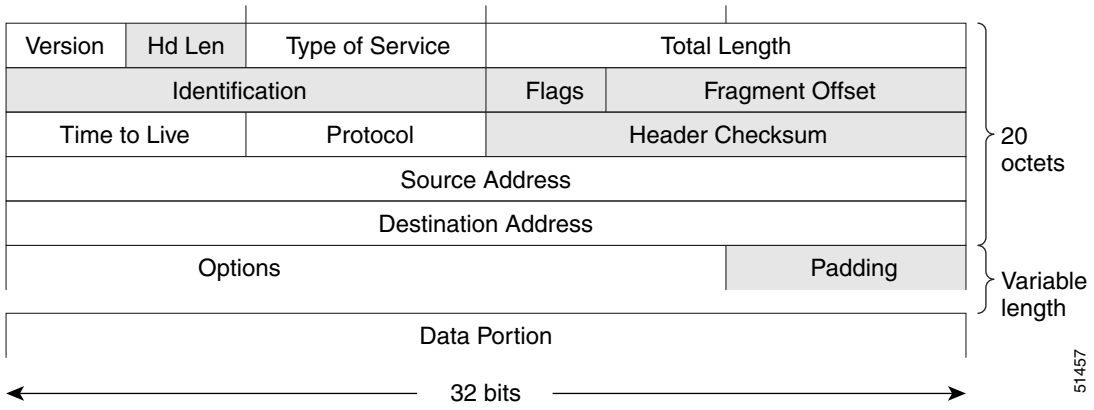


Note IPv6 has no broadcast addresses. IPv6 multicast addresses are used instead of broadcast addresses.

IPv4 Packet Header

The base IPv4 packet header has 12 fields with a total size of 20 octets (160 bits) (see Figure 3-8). The 12 fields may be followed by an Options field, which is followed by a data portion that is usually the transport-layer packet. The variable length of the Options field adds to the total size of the IPv4 packet header. The shaded fields of the IPv4 packet header are not included in the IPv6 packet header.

Figure 3-8 IPv4 Packet Header Format



Simplified IPv6 Packet Header

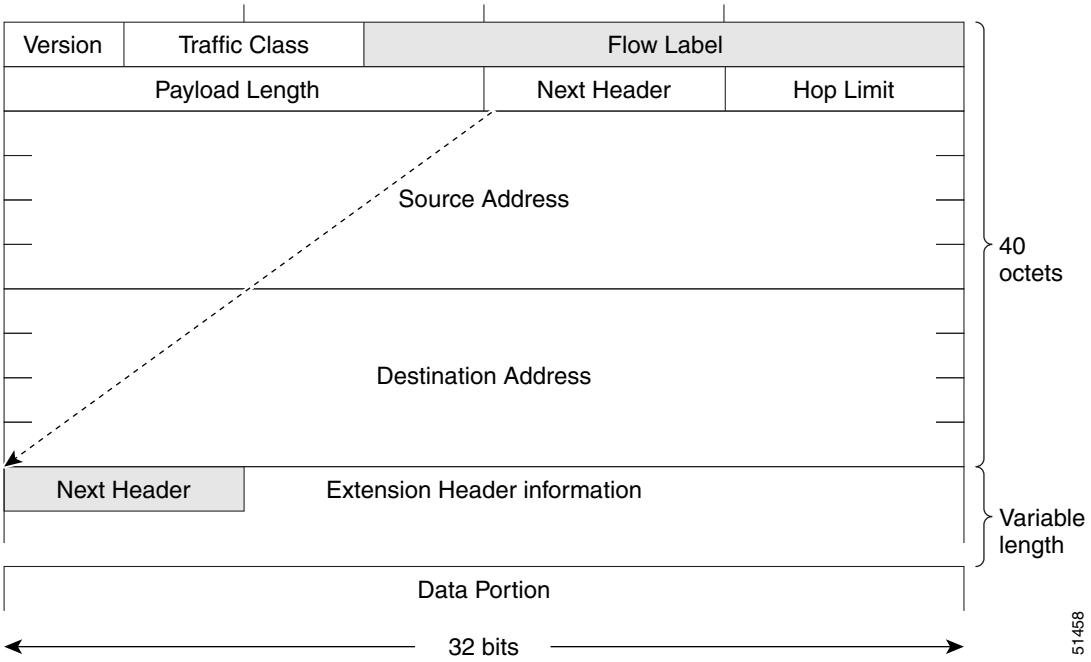
The base IPv6 packet header has 8 fields with a total size of 40 octets (320 bits) (see Figure 3-9). Fragmentation is handled by the source of a packet and checksums at the data link layer and transport layer are used. The User Datagram Protocol (UDP) checksum checks the integrity of the inner packet and the base IPv6 packet header and Options field are aligned to 64 bits, which can facilitate the processing of IPv6 packets.

Table 3-2 lists the fields in the base IPv6 packet header.

Table 3-2 Base IPv6 Packet Header Fields

Field	Description
Version	Similar to the Version field in the IPv4 packet header, except that the field lists number 6 for IPv6 instead of number 4 for IPv4.
Traffic Class	Similar to the Type of Service field in the IPv4 packet header. The Traffic Class field tags packets with a traffic class that is used in differentiated services.
Flow Label	New field in the IPv6 packet header. The Flow Label field tags packets with a specific flow that differentiates the packets at the network layer.
Payload Length	Similar to the Total Length field in the IPv4 packet header. The Payload Length field indicates the total length of the data portion of the packet.
Next Header	Similar to the Protocol field in the IPv4 packet header. The value of the Next Header field determines the type of information that follows the base IPv6 header. The type of information that follows the base IPv6 header can be a transport-layer packet, for example, a TCP or UDP packet, or an Extension Header, as shown in Figure 3-9.
Hop Limit	Similar to the Time to Live field in the IPv4 packet header. The value of the Hop Limit field specifies the maximum number of routers that an IPv6 packet can pass through before the packet is considered invalid. Each router decrements the value by one. Because no checksum is in the IPv6 header, the router can decrement the value without needing to recalculate the checksum, which saves processing resources.
Source Address	Similar to the Source Address field in the IPv4 packet header, except that the field contains a 128-bit source address for IPv6 instead of a 32-bit source address for IPv4.
Destination Address	Similar to the Destination Address field in the IPv4 packet header, except that the field contains a 128-bit destination address for IPv6 instead of a 32-bit destination address for IPv4.

Figure 3-9 IPv6 Packet Header Format



Optional extension headers and the data portion of the packet are after the eight fields of the base IPv6 packet header. If present, each extension header is aligned to 64 bits. There is no fixed number of extension headers in an IPv6 packet. Each extension header is identified by the Next Header field of the previous header. Typically, the final extension header has a Next Header field of a transport-layer protocol, such as TCP or UDP. Figure 3-10 shows the IPv6 extension header format.

Figure 3-10 IPv6 Extension Header Format

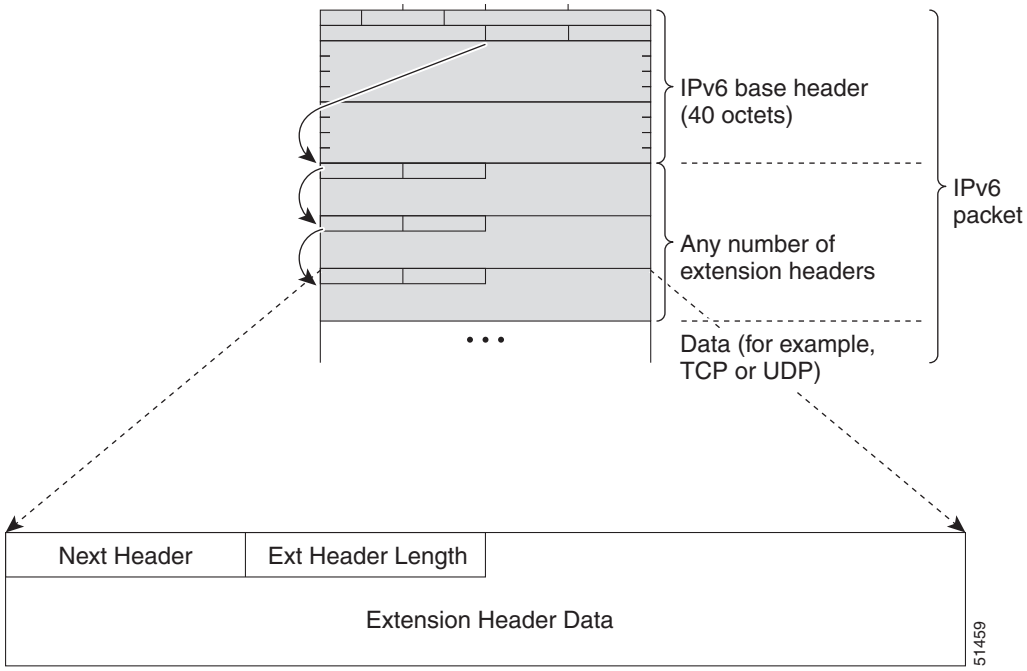


Table 3-3 lists the extension header types and their Next Header field values.

Table 3-3 IPv6 Extension Header Types

Header Type	Next Header Value	Description
Hop-by-hop options header	0	Header that is processed by all hops in the path of a packet. When present, the hop-by-hop options header always follows immediately after the base IPv6 packet header.
Destination options header	60	Header that can follow any hop-by-hop options header. The header is processed at the final destination and at each visited address specified by a routing header
Routing header	43	Header that is used for source routing.
Fragment header	44	Header that is used when a source fragments a packet that is larger than the maximum transmission unit (MTU) for the path between itself and a destination. The Fragment header is used in each fragmented packet.
Upper-layer headers	6 (TCP) 17 (UDP)	Headers that are used inside a packet to transport the data. The two main transport protocols are TCP and UDP.

DNS for IPv6

IPv6 supports DNS record types that are supported in the DNS name-to-address and address-to-name lookup processes. The DNS record types support IPv6 addresses (see Table 3-4).

Note IPv6 also supports the reverse mapping of IPv6 addresses to DNS names.

Table 3-4 IPv6 DNS Record Types

Record Type	Description	Format
AAAA	Maps a hostname to an IPv6 address. (Equivalent to an A record in IPv4.)	www.abc.test AAAA 3FFE:YYYY:C18:1::2
PTR	Maps an IPv6 address to a hostname. (Equivalent to a PTR record in IPv4.)	2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.1.0.0.0.8.1.c.0.y.y.y.y.e.f.f.3.ip6.int PTR www.abc.test

Path MTU Discovery for IPv6

As in IPv4, you can use path MTU discovery in IPv6 to allow a host to dynamically discover and adjust to differences in the MTU size of every link along a data path. In IPv6, however, fragmentation is handled by the source of a packet when the path MTU of one link along a given data path is not large enough to accommodate the size of the packets. Having IPv6 hosts handle packet fragmentation saves

IPv6 router processing resources and helps IPv6 networks run more efficiently. Once the path MTU is reduced by the arrival of an ICMP Too Big message, Cisco NX-OS retains the lower value. The connection does not increase the segment size to gauge the throughput.

Note In IPv6, the minimum link MTU is 1280 octets. We recommend that you use an MTU value of 1500 octets for IPv6 links.

CDP IPv6 Address Support

You can use the Cisco Discovery Protocol (CDP) IPv6 address support for the neighbor information feature to transfer IPv6 addressing information between two Cisco devices. Cisco Discovery Protocol support for IPv6 addresses provides IPv6 information to network management products and troubleshooting tools.

LPM Routing Modes

By default, Cisco NX-OS programs routes in a hierarchical fashion to allow for the longest prefix match (LPM) on the device. However, you can configure the device for different routing modes to support significantly more LPM route entries.

The following tables list the LPM routing modes that are supported on the Cisco Nexus 9300 Series and 9500 Series switches.

Table 3-5 LPM Routing Modes for Cisco Nexus 9200 and 9300-EX Series Switches

LPM Routing Mode	CLI Command
Default system routing mode	
LPM heavy routing mode[1]	**system routing template-lpm-heavy**
LPM dual-host routing mode	**system routing template-dual-stack-host-scale**

1. This mode is also supported for Cisco Nexus 9508 switches with the X9732C-EX line card.

Table 3-6 LPM Routing Modes for Cisco Nexus 9300 Series Switches

LPM Routing Mode	Broadcom T2 Mode	CLI Command
Default system routing mode	3	
ALPM routing mode	4	**system routing max-mode l3**

Table 3-7 LPM Routing Modes for Cisco Nexus 9500 Series Switches

LPM Routing Mode	Broadcom T2 Mode	CLI Command
Default system routing mode	3 (for line cards); 4 (for fabric modules)	
Max-host routing mode	2 (for line cards); 3 (for fabric modules)	**system routing max-mode host**

Table 3-7 LPM Routing Modes for Cisco Nexus 9500 Series Switches (continued)

LPM Routing Mode	Broadcom T2 Mode	CLI Command
Nonhierarchical routing mode	3 (for line cards); 4 with **max-l3-mode** option (for line cards)	**system routing non-hierarchical-routing** [**max-l3-mode**]
64-bit ALPM routing mode	Submode of mode 4 (for fabric modules)	**system routing mode hierarchical 64b-alpm**

For detailed configuration information, see the "Configuring IPv6" section on page 3-14.

Host to LPM Spillover

Beginning with Cisco NX-OS Release 7.0(3)I5(1), host routes can be stored in the LPM table in order to achieve a larger host scale. In ALPM mode, the switch allows fewer host routes. If you add more host routes than the supported scale, the routes that are spilled over from the host table take the space of the LPM routes in the LPM table. The total number of LPM routes allowed in that mode is reduced by the number of host routes stored. This feature is supported on Cisco Nexus 9300 and 9500 Series switches.

In the default system routing mode, Cisco Nexus 9300 Series switches are configured for higher host scale and fewer LPM routes, and the LPM space can be used to store additional host routes. For Cisco Nexus 9500 Series switches, only the default system routing and nonhierarchical routing modes support this feature on line cards. Fabric modules do not support this feature.

Virtualization Support

IPv6 supports virtual routing and forwarding (VRF) instances.

Licensing Requirements for IPv6

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	IPv6 requires no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for IPv6

IPv6 has the following prerequisites:

- You must be familiar with IPv6 basics such as IPv6 addressing and IPv6 header information.
- Ensure that you follow the memory/processing guidelines when you make a device a dual-stack device (IPv4/IPv6).

Guidelines and Limitations for IPv6

IPv6 has the following configuration guidelines and limitations:

- IPv6 packets are transparent to Layer 2 LAN switches because the switches do not examine Layer 3 packet information before forwarding IPv6 frames. IPv6 hosts can be directly attached to Layer 2 LAN switches.
- You can configure multiple IPv6 global addresses within the same prefix on an interface. However, multiple IPv6 link-local addresses on an interface are not supported.
- Because RFC 3879 deprecates the use of site-local addresses, you should configure private IPv6 addresses according to the recommendations of unique local addressing (ULA) in RFC 4193.

Configuring IPv6

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Configuring IPv6 Addressing

You must configure an IPv6 address on an interface so that the interface can forward IPv6 traffic. When you configure a global IPv6 address on an interface, it automatically configures a link-local address and activates IPv6 for that interface.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *number*
3. **ipv6 address** {*addr* [**eui64**] [**route-preference** *preference*] [**secondary**] **tag** *tag-id*]]

   or

   ipv6 address *ipv6-address* **use-link-local-only**
4. (Optional) **show ipv6 interface**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**interface ethernet** *number* **Example:** switch(config)# interface ethernet 2/3 switch(config-if)#	Enters interface configuration mode.
Step 3	**ipv6 address** {*addr* [**eui64**] [**route-preference** *preference*] [**secondary**] **tag** *tag-id*] or **ipv6 address** *ipv6-address* **use-link-local-only** **Example:** switch(config-if)# ipv6 address 2001:0DB8::1/10 or switch(config-if)# ipv6 address use-link-local-only	Specifies an IPv6 address assigned to the interface and enables IPv6 processing on the interface. Entering the **ipv6 address** command configures global IPv6 addresses with an interface identifier (ID) in the low-order 64 bits of the IPv6 address. Only the 64-bit network prefix for the address needs to be specified; the last 64 bits are automatically computed from the interface ID. Entering the **ipv6 address use-link-local-only** command configures a link-local address on the interface that is used instead of the link-local address that is automatically configured when IPv6 is enabled on the interface. This command enables IPv6 processing on an interface without configuring an IPv6 address.
Step 4	**show ipv6 interface** **Example:** switch(config-if)# show ipv6 interface	(Optional) Displays interfaces configured for IPv6.
Step 5	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to configure an IPv6 address:

```
switch# configure terminal
switch(config)# interface ethernet 3/1
switch(config-if)# ipv6 address ?
A:B::C:D/LEN IPv6 prefix format: xxxx:xxxx/ml, xxxx:xxxx::/ml,
xxxx::xx/128
use-link-local-only  Enable IPv6 on interface using only a single link-local
address
switch(config-if)# ipv6 address 2001:db8::/64 eui64
```

This example shows how to display an IPv6 interface:

```
switch(config-if)# show ipv6 interface ethernet 3/1
Ethernet3/1, Interface status: protocol-down/link-down/admin-down, iod: 36
    IPv6 address: 2001:db8:0000:0000:0218:baff:fed8:239d
    IPv6 subnet: 2001:db8::/64
```

```
IPv6 link-local address: fe80::0218:baff:fed8:239d (default)
IPv6 multicast routing: disabled
IPv6 multicast groups locally joined:
    ff02::0001:ffd8:239d  ff02::0002  ff02::0001  ff02::0001:ffd8:239d
IPv6 multicast (S,G) entries joined: none
IPv6 MTU: 1500 (using link MTU)
IPv6 RP inbound packet-filtering policy: none
IPv6 RP outbound packet-filtering policy: none
IPv6 inbound packet-filtering policy: none
IPv6 outbound packet-filtering policy: none
IPv6 interface statistics last reset: never
IPv6 interface RP-traffic statistics: (forwarded/originated/consumed)
    Unicast packets: 0/0/0
    Unicast bytes: 0/0/0
    Multicast packets: 0/0/0
    Multicast bytes: 0/0/0
```

Configuring Max-Host Routing Mode (Cisco Nexus 9500 Series Switches Only)

By default, the device programs routes in a hierarchical fashion (with fabric modules configured to be in mode 4 and line card modules configured to be in mode 3), which allows for longest prefix match (LPM) and host scale on the device.

You can modify the default LPM and host scale to program more hosts in the system, as might be required when the node is positioned as a Layer-2 to Layer-3 boundary node.

Note If you want to further scale the entries in the LPM table, see the "Configuring Nonhierarchical Routing Mode (Cisco Nexus 9500 Series Switches Only)" section on page 3-17 to configure the device to program all of the Layer 3 IPv4 and IPv6 routes on the line cards and none of the routes on the fabric modules.

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For the max-host routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system routing max-mode host**
3. (Optional) **show forwarding route summary**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[**no**] **system routing max-mode host** **Example:** switch(config)# system routing max-mode host	Puts the line cards in Broadcom T2 mode 2 and the fabric modules in Broadcom T2 mode 3 to increase the number of supported hosts.
Step 3	**show forwarding route summary** **Example:** switch(config)# show forwarding route summary	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	Saves this configuration change.
Step 5	**reload** **Example:** switch(config)# reload	Reboots the entire device.

Configuring Nonhierarchical Routing Mode (Cisco Nexus 9500 Series Switches Only)

If the host scale is small (as in a pure Layer 3 deployment), we recommend programming the longest prefix match (LPM) routes in the line cards to improve convergence performance. Doing so programs routes and hosts in the line cards and does not program any routes in the fabric modules.

Note This configuration impacts both the IPv4 and IPv6 address families.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system routing non-hierarchical-routing** [**max-l3-mode**]
3. (Optional) **show forwarding route summary**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[**no**] **system routing non-hierarchical-routing** [**max-l3-mode**] **Example:** switch(config)# system routing non-hierarchical-routing max-l3-mode	Puts the line cards in Broadcom T2 mode 3 (or Broadcom T2 mode 4 if you use the **max-l3-mode** option) to support a larger LPM scale. As a result, all of the IPv4 and IPv6 routes will be programmed on the line cards rather than on the fabric modules.
Step 3	**show forwarding route summary** **Example:** switch(config)# show forwarding route summary Mode 3: 120K IPv4 Host table 16k LPM table (> 65 < 127 1k entry reserved) Mode 4: 16k V4 host/4k V6 host 128k v4 LPM/20K V6 LPM	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	Saves this configuration change.
Step 5	**reload** **Example:** switch(config)# reload	Reboots the entire device.

Configuring 64-Bit ALPM Routing Mode (Cisco Nexus 9500 Series Switches Only)

You can use the 64-bit algorithmic longest prefix match (ALPM) feature to manage IPv4 and IPv6 route table entries. In 64-bit ALPM routing mode, the device can store significantly more route entries. Using this mode, you can program one of the following:

- 80,000 IPv6 entries and no IPv4 entries
- No IPv6 entries and 128,000 IPv4 entries
- *x* IPv6 entries and *y* IPv4 entries, where $2x + y <= 128,000$

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For the 64-bit ALPM routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system routing mode hierarchical 64b-alpm**
3. (Optional) **show system routing mode**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[**no**] **system routing mode hierarchical 64b-alpm** **Example:** switch(config)# system routing mode hierarchical 64b-alpm	Causes all IPv4 and IPv6 LPM routes with a mask length that is less than or equal to 64 to be programmed in the fabric module. All host routes for IPv4 and IPv6 and all LPM routes with a mask length of 65 through 127 are programmed in the line card.
Step 3	**show system routing mode** **Example:** switch(config)# show system routing mode	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	Saves this configuration change.
Step 5	**reload** **Example:** switch(config)# reload	Reboots the entire device.

Configuring ALPM Routing Mode (Cisco Nexus 9300 Series Switches Only)

You can configure Cisco Nexus 9300 Series switches to support significantly more LPM route entries.

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For the ALPM routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system routing max-mode l3**
3. (Optional) **show system routing mode**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	[**no**] **system routing max-mode l3** **Example:** `switch(config)# system routing max-mode l3`	Puts the device in Broadcom T2 mode 4 to support a larger LPM scale.
Step 3	**show system routing mode** **Example:** `switch(config)# show system routing mode`	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	Saves this configuration change.
Step 5	**reload** **Example:** `switch(config)# reload`	Reboots the entire device.

Configuring LPM Heavy Routing Mode (Cisco Nexus 9200 and 9300-EX Series Switches and X9732C-EX Line Card Only)

Beginning with Cisco NX-OS Release 7.0(3)I4(4), you can configure LPM heavy routing mode in order to support significantly more LPM route entries. Only the Cisco Nexus 9200 and 9300-EX Series switches and the Cisco Nexus 9508 switch with an X9732C-EX line card support this routing mode.

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For LPM heavy routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] s**ystem routing template-lpm-heav**y
3. (Optional) **show system routing mode**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[**no**] **system routing template-lpm-heavy** **Example:** switch(config)# system routing template-lpm-heavy	Puts the device in LPM heavy routing mode to support a larger LPM scale.
Step 3	**show system routing mode** **Example:** switch(config)# show system routing mode Configured System Routing Mode: LPM Heavy Applied System Routing Mode: LPM Heavy	(Optional) Displays the LPM routing mode.

	Command	Purpose
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	Saves this configuration change.
Step 5	**reload** **Example:** `switch(config)# reload`	Reboots the entire device.

Configuring LPM Dual-Host Routing Mode (Cisco Nexus 9200 and 9300-EX Series Switches)

Beginning with Cisco NX-OS Release 7.0(3)I5(1), you can configure LPM dual-host routing mode in order to increase the ARP/ND scale to double the default mode value. Only the Cisco Nexus 9200 and 9300-EX Series switches support this routing mode.

Note This configuration impacts both the IPv4 and IPv6 address families.

Note For LPM dual-host routing mode scale numbers, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system routing template-dual-stack-host-scale**
3. (Optional) **show system routing mode**
4. **copy running-config startup-config**
5. **reload**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[**no**] **system routing template-dual-stack-host-scale** **Example:** switch(config)# system routing template-dual-stack-host-scale Warning: The command will take effect after next reload. Multicast is not supported in this profile Note: This requires copy running-config to startup-config before switch reload	Puts the device in LPM dual-host routing mode to support a larger ARP/ND scale.
Step 3	**show system routing mode** **Example:** switch(config)# show system routing mode	(Optional) Displays the LPM routing mode.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	Saves this configuration change.
Step 5	**reload** **Example:** switch(config)# reload	Reboots the entire device.

Verifying the IPv6 Configuration

To display the IPv6 configuration, perform one of the following tasks:

Command	Purpose
show ipv6 interface	Displays IPv6-related interface information.
show ipv6 adjacency	Displays the adjacency table.
show system routing mode	Displays the LPM routing mode.

Configuration Examples for IPv6

This example shows how to configure IPv6:

```
configure terminal
 interface ethernet 3/1
  ipv6 address 2001:db8::/64 eui64
   ipv6 nd reachable-time 10
```

Configuring DNS

This chapter describes how to configure the Domain Name Server (DNS) client on the Cisco NX-OS device.

This chapter includes the following sections:

About DNS Clients

This section includes the following topics:

DNS Client Overview

If your network devices require connectivity with devices in networks for which you do not control the name assignment, you can assign device names that uniquely identify your devices within the entire internetwork using the domain name server (DNS). DNS uses a hierarchical scheme for establishing host names for network nodes, which allows local control of the segments of the network through a client-server scheme. The DNS system can locate a network device by translating the hostname of the device into its associated IP address.

On the Internet, a domain is a portion of the naming hierarchy tree that refers to general groupings of networks based on the organization type or geography. Domain names are pieced together with periods (.) as the delimiting characters. For example, Cisco is a commercial organization that the Internet identifies by a *com* domain, so its domain name is *cisco.com*. A specific hostname in this domain, the File Transfer Protocol (FTP) system, for example, is identified as *ftp.cisco.com*.

Name Servers

Name servers keep track of domain names and know the parts of the domain tree for which they have complete information. A name server may also store information about other parts of the domain tree. To map domain names to IP addresses in Cisco NX-OS, you must identify the hostnames, specify a name server, and enable the DNS service.

Cisco NX-OS allows you to statically map IP addresses to domain names. You can also configure Cisco NX-OS to use one or more domain name servers to find an IP address for a host name.

DNS Operation

A name server handles client-issued queries to the DNS server for locally defined hosts within a particular zone as follows:

- An authoritative name server responds to DNS user queries for a domain name that is under its zone of authority by using the permanent and cached entries in its own host table. If the query is for a domain name that is under its zone of authority but for which it does not have any configuration information, the authoritative name server replies that no such information exists.
- A name server that is not configured as the authoritative name server responds to DNS user queries by using information that it has cached from previously received query responses. If no router is configured as the authoritative name server for a zone, queries to the DNS server for locally defined hosts receive nonauthoritative responses.

Name servers answer DNS queries (forward incoming DNS queries or resolve internally generated DNS queries) according to the forwarding and lookup parameters configured for the specific domain.

High Availability

Cisco NX-OS supports stateless restarts for the DNS client. After a reboot or supervisor switchover, Cisco NX-OS applies the running configuration.

Virtualization Support

Cisco NX-OS supports multiple instances of the DNS clients that run on the same system. You can configure a DNS client. You can optionally have a different DNS client configuration in each virtual routing and forwarding (VRF) instance.

Licensing Requirements for DNS Clients

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	DNS requires no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for DNS Clients

The DNS client has the following prerequisites:

- You must have a DNS name server on your network.

Guidelines and Limitations for DNS

The DNS client has the following configuration guidelines and limitations:

- You configure the DNS client in a specific VRF. If you do not specify a VRF, Cisco NX-OS uses the default VRF.
- Beginning with Cisco NX-OS Release 7.0(3)I5(1), DNS supports IPv6 addresses.

Default Settings

Table 4-1 lists the default settings for DNS client parameters.

Table 4-1 Default DNS Client Parameters

Parameters	Default
DNS client	Enabled

Configuring DNS Clients

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Configuring the DNS Client

You can configure the DNS client to use a DNS server on your network.

BEFORE YOU BEGIN

Ensure that you have a domain name server on your network.

SUMMARY STEPS

1. **configure terminal**
2. {**ip** | **ipv6**} **host** *name ip/ipv6-address1* [*ip/ipv6-address2... ip/ipv6-address6*]
3. (Optional) **ip domain-name** *name* [**use-vrf** *vrf-name*]
4. (Optional) **ip domain-list** *name* [**use-vrf** *vrf-name*]
5. (Optional) **ip name-server** *ip/ipv6-address1* [*ip/ipv6-address2... ip/ipv6-address6*] [**use-vrf** *vrf-name*]
6. (Optional) **ip domain lookup**
7. (Optional) **show hosts**
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	{**ip** | **ipv6**} **host** *name ip/ipv6-address1* [*ip/ipv6-address2... ip/ipv6-address6*] **Example:** `switch(config)# ip host cisco-rtp 192.0.2.1` **Example:** `switch(config)# ipv6 host cisco-rtp 2001:DB8:1::1`	Defines up to six static hostname-to-address mappings in the hostname cache. The address can be either an IPv4 or IPv6 address.
Step 3	**ip domain-name** *name* [**use-vrf** *vrf-name*] **Example:** `switch(config)# ip domain-name myserver.com`	(Optional) Defines the default domain name that Cisco NX-OS uses to complete unqualified host names. You can optionally define a VRF that Cisco NX-OS uses to resolve this domain name if it cannot be resolved in the VRF that you configured this domain name under. Cisco NX-OS appends the default domain name to any hostname that does not contain a complete domain name before starting a domain-name lookup.

	Command	Purpose
Step 4	**ip domain-list** *name* [**use-vrf** *vrf-name*] **Example:** switch(config)# ip domain-list mycompany.com	(Optional) Defines additional domain names that Cisco NX-OS can use to complete unqualified hostnames. You can optionally define a VRF that Cisco NX-OS uses to resolve these domain names if they cannot be resolved in the VRF that you configured this domain name under. Cisco NX-OS uses each entry in the domain list to append that domain name to any hostname that does not contain a complete domain name before starting a domain-name lookup. Cisco NX-OS continues this process for each entry in the domain list until it finds a match.
Step 5	**ip name-server** *ip/ipv6-address1* [*ip/ipv6-address2... ip/ipv6-address6*] [**use-vrf** *vrf-name*] **Example:** switch(config)# ip name-server 192.0.2.22 **Example:** switch(config)# ip name-server 2001:DB8:1::1	(Optional) Defines up to six name servers. The address can be either an IPv4 or IPv6 address. You can optionally define a VRF that Cisco NX-OS uses to reach this name server if it cannot be reached in the VRF that you configured this name server under.
Step 6	**ip domain-lookup** **Example:** switch(config)# ip domain-lookup	(Optional) Enables DNS-based address translation. This feature is enabled by default.
Step 7	**show hosts** **Example:** switch(config)# show hosts	(Optional) Displays information about DNS.
Step 8	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to configure a default domain name and enable DNS lookup:

```
switch# configure terminal
switch(config)# ip domain-name cisco.com
switch(config)# ip name-server 192.0.2.1 use-vrf management
switch(config)# ip domain-lookup
switch(config)# copy running-config startup-config
```

Configuring Virtualization

You can configure a DNS client within a VRF. If you do not enter VRF configuration mode, your DNS client configuration applies to the default VRF.

You can optionally configure a DNS client to use a specified VRF other than the VRF under which you configured the DNS client as a backup VRF. For example, you can configure a DNS client in the Red VRF but use the Blue VRF to communicate with the DNS server if the server cannot be reached through the Red VRF.

BEFORE YOU BEGIN

Ensure that you have a domain name server on your network.

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf-name*
3. (Optional) **ip domain-name** *name* [**use-vrf** *vrf-name*]
4. (Optional) **ip domain-list** *name* [**use-vrf** *vrf-name*]
5. (Optional) **ip name-server** *ip/ipv6-address1* [*ip/ipv6-address2... ip/ipv6-address6*] [**use-vrf** *vrf-name*]
6. (Optional) **show hosts**
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** `switch(config)# vrf context Red` `switch(config-vrf)#`	Creates a VRF and enters VRF configuration mode.
Step 3	**ip domain-name** *name* [**use-vrf** *vrf-name*] **Example:** `switch(config-vrf)# ip domain-name myserver.com`	(Optional) Defines the default domain name server that Cisco NX-OS uses to complete unqualified hostnames. You can optionally define a VRF that Cisco NX-OS uses to resolve this domain name server if it cannot be resolved in the VRF under which you configured this domain name. Cisco NX-OS appends the default domain name to any hostname that does not contain a complete domain name before starting a domain-name lookup.

	Command	Purpose
Step 4	**ip domain-list** *name* [**use-vrf** *vrf-name*] **Example:** switch(config-vrf)# ip domain-list mycompany.com	(Optional) Defines additional domain name servers that Cisco NX-OS can use to complete unqualified hostnames. You can optionally define a VRF that Cisco NX-OS uses to resolve this domain name server if it cannot be resolved in the VRF under which you configured this domain name. Cisco NX-OS uses each entry in the domain list to append that domain name to any hostname that does not contain a complete domain name before starting a domain-name lookup. Cisco NX-OS continues this process for each entry in the domain list until it finds a match.
Step 5	**ip name-server** *ip/ipv6-address1* [*ip/ipv6-address2... ip/ipv6-address6*] [**use-vrf** *vrf-name*] **Example:** switch(config-vrf)# ip name-server 192.0.2.22 **Example:** switch(config)# ip name-server 2001:DB8:1::1	(Optional) Defines up to six name servers. The address can be either an IPv4 or IPv6 address. You can optionally define a VRF that Cisco NX-OS uses to reach this name server if it cannot be reached in the VRF that you configured this name server under.
Step 6	**show hosts** **Example:** switch(config-vrf)# show hosts	(Optional) Displays information about DNS.
Step 7	**copy running-config startup-config** **Example:** switch(config-vrf)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to configure a default domain name and enable DNS lookup within a VRF:

```
switch# configure terminal
switch(config)# vrf context Red
switch(config-vrf)# ip domain-name cisco.com
switch(config-vrf)# ip name-server 192.0.2.1 use-vrf management
switch(config-vrf)# copy running-config startup-config
```

Verifying the DNS Client Configuration

To display the DNS client configuration, perform one of the following tasks:

Command	Purpose
show hosts	Displays information about DNS.

Configuration Examples for the DNS Client

This example shows how to establish a domain list with several alternate domain names:

```
ip domain-list csi.com
ip domain-list telecomprog.edu
ip domain-list merit.edu
```

This example shows how to configure the hostname-to-address mapping process and specify IP DNS-based translation. The example also configures the addresses of the name servers and the default domain name.

```
ip domain-lookup
ip name-server 192.168.1.111 192.168.1.2
ip domain-name cisco.com
```

Configuring OSPFv2

This chapter describes how to configure Open Shortest Path First version 2 (OSPFv2) for IPv4 networks on the Cisco NX-OS device.

This chapter includes the following sections:

About OSPFv2

OSPFv2 is an IETF link-state protocol (see the "Link-State Protocols" section on page 1-9) for IPv4 networks. An OSPFv2 router sends a special message, called a hello packet, out each OSPF-enabled interface to discover other OSPFv2 neighbor routers. Once a neighbor is discovered, the two routers compare information in the Hello packet to determine if the routers have compatible configurations. The neighbor routers try to establish adjacency, which means that the routers synchronize their link-state databases to ensure that they have identical OSPFv2 routing information. Adjacent routers share link-state advertisements (LSAs) that include information about the operational state of each link, the cost of the link, and any other neighbor information. The routers then flood these received LSAs out every OSPF-enabled interface so that all OSPFv2 routers eventually have identical link-state databases. When all OSPFv2 routers have identical link-state databases, the network is converged (see the "Convergence" section on page 1-6). Each router then uses Dijkstra's Shortest Path First (SPF) algorithm to build its route table.

You can divide OSPFv2 networks into areas. Routers send most LSAs only within one area, which reduces the CPU and memory requirements for an OSPF-enabled router.

OSPFv2 supports IPv4, while OSPFv3 supports IPv6. For more information, see Chapter 6, "Configuring OSPFv3."

Note OSPFv2 on Cisco NX-OS supports RFC 2328. This RFC introduced a different method to calculate route summary costs which is not compatible with the calculation used by RFC 1583. RFC 2328 also introduced different selection criteria for AS-external paths. It is important to ensure that all routers support the same RFC. Use the **rfc1583compatibility** command if your network includes routers that are only compliant with RFC 1583. The default supported RFC standard for OSPFv2 might be different for Cisco NX-OS and Cisco IOS. You must make adjustments to set the values identically. See the "OSPF RFC Compatibility Mode Example" section on page 5-50 for more information.

This section includes the following topics:

Hello Packet

OSPFv2 routers periodically send Hello packets on every OSPF-enabled interface. The hello interval determines how frequently the router sends these Hello packets and is configured per interface. OSPFv2 uses Hello packets for the following tasks:

- Neighbor discovery
- Keepalives
- Bidirectional communications
- Designated router election (see the "Designated Routers" section on page 5-3)

The Hello packet contains information about the originating OSPFv2 interface and router, including the assigned OSPFv2 cost of the link, the hello interval, and optional capabilities of the originating router. An OSPFv2 interface that receives these Hello packets determines if the settings are compatible with the receiving interface settings. Compatible interfaces are considered neighbors and are added to the neighbor table (see the "Neighbors" section on page 5-3).

Hello packets also include a list of router IDs for the routers that the originating interface has communicated with. If the receiving interface sees its own router ID in this list, bidirectional communication has been established between the two interfaces.

OSPFv2 uses Hello packets as a keepalive message to determine if a neighbor is still communicating. If a router does not receive a Hello packet by the configured dead interval (usually a multiple of the hello interval), then the neighbor is removed from the local neighbor table.

Neighbors

An OSPFv2 interface must have a compatible configuration with a remote interface before the two can be considered neighbors. The two OSPFv2 interfaces must match the following criteria:

- Hello interval
- Dead interval
- Area ID (see the "Areas" section on page 5-4)
- Authentication
- Optional capabilities

If there is a match, the following information is entered into the neighbor table:

- Neighbor ID—The router ID of the neighbor.
- Priority—Priority of the neighbor. The priority is used for designated router election (see the "Designated Routers" section on page 5-3).
- State—Indication of whether the neighbor has just been heard from, is in the process of setting up bidirectional communications, is sharing the link-state information, or has achieved full adjacency.
- Dead time—Indication of the time since the last Hello packet was received from this neighbor.
- IP Address—The IP address of the neighbor.
- Designated Router—Indication of whether the neighbor has been declared as the designated router or as the backup designated router (see the "Designated Routers" section on page 5-3).
- Local interface—The local interface that received the Hello packet for this neighbor.

Adjacency

Not all neighbors establish adjacency. Depending on the network type and designated router establishment, some neighbors become fully adjacent and share LSAs with all their neighbors, while other neighbors do not. For more information, see the "Designated Routers" section on page 5-3.

Adjacency is established using Database Description packets, Link State Request packets, and Link State Update packets in OSPF. The Database Description packet includes just the LSA headers from the link-state database of the neighbor (see the "Link-State Database" section on page 5-7). The local router compares these headers with its own link-state database and determines which LSAs are new or updated. The local router sends a Link State Request packet for each LSA that it needs new or updated information on. The neighbor responds with a Link State Update packet. This exchange continues until both routers have the same link-state information.

Designated Routers

Networks with multiple routers present a unique situation for OSPF. If every router floods the network with LSAs, the same link-state information is sent from multiple sources. Depending on the type of network, OSPFv2 might use a single router, the designated router (*DR*), to control the LSA floods and represent the network to the rest of the OSPFv2 area (see the "Areas" section on page 5-4). If the DR fails, OSPFv2 selects a backup designated router (BDR). If the DR fails, OSPFv2 uses the BDR.

Network types are as follows:

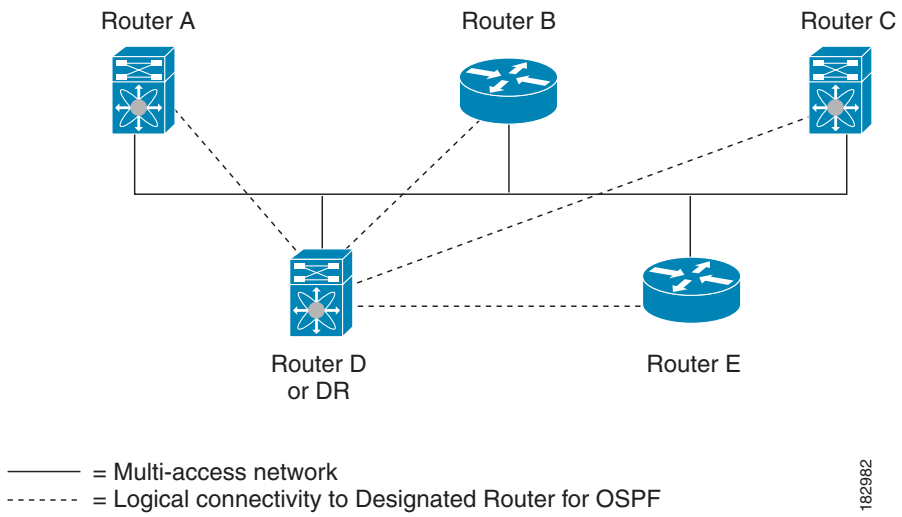
- Point-to-point—A network that exists only between two routers. All neighbors on a point-to-point network establish adjacency and there is no DR.
- Broadcast—A network with multiple routers that can communicate over a shared medium that allows broadcast traffic, such as Ethernet. OSPFv2 routers establish a DR and BDR that controls LSA flooding on the network. OSPFv2 uses the well-known IPv4 multicast addresses 224.0.0.5 and a MAC address of 0100.5300.0005 to communicate with neighbors.

The DR and BDR are selected based on the information in the Hello packet. When an interface sends a Hello packet, it sets the priority field and the DR and BDR field if it knows who the DR and BDR are. The routers follow an election procedure based on which routers declare themselves in the DR and BDR fields and the priority field in the Hello packet. As a final tie breaker, OSPFv2 chooses the highest router IDs as the DR and BDR.

All other routers establish adjacency with the DR and the BDR and use the IPv4 multicast address 224.0.0.6 to send LSA updates to the DR and BDR. Figure 5-1 shows this adjacency relationship between all routers and the DR.

DRs are based on a router interface. A router might be the DR for one network and not for another network on a different interface.

Figure 5-1 DR in Multi-Access Network



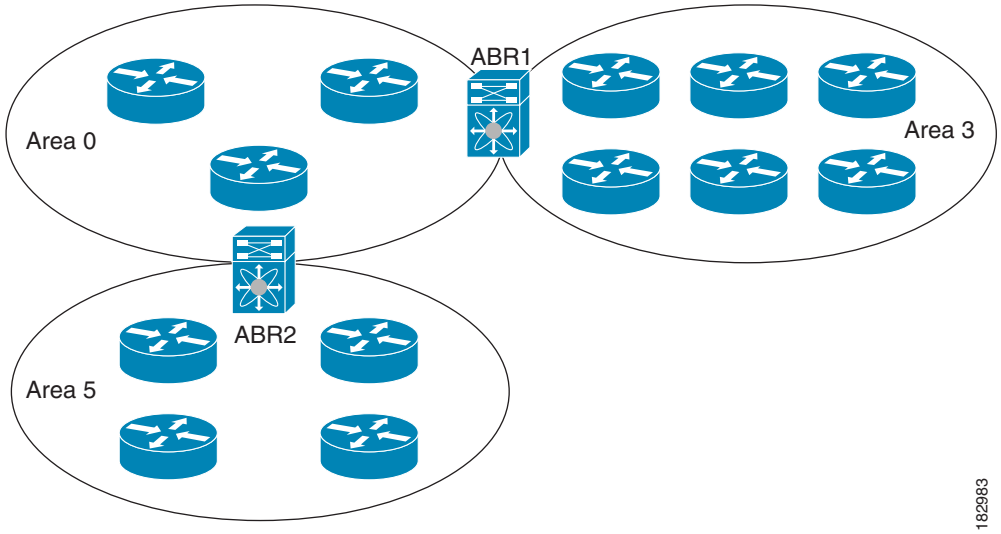
Areas

You can limit the CPU and memory requirements that OSPFv2 puts on the routers by dividing an OSPFv2 network into areas. An area is a logical division of routers and links within an OSPFv2 domain that creates separate subdomains. LSA flooding is contained within an area, and the link-state database is limited to links within the area. You can assign an area ID to the interfaces within the defined area. The Area ID is a 32-bit value that you can enter as a number or in dotted decimal notation, such as 10.2.3.1.

Cisco NX-OS always displays the area in dotted decimal notation.

If you define more than one area in an OSPFv2 network, you must also define the backbone area, which has the reserved area ID of 0. If you have more than one area, then one or more routers become area border routers (ABRs). An ABR connects to both the backbone area and at least one other defined area (see Figure 5-2).

Figure 5-2 OSPFv2 Areas



The ABR has a separate link-state database for each area to which it connects. The ABR sends Network Summary (type 3) LSAs (see the "Route Summarization" section on page 5-10) from one connected area to the backbone area. The backbone area sends summarized information about one area to another area. In Figure 5-2, Area 0 sends summarized information about Area 5 to Area 3.

OSPFv2 defines one other router type: the autonomous system boundary router (ASBR). This router connects an OSPFv2 area to another autonomous system. An autonomous system is a network controlled by a single technical administration entity. OSPFv2 can redistribute its routing information into another autonomous system or receive redistributed routes from another autonomous system. For more information, see the "Advanced Features" section on page 5-8.

Link-State Advertisements

OSPFv2 uses link-state advertisements (LSAs) to build its routing table.

This section includes the following topics:

- LSA Types, page 5-5
- Link Cost, page 5-6
- Flooding and LSA Group Pacing, page 5-6
- Link-State Database, page 5-7
- Opaque LSAs, page 5-7

LSA Types

Table 5-1 shows the LSA types supported by Cisco NX-OS.

Table 5-1 LSA Types

Type	Name	Description
1	Router LSA	LSA sent by every router. This LSA includes the state and the cost of all links and a list of all OSPFv2 neighbors on the link. Router LSAs trigger an SPF recalculation. Router LSAs are flooded to local OSPFv2 area.
2	Network LSA	LSA sent by the DR. This LSA lists all routers in the multi-access network. Network LSAs trigger an SPF recalculation. See the "Designated Routers" section on page 5-3.
3	Network Summary LSA	LSA sent by the area border router to an external area for each destination in the local area. This LSA includes the link cost from the area border router to the local destination. See the "Areas" section on page 5-4.
4	ASBR Summary LSA	LSA sent by the area border router to an external area. This LSA advertises the link cost to the ASBR only. See the "Areas" section on page 5-4.
5	AS External LSA	LSA generated by the ASBR. This LSA includes the link cost to an external autonomous system destination. AS External LSAs are flooded throughout the autonomous system. See the "Areas" section on page 5-4.
7	NSSA External LSA	LSA generated by the ASBR within a not-so-stubby area (NSSA). This LSA includes the link cost to an external autonomous system destination. NSSA External LSAs are flooded only within the local NSSA. See the "Areas" section on page 5-4.
9–11	Opaque LSAs	LSA used to extend OSPF. See the "Opaque LSAs" section on page 5-7.

Link Cost

Each OSPFv2 interface is assigned a link cost. The cost is an arbitrary number. By default, Cisco NX-OS assigns a cost that is the configured reference bandwidth divided by the interface bandwidth. By default, the reference bandwidth is 40 Gb/s. The link cost is carried in the LSA updates for each link.

Flooding and LSA Group Pacing

When an OSPFv2 router receives an LSA, it forwards that LSA out every OSPF-enabled interface, flooding the OSPFv2 area with this information. This LSA flooding guarantees that all routers in the network have identical routing information. LSA flooding depends on the OSPFv2 area configuration (see the "Areas" section on page 5-4). The LSAs are flooded based on the link-state refresh time (every 30 minutes by default). Each LSA has its own link-state refresh time.

You can control the flooding rate of LSA updates in your network by using the LSA group pacing feature. LSA group pacing can reduce high CPU or buffer usage. This feature groups LSAs with similar link-state refresh times to allow OSPFv2 to pack multiple LSAs into an OSPFv2 Update message.

By default, LSAs with link-state refresh times within 10 seconds of each other are grouped together. You should lower this value for large link-state databases or raise it for smaller databases to optimize the OSPFv2 load on your network.

Link-State Database

Each router maintains a link-state database for the OSPFv2 network. This database contains all the collected LSAs, and includes information on all the routes through the network. OSPFv2 uses this information to calculate the best path to each destination and populates the routing table with these best paths.

LSAs are removed from the link-state database if no LSA update has been received within a set interval, called the MaxAge. Routers flood a repeat of the LSA every 30 minutes to prevent accurate link-state information from being aged out. Cisco NX-OS supports the LSA grouping feature to prevent all LSAs from refreshing at the same time. For more information, see the "Flooding and LSA Group Pacing" section on page 5-6.

Opaque LSAs

Opaque LSAs allow you to extend OSPF functionality. Opaque LSAs consist of a standard LSA header followed by application-specific information. This information might be used by OSPFv2 or by other applications. OSPFv2 uses Opaque LSAs to support OSPFv2 Graceful Restart capability (see the "High Availability and Graceful Restart" section on page 5-11). Three Opaque LSA types are defined as follows:

- LSA type 9—Flooded to the local network.
- LSA type 10—Flooded to the local area.
- LSA type 11—Flooded to the local autonomous system.

OSPFv2 and the Unicast RIB

OSPFv2 runs the Dijkstra shortest path first algorithm on the link-state database. This algorithm selects the best path to each destination based on the sum of all the link costs for each link in the path. The resultant shortest path for each destination is then put in the OSPFv2 route table. When the OSPFv2 network is converged, this route table feeds into the unicast Routing Information Base (RIB). OSPFv2 communicates with the unicast RIB to do the following:

- Add or remove routes
- Handle route redistribution from other protocols
- Provide convergence updates to remove stale OSPFv2 routes and for stub router advertisements (see the "OSPFv2 Stub Router Advertisements" section on page 5-12)

OSPFv2 also runs a modified Dijkstra algorithm for fast recalculation for summary and external (type 3, 4, 5, and 7) LSA changes.

Authentication

You can configure authentication on OSPFv2 messages to prevent unauthorized or invalid routing updates in your network. Cisco NX-OS supports the following authentication methods:

- Simple password authentication
- Cryptographic authentication

You can configure the OSPFv2 authentication for an OSPFv2 area or per interface.

Simple Password Authentication

Simple password authentication uses a simple cleartext password that is sent as part of the OSPFv2 message. The receiving OSPFv2 router must be configured with the same cleartext password to accept the OSPFv2 message as a valid route update. Because the password is in cleartext, anyone who can watch traffic on the network can learn the password.

Cryptographic Authentication

Cryptographic authentication uses an encrypted password for OSPFv2 authentication. The transmitter computes a code using the packet to be transmitted and the key string, inserts the code and the key ID in the packet, and transmits the packet. The receiver validates the code in the packet by computing the code locally using the received packet and the key string (corresponding to the key ID in the packet) configured locally.

Both message digest 5 (MD5) and hash-based message authentication code secure hash algorithm (HMAC-SHA) cryptographic authentication are supported.

MD5 Authentication

You can use MD5 authentication to authenticate OSPFv2 messages by configuring a password that is shared at the local router and all remote OSPFv2 neighbors. For each OSPFv2 message, Cisco NX-OS creates an MD5 one-way message digest based on the message itself and the encrypted password. The interface sends this digest with the OSPFv2 message. The receiving OSPFv2 neighbor validates the digest using the same encrypted password. If the message has not changed, the digest calculation is identical, and the OSPFv2 message is considered valid.

MD5 authentication includes a sequence number with each OSPFv2 message to ensure that no message is replayed in the network.

HMAC-SHA Authentication

Starting with Cisco NX-OS Release 7.0(3)I3(1), OSPFv2 supports RFC 5709 to allow the use of HMAC-SHA algorithms, which offer more security than MD5. The HMAC-SHA-1, HMAC-SHA-256, HMAC-SHA-384. and HMAC-SHA-512 algorithms are supported for OSPFv2 authentication.

Advanced Features

Cisco NX-OS supports advanced OSPFv2 features that enhance the usability and scalability of OSPFv2 in the network. This section includes the following topics:

- BFD, page 5-12
- Virtualization Support, page 5-12

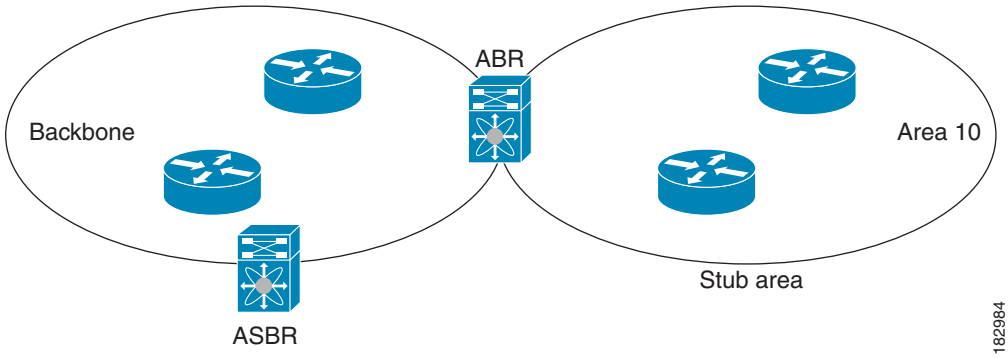
Stub Area

You can limit the amount of external routing information that floods an area by making it a stub area. A stub area is an area that does not allow AS External (type 5) LSAs (see the "Link-State Advertisements" section on page 5-5). These LSAs are usually flooded throughout the local autonomous system to propagate external route information. Stub areas have the following requirements:

- All routers in the stub area are stub routers. See the "Stub Routing" section on page 1-7.
- No ASBR routers exist in the stub area.
- You cannot configure virtual links in the stub area.

Figure 5-3 shows an example of an OSPFv2 autonomous system where all routers in area 0.0.0.10 have to go through the ABR to reach external autonomous systems. Area 0.0.0.10 can be configured as a stub area.

Figure 5-3 Stub Area



Stub areas use a default route for all traffic that must go through the backbone area to the external autonomous system. The default route is 0.0.0.0 for IPv4.

Not-So-Stubby Area

A Not-so-Stubby Area (NSSA) is similar to a stub area, except that an NSSA allows you to import autonomous system external routes within an NSSA using redistribution. The NSSA ASBR redistributes these routes and generates NSSA External (type 7) LSAs that it floods throughout the NSSA. You can optionally configure the ABR that connects the NSSA to other areas to translate this NSSA External LSA to AS External (type 5) LSAs. The ABR then floods these AS External LSAs throughout the OSPFv2 autonomous system. Summarization and filtering are supported during the translation. See the "Link-State Advertisements" section on page 5-5 for information about NSSA External LSAs.

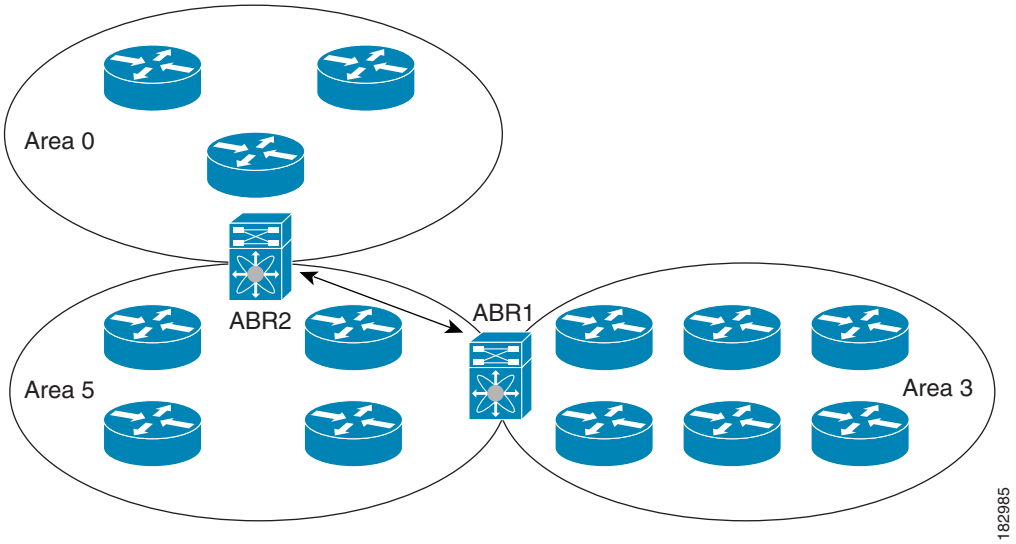
You can, for example, use NSSA to simplify administration if you are connecting a central site using OSPFv2 to a remote site that is using a different routing protocol. Before NSSA, the connection between the corporate site border router and a remote router could not be run as an OSPFv2 stub area because routes for the remote site could not be redistributed into a stub area. With NSSA, you can extend OSPFv2 to cover the remote connection by defining the area between the corporate router and remote router as an NSSA (see the "Configuring NSSA" section on page 5-28).

The backbone Area 0 cannot be an NSSA.

Virtual Links

Virtual links allow you to connect an OSPFv2 area ABR to a backbone area ABR when a direct physical connection is not available. Figure 5-4 shows a virtual link that connects Area 3 to the backbone area through Area 5.

Figure 5-4 Virtual Links



You can also use virtual links to temporarily recover from a partitioned area, which occurs when a link within the area fails, isolating part of the area from reaching the designated ABR to the backbone area.

Route Redistribution

OSPFv2 can learn routes from other routing protocols by using route redistribution. See the "Route Redistribution" section on page 1-6. You configure OSPFv2 to assign a link cost for these redistributed routes or a default link cost for all redistributed routes.

Route redistribution uses route maps to control which external routes are redistributed. You must configure a route map with the redistribution to control which routes are passed into OSPFv2. A route map allows you to filter routes based on attributes such as the destination, origination protocol, route type, route tag, and so on. You can use route maps to modify parameters in the AS External (type 5) and NSSA External (type 7) LSAs before these external routes are advertised in the local OSPFv2 autonomous system. See Chapter 15, "Configuring Route Policy Manager," for information about configuring route maps.

Route Summarization

Because OSPFv2 shares all learned routes with every OSPF-enabled router, you might want to use route summarization to reduce the number of unique routes that are flooded to every OSPF-enabled router. Route summarization simplifies route tables by replacing more-specific addresses with an address that represents all the specific addresses. For example, you can replace 10.1.1.0/24, 10.1.2.0/24, and 10.1.3.0/24 with one summary address, 10.1.0.0/16.

Typically, you would summarize at the boundaries of area border routers (ABRs). Although you could configure summarization between any two areas, it is better to summarize in the direction of the backbone so that the backbone receives all the aggregate addresses and injects them, already summarized, into other areas. The two types of summarization are as follows:

- Inter-area route summarization
- External route summarization

You configure inter-area route summarization on ABRs, summarizing routes between areas in the autonomous system. To take advantage of summarization, you should assign network numbers in areas in a contiguous way to be able to lump these addresses into one range.

External route summarization is specific to external routes that are injected into OSPFv2 using route redistribution. You should make sure that external ranges that are being summarized are contiguous. Summarizing overlapping ranges from two different routers could cause packets to be sent to the wrong destination. Configure external route summarization on ASBRs that are redistributing routes into OSPF.

When you configure a summary address, Cisco NX-OS automatically configures a discard route for the summary address to prevent routing black holes and route loops.

High Availability and Graceful Restart

Cisco NX-OS provides a multilevel high-availability architecture. OSPFv2 supports stateful restart, which is also referred to as non-stop routing (NSR). If OSPFv2 experiences problems, it attempts to restart from its previous run-time state. The neighbors do not register any neighbor event in this case. If the first restart is not successful and another problem occurs, OSPFv2 attempts a graceful restart.

A graceful restart, or nonstop forwarding (NSF), allows OSPFv2 to remain in the data forwarding path through a process restart. When OSPFv2 needs to perform a graceful restart, it sends a link-local opaque (type 9) LSA, called a grace LSA (see the "Opaque LSAs" section on page 5-7). This restarting OSPFv2 platform is called NSF capable.

The grace LSA includes a grace period, which is a specified time that the neighbor OSPFv2 interfaces hold onto the LSAs from the restarting OSPFv2 interface. (Typically, OSPFv2 tears down the adjacency and discards all LSAs from a down or restarting OSPFv2 interface.) The participating neighbors, which are called NSF helpers, keep all LSAs that originate from the restarting OSPFv2 interface as if the interface was still adjacent.

When the restarting OSPFv2 interface is operational again, it rediscovers its neighbors, establishes adjacency, and starts sending its LSA updates again. At this point, the NSF helpers recognize that the graceful restart has finished.

Stateful restart is used in the following scenarios:

- First recovery attempt after the process experiences problems
- User-initiated switchover using the **system switchover** command

Graceful restart is used in the following scenarios:

- Second recovery attempt after the process experiences problems within a 4-minute interval
- Manual restart of the process using the **restart ospf** command
- Active supervisor removal
- Active supervisor reload using the **reload module** *active-sup* command

OSPFv2 Stub Router Advertisements

You can configure an OSPFv2 interface to act as a stub router using the OSPFv2 Stub Router Advertisements feature. Use this feature when you want to limit the OSPFv2 traffic through this router, such as when you want to introduce a new router to the network in a controlled manner or limit the load on a router that is already overloaded. You might also want to use this feature for various administrative or traffic engineering reasons.

OSPFv2 stub router advertisements do not remove the OSPFv2 router from the network topology, but they do prevent other OSPFv2 routers from using this router to route traffic to other parts of the network. Only the traffic that is destined for this router or directly connected to this router is sent.

OSPFv2 stub router advertisements mark all stub links (directly connected to the local router) to the cost of the local OSPFv2 interface. All remote links are marked with the maximum cost (0xFFFF).

Multiple OSPFv2 Instances

Cisco NX-OS supports multiple instances of the OSPFv2 protocol that run on the same node. You cannot configure multiple instances over the same interface. By default, every instance uses the same system router ID. You must manually configure the router ID for each instance if the instances are in the same OSPFv2 autonomous system. For the number of supported OSPFv2 instances, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

SPF Optimization

Cisco NX-OS optimizes the SPF algorithm in the following ways:

- Partial SPF for Network (type 2) LSAs, Network Summary (type 3) LSAs, and AS External (type 5) LSAs—When there is a change on any of these LSAs, Cisco NX-OS performs a faster partial calculation rather than running the whole SPF calculation.
- SPF timers—You can configure different timers for controlling SPF calculations. These timers include exponential backoff for subsequent SPF calculations. The exponential backoff limits the CPU load of multiple SPF calculations.

BFD

This feature supports bidirectional forwarding detection (BFD) for IPv4. BFD is a detection protocol that provides fast forwarding-path failure detection times. BFD provides subsecond failure detection between two adjacent devices and can be less CPU-intensive than protocol hello messages because some of the BFD load can be distributed onto the data plane on supported modules. See the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide* for more information.

Virtualization Support

Cisco NX-OS supports multiple process instances for OSPFv2. Each OSPFv2 instance can support multiple virtual routing and forwarding (VRF) instances, up to the system limit. For the number of supported OSPFv2 instances, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

Licensing Requirements for OSPFv2

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	OSPFv2 requires an Enterprise Services license. For a complete explanation of the Cisco NX-OS licensing scheme and how to obtain and apply licenses, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for OSPFv2

OSPFv2 has the following prerequisites:

- You must be familiar with routing fundamentals to configure OSPF.
- You are logged on to the switch.
- You have configured at least one interface for IPv4 that can communicate with a remote OSPFv2 neighbor.
- You have installed the Enterprise Services license.
- You have completed the OSPFv2 network strategy and planning for your network. For example, you must decide whether multiple areas are required.
- You have enabled the OSPF feature (see the "Enabling OSPFv2" section on page 5-15).

Guidelines and Limitations for OSPFv2

OSPFv2 has the following configuration guidelines and limitations:

- Cisco NX-OS displays areas in dotted decimal notation regardless of whether you enter the area in decimal or dotted decimal notation.
- All OSPFv2 routers must operate in the same RFC compatibility mode. OSPFv2 for Cisco NX-OS complies with RFC 2328. Use the **rfc1583compatibility** command in router configuration mode if your network includes routers that support only RFC 1583.
- In scaled scenarios, when the number of interfaces and link-state advertisements in an OSPF process is large, the snmp-walk on OSPF MIB objects is expected to time out with a small-values timeout at the SNMP agent. If your observe a timeout on the querying SNMP agent while polling OSPF MIB objects, increase the timeout value on the polling SNMP agent.
- The following guidelines and limitations apply to the administrative distance feature:
  - When an OSPF route has two or more equal cost paths, configuring the administrative distance is nondeterministic for the **match ip route-source** command.
  - Configuring the administrative distance is supported only for the **match route-type**, **match ip address prefix-list**, and **match ip route-source prefix-list** commands. The other match statements are ignored.
  - There is no preference among the **match route-type**, **match ip address**, and **match ip route-source** commands for setting the administrative distance of OSPF routes. In this way, the behavior of the table map for setting the administrative distance in Cisco NX-OS OSPF is different from that in Cisco IOS OSPF.

  - The discard route is always assigned an administrative distance of 220. No configuration in the table map applies to OSPF discard routes.

- If you configure the **delay restore** *seconds* command in vPC configuration mode and if the VLANs on the multichassis EtherChannel trunk (MCT) are announced by OSPFv2 or OSPFv3 using switch virtual interfaces (SVIs), those SVIs are announced with MAX_LINK_COST on the vPC secondary node for the duration of the configured time. As a result, all route or host programming completes after the vPC synchronization operation (on a peer reload of the secondary vPC node) before attracting traffic. This behavior allows for minimal packet loss for any north-to-south traffic.

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Default Settings

Table 5-2 lists the default settings for OSPFv2 parameters.

Table 5-2 Default OSPFv2 Parameters

Parameters	Default
Administrative distance	110
Hello interval	10 seconds
Dead interval	40 seconds
Discard routes	Enabled
Graceful restart grace period	60 seconds
OSPFv2 feature	Disabled
Stub router advertisement announce time	600 seconds
Reference bandwidth for link cost calculation	40 Gb/s
LSA minimal arrival time	1000 milliseconds
LSA group pacing	10 seconds
SPF calculation initial delay time	200 milliseconds
SPF minimum hold time	5000 milliseconds
SPF calculation initial delay time	1000 milliseconds

Configuring Basic OSPFv2

Configure OSPFv2 after you have designed your OSPFv2 network.

This section includes the following topics:

- Enabling OSPFv2, page 5-15
- Creating an OSPFv2 Instance, page 5-16
- Configuring Optional Parameters on an OSPFv2 Instance, page 5-17
- Configuring Networks in OSPFv2, page 5-18

- Configuring Authentication for an Area, page 5-20
- Configuring Authentication for an Interface, page 5-21

Enabling OSPFv2

You must enable the OSPFv2 feature before you can configure OSPFv2.

SUMMARY STEPS

1. **configure terminal**
2. **feature ospf**
3. (Optional) **show feature**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**feature ospf** **Example:** `switch(config)# feature ospf`	Enables the OSPFv2 feature.
Step 3	**show feature** **Example:** `switch(config)# show feature`	(Optional) Displays enabled and disabled features.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

To disable the OSPFv2 feature and remove all associated configuration, use the **no feature ospf** command in global configuration mode:

Command	Purpose
no feature ospf **Example:** `switch(config)# no feature ospf`	Disables the OSPFv2 feature and removes all associated configuration.

Creating an OSPFv2 Instance

The first step in configuring OSPFv2 is to create an OSPFv2 instance. You assign a unique instance tag for this OSPFv2 instance. The instance tag can be any string.

For more information about OSPFv2 instance parameters, see the "Configuring Advanced OSPFv2" section on page 5-24.

BEFORE YOU BEGIN

Ensure that you have enabled the OSPF feature (see the "Enabling OSPFv2" section on page 5-15).

Use the **show ip ospf** *instance-tag* command to verify that the instance tag is not in use.

OSPFv2 must be able to obtain a router identifier (for example, a configured loopback address) or you must configure the router ID option.

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **router-id** *ip-address*
4. (Optional) **show ip ospf** *instance-tag*
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** `switch(config)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**router-id** *ip-address* **Example:** `switch(config-router)# router-id 192.0.2.1`	(Optional) Configures the OSPFv2 router ID. This IP address identifies this OSPFv2 instance and must exist on a configured interface in the system.
Step 4	**show ip ospf** *instance-tag* **Example:** `switch(config-router)# show ip ospf 201`	(Optional) Displays OSPF information.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

To remove the OSPFv2 instance and all associated configuration, use the **no router ospf** command in global configuration mode.

Command	Purpose
no router ospf *instance-tag* **Example:** `switch(config)# no router ospf 201`	Deletes the OSPF instance and the associated configuration.

Note This command does not remove the OSPF configuration in interface mode. You must manually remove any OSPFv2 commands configured in interface mode.

Configuring Optional Parameters on an OSPFv2 Instance

You can configure optional parameters for OSPF.

For more information about OSPFv2 instance parameters, see the "Configuring Advanced OSPFv2" section on page 5-24.

BEFORE YOU BEGIN

Ensure that you have enabled the OSPF feature (see the "Enabling OSPFv2" section on page 5-15).

OSPFv2 must be able to obtain a router identifier (for example, a configured loopback address) or you must configure the router ID option.

DETAILED STEPS

You can configure the following optional parameters for OSPFv2 in router configuration mode:

Command	Purpose
distance *number* **Example:** `switch(config-router)# distance 25`	Configures the administrative distance for this OSPFv2 instance. The range is from 1 to 255. The default is 110.
log-adjacency-changes [**detail**] **Example:** `switch(config-router)#` `log-adjacency-changes`	Generates a system message whenever a neighbor changes state.
maximum-paths *path-number* **Example:** `switch(config-router)# maximum-paths 4`	Configures the maximum number of equal OSPFv2 paths to a destination in the route table. This command is used for load balancing. The range is from 1 to 64. The default is 8.
passive-interface default **Example:** `switch(config-router)# passive-interface` `default`	Suppresses routing updates on all interfaces. This command is overridden by the VRF or interface command mode configuration.

This example shows how to create an OSPFv2 instance:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# copy running-config startup-config
```

Configuring Networks in OSPFv2

You can configure a network to OSPFv2 by associating it through the interface that the router uses to connect to that network (see the "Neighbors" section on page 5-3). You can add all networks to the default backbone area (Area 0), or you can create new areas using any decimal number or an IP address.

Note All areas must connect to the backbone area either directly or through a virtual link.

Note OSPF is not enabled on an interface until you configure a valid IP address for that interface.

BEFORE YOU BEGIN

Ensure that you have enabled the OSPF feature (see the "Enabling OSPFv2" section on page 5-15).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **ip address** *ip-prefix/length*
4. **ip router ospf** *instance-tag* **area** *area-id* [**secondaries none**]
5. (Optional) **show ip ospf** *instance-tag* **interface** *interface-type slot/port*
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip address** *ip-prefix/length* **Example:** `switch(config-if)# ip address 192.0.2.1/16`	Assigns an IP address and subnet mask to this interface.

	Command	Purpose
Step 4	**ip router ospf** *instance-tag* **area** *area-id* [**secondaries none**] **Example:** switch(config-if)# ip router ospf 201 area 0.0.0.15	Adds the interface to the OSPFv2 instance and area.
Step 5	**show ip ospf** *instance-tag* **interface** *interface-type slot/port* **Example**: switch(config-if)# show ip ospf 201 interface ethernet 1/2	(Optional) Displays OSPF information.
Step 6	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

You can configure the following optional parameters for OSPFv2 in interface configuration mode:

Command	Purpose
ip ospf cost *number* **Example:** switch(config-if)# ip ospf cost 25	Configures the OSPFv2 cost metric for this interface. The default is to calculate cost metric, based on the reference bandwidth and interface bandwidth. The range is from 1 to 65535.
ip ospf dead-interval *seconds* **Example:** switch(config-if)# ip ospf dead-interval 50	Configures the OSPFv2 dead interval, in seconds. The range is from 1 to 65535. The default is four times the hello interval, in seconds.
ip ospf hello-interval *seconds* **Example:** switch(config-if)# ip ospf hello-interval 25	Configures the OSPFv2 hello interval, in seconds. The range is from 1 to 65535. The default is 10 seconds.
ip ospf mtu-ignore **Example:** switch(config-if)# ip ospf mtu-ignore	Configures OSPFv2 to ignore any IP MTU mismatch with a neighbor. The default is to not establish adjacency if the neighbor MTU does not match the local interface MTU.
[**default** | **no**] **ip ospf passive-interface** **Example:** switch(config-if)# ip ospf passive-interface	Suppresses routing updates on the interface. This command overrides the router or VRF command mode configuration. The **default** option removes this interface mode command and reverts to the router or VRF configuration, if present.
ip ospf priority *number* **Example:** switch(config-if)# ip ospf priority 25	Configures the OSPFv2 priority, used to determine the DR for an area. The range is from 0 to 255. The default is 1. See the "Designated Routers" section on page 5-3.
ip ospf shutdown **Example:** switch(config-if)# ip ospf shutdown	Shuts down the OSPFv2 instance on this interface.

This example shows how to add a network area 0.0.0.10 in OSPFv2 instance 201:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# ip address 192.0.2.1/16
switch(config-if)# ip router ospf 201 area 0.0.0.10
switch(config-if)# copy running-config startup-config
```

Use the **show ip ospf interface** command to verify the interface configuration. Use the **show ip ospf neighbor** command to see the neighbors for this interface.

Configuring Authentication for an Area

You can configure authentication for all networks in an area or for individual interfaces in the area. Interface authentication configuration overrides area authentication.

BEFORE YOU BEGIN

Ensure that you have enabled the OSPF feature (see the "Enabling OSPFv2" section on page 5-15).

Ensure that all neighbors on an interface share the same authentication configuration, including the shared authentication key.

Create the keychain for this authentication configuration. See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide*.

Note For OSPFv2, the key identifier in the **key** *key-id* command supports values from 0 to 255 only.

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **area** *area-id* **authentication** [**message-digest**]
4. **interface** *interface-type slot/port*
5. (Optional) **ip ospf authentication-key** [**0** | **3**] *key*

   or

   ip ospf message-digest-key *key-id* **md5** [**0** | **3**] *key*
6. (Optional) **show ip ospf** *instance-tag* **interface** *interface-type slot/port*
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** switch(config)# router ospf 201 switch(config-router)#	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**area** *area-id* **authentication** [**message-digest**] **Example:** switch(config-router)# area 0.0.0.10 authentication	Configures the authentication mode for an area.
Step 4	**interface** *interface-type slot/port* **Example:** switch(config-router)# interface ethernet 1/2 switch(config-if)#	Enters interface configuration mode.
Step 5	**ip ospf authentication-key** [**0** | **3**] *key* **Example:** switch(config-if)# ip ospf authentication-key 0 mypass	(Optional) Configures simple password authentication for this interface. Use this command if the authentication is not set to keychain or message-digest. 0 configures the password in cleartext. 3 configures the password as 3DES encrypted.
	ip ospf message-digest-key *key-id* **md5** [**0** | **3**] *key* **Example:** switch(config-if)# ip ospf message-digest-key 21 md5 0 mypass	(Optional) Configures message digest authentication for this interface. Use this command if the authentication is set to message-digest. The *key-id* range is from 1 to 255. The MD5 option 0 configures the password in cleartext and 3 configures the pass key as 3DES encrypted.
Step 6	**show ip ospf** *instance-tag* **interface** *interface-type slot/port* **Example**: switch(config-if)# show ip ospf 201 interface ethernet 1/2	(Optional) Displays OSPF information.
Step 7	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

Configuring Authentication for an Interface

You can configure authentication for individual interfaces in the area. Interface authentication configuration overrides area authentication.

BEFORE YOU BEGIN

Ensure that you have enabled the OSPF feature (see the "Enabling OSPFv2" section on page 5-15).

Ensure that all neighbors on an interface share the same authentication configuration, including the shared authentication key.

Create the keychain for this authentication configuration. To configure OSPFv2 HMAC-SHA authentication, you must specify the HMAC-SHA algorithm to be used for the key. OSPFv2 will use the MD5 cryptographic algorithm if cryptographic authentication using keychain is configured without selecting a cryptographic-algorithm. See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide*.

Note For OSPFv2, the key identifier in the **key** *key-id* command supports values from 0 to 255 only.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **ip ospf authentication** [**message-digest**]
4. (Optional) **ip ospf authentication key-chain** *key-id*
5. (Optional) **ip ospf authentication-key** [**0** | **3** | **7**] *key*
6. (Optional) **ip ospf message-digest-key** *key-id* **md5** [**0** | **3** | **7**] *key*
7. (Optional) **show ip ospf** *instance-tag* **interface** *interface-type slot/port*
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip ospf authentication** [**message-digest**] **Example:** `switch(config-if)# ip ospf authentication`	Enables interface authentication mode for OSPFv2 for either cleartext or message-digest type. Use this command to override area-based authentication for this interface. All neighbors must share this authentication type.
Step 4	**ip ospf authentication key-chain** *key-id* **Example:** `switch(config-if)# ip ospf authentication key-chain Test1`	(Optional) Configures interface authentication to use keychains for OSPFv2. See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide* for details on keychains.

	Command	Purpose
Step 5	**ip ospf authentication-key** [**0** | **3** | **7**] *key* **Example:** switch(config-if)# ip ospf authentication-key 0 mypass	(Optional) Configures simple password authentication for this interface. Use this command if the authentication is not set to keychain or message-digest. The options are as follows: • 0—Configures the password in cleartext. • 3—Configures the pass key as 3DES encrypted. • 7—Configures the key as Cisco type 7 encrypted.
Step 6	**ip ospf message-digest-key** *key-id* **md5** [**0** | **3** | **7**] *key* **Example:** switch(config-if)# ip ospf message-digest-key 21 md5 0 mypass	(Optional) Configures message digest authentication for this interface. Use this command if the authentication is set to message-digest.The *key-id* range is from 1 to 255. The MD5 options are as follows: • 0—Configures the password in cleartext. • 3—Configures the pass key as 3DES encrypted. • 7—Configures the key as Cisco type 7 encrypted.
Step 7	**show ip ospf** *instance-tag* **interface** *interface-type slot/port* **Example**: switch(config-if)# show ip ospf 201 interface ethernet 1/2	(Optional) Displays OSPF information.
Step 8	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to set an interface for simple, unencrypted passwords and set the password for Ethernet interface 1/2:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# exit
switch(config)# interface ethernet 1/2
switch(config-if)# ip router ospf 201 area 0.0.0.10
switch(config-if)# ip ospf authentication
switch(config-if)# ip ospf authentication-key 0 mypass
switch(config-if)# copy running-config startup-config
```

This example shows how to configure OSPFv2 HMAC-SHA-1 and MD5 cryptographic authentication:

```
switch# configure terminal
switch(config)# key chain chain1
switch(config-keychain)# key 1
switch(config-keychain-key)# key-string 7 070724404206
switch(config-keychain-key)# accept-lifetime 01:01:01 Jan 01 2015  infinite
switch(config-keychain-key)# send-lifetime 01:01:01 Jan 01 2015  infinite
switch(config-keychain-key)# cryptographic-algorithm HMAC-SHA-1
switch(config-keychain-key)# exit
switch(config-keychain)# key 2
switch(config-keychain-key)# key-string 7 070e234f1f5b4a
switch(config-keychain-key)# accept-lifetime 10:51:01 Jul 24 2015  infinite
switch(config-keychain-key)# send-lifetime 10:51:01 Jul 24 2015  infinite
switch(config-keychain-key)# cryptographic-algorithm MD5
switch(config-keychain-key)# exit
switch(config-keychain)# exit

switch(config)# interface ethernet 1/1
switch(config-if)# ip router ospf 1 area 0.0.0.0
switch(config-if)# ip ospf authentication message-digest
switch(config-if)# ip ospf authentication key-chain chain1

switch(config-if)# show key chain chain1
Key-Chain chain1
  Key 1 -- text 7 "070724404206"
    cryptographic-algorithm HMAC-SHA-1
    accept lifetime UTC (01:01:01 Jan 01 2015)-(always valid) [active]
    send lifetime UTC (01:01:01 Jan 01 2015)-(always valid) [active]
  Key 2 -- text 7 "070e234f1f5b4a"
    cryptographic-algorithm MD5
    accept lifetime UTC (10:51:00 Jul 24 2015)-(always valid) [active]
    send lifetime UTC (10:51:00 Jul 24 2015)-(always valid) [active]

switch(config-if)# show ip ospf interface ethernet 1/1
Ethernet1/1 is up, line protocol is up
    IP address 11.11.11.1/24
    Process ID 1 VRF default, area 0.0.0.3
    Enabled by interface configuration
    State BDR, Network type BROADCAST, cost 40
    Index 6, Transmit delay 1 sec, Router Priority 1
    Designated Router ID: 33.33.33.33, address: 11.11.11.3
    Backup Designated Router ID: 1.1.1.1, address: 11.11.11.1
    2 Neighbors, flooding to 2, adjacent with 2
    Timer intervals: Hello 10, Dead 40, Wait 40, Retransmit 5
      Hello timer due in 00:00:08
    Message-digest authentication, using keychain key1 (ready)
      Sending SA: Key id 2, Algorithm MD5
    Number of opaque link LSAs: 0, checksum sum 0
```

Configuring Advanced OSPFv2

Configure OSPFv2 after you have designed your OSPFv2 network.

This section includes the following topics:

Configuring Filter Lists for Border Routers

You can separate your OSPFv2 domain into a series of areas that contain related networks. All areas must connect to the backbone area through an area border router (ABR). OSPFv2 domains can connect to external domains through an autonomous system border router (ASBR). See the "Areas" section on page 5-4.

ABRs have the following optional configuration parameters:

- Area range—Configures route summarization between areas. See the "Configuring Route Summarization" section on page 5-37.
- Filter list—Filters the Network Summary (type 3) LSAs that are allowed in from an external area.

ASBRs also support filter lists.

BEFORE YOU BEGIN

Ensure that you have enabled the OSPF feature (see the "Enabling OSPFv2" section on page 5-15).

Create the route map that the filter list uses to filter IP prefixes in incoming or outgoing Network Summary (type 3) LSAs. See Chapter 15, "Configuring Route Policy Manager."

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **area** *area-id* **filter-list route-map** *map-name* {**in** | **out**}
4. (Optional) **show ip ospf policy statistics area** *id* **filter-list** {**in** | **out**}
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** switch(config)# router ospf 201 switch(config-router)#	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**area** *area-id* **filter-list route-map** *map-name* {**in** | **out**} **Example:** switch(config-router)# area 0.0.0.10 filter-list route-map FilterLSAs in	Filters incoming or outgoing Network Summary (type 3) LSAs on an ABR.
Step 4	**show ip ospf policy statistics area** *id* **filter-list** {**in** | **out**} **Example:** switch(config-if)# show ip ospf policy statistics area 0.0.0.10 filter-list in	(Optional) Displays OSPF policy information.
Step 5	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to configure a filter list in area 0.0.0.10:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# area 0.0.0.10 filter-list route-map FilterLSAs in
switch(config-router)# copy running-config startup-config
```

Configuring Stub Areas

You can configure a stub area for part of an OSPFv2 domain where external traffic is not necessary. Stub areas block AS External (type 5) LSAs and limit unnecessary routing to and from selected networks. See the "Stub Area" section on page 5-9. You can optionally block all summary routes from going into the stub area.

BEFORE YOU BEGIN

Ensure that you have enabled the OSPF feature (see the "Enabling OSPFv2" section on page 5-15).

Ensure that there are no virtual links or ASBRs in the proposed stub area.

SUMMARY STEPS

1. **configure terminal**

2. **router ospf** *instance-tag*
3. **area** *area-id* **stub**
4. (Optional) **area** *area-id* **default-cost** *cost*
5. (Optional) **show ip ospf** *instance-tag*
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** `switch(config)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**area** *area-id* **stub** **Example:** `switch(config-router)# area 0.0.0.10 stub`	Creates this area as a stub area.
Step 4	**area** *area-id* **default-cost** *cost* **Example:** `switch(config-router)# area 0.0.0.10 default-cost 25`	(Optional) Sets the cost metric for the default summary route sent into this stub area. The range is from 0 to 16777215. The default is 1.
Step 5	**show ip ospf** *instance-tag* **Example**: `switch(config-if)# show ip ospf 201`	(Optional) Displays OSPF information.
Step 6	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to create a stub area:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# area 0.0.0.10 stub
switch(config-router)# copy running-config startup-config
```

Configuring a Totally Stubby Area

You can create a totally stubby area and prevent all summary route updates from going into the stub area.

To create a totally stubby area, use the following command in router configuration mode:

Command	Purpose
area *area-id* **stub no-summary** **Example:** `switch(config-router)# area 20 stub no-summary`	Creates this area as a totally stubby area.

Configuring NSSA

You can configure an NSSA for part of an OSPFv2 domain where limited external traffic is required. For information about NSSAs, see the "Not-So-Stubby Area" section on page 5-9. You can optionally translate this external traffic to an AS External (type 5) LSA and flood the OSPFv2 domain with this routing information. An NSSA can be configured with the following optional parameters:

- No redistribution—Redistributed routes bypass the NSSA and are redistributed to other areas in the OSPFv2 autonomous system. Use this option when the NSSA ASBR is also an ABR.
- Default information originate—Generates an NSSA External (type 7) LSA for a default route to the external autonomous system. Use this option on an NSSA ASBR if the ASBR contains the default route in the routing table. This option can be used on an NSSA ABR whether or not the ABR contains the default route in the routing table.
- Route map—Filters the external routes so that only those routes that you want are flooded throughout the NSSA and other areas.
- Translate—Translates NSSA External LSAs to AS External LSAs for areas outside the NSSA. Use this command on an NSSA ABR to flood the redistributed routes throughout the OSPFv2 autonomous system. You can optionally suppress the forwarding address in these AS External LSAs. If you choose this option, the forwarding address is set to 0.0.0.0.
- No summary—Blocks all summary routes from flooding the NSSA. Use this option on the NSSA ABR.

BEFORE YOU BEGIN

Ensure that you have enabled the OSPF feature (see the "Enabling OSPFv2" section on page 5-15).

Ensure that there are no virtual links in the proposed NSSA and that it is not the backbone area.

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **area** *area-id* **nssa** [**no-redistribution**] [**default-information-originate** [**route-map** *map-name*]] [**no-summary**] [**translate type7** {**always** | **never**} [**suppress-fa**]]
4. (Optional) **area** *area-id* **default-cost** *cost*
5. (Optional) **show ip ospf** *instance-tag*
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** switch(config)# router ospf 201 switch(config-router)#	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**area** *area-id* **nssa** [**no-redistribution**] [**default-information-originate** [**route-map** *map-name*]] [**no-summary**] [**translate type7** {**always** | **never**} [**suppress-fa**]] **Example:** switch(config-router)# area 0.0.0.10 nssa	Creates this area as an NSSA.
Step 4	**area** *area-id* **default-cost** *cost* **Example:** switch(config-router)# area 0.0.0.10 default-cost 25	(Optional) Sets the cost metric for the default summary route sent into this NSSA.
Step 5	**show ip ospf** *instance-tag* **Example**: switch(config-if)# show ip ospf 201	(Optional) Displays OSPF information.
Step 6	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create an NSSA that blocks all summary route updates:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# area 0.0.0.10 nssa no-summary
switch(config-router)# copy running-config startup-config
```

This example shows how to create an NSSA that generates a default route:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# area 0.0.0.10 nssa default-info-originate
switch(config-router)# copy running-config startup-config
```

This example shows how to create an NSSA that filters external routes and blocks all summary route updates:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# area 0.0.0.10 nssa route-map ExternalFilter no-summary
switch(config-router)# copy running-config startup-config
```

This example shows how to create an NSSA that always translates NSSA External (type 5) LSAs to AS External (type 7) LSAs:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# area 0.0.0.10 nssa translate type 7 always
switch(config-router)# copy running-config startup-config
```

Configuring Multi-Area Adjacency

You can add more than one area to an existing OSPFv2 interface. The additional logical interfaces support multi-area adjacency.

BEFORE YOU BEGIN

You must enable OSPFv2 (see the "Enabling OSPFv2" section on page 5-15).

Ensure that you have configured a primary area for the interface (see the "Configuring Networks in OSPFv2" section on page 5-18).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **ip router ospf** [*instance-tag*] **multi-area** *area-id*
4. (Optional) **show ip ospf** *instance-tag* **interface** *interface-type slot/port*
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip router ospf** [*instance-tag*] **multi-area** *area-id* **Example:** `switch(config-if)# ip router ospf 201 multi-area 3`	Adds the interface to another area. **Note** Beginning with Cisco NX-OS Release 7.0(3)I5(1), the *instance-tag* argument is optional. If you do not specify an instance, the multi-area configuration is applied to the same instance that is configured for the primary area on that interface.

	Command	Purpose
Step 4	**show ip ospf** *instance-tag* **interface** *interface-type slot/port* **Example:** `switch(config-if)# show ip ospf 201 interface ethernet 1/2`	(Optional) Displays OSPFv2 information.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to add a second area to an OSPFv2 interface:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# ip address 192.0.2.1/16
switch(config-if)# ip router ospf 201 area 0.0.0.10
switch(config-if)# ip router ospf 201 multi-area 20
switch(config-if)# copy running-config startup-config
```

Configuring Virtual Links

A virtual link connects an isolated area to the backbone area through an intermediate area. See the "Virtual Links" section on page 5-10. You can configure the following optional parameters for a virtual link:

- Authentication—Sets a simple password or MD5 message digest authentication and associated keys.
- Dead interval—Sets the time that a neighbor waits for a Hello packet before declaring the local router as dead and tearing down adjacencies.
- Hello interval—Sets the time between successive Hello packets.
- Retransmit interval—Sets the estimated time between successive LSAs.
- Transmit delay—Sets the estimated time to transmit an LSA to a neighbor.

Note You must configure the virtual link on both routers involved before the link becomes active.

You cannot add a virtual link to a stub area.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv2" section on page 5-15).

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **area** *area-id* **virtual-link** *router-id*
4. (Optional) **show ip ospf virtual-link** [**brief**]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** switch(config)# router ospf 201 switch(config-router)#	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**area** *area-id* **virtual-link** *router-id* **Example:** switch(config-router)# area 0.0.0.10 virtual-link 10.1.2.3 switch(config-router-vlink)#	Creates one end of a virtual link to a remote router. You must create the virtual link on that remote router to complete the link.
Step 4	**show ip ospf virtual-link** [**brief**] **Example**: switch(config-router-vlink)# show ip ospf virtual-link	(Optional) Displays OSPF virtual link information.
Step 5	**copy running-config startup-config** **Example:** switch(config-router-vlink)# copy running-config startup-config	(Optional) Saves this configuration change.

You can configure the following optional commands in virtual link configuration mode:

Command	Purpose
authentication [**key-chain** *key-id* | **message-digest** | **null**] **Example:** switch(config-router-vlink)# authentication message-digest	(Optional) Overrides area-based authentication for this virtual link.
authentication-key [**0** | **3**] *key* **Example:** switch(config-router-vlink)# authentication-key 0 mypass	(Optional) Configures a simple password for this virtual link. Use this command if the authentication is not set to keychain or message-digest. 0 configures the password in cleartext. 3 configures the password as 3DES encrypted.
dead-interval *seconds* **Example**: switch(config-router-vlink)# dead-interval 50	(Optional) Configures the OSPFv2 dead interval, in seconds. The range is from 1 to 65535. The default is four times the hello interval, in seconds.
hello-interval *seconds* **Example:** switch(config-router-vlink)# hello-interval 25	(Optional) Configures the OSPFv2 hello interval, in seconds. The range is from 1 to 65535. The default is 10 seconds.

Command	Purpose
message-digest-key *key-id* **md5** [**0** | **3**] *key* **Example:** switch(config-router-vlink)# message-digest-key 21 md5 0 mypass	(Optional) Configures message digest authentication for this virtual link. Use this command if the authentication is set to message-digest. 0 configures the password in cleartext. 3 configures the pass key as 3DES encrypted.
retransmit-interval *seconds* **Example**: switch(config-router-vlink)# retransmit-interval 50	(Optional) Configures the OSPFv2 retransmit interval, in seconds. The range is from 1 to 65535. The default is 5.
transmit-delay *seconds* **Example:** switch(config-router-vlink)# transmit-delay 2	(Optional) Configures the OSPFv2 transmit-delay, in seconds. The range is from 1 to 450. The default is 1.

This example shows how to create a simple virtual link between two ABRs.

The configuration for ABR 1 (router ID 27.0.0.55) is as follows:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# area 0.0.0.10 virtual-link 10.1.2.3
switch(config-router)# copy running-config startup-config
```

The configuration for ABR 2 (Router ID 10.1.2.3) is as follows:

```
switch# configure terminal
switch(config)# router ospf 101
switch(config-router)# area 0.0.0.10 virtual-link 27.0.0.55
switch(config-router)# copy running-config startup-config
```

Configuring Redistribution

You can redistribute routes learned from other routing protocols into an OSPFv2 autonomous system through the ASBR.

You can configure the following optional parameters for route redistribution in OSPF:

- Default information originate—Generates an AS External (type 5) LSA for a default route to the external autonomous system.

Note Default information originate ignores **match** statements in the optional route map.

- Default metric—Sets all redistributed routes to the same cost metric.

Note If you redistribute static routes, Cisco NX-OS also redistributes the default static route.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv2" section on page 5-15).

Create the necessary route maps used for redistribution.

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **redistribute** {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} **route-map** *map-name*
4. **default-information originate** [**always**] [**route-map** *map-name*]
5. **default-metric** *cost*
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** `switch(config)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**redistribute** {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} **route-map** *map-name* **Example:** `switch(config-router)# redistribute bgp route-map FilterExternalBGP`	Redistributes the selected protocol into OSPF through the configured route map. **Note** If you redistribute static routes, Cisco NX-OS also redistributes the default static route.
Step 4	**default-information originate** [**always**] [**route-map** map-name] **Example:** `switch(config-router)# default-information-originate route-map DefaultRouteFilter`	Creates a default route into this OSPF domain if the default route exists in the RIB. Use the following optional keywords: • **always** —Always generates the default route of 0.0.0. even if the route does not exist in the RIB. • **route-map**—Generates the default route if the route map returns true. **Note** This command ignores **match** statements in the route map.

	Command	Purpose
Step 5	**default-metric** *cost* **Example:** `switch(config-router)# default-metric 25`	Sets the cost metric for the redistributed routes. This command does not apply to directly connected routes. Use a route map to set the default metric for directly connected routes.
Step 6	**copy running-config startup-config** **Example:** `switch(config-router)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to redistribute the Border Gateway Protocol (BGP) into OSPF:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# redistribute bgp route-map FilterExternalBGP
switch(config-router)# copy running-config startup-config
```

Limiting the Number of Redistributed Routes

Route redistribution can add many routes to the OSPFv2 route table. You can configure a maximum limit to the number of routes accepted from external protocols. OSPFv2 provides the following options to configure redistributed route limits:

- Fixed limit—Logs a message when OSPFv2 reaches the configured maximum. OSPFv2 does not accept any more redistributed routes. You can optionally configure a threshold percentage of the maximum where OSPFv2 logs a warning when that threshold is passed.
- Warning only—Logs a warning only when OSPFv2 reaches the maximum. OSPFv2 continues to accept redistributed routes.
- Withdraw—Starts the timeout period when OSPFv2 reaches the maximum. After the timeout period, OSPFv2 requests all redistributed routes if the current number of redistributed routes is less than the maximum limit. If the current number of redistributed routes is at the maximum limit, OSPFv2 withdraws all redistributed routes. You must clear this condition before OSPFv2 accepts more redistributed routes.
- You can optionally configure the timeout period.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv2" section on page 5-15).

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **redistribute** {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} **route-map** *map-name*
4. **redistribute maximum-prefix** *max* [*threshold*] [**warning-only** | **withdraw** [*num-retries timeout*]]
5. (Optional) **show running-config ospf**
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** switch(config)# router ospf 201 switch(config-router)#	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**redistribute** {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} **route-map** *map-name* **Example:** switch(config-router)# redistribute bgp route-map FilterExternalBGP	Redistributes the selected protocol into OSPF through the configured route map.
Step 4	**redistribute maximum-prefix** *max* [*threshold*] [**warning-only** | **withdraw** [*num-retries timeout*]] **Example:** switch(config-router)# redistribute maximum-prefix 1000 75 warning-only	Specifies a maximum number of prefixes that OSPFv2 distributes. The range is from 1 to 65535. Optionally specifies the following: • *threshold*—Percentage of maximum prefixes that trigger a warning message. • **warning-only**—Logs a warning message when the maximum number of prefixes is exceeded. • **withdraw**—Withdraws all redistributed routes. Optionally tries to retrieve the redistributed routes. The *num-retries* range is from 1 to 12. The *timeout* is 60 to 600 seconds. The default is 300 seconds. Use the **clear ip ospf redistribution** command if all routes are withdrawn.
Step 5	**show running-config ospf** **Example:** switch(config-router)# show running-config ospf	(Optional) Displays the OSPFv2 configuration.
Step 6	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to limit the number of redistributed routes into OSPF:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# redistribute bgp route-map FilterExternalBGP
switch(config-router)# redistribute maximum-prefix 1000 75
```

Configuring Route Summarization

You can configure route summarization for inter-area routes by configuring an address range that is summarized. You can also configure route summarization for external, redistributed routes by configuring a summary address for those routes on an ASBR. For more information, see the "Route Summarization" section on page 5-10.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv2" section on page 5-15).

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **area** *area-id* **range** *ip-prefix/length* [**no-advertise**] [**cost** *cost*]

   or
4. **summary-address** *ip-prefix/length* [**no-advertise** | **tag** *tag-id*]
5. (Optional) **show ip ospf summary-address**
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** `switch(config)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**area** *area-id* **range** *ip-prefix/length* [**no-advertise**] [**cost** *cost*] **Example:** `switch(config-router)# area 0.0.0.10 range 10.3.0.0/16`	Creates a summary address on an ABR for a range of addresses and optionally does not advertise this summary address in a Network Summary (type 3) LSA. The *cost* range is from 0 to 16777215.
Step 4	**summary-address** *ip-prefix/length* [**no-advertise** | **tag** tag] **Example:** `switch(config-router)# summary-address 10.5.0.0/16 tag 2`	Creates a summary address on an ASBR for a range of addresses and optionally assigns a tag for this summary address that can be used for redistribution with route maps.

	Command	Purpose
Step 5	**show ip ospf summary-address** **Example:** switch(config-router)# show ip ospf summary-address	(Optional) Displays information about OSPF summary addresses.
Step 6	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create summary addresses between areas on an ABR:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# area 0.0.0.10 range 10.3.0.0/16
switch(config-router)# copy running-config startup-config
```

This example shows how to create summary addresses on an ASBR:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# summary-address 10.5.0.0/16
switch(config-router)# no discard-route internal
switch(config-router)# copy running-config startup-config
```

Configuring Stub Route Advertisements

Use stub route advertisements when you want to limit the OSPFv2 traffic through this router for a short time. For more information, see the "OSPFv2 Stub Router Advertisements" section on page 5-12.

Stub route advertisements can be configured with the following optional parameters:

- On startup—Sends stub route advertisements for the specified announce time.
- Wait for BGP—Sends stub router advertisements until BGP converges.

Note You should not save the running configuration of a router when it is configured for a graceful shutdown because the router continues to advertise a maximum metric after it is reloaded.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv2" section on page 5-15).

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **max-metric router-lsa** [**external-lsa** [*max-metric-value*]] [**include-stub**] [**on-startup** {*seconds* | **wait-for bgp** *tag*}] [**summary-lsa** [*max-metric-value*]]
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** switch(config)# router ospf 201 switch(config-router)#	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**max-metric router-lsa** [**external-lsa** [*max-metric-value*]] [**include-stub**] [**on-startup** {*seconds* | **wait-for bgp** *tag*}] [**summary-lsa** [*max-metric-value*]] **Example:** switch(config-router)# max-metric router-lsa	Configures OSPFv2 stub route advertisements.
Step 4	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to enable the stub router advertisements on startup for the default 600 seconds:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# max-metric router-lsa on-startup
switch(config-router)# copy running-config startup-config
```

Configuring the Administrative Distance of Routes

You can set the administrative distance of routes added by OSPFv2 into the RIB.

The administrative distance is a rating of the trustworthiness of a routing information source. A higher value indicates a lower trust rating. Typically, a route can be learned through more than one routing protocol. The administrative distance is used to discriminate between routes learned from more than one routing protocol. The route with the lowest administrative distance is installed in the IP routing table.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv2" section on page 5-15).

See the guidelines and limitations for this feature in the "Guidelines and Limitations for OSPFv2" section on page 5-13.

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*

3. [**no**] **table-map** *map-name*
4. **exit**
5. **route-map** *map-name* [**permit** | **deny**] [*seq*]
6. **match route-type** *route-type*
7. **match ip route-source prefix-list** *name*
8. **match ip address prefix-list** *name*
9. **set distance** *value*
10. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** `switch(config)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	[**no**] **table-map** *map-name* **Example:** `switch(config-router)# table-map foo`	Configures the policy for filtering or modifying OSPFv2 routes before sending them to the RIB. You can enter up to 63 alphanumeric characters for the map name.
Step 4	**exit** **Example:** `switch(config-router)# exit` `switch(config)#`	Exits router configuration mode.
Step 5	**route-map** *map-name* [**permit** | **deny**] [*seq*] **Example:** `switch(config)# route-map foo permit 10` `switch(config-route-map)#`	Creates a route map or enters route-map configuration mode for an existing route map. Use *seq* to order the entries in a route map. **Note** The **permit** option enables you to set the distance. If you use the **deny** option, the default distance is applied.

	Command	Purpose
Step 6	**match route-type** *route-type* **Example:** `switch(config-route-map)# match route-type external`	Matches against one of the following route types: • external—The external route (BGP, EIGRP, and OSPF type 1 or 2) • inter-area—OSPF inter-area route • internal—The internal route (including the OSPF intra- or inter-area) • intra-area—OSPF intra-area route • nssa-external—The NSSA external route (OSPF type 1 or 2). • type-1—The OSPF external type 1 route • type-2—The OSPF external type 2 route
Step 7	**match ip route-source prefix-list** *name* **Example:** `switch(config-route-map)# match ip route-source prefix-list p1`	Matches the IPv4 route source address or router ID of a route to one or more IP prefix lists. Use the **ip prefix-list** command to create the prefix list.
Step 8	**match ip address prefix-list** *name* **Example:** `switch(config-route-map)# match ip address prefix-list p1`	Matches against one or more IPv4 prefix lists. Use the **ip prefix-list** command to create the prefix list.
Step 9	**set distance** *value* **Example:** `switch(config-route-map)# set distance 150`	Sets the administrative distance of routes for OSPFv2. The range is from 1 to 255.
Step 10	**copy running-config startup-config** **Example:** `switch(config-route-map)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to configure the OSPFv2 administrative distance for inter-area routes to 150, for external routes to 200, and for all prefixes in prefix list p1 to 190:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# table-map foo
switch(config-router)# exit
switch(config)# route-map foo permit 10
switch(config-route-map)# match route-type inter-area
switch(config-route-map)# set distance 150
switch(config)# route-map foo permit 20
switch(config-route-map)# match route-type external
switch(config-route-map)# set distance 200
switch(config)# route-map foo permit 30
switch(config-route-map)# match ip route-source prefix-list p1
switch(config-route-map)# match ip address prefix-list p1
switch(config-route-map)# set distance 190
```

Modifying the Default Timers

OSPFv2 includes a number of timers that control the behavior of protocol messages and shortest path first (SPF) calculations. OSPFv2 includes the following optional timer parameters:

- LSA arrival time—Sets the minimum interval allowed between LSAs that arrive from a neighbor. LSAs that arrive faster than this time are dropped.
- Pacing LSAs—Sets the interval at which LSAs are collected into a group and refreshed, checksummed, or aged. This timer controls how frequently LSA updates occur and optimizes how many are sent in an LSA update message (see the "Flooding and LSA Group Pacing" section on page 5-6).
- Throttle LSAs—Sets the rate limits for generating LSAs. This timer controls how frequently LSAs are generated after a topology change occurs.
- Throttle SPF calculation—Controls how frequently the SPF calculation is run.

At the interface level, you can also control the following timers:

- Retransmit interval—Sets the estimated time between successive LSAs.
- Transmit delay—Sets the estimated time to transmit an LSA to a neighbor.

See the "Configuring Networks in OSPFv2" section on page 5-18 for information about the hello interval and dead timer.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv2" section on page 5-15).

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **timers lsa-arrival** *msec*
4. **timers lsa-group-pacing** *seconds*
5. **timers throttle lsa** *start-time hold-interval max-time*
6. **timers throttle spf** *delay-time hold-time*
7. **interface** *type slot/port*
8. **ip ospf hello-interval** *seconds*
9. **ip ospf dead-interval** *seconds*
10. **ip ospf retransmit-interval** *seconds*
11. **ip ospf transmit-delay** *seconds*
12. (Optional) **show ip ospf**
13. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** `switch(config)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**timers lsa-arrival** *msec* **Example:** `switch(config-router)# timers lsa-arrival 2000`	Sets the LSA arrival time in milliseconds. The range is from 10 to 600000. The default is 1000 milliseconds.
Step 4	**timers lsa-group-pacing** *seconds* **Example:** `switch(config-router)# timers lsa-group-pacing 200`	Sets the interval in seconds for grouping LSAs. The range is from 1 to 1800. The default is 10 seconds.
Step 5	**timers throttle lsa** *start-time hold-interval max-time* **Example:** `switch(config-router)# timers throttle lsa 3000`	Sets the rate limit in milliseconds for generating LSAs with the following timers: *start-time*—The range is from 0 to 5000 milliseconds. The default value is 0 milliseconds. *hold-interva*l—The range is from 50 to 30,000 milliseconds. The default value is 5000 milliseconds. *max-time*—The range is from 50 to 30,000 milliseconds. The default value is 5000 milliseconds.
Step 6	**timers throttle spf** *delay-time hold-time max-wait* **Example:** `switch(config-router)# timers throttle spf 3000 2000 4000`	Sets the SPF best-path schedule initial delay time and the minimum hold time in seconds between SPF best-path calculations. The range is from 1 to 600000. The default is no delay time and a 5000-millisecond hold time.
Step 7	**interface** *type slot/port* **Example**: `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 8	**ip ospf hello-interval** *seconds* **Example:** `switch(config-if)# ip ospf hello-interval 30`	Sets the hello interval for this interface. The range is from 1 to 65535. The default is 10.
Step 9	**ip ospf dead-interval** *seconds* **Example:** `switch(config-if)# ip ospf dead-interval 30`	Sets the dead interval for this interface. The range is from 1 to 65535.

	Command	Purpose
Step 10	**ip ospf retransmit-interval** *seconds* **Example:** switch(config-if)# ip ospf retransmit-interval 30	Sets the estimated time in seconds between LSAs transmitted from this interface. The range is from 1 to 65535. The default is 5.
Step 11	**ip ospf transmit-delay** *seconds* **Example:** switch(config-if)# ip ospf transmit-delay 600 switch(config-if)#	Sets the estimated time in seconds to transmit an LSA to a neighbor. The range is from 1 to 450. The default is 1.
Step 12	**show ip ospf** **Example:** switch(config-if)# show ip ospf	(Optional) Displays information about OSPF.
Step 13	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to control LSA flooding with the lsa-group-pacing option:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# timers lsa-group-pacing 300
switch(config-router)# copy running-config startup-config
```

Configuring Graceful Restart

Graceful restart is enabled by default. You can configure the following optional parameters for graceful restart in an OSPFv2 instance:

- Grace period—Configures how long neighbors should wait after a graceful restart has started before tearing down adjacencies.
- Helper mode disabled—Disables helper mode on the local OSPFv2 instance. OSPFv2 does not participate in the graceful restart of a neighbor.
- Planned graceful restart only—Configures OSPFv2 to support graceful restart only in the event of a planned restart.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv2" section on page 5-15).

Ensure that all neighbors are configured for graceful restart with matching optional parameters set.

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **graceful-restart**
4. (Optional) **graceful-restart grace-period** *seconds*

5. (Optional) **graceful-restart helper-disable**
6. (Optional) **graceful-restart planned-only**
7. (Optional) **show ip ospf** *instance-tag*
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** `switch(config)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**graceful-restart** **Example:** `switch(config-router)# graceful-restart`	Enables a graceful restart. A graceful restart is enabled by default.
Step 4	**graceful-restart grace-period** *seconds* **Example:** `switch(config-router)# graceful-restart grace-period 120`	(Optional) Sets the grace period, in seconds. The range is from 5 to 1800. The default is 60 seconds.
Step 5	**graceful-restart helper-disable** **Example:** `switch(config-router)# graceful-restart helper-disable`	(Optional) Disables helper mode. This feature is enabled by default.
Step 6	**graceful-restart planned-only** **Example:** `switch(config-router)# graceful-restart planned-only`	(Optional) Configures a graceful restart for planned restarts only.
Step 7	**show ip ospf** *instance-tag* **Example**: `switch(config-if)# show ip ospf 201`	(Optional) Displays OSPF information.
Step 8	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to enable a graceful restart if it has been disabled and set the grace period to 120 seconds:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# graceful-restart
switch(config-router)# graceful-restart grace-period 120
switch(config-router)# copy running-config startup-config
```

Restarting an OSPFv2 Instance

You can restart an OSPv2 instance. This action clears all neighbors for the instance.

To restart an OSPFv2 instance and remove all associated neighbors, use the following command:

Command	Purpose
restart ospf instance-tag **Example:** switch(config)# restart ospf 201	Restarts the OSPFv2 instance and removes all neighbors.

Configuring OSPFv2 with Virtualization

You can configure multiple OSPFv2 instances. You can also create multiple VRFs and use the same or multiple OSPFv2 instances in each VRF. You assign an OSPFv2 interface to a VRF.

Note Configure all other parameters for an interface after you configure the VRF for an interface. Configuring a VRF for an interface deletes all the configuration for that interface.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv2" section on page 5-15).

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf_name*
3. **router ospf** *instance-tag*
4. **vrf** *vrf-name*
5. (Optional) **maximum-paths** *paths*
6. **interface** *interface-type slot/port*
7. **vrf member** *vrf-name*
8. **ip-address** *ip-prefix/length*
9. **router ospf** *instance-tag* **area** *area-id*
10. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** `switch(config)# vrf context RemoteOfficeVRF` `switch(config-vrf)#`	Creates a new VRF and enters VRF configuration mode.
Step 3	**router ospf** *instance-tag* **Example:** `switch(config-vrf)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv2 instance with the configured instance tag.
Step 4	**vrf** *vrf-name* **Example:** `switch(config-router)# vrf RemoteOfficeVRF` `switch(config-router-vrf)#`	Enters VRF configuration mode.
Step 5	**maximum-paths** *paths* **Example**: `switch(config-router-vrf)# maximum-paths 4`	(Optional) Configures the maximum number of equal OSPFv2 paths to a destination in the route table for this VRF. This feature is used for load balancing.
Step 6	**interface** *interface-type slot/port* **Example**: `switch(config-router-vrf)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 7	**vrf member** *vrf-name* **Example:** `switch(config-if)# vrf member RemoteOfficeVRF`	Adds this interface to a VRF.
Step 8	**ip address** *ip-prefix/length* **Example:** `switch(config-if)# ip address 192.0.2.1/16`	Configures an IP address for this interface. You must do this step after you assign this interface to a VRF.
Step 9	**ip router ospf** *instance-tag* **area** *area-id* **Example:** `switch(config-if)# ip router ospf 201 area 0`	Assigns this interface to the OSPFv2 instance and area configured.
Step 10	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to create a VRF and add an interface to the VRF:

```
switch# configure terminal
switch(config)# vrf context NewVRF
switch(config)# router ospf 201
switch(config)# interface ethernet 1/2
switch(config-if)# vrf member NewVRF
switch(config-if)# ip address 192.0.2.1/16
switch(config-if)# ip router ospf 201 area 0
switch(config)# copy running-config startup-config
```

Verifying the OSPFv2 Configuration

To display the OSPFv2 configuration, perform one of the following tasks:

Command	Purpose
show ip ospf [*instance-tag*] [**vrf** *vrf-name*]	Displays information about one or more OSPF routing instances. The output includes the following area-level counts: • Interfaces in this area—A count of all interfaces added to this area (configured interfaces). • Active interfaces—A count of all interfaces considered to be in router link states and SPF (UP interfaces). • Passive interfaces—A count of all interfaces considered to be OSPF passive (no adjacencies will be formed). • Loopback interfaces—A count of all local loopback interfaces.
show ip ospf border-routers [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv2 border router configuration.
show ip ospf database [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv2 link-state database summary.
show ip ospf interface *number* [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays OSPFv2-related interface information.
show ip ospf lsa-content-changed-list *neighbor-id interface-type number* [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv2 LSAs that have changed.
show ip ospf neighbors [*neighbor-id*] [**detail**] [*interface-type number*] [**vrf** {*vrf-name* | **all** | **default** | **management**}] [**summary**]	Displays the list of OSPFv2 neighbors.
show ip ospf request-list *neighbor-id interface-type number* [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the list of OSPFv2 link-state requests.

Command	Purpose
show ip ospf retransmission-list *neighbor-id interface-type number* [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the list of OSPFv2 link-state retransmissions.
show ip ospf route [*ospf-route*] [**summary**] [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the internal OSPFv2 routes.
show ip ospf summary-address [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays information about the OSPFv2 summary addresses.
show ip ospf virtual-links [**brief**] [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays information about OSPFv2 virtual links.
show ip ospf vrf {*vrf-name* | **all** | **default** | **management**}	Displays information about the VRF-based OSPFv2 configuration.
show running-configuration ospf	Displays the current running OSPFv2 configuration.

Monitoring OSPFv2

To display OSPFv2 statistics, use the following commands:

Command	Purpose
show ip ospf policy statistics area *area-id* **filter-list** {**in** | **out**} [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv2 route policy statistics for an area.
show ip ospf policy statistics redistribute {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv2 route policy statistics.
show ip ospf statistics [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv2 event counters.
show ip ospf traffic [*interface-type number*] [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv2 packet counters.

Configuration Examples for OSPFv2

The following example shows how to configure OSPFv2:

```
feature ospf
router ospf 201
 router-id 290.0.2.1

interface ethernet 1/2
 ip router ospf 201 area 0.0.0.10
 ip ospf authentication
 ip ospf authentication-key 0 mypass
```

OSPF RFC Compatibility Mode Example

The following example shows how to configure OSPF to be compatible with routers that comply with RFC 1583:

Note You must configure RFC 1583 compatibility on any VRF that connects to routers running only RFC1583 compatible OSPF.

```
switch# configure terminal
switch(config)# feature ospf
switch(config)# router ospf Test1
switch(config-router)# rfc1583compatibility
switch(config-router)# vrf A
switch(config-router-vrf)# rfc1583compatibility
```

Additional References

For additional information related to implementing OSPF, see the following sections:

- Related Documents, page 5-50
- MIBs, page 5-50

Related Documents

Related Topic	Document Title
Keychains	*Cisco Nexus 9000 Series NX-OS Security Configuration Guide*
OSPFv3 for IPv6 networks	Chapter 6, “Configuring OSPFv3”
Route maps	Chapter 15, “Configuring Route Policy Manager”

MIBs

MIBs	MIBs Link
MIBs related to OSPFv2	To locate and download supported MIBs, go to the following URL: ftp://ftp.cisco.com/pub/mibs/supportlists/nexus9000/Nexus9000MIBSupportList.html

Configuring OSPFv3

This chapter describes how to configure Open Shortest Path First version 3 (OSPFv3) for IPv6 networks on the Cisco NX-OS device.

This chapter includes the following sections:

About OSPFv3

OSPFv3 is an IETF link-state protocol (see "Overview" section on page 1-1). An OSPFv3 router sends a special message, called a hello packet, out each OSPF-enabled interface to discover other OSPFv3 neighbor routers. Once a neighbor is discovered, the two routers compare information in the Hello packet to determine if the routers have compatible configurations. The neighbor routers attempt to establish adjacency, which means that the routers synchronize their link-state databases to ensure that they have identical OSPFv3 routing information. Adjacent routers share link-state advertisements (LSAs) that include information about the operational state of each link, the cost of the link, and any other neighbor information. The routers then flood these received LSAs out every OSPF-enabled interface so that all OSPFv3 routers eventually have identical link-state databases. When all OSPFv3 routers have identical link-state databases, the network is converged (see the "Convergence" section on page 1-6). Each router then uses Dijkstra's Shortest Path First (SPF) algorithm to build its route table.

You can divide OSPFv3 networks into areas. Routers send most LSAs only within one area, which reduces the CPU and memory requirements for an OSPF-enabled router.

OSPFv3 supports IPv6. For information about OSPF for IPv4, see Chapter 5, "Configuring OSPFv2."

This section includes the following topics:

Comparison of OSPFv3 and OSPFv2

Much of the OSPFv3 protocol is the same as in OSPFv2. OSPFv3 is described in RFC 2740.

The key differences between the OSPFv3 and OSPFv2 protocols are as follows:

- OSPFv3 expands on OSPFv2 to provide support for IPv6 routing prefixes and the larger size of IPv6 addresses.
- LSAs in OSPFv3 are expressed as prefix and prefix length instead of address and mask.
- The router ID and area ID are 32-bit numbers with no relationship to IPv6 addresses.
- OSPFv3 uses link-local IPv6 addresses for neighbor discovery and other features.
- OSPFv3 can use the IPv6 authentication trailer (RFC 6506) or IPSec (RFC 4552) for authentication. However, Cisco NX-OS does not support RFC 6506 and provides only partial support for RFC 4552, beginning with Cisco NX-OS release 7.0(3)I3(1).
- OSPFv3 redefines LSA types.

Hello Packet

OSPFv3 routers periodically send Hello packets on every OSPF-enabled interface. The hello interval determines how frequently the router sends these Hello packets and is configured per interface. OSPFv3 uses Hello packets for the following tasks:

- Neighbor discovery
- Keepalives
- Bidirectional communications
- Designated router election (see the "Designated Routers" section on page 6-4)

The Hello packet contains information about the originating OSPFv3 interface and router, including the assigned OSPFv3 cost of the link, the hello interval, and optional capabilities of the originating router. An OSPFv3 interface that receives these Hello packets determines if the settings are compatible with the receiving interface settings. Compatible interfaces are considered neighbors and are added to the neighbor table (see the "Neighbors" section on page 6-3).

Hello packets also include a list of router IDs for the routers that the originating interface has communicated with. If the receiving interface sees its own router ID in this list, bidirectional communication has been established between the two interfaces.

OSPFv3 uses Hello packets as a keepalive message to determine if a neighbor is still communicating. If a router does not receive a Hello packet by the configured dead interval (usually a multiple of the hello interval), then the neighbor is removed from the local neighbor table.

Neighbors

An OSPFv3 interface must have a compatible configuration with a remote interface before the two can be considered neighbors. The two OSPFv3 interfaces must match the following criteria:

- Hello interval
- Dead interval
- Area ID (see the "Areas" section on page 6-5)
- Optional capabilities

If there is a match, the information is entered into the neighbor table:

- Neighbor ID—The router ID of the neighbor router.
- Priority—Priority of the neighbor router. The priority is used for designated router election (see the "Designated Routers" section on page 6-4).
- State—Indication of whether the neighbor has just been heard from, is in the process of setting up bidirectional communications, is sharing the link-state information, or has achieved full adjacency.
- Dead time—Indication of how long since the last Hello packet was received from this neighbor.
- Link-local IPv6 Address—The link-local IPv6 address of the neighbor.
- Designated Router—Indication of whether the neighbor has been declared the designated router or backup designated router (see the "Designated Routers" section on page 6-4).
- Local interface—The local interface that received the Hello packet for this neighbor.

When the first Hello packet is received from a new neighbor, the neighbor is entered into the neighbor table in the initialization state. Once bidirectional communication is established, the neighbor state becomes two-way. ExStart and exchange states come next, as the two interfaces exchange their link-state database. Once this is all complete, the neighbor moves into the full state, which signifies full adjacency. If the neighbor fails to send any Hello packets in the dead interval, the neighbor is moved to the down state and is no longer considered adjacent.

Adjacency

Not all neighbors establish adjacency. Depending on the network type and designated router establishment, some neighbors become fully adjacent and share LSAs with all their neighbors, while other neighbors do not. For more information, see the "Designated Routers" section on page 6-4.

Adjacency is established using Database Description packets, Link State Request packets, and Link State Update packets in OSPFv3. The Database Description packet includes the LSA headers from the link-state database of the neighbor (see the "Link-State Database" section on page 6-8). The local router compares these headers with its own link-state database and determines which LSAs are new or updated. The local router sends a Link State Request packet for each LSA that it needs new or updated information on. The neighbor responds with a Link State Update packet. This exchange continues until both routers have the same link-state information.

Designated Routers

Networks with multiple routers present a unique situation for OSPFv3. If every router floods the network with LSAs, the same link-state information is sent from multiple sources. Depending on the type of network, OSPFv3 might use a single router, the designated router (*DR*), to control the LSA floods and represent the network to the rest of the OSPFv3 area (see the "Areas" section on page 6-5). If the DR fails, OSPFv3 selects a backup designated router (BDR). If the DR fails, OSPFv3 uses the BDR.

Network types are as follows:

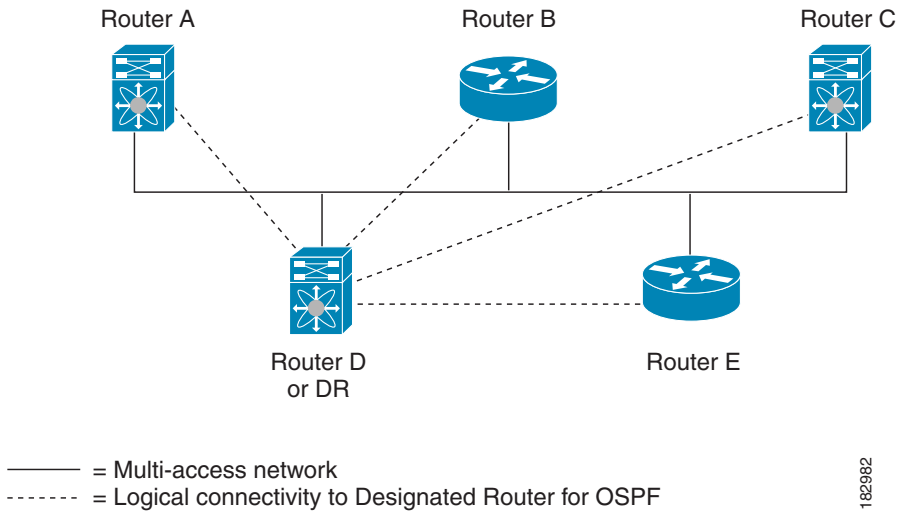
- Point-to-point—A network that exists only between two routers. All neighbors on a point-to-point network establish adjacency and there is no DR.
- Broadcast—A network with multiple routers that can communicate over a shared medium that allows broadcast traffic, such as Ethernet. OSPFv3 routers establish a DR and BDR that controls LSA flooding on the network. OSPFv3 uses the well-known IPv6 multicast addresses, FF02::5, and a MAC address of 0100.5300.0005 to communicate with neighbors.

The DR and BDR are selected based on the information in the Hello packet. When an interface sends a Hello packet, it sets the priority field and the DR and BDR field if it knows who the DR and BDR are. The routers follow an election procedure based on which routers declare themselves in the DR and BDR fields and the priority field in the Hello packet. As a final determinant, OSPFv3 chooses the highest router IDs as the DR and BDR.

All other routers establish adjacency with the DR and the BDR and use the IPv6 multicast address FF02::6 to send LSA updates to the DR and BDR. Figure 6-1 shows this adjacency relationship between all routers and the DR.

DRs are based on a router interface. A router might be the DR for one network and not for another network on a different interface.

Figure 6-1 DR in Multi-Access Network



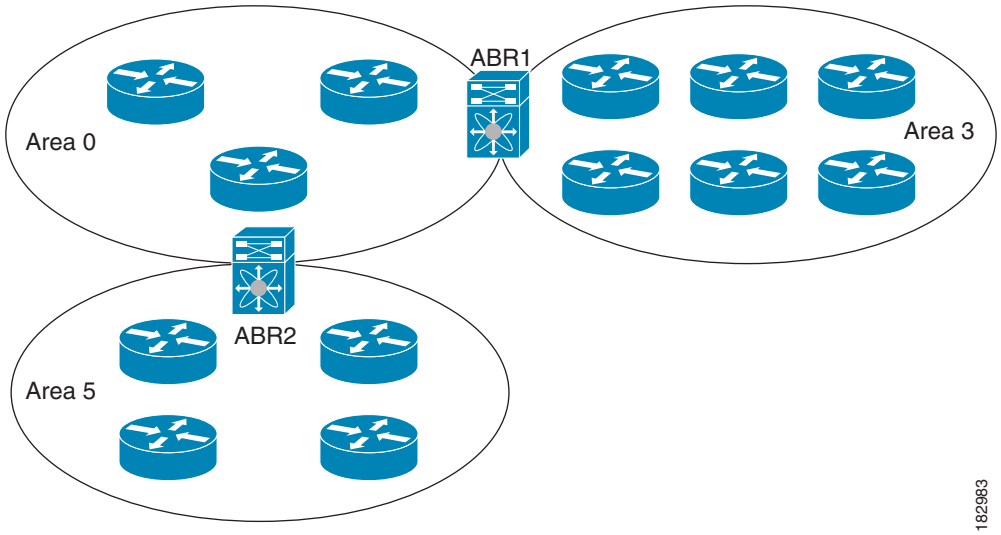
Areas

You can limit the CPU and memory requirements that OSPFv3 puts on the routers by dividing an OSPFv3 network into areas. An area is a logical division of routers and links within an OSPFv3 domain that creates separate subdomains. LSA flooding is contained within an area, and the link-state database is limited to links within the area. You can assign an area ID to the interfaces within the defined area. The Area ID is a 32-bit value that can be expressed as a number or in dotted decimal notation, such as 10.2.3.1.

Cisco NX-OS always displays the area in dotted decimal notation.

If you define more than one area in an OSPFv3 network, you must also define the backbone area, which has the reserved area ID of 0. If you have more than one area, then one or more routers become area border routers (ABRs). An ABR connects to both the backbone area and at least one other defined area (see Figure 6-2).

Figure 6-2 OSPFv3 Areas



The ABR has a separate link-state database for each area which it connects to. The ABR sends Inter-Area Prefix (type 3) LSAs (see the "Route Summarization" section on page 6-12) from one connected area to the backbone area. The backbone area sends summarized information about one area to another area. In Figure 6-2, Area 0 sends summarized information about Area 5 to Area 3.

OSPFv3 defines one other router type: the autonomous system boundary router (ASBR). This router connects an OSPFv3 area to another autonomous system. An autonomous system is a network controlled by a single technical administration entity. OSPFv3 can redistribute its routing information into another autonomous system or receive redistributed routes from another autonomous system. For more information, see the "Advanced Features" section on page 6-9.

Link-State Advertisement

OSPFv3 uses link-state advertisements (LSAs) to build its routing table.

This section includes the following topics:

LSA Types

Table 6-1 shows the LSA types supported by Cisco NX-OS.

Table 6-1 LSA Types

Type	Name	Description
1	Router LSA	LSA sent by every router. This LSA includes the state and cost of all links but does not include prefix information. Router LSAs trigger an SPF recalculation. Router LSAs are flooded to the local OSPFv3 area.
2	Network LSA	LSA sent by the DR. This LSA lists all routers in the multi-access network but does not include prefix information. Network LSAs trigger an SPF recalculation. See the "Designated Routers" section on page 6-4.
3	Inter-Area Prefix LSA	LSA sent by the area border router to an external area for each destination in local area. This LSA includes the link cost from the border router to the local destination. See the "Areas" section on page 6-5.
4	Inter-Area Router LSA	LSA sent by the area border router to an external area. This LSA advertises the link cost to the ASBR only. See the "Areas" section on page 6-5.
5	AS External LSA	LSA generated by the ASBR. This LSA includes the link cost to an external autonomous system destination. AS External LSAs are flooded throughout the autonomous system. See the "Areas" section on page 6-5.
7	Type-7 LSA	LSA generated by the ASBR within an NSSA. This LSA includes the link cost to an external autonomous system destination. Type-7 LSAs are flooded only within the local NSSA. See the "Areas" section on page 6-5.
8	Link LSA	LSA sent by every router, using a link-local flooding scope (see the "Flooding and LSA Group Pacing" section on page 6-7. This LSA includes the link-local address and IPv6 prefixes for this link.
9	Intra-Area Prefix LSA	LSA sent by every router. This LSA includes any prefix or link state changes. Intra-Area Prefix LSAs are flooded to the local OSPFv3 area. This LSA does not trigger an SPF recalculation.
11	Grace LSAs	LSA sent by a restarting router, using a link-local flooding scope. This LSA is used for a graceful restart of OSPFv3. See the "High Availability and Graceful Restart" section on page 6-12.

Link Cost

Each OSPFv3 interface is assigned a link cost. The cost is an arbitrary number. By default, Cisco NX-OS assigns a cost that is the configured reference bandwidth divided by the interface bandwidth. By default, the reference bandwidth is 40 Gb/s. The link cost is carried in the LSA updates for each link.

Flooding and LSA Group Pacing

OSPFv3 floods LSA updates to different sections of the network, depending on the LSA type. OSPFv3 uses the following flooding scopes:

- Link-local—LSA is flooded only on the local link. Used for Link LSAs and Grace LSAs.
- Area-local—LSA is flooded throughout a single OSPF area only. Used for Router LSAs, Network LSAs, Inter-Area-Prefix LSAs, Inter-Area-Router LSAs, and Intra-Area-Prefix LSAs.
- AS scope—LSA is flooded throughout the routing domain. An AS scope is used for AS External LSAs.

LSA flooding guarantees that all routers in the network have identical routing information. LSA flooding depends on the OSPFv3 area configuration (see the "Areas" section on page 6-5). The LSAs are flooded based on the link-state refresh time (every 30 minutes by default). Each LSA has its own link-state refresh time.

You can control the flooding rate of LSA updates in your network by using the LSA group pacing feature. LSA group pacing can reduce high CPU or buffer utilization. This feature groups LSAs with similar link-state refresh times to allow OSPFv3 to pack multiple LSAs into an OSPFv3 Update message.

By default, LSAs with link-state refresh times within 10 seconds of each other are grouped together. You should lower this value for large link-state databases or raise it for smaller databases to optimize the OSPFv3 load on your network.

Link-State Database

Each router maintains a link-state database for the OSPFv3 network. This database contains all the collected LSAs and includes information on all the routes through the network. OSPFv3 uses this information to calculate the bast path to each destination and populates the routing table with these best paths.

LSAs are removed from the link-state database if no LSA update has been received within a set interval, called the MaxAge. Routers flood a repeat of the LSA every 30 minutes to prevent accurate link-state information from being aged out. Cisco NX-OS supports the LSA grouping feature to prevent all LSAs from refreshing at the same time. For more information, see the "Flooding and LSA Group Pacing" section on page 6-7.

Multi-Area Adjacency

OSPFv3 multi-area adjacency allows you to configure a link on the primary interface that is in more than one area. This link becomes the preferred intra-area link in those areas. Multi-area adjacency establishes a point-to-point unnumbered link in an OSPFv3 area that provides a topological path for that area. The primary adjacency uses the link to advertise an unnumbered point-to-point link in the Router LSA for the corresponding area when the neighbor state is full.

The multi-area interface exists as a logical construct over an existing primary interface for OSPF; however, the neighbor state on the primary interface is independent of the multi-area interface. The multi-area interface establishes a neighbor relationship with the corresponding multi-area interface on the neighboring router. See the "Configuring Multi-Area Adjacency" section on page 6-30 for more information.

OSPFv3 and the IPv6 Unicast RIB

OSPFv3 runs the Dijkstra shortest path first algorithm on the link-state database. This algorithm selects the best path to each destination based on the sum of all the link costs for each link in the path. The shortest path for each destination is then put in the OSPFv3 route table. When the OSPFv3 network is converged, this route table feeds into the IPv6 unicast Routing Information Base (RIB). OSPFv3 communicates with the IPv6 unicast RIB to do the following:

- Add or remove routes
- Handle route redistribution from other protocols

- Provide convergence updates to remove stale OSPFv3 routes and for stub router advertisements (see the "Multiple OSPFv3 Instances" section on page 6-13)

OSPFv3 also runs a modified Dijkstra algorithm for fast recalculation for Inter-Area Prefix, Inter-Area Router, AS-External, type-7, and Intra-Area Prefix (type 3, 4, 5, 7, 8) LSA changes.

Address Family Support

Cisco NX-OS supports multiple address families, such as unicast IPv6 and multicast IPv6. OSPFv3 features that are specific to an address family are as follows:

- Default routes
- Route summarization
- Route redistribution
- Filter lists for border routers
- SPF optimization

Use the **address-family ipv6 unicast** command to enter the IPv6 unicast address family configuration mode when configuring these features.

Authentication

You can configure authentication on OSPFv3 messages to prevent unauthorized or invalid routing updates in your network.

RFC 4552 provides authentication to OSPFv3 using an IPv6 authentication header (AH) or encapsulating security payload (ESP) extension header. Beginning with Cisco NX-OS 7.0(3)I3(1), Cisco NX-OS partially supports RFC 4552 by using the IPv6 AH header to authenticate OSPFv3 packets.

Cisco NX-OS supports the IP security (IPSec) authentication method and the message digest 5 (MD5) or secure hash algorithm 1 (SHA1) algorithm to authenticate OSPFv3 packets. OSPFv3 IPSec authentication supports only static keys.

You can configure IPSec authentication for an OSPFv3 process, area, or interface.

Advanced Features

Cisco NX-OS supports advanced OSPFv3 features that enhance the usability and scalability of OSPFv3 in the network.

This section includes the following topics:

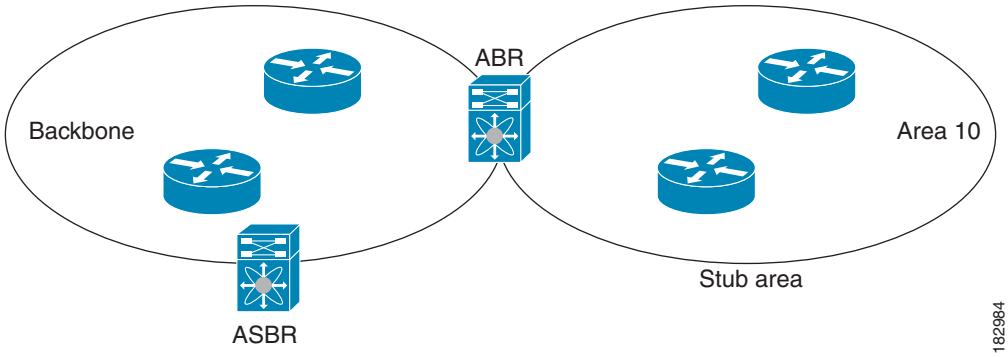
Stub Area

You can limit the amount of external routing information that floods an area by making it a stub area. A stub area is an area that does not allow AS External (type 5) LSAs (see the "Link-State Advertisement" section on page 6-6). These LSAs are usually flooded throughout the local autonomous system to propagate external route information. Stub areas have the following requirements:

- All routers in the stub area are stub routers. See the "Stub Routing" section on page 1-7.
- No ASBR routers exist in the stub area.
- You cannot configure virtual links in the stub area.

Figure 6-3 shows an example an OSPFv3 autonomous system where all routers in area 0.0.0.10 have to go through the ABR to reach external autonomous systems. Area 0.0.0.10 can be configured as a stub area.

Figure 6-3 Stub Area



Stub areas use a default route for all traffic that needs to go through the backbone area to the external autonomous system. The default route is an Inter-Area-Prefix LSA with the prefix length set to 0 for IPv6.

Not-So-Stubby Area

A Not-So-Stubby Area (NSSA) is similar to the stub area, except that an NSSA allows you to import autonomous system external routes within an NSSA using redistribution. The NSSA ASBR redistributes these routes and generates type-7 LSAs that it floods throughout the NSSA. You can optionally configure the ABR that connects the NSSA to other areas to translate this type-7 LSA to AS External (type 5) LSAs. The ABR then floods these AS External LSAs throughout the OSPFv3 autonomous system. Summarization and filtering are supported during the translation. See the "Link-State Advertisement" section on page 6-6 for details on type-7 LSAs.

You can, for example, use NSSA to simplify administration if you are connecting a central site using OSPFv3 to a remote site that is using a different routing protocol. Before NSSA, the connection between the corporate site border router and a remote router could not be run as an OSPFv3 stub area because routes for the remote site could not be redistributed into a stub area. With NSSA, you can extend OSPFv3

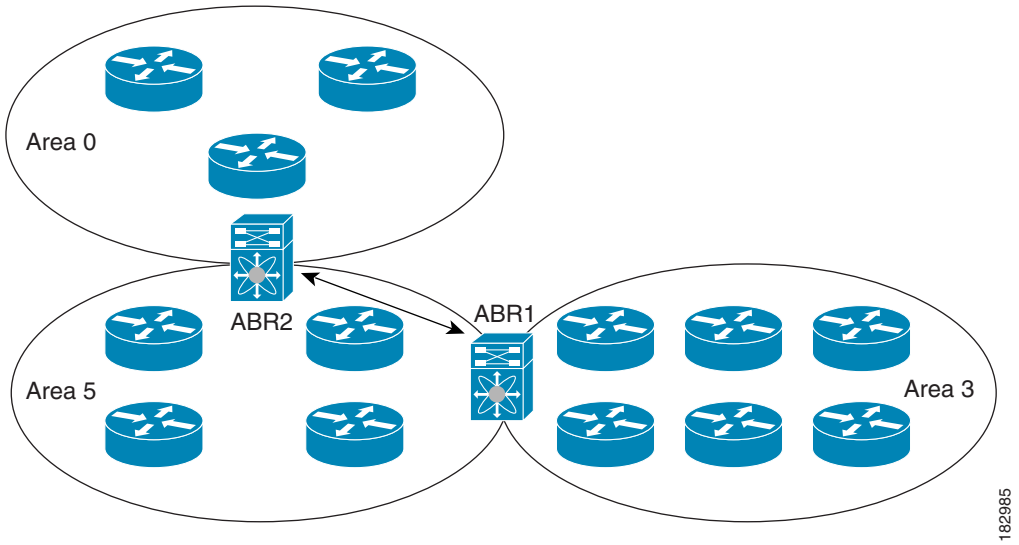
to cover the remote connection by defining the area between the corporate router and remote router as an NSSA (see the "Configuring NSSA" section on page 6-28).

The backbone Area 0 cannot be an NSSA.

Virtual Links

Virtual links allow you to connect an OSPFv3 area ABR to a backbone area ABR when a direct physical connection is not available. Figure 6-4 shows a virtual link that connects Area 3 to the backbone area through Area 5.

Figure 6-4 Virtual Links



You can also use virtual links to temporarily recover from a partitioned area, which occurs when a link within the area fails, isolating part of the area from reaching the designated ABR to the backbone area.

Route Redistribution

OSPFv3 can learn routes from other routing protocols by using route redistribution. See the "Route Redistribution" section on page 1-6. You configure OSPFv3 to assign a link cost for these redistributed routes or a default link cost for all redistributed routes.

Route redistribution uses route maps to control which external routes are redistributed. You must configure a route map with the redistribution to control which routes are passed into OSPFv2. A route map allows you to filter routes based on attributes such as the destination, origination protocol, route type, route tag, and so on. You can use route maps to modify parameters in the AS External (type 5) and NSSA External (type 7) LSAs before these external routes are advertised in the local OSPFv3 autonomous system. For more information, see Chapter 15, "Configuring Route Policy Manager."

Route Summarization

Because OSPFv3 shares all learned routes with every OSPF-enabled router, you might want to use route summarization to reduce the number of unique routes that are flooded to every OSPF-enabled router. Route summarization simplifies route tables by replacing more-specific addresses with an address that represents all the specific addresses. For example, you can replace 2010:11:22:0:1000::1 and 2010:11:22:0:2000:679:1 with one summary address, 2010:11:22::/32.

Typically, you would summarize at the boundaries of area border routers (ABRs). Although you could configure summarization between any two areas, it is better to summarize in the direction of the backbone so that the backbone receives all the aggregate addresses and injects them, already summarized, into other areas. The two types of summarization are as follows:

- Inter-area route summarization
- External route summarization

You configure inter-area route summarization on ABRs, summarizing routes between areas in the autonomous system. To take advantage of summarization, assign network numbers in areas in a contiguous way to be able to lump these addresses into one range.

External route summarization is specific to external routes that are injected into OSPFv3 using route redistribution. You should make sure that external ranges that are being summarized are contiguous. Summarizing overlapping ranges from two different routers could cause packets to be sent to the wrong destination. Configure external route summarization on ASBRs that are redistributing routes into OSPF.

When you configure a summary address, Cisco NX-OS automatically configures a discard route for the summary address to prevent routing black holes and route loops.

High Availability and Graceful Restart

Cisco NX-OS provides a multilevel high-availability architecture. OSPFv3 supports stateful restart, which is also referred to as non-stop routing (NSR). If OSPFv3 experiences problems, it attempts to restart from its previous run-time state. The neighbors do not register any neighbor event in this case. If the first restart is not successful and another problem occurs, OSPFv3 attempts a graceful restart.

A graceful restart, or non-stop forwarding (NSF), allows OSPFv3 to remain in the data forwarding path through a process restart. When OSPFv3 needs to perform a graceful restart, it sends a link-local Grace (type 11) LSA. This restarting OSPFv3 platform is called NSF capable.

The Grace LSA includes a grace period, which is a specified time that the neighbor OSPFv3 interfaces hold onto the LSAs from the restarting OSPFv3 interface. (Typically, OSPFv3 tears down the adjacency and discards all LSAs from a down or restarting OSPFv3 interface.) The participating neighbors, which are called NSF helpers, keep all LSAs that originate from the restarting OSPFv3 interface as if the interface was still adjacent.

When the restarting OSPFv3 interface is operational again, it rediscovers its neighbors, establishes adjacency, and starts sending its LSA updates again. At this point, the NSF helpers recognize that the graceful restart has finished.

Stateful restart is used in the following scenarios:

- First recovery attempt after the process experiences problems
- User-initiated switchover using the **system switchover** command

Graceful restart is used in the following scenarios:

- Second recovery attempt after the process experiences problems within a 4-minute interval
- Manual restart of the process using the **restart ospfv3** command

- Active supervisor removal
- Active supervisor reload using the **reload module** *active-sup* command

Multiple OSPFv3 Instances

Cisco NX-OS supports multiple instances of the OSPFv3 protocol. By default, every instance uses the same system router ID. You must manually configure the router ID for each instance if the instances are in the same OSPFv3 autonomous system. For the number of supported OSPFv3 instances, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

The OSPFv3 header includes an instance ID field to identify that OSPFv3 packet for a particular OSPFv3 instance. You can assign the OSPFv3 instance. The interface drops all OSPFv3 packets that do not have a matching OSPFv3 instance ID in the packet header.

Cisco NX-OS allows only one OSPFv3 instance on an interface.

SPF Optimization

Cisco NX-OS optimizes the SPF algorithm in the following ways:

- Partial SPF for Network (type 2) LSAs, Inter-Area Prefix (type 3) LSAs, and AS External (type 5) LSAs—When there is a change on any of these LSAs, Cisco NX-OS performs a faster partial calculation rather than running the whole SPF calculation.
- SPF timers—You can configure different timers for controlling SPF calculations. These timers include exponential backoff for subsequent SPF calculations. The exponential backoff limits the CPU load of multiple SPF calculations.

BFD

This feature supports bidirectional forwarding detection (BFD) for IPv6. BFD is a detection protocol that provides fast forwarding-path failure detection times. BFD provides subsecond failure detection between two adjacent devices and can be less CPU-intensive than protocol hello messages because some of the BFD load can be distributed onto the data plane on supported modules. See the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide* for more information.

Virtualization Support

Cisco NX-OS supports multiple process instances for OSPFv3. Each OSPFv3 instance can support multiple virtual routing and forwarding (VRF) instances, up to the system limit. For the number of supported OSPFv3 instances, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

Licensing Requirements for OSPFv3

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	OSPFv3 requires an Enterprise Services license. For a complete explanation of the Cisco NX-OS licensing scheme and how to obtain and apply licenses, see the *Cisco NX-OS Licensing Guide.*

Prerequisites for OSPFv3

OSPFv3 has the following prerequisites:

- You must be familiar with routing fundamentals to configure OSPFv3.
- You must be logged on to the switch.
- You have configured at least one interface for IPv6 that is capable of communicating with a remote OSPFv3 neighbor.
- You have installed the Enterprise Services license.
- You have completed the OSPFv3 network strategy and planning for your network. For example, you must decide whether multiple areas are required.
- You have enabled OSPF (see the "Enabling OSPFv3" section on page 6-16).
- You are familiar with IPv6 addressing and basic configuration. See Chapter 3, "Configuring IPv6" for information on IPv6 routing and addressing.

Guidelines and Limitations for OSPFv3

OSPFv3 has the following configuration guidelines and limitations:

- Cisco NX-OS displays areas in dotted decimal notation regardless of whether you enter the area in decimal or dotted decimal notation.
- If you configure OSPFv3 in a virtual port channel (vPC) environment, use the following timer commands in router configuration mode on the core switch to ensure fast OSPF convergence when a vPC peer link is shut down:

```
switch (config-router)# timers throttle spf 1 50 50
switch (config-router)# timers lsa-arrival 10
```

- In scaled scenarios, when the number of interfaces and link-state advertisements in an OSPF process is large, the snmp-walk on OSPF MIB objects is expected to time out with a small-values timeout at the SNMP agent. If your observe a timeout on the querying SNMP agent while polling OSPF MIB objects, increase the timeout value on the polling SNMP agent.
- The following guidelines and limitations apply to the administrative distance feature:
  - When an OSPF route has two or more equal cost paths, configuring the administrative distance is non-deterministic for the **match ip route-source** command.
  - For matching route sources in OSPFv3 routes, you must configure **match ip route-source** instead of **match ipv6 route-source** because the route sources and router IDs for OSPFv3 are IPv4 addresses.
  - Configuring the administrative distance is supported only for the **match route-type**, **match ipv6 address prefix-list**, and **match ip route-source prefix-list** commands. The other match statements are ignored.
  - The discard route is always assigned an administrative distance of 220. No configuration in the table map applies to OSPF discard routes.
  - There is no preference among the **match route-type**, **match ipv6 address**, and **match ip route-source** commands for setting the administrative distance of OSPF routes. In this way, the behavior of the table map for setting the administrative distance in Cisco NX-OS OSPF is different from that in Cisco IOS OSPF.

- If you configure the **delay restore** *seconds* command in vPC configuration mode and if the VLANs on the multichassis EtherChannel trunk (MCT) are announced by OSPFv2 or OSPFv3 using switch virtual interfaces (SVIs), those SVIs are announced with MAX_LINK_COST on the vPC secondary node for the duration of the configured time. As a result, all route or host programming completes after the vPC synchronization operation (on a peer reload of the secondary vPC node) before attracting traffic. This behavior allows for minimal packet loss for any north-to-south traffic.

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Default Settings

Table 6-2 lists the default settings for OSPFv3 parameters.

Table 6-2 Default OSPFv3 Parameters

Parameters	Default
Administrative distance	110
Hello interval	10 seconds
Dead interval	40 seconds
Discard routes	Enabled
Graceful restart grace period	60 seconds
Graceful restart notify period	15 seconds
OSPFv3 feature	Disabled
Stub router advertisement announce time	600 seconds
Reference bandwidth for link cost calculation	40 Gb/s
LSA minimal arrival time	1000 milliseconds
LSA group pacing	10 seconds
SPF calculation initial delay time	0 milliseconds
SPF calculation hold time	5000 milliseconds
SPF calculation initial delay time	0 milliseconds

Configuring Basic OSPFv3

Configure OSPFv3 after you have designed your OSPFv3 network.

This section includes the following topics:

Enabling OSPFv3

You must enable OSPFv3 before you can configure OSPFv3.

SUMMARY STEPS

1. **configure terminal**
2. **feature ospfv3**
3. (Optional) **show feature**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**feature ospfv3** **Example:** `switch(config)# feature ospfv3`	Enables OSPFv3.
Step 3	**show feature** **Example:** `switch(config)# show feature`	(Optional) Displays enabled and disabled features.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

To disable the OSPFv3 feature and remove all associated configuration, use the following command in global configuration mode:

Command	Purpose
no feature ospfv3 **Example:** `switch(config)# no feature ospfv3`	Disables the OSPFv3 feature and removes all associated configuration.

Creating an OSPFv3 Instance

The first step in configuring OSPFv3 is to create an instance or OSPFv3 instance. You assign a unique instance tag for this OSPFv3 instance. The instance tag can be any string. For each OSPFv3 instance, you can also configure the following optional parameters:

- Router ID—Configures the router ID for this OSPFv3 instance. If you do not use this parameter, the router ID selection algorithm is used. For more information, see the "Router IDs" section on page 1-5.
- Administrative distance—Rates the trustworthiness of a routing information source. For more information, see the "Administrative Distance" section on page 1-7.
- Log adjacency changes—Creates a system message whenever an OSPFv3 neighbor changes its state.
- Name lookup—Translates OSPF router IDs to hostnames, either by looking up the local hosts database or querying DNS names in IPv6.
- Maximum paths—Sets the maximum number of equal paths that OSPFv3 installs in the route table for a particular destination. Use this parameter for load balancing between multiple paths.
- Reference bandwidth—Controls the calculated OSPFv3 cost metric for a network. The calculated cost is the reference bandwidth divided by the interface bandwidth. You can override the calculated cost by assigning a link cost when a network is added to the OSPFv3 instance. For more information, see the "Configuring Networks in OSPFv3" section on page 6-19.

For more information about OSPFv3 instance parameters, see the "Configuring Advanced OSPFv3" section on page 6-24.

BEFORE YOU BEGIN

You must enable OSPFv3 (see the "Enabling OSPFv3" section on page 6-16).

Ensure that the OSPFv3 instance tag that you plan on using is not already in use on this router.

Use the **show ospfv3** *instance-tag* command to verify that the instance tag is not in use.

OSPFv3 must be able to obtain a router identifier (for example, a configured loopback address) or you must configure the router ID option.

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. (Optional) **router-id** *ip-address*
4. (Optional) **show ipv6 ospfv3** *instance-tag*
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.

	Command	Purpose
Step 3	**router-id** *ip-address* **Example:** `switch(config-router)# router-id 192.0.2.1`	(Optional) Configures the OSPFv3 router ID. This ID uses the dotted decimal notation and identifies this OSPFv3 instance and must exist on a configured interface in the system.
Step 4	**show ipv6 ospfv3** *instance-tag* **Example**: `switch(config-router)# show ipv6 ospfv3 201`	(Optional) Displays OSPFv3 information.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

To remove the OSPFv3 instance and all associated configuration, use the following command in configuration mode:

Command	Purpose
no router ospfv3 *instance-tag* **Example:** `switch(config)# no router ospfv3 201`	Deletes the OSPFv3 instance and all associated configuration.

Note This command does not remove OSPF configuration in interface mode. You must manually remove any OSPFv3 commands configured in interface mode.

You can configure the following optional parameters for OSPFv3 in router configuration mode:

Command	Purpose
log-adjacency-changes [**detail**] **Example:** `switch(config-router)# log-adjacency-changes`	Generates a system message whenever a neighbor changes state.
passive-interface default **Example:** `switch(config-router)# passive-interface default`	Suppresses routing updates on all interfaces. This command is overridden by the VRF or interface command mode configuration.

You can configure the following optional parameters for OSPFv3 in address family configuration mode:

Command	Purpose
distance *number* **Example:** `switch(config-router-af)# distance 25`	Configures the administrative distance for this OSPFv3 instance. The range is from 1 to 255. The default is 110.
maximum-paths *paths* **Example:** `switch(config-router-af)# maximum-paths 4`	Configures the maximum number of equal OSPFv3 paths to a destination in the route table. This command is used for load balancing. The range is from 1 to 64. The default is 8.

This example shows how to create an OSPFv3 instance:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# copy running-config startup-config
```

Configuring Networks in OSPFv3

You can configure a network to OSPFv3 by associating it through the interface that the router uses to connect to that network (see the "Neighbors" section on page 6-3). You can add all networks to the default backbone area (Area 0), or you can create new areas using any decimal number or an IP address.

Note All areas must connect to the backbone area either directly or through a virtual link.

Note OSPFv3 is not enabled on an interface until you configure a valid IPv6 address for that interface.

BEFORE YOU BEGIN

You must enable OSPFv3 (see the "Enabling OSPFv3" section on page 6-16).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **ipv6 address** *ipv6-prefix/length*
4. **ipv6 router ospfv3** *instance-tag* **area** *area-id* [**secondaries none**]
5. (Optional) **show ipv6 ospfv3** *instance-tag* **interface** *interface-type slot/port*
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ipv6 address** *ipv6-prefix/length* **Example:** `switch(config-if)# ipv6 address 2001:0DB8::1/48`	Assigns an IPv6 address to this interface.
Step 4	**ipv6 router ospfv3** *instance-tag* **area** *area-id* [**secondaries none**] **Example:** `switch(config-if)# ipv6 router ospfv3 201 area 0`	Adds the interface to the OSPFv3 instance and area.
Step 5	**show ipv6 ospfv3** *instance-tag* **interface** *interface-type slot/port* **Example**: `switch(config-if)# show ipv6 ospfv3 201 interface ethernet 1/2`	(Optional) Displays OSPFv3 information.
Step 6	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

You can configure the following optional parameters for OSPFv3 in interface configuration mode:

Command	Purpose
ospfv3 cost *number* **Example:** `switch(config-if)# ospfv3 cost 25`	Configures the OSPFv3 cost metric for this interface. The default is to calculate a cost metric, based on the reference bandwidth and interface bandwidth. The range is from 1 to 65535.
ospfv3 dead-interval *seconds* **Example:** `switch(config-if)# ospfv3 dead-interval 50`	Configures the OSPFv3 dead interval, in seconds. The range is from 1 to 65535. The default is four times the hello interval, in seconds.
ospfv3 hello-interval *seconds* **Example:** `switch(config-if)# ospfv3 hello-interval 25`	Configures the OSPFv3 hello interval, in seconds. The range is from 1 to 65535. The default is 10 seconds.

Command	Purpose
ospfv3 instance *instance* **Example:** switch(config-if)# ospfv3 instance 25	Configures the OSPFv3 instance ID. The range is from 0 to 255. The default is 0. The instance ID is link-local in scope.
ospfv3 mtu-ignore **Example:** switch(config-if)# ospfv3 mtu-ignore	Configures OSPFv3 to ignore any IP maximum transmission unit (MTU) mismatch with a neighbor. The default is to not establish adjacency if the neighbor MTU does not match the local interface MTU.
ospfv3 network {**broadcast** | **point-point**} **Example:** switch(config-if)# ospfv3 network broadcast	Sets the OSPFv3 network type.
[**default** | **no**] **ospfv3 passive-interface** **Example:** switch(config-if)# ospfv3 passive-interface	Suppresses routing updates on the interface. This command overrides the router or VRF command mode configuration. The **default** option removes this interface mode command and reverts to the router or VRF configuration, if present.
ospfv3 priority *number* **Example:** switch(config-if)# ospfv3 priority 25	Configures the OSPFv3 priority, used to determine the DR for an area. The range is from 0 to 255. The default is 1. See the "Designated Routers" section on page 6-4.
ospfv3 shutdown **Example:** switch(config-if)# ospfv3 shutdown	Shuts down the OSPFv3 instance on this interface.

This example shows how to add a network area 0.0.0.10 in OSPFv3 instance 201:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# ipv6 address 2001:0DB8::1/48
switch(config-if)# ipv6 ospfv3 201 area 0.0.0.10
switch(config-if)# copy running-config startup-config
```

Configuring OSPFv3 IPSec Authentication

You can configure OSPFv3 IP security (IPSec) authentication for a process, an area, and/or an interface.

The authentication configuration is inherited from process to area to interface level. If authentication is configured at all three levels, the interface configuration takes precedence over the process and area configurations.

BEFORE YOU BEGIN

Ensure that you have enabled OSPFv3 (see the "Enabling OSPFv3" section on page 6-16).

Ensure that you have enabled the Internet messaging program (IMP) using the **feature imp** command.

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **exit**
4. **authentication ipsec spi** *spi auth* [**0** | **3** | **7**] *key*

   or

   area *area* **authentication ipsec spi** *spi auth* [**0** | **3** | **7**] *key*

   or

   interface *interface-type slot/port*

   ospfv3 authentication ipsec spi *spi auth* [**0** | **3** | **7**] *key*
5. (Optional) **show ospfv3** *process*
6. (Optional) **show ospfv3 interface** *interface-type slot/port*
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 100` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**exit** **Example:** `switch(config-router)# exit` `switch(config)#`	Exits OSPFv3 router configuration mode.

	Command	Purpose
Step 4	**authentication ipsec spi** *spi auth* [**0** | **3** | **7**] *key* **Example:** `switch(config)# authentication ipsec spi 475 md5 11111111111111112222222222222222`	Configures OSPFv3 IPSec authentication at the process (or VRF) level. The *spi* argument specifies the security parameter index (SPI). The range is from 256 to 4294967295. The *auth* argument specifies the type of authentication. The supported values are md5 or sha1. 0 configures the password in cleartext. 3 configures the pass key as 3DES encrypted. 7 configures the key as Cisco type 7 encrypted. If the cleartext option (0) is used, the *key* argument must be 32 characters long for md5 or 40 characters long for sha1.
	area *area* **authentication ipsec spi** *spi auth* [**0** | **3** | **7**] *key* **Example:** `switch(config)# area 0 authentication ipsec spi 475 md5 11111111111111112222222222222222`	Configures OSPFv3 IPSec authentication at the area level. The *spi* argument specifies the security parameter index (SPI). The range is from 256 to 4294967295. The *auth* argument specifies the type of authentication. The supported values are md5 or sha1. 0 configures the password in cleartext. 3 configures the pass key as 3DES encrypted. 7 configures the key as Cisco type 7 encrypted. If the cleartext option (0) is used, the *key* argument must be 32 characters long for md5 or 40 characters long for sha1. **Note** Use the **area** *area* **authentication disable** command to disable OSPFv3 IPSec authentication at the area level.
	interface *interface-type slot/port* **ospfv3 authentication ipsec spi** *spi auth* [**0** | **3** | **7**] *key* **Example:** `switch(config)# interface ethernet 1/1` `switch(config-if)# ospfv3 authentication ipsec spi 475 md5 11111111111111112222222222222222`	Configures OSPFv3 IPSec authentication for the specified interface. The *spi* argument specifies the security parameter index (SPI). The range is from 256 to 4294967295. The *auth* argument specifies the type of authentication. The supported values are md5 or sha1. 0 configures the password in cleartext. 3 configures the pass key as 3DES encrypted. 7 configures the key as Cisco type 7 encrypted. If the cleartext option (0) is used, the *key* argument must be 32 characters long for md5 or 40 characters long for sha1. **Note** Use the **ospfv3 authentication disable** command to disable OSPFv3 IPSec authentication for the specified interface.

	Command	Purpose
Step 5	**show ospfv3** *process* **Example:** switch(config)# show ospfv3 100	(Optional) Displays the OSPFv3 authentication configuration at the process level.
Step 6	**show ospfv3 interface** *interface-type slot/port* **Example:** switch(config)# show ospfv3 interface ethernet 1/1	(Optional) Displays the OSPFv3 authentication configuration at the interface level.
Step 7	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

Configuring Advanced OSPFv3

Configure OSPFv3 after you have designed your OSPFv3 network.

This section includes the following topics:

Configuring Filter Lists for Border Routers

You can separate your OSPFv3 domain into a series of areas that contain related networks. All areas must connect to the backbone area through an area border router (ABR). OSPFv3 domains can connect to external domains as well through an autonomous system border router (ASBR). See the "Areas" section on page 6-5.

ABRs have the following optional configuration parameters:

- Area range—Configures route summarization between areas. For more information, see the "Configuring Route Summarization" section on page 6-37.
- Filter list—Filters the Inter-Area Prefix (type 3) LSAs on an ABR that are allowed in from an external area.

ASBRs also support filter lists.

BEFORE YOU BEGIN

Create the route map that the filter list uses to filter IP prefixes in incoming or outgoing Inter-Area Prefix (type 3) LSAs. See Chapter 15, "Configuring Route Policy Manager."

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **address-family ipv6 unicast**
4. **area** *area-id* **filter-list route-map** *map-name* **{in | out}**
5. (Optional) **show ipv6 ospfv3 policy statistics area** *id* **filter-list** {**in** | **out**}
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**address-family ipv6 unicast** **Example:** `switch(config-router)# address-family ipv6 unicast` `switch(config-router-af)#`	Enters IPv6 unicast address family mode.
Step 4	**area** *area-id* **filter-list route-map** *map-name* {**in** | **out**} **Example:** `switch(config-router-af)# area 0.0.0.10 filter-list route-map FilterLSAs in`	Filters incoming or outgoing Inter-Area Prefix (type 3) LSAs on an ABR.

	Command	Purpose
Step 5	**show ipv6 ospfv3 policy statistics area** *id* **filter-list** {**in** | **out**} **Example:** switch(config-if)# show ipv6 ospfv3 policy statistics area 0.0.0.10 filter-list in	(Optional) Displays OSPFv3 policy information.
Step 6	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to enable graceful restart if it has been disabled:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# address-family ipv6 unicast
switch(config-router-af)# area 0.0.0.10 filter-list route-map FilterLSAs in
switch(config-router-af)# copy running-config startup-config
```

Configuring Stub Areas

You can configure a stub area for part of an OSPFv3 domain where external traffic is not necessary. Stub areas block AS External (type 5) LSAs, limiting unnecessary routing to and from selected networks. See the "Stub Area" section on page 6-10. You can optionally block all summary routes from going into the stub area.

BEFORE YOU BEGIN

You must enable OSPF (see the "Enabling OSPFv3" section on page 6-16).

Ensure that there are no virtual links or ASBRs in the proposed stub area.

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **area** *area-id* **stub**
4. (Optional) **address-family ipv6 unicast**
5. (Optional) **area** *area-id* **default-cost** *cost*
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**area** *area-id* **stub** **Example:** `switch(config-router)# area 0.0.0.10 stub`	Creates this area as a stub area.
Step 4	**address-family ipv6 unicast** **Example:** `switch(config-router)# address-family ipv6 unicast` `switch(config-router-af)#`	(Optional) Enters IPv6 unicast address family mode.
Step 5	**area** *area-id* **default-cost** *cost* **Example:** `switch(config-router-af)# area 0.0.0.10 default-cost 25`	(Optional) Sets the cost metric for the default summary route sent into this stub area. The range is from 0 to 16777215.
Step 6	**copy running-config startup-config** **Example:** `switch(config-router)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to create a stub area that blocks all summary route updates:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# area 0.0.0.10 stub no-summary
switch(config-router)# copy running-config startup-config
```

Configuring a Totally Stubby Area

You can create a totally stubby area and prevent all summary route updates from going into the stub area.

To create a totally stubby area, use the following command in router configuration mode:

Command	Purpose
area *area-id* **stub no-summary** **Example:** `switch(config-router)# area 20 stub no-summary`	Creates this area as a totally stubby area.

Configuring NSSA

You can configure an NSSA for part of an OSPFv3 domain where limited external traffic is required. See the "Not-So-Stubby Area" section on page 6-10. You can optionally translate this external traffic to an AS External (type 5) LSA and flood the OSPFv3 domain with this routing information. An NSSA can be configured with the following optional parameters:

- No redistribution—Redistributes routes that bypass the NSSA to other areas in the OSPFv3 autonomous system. Use this option when the NSSA ASBR is also an ABR.
- Default information originate—Generates a Type-7 LSA for a default route to the external autonomous system. Use this option on an NSSA ASBR if the ASBR contains the default route in the routing table. This option can be used on an NSSA ABR whether or not the ABR contains the default route in the routing table.
- Route map—Filters the external routes so that only those routes you want are flooded throughout the NSSA and other areas.
- Translate—Translates Type-7 LSAs to AS External (type 5) LSAs for areas outside the NSSA. Use this command on an NSSA ABR to flood the redistributed routes throughout the OSPFv3 autonomous system. You can optionally suppress the forwarding address in these AS External LSAs.
- No summary—Blocks all summary routes from flooding the NSSA. Use this option on the NSSA ABR.

BEFORE YOU BEGIN

You must enable OSPF (see the "Enabling OSPFv3" section on page 6-16).

Ensure that there are no virtual links in the proposed NSSA and that it is not the backbone area.

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **area** *area-id* **nssa** [**no-redistribution**] [**default-information-originate**] [**route-map** *map-name*] [**no-summary**] [**translate type7** {**always** | **never**} [**suppress-fa**]]
4. (Optional) **address-family ipv6 unicast**
5. (Optional) **area** *area-id* **default-cost** *cost*
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** switch(config)# router ospfv3 201 switch(config-router)#	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**area** *area-id* **nssa** [**no-redistribution**] [**default-information-originate**] [**route-map** *map-name] [no*-**summary**] [**translate type7** {**always** | **never**} [**suppress-fa**]] **Example:** switch(config-router)# area 0.0.0.10 nssa	Creates this area as an NSSA.
Step 4	**address-family ipv6 unicast** **Example:** switch(config-router)# address-family ipv6 unicast switch(config-router-af)#	(Optional) Enters IPv6 unicast address family mode.
Step 5	**area** *area-id* **default-cost** *cost* **Example:** switch(config-router-af)# area 0.0.0.10 default-cost 25	(Optional) Sets the cost metric for the default summary route sent into this NSSA. The range is from 0 to 16777215.
Step 6	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create an NSSA that blocks all summary route updates:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# area 0.0.0.10 nssa no-summary
switch(config-router)# copy running-config startup-config
```

This example shows how to create an NSSA that generates a default route:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# area 0.0.0.10 nssa default-info-originate
switch(config-router)# copy running-config startup-config
```

This example shows how to create an NSSA that filters external routes and blocks all summary route updates:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# area 0.0.0.10 nssa route-map ExternalFilter no-summary
switch(config-router)# copy running-config startup-config
```

This example shows how to create an NSSA that always translates Type-7 LSAs to AS External (type 5) LSAs:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# area 0.0.0.10 nssa translate type 7 always
switch(config-router)# copy running-config startup-config
```

This example shows how to create an NSSA that blocks all summary route updates:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# area 0.0.0.10 nssa no-summary
switch(config-router)# copy running-config startup-config
```

Configuring Multi-Area Adjacency

You can add more than one area to an existing OSPFv3 interface. The additional logical interfaces support multi-area adjacency.

BEFORE YOU BEGIN

You must enable OSPFv3 (see the "Enabling OSPFv3" section on page 6-16).

Ensure that you have configured a primary area for the interface (see the "Configuring Networks in OSPFv3" section on page 6-19).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **ipv6 router ospfv3** [*instance-tag*] **multi-area** *area-id*
4. (Optional) **show ipv6 ospfv3** *instance-tag* **interface** *interface-type slot/port*
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** switch(config)# interface ethernet 1/2 switch(config-if)#	Enters interface configuration mode.
Step 3	**ipv6 router ospfv3** [*instance-tag*] **multi-area** *area-id* **Example:** switch(config-if)# ipv6 router ospfv3 201 multi-area 3	Adds the interface to another area. **Note** Beginning with Cisco NX-OS Release 7.0(3)I5(1), the *instance-tag* argument is optional. If you do not specify an instance, the multi-area configuration is applied to the same instance that is configured for the primary area on that interface.
Step 4	**show ipv6 ospfv3** *instance-tag* **interface** *interface-type slot/port* **Example**: switch(config-if)# show ipv6 ospfv3 201 interface ethernet 1/2	(Optional) Displays OSPFv3 information.
Step 5	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to add a second area to an OSPFv3 interface:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# ipv6 address 2001:0DB8::1/48
switch(config-if)# ipv6 router ospfv3 201 area 0.0.0.10
switch(config-if)# ipv6 router ospfv3 201 multi-area 20
switch(config-if)# copy running-config startup-config
```

Configuring Virtual Links

A virtual link connects an isolated area to the backbone area through an intermediate area. See the "Virtual Links" section on page 6-11. You can configure the following optional parameters for a virtual link:

- Dead interval—Sets the time that a neighbor waits for a Hello packet before declaring the local router as dead and tearing down adjacencies.
- Hello interval—Sets the time between successive Hello packets.
- Retransmit interval—Sets the estimated time between successive LSAs.
- Transmit delay—Sets the estimated time to transmit an LSA to a neighbor.

Note You must configure the virtual link on both routers involved before the link becomes active.

BEFORE YOU BEGIN

You must enable OSPF (see the "Enabling OSPFv3" section on page 6-16).

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **area** *area-id* **virtual-link** *router-id*
4. (Optional) **show ipv6 ospfv3 virtual-link** [**brief**]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**area** *area-id* **virtual-link** *router-id* **Example:** `switch(config-router)# area 0.0.0.10 virtual-link 2001:0DB8::1` `switch(config-router-vlink)#`	Creates one end of a virtual link to a remote router. You must create the virtual link on that remote router to complete the link.
Step 4	**show ipv6 ospfv3 virtual-link** [**brief**] **Example:** `switch(config-if)# show ipv6 ospfv3 virtual-link`	(Optional) Displays OSPFv3 virtual link information.
Step 5	**copy running-config startup-config** **Example:** `switch(config-router)# copy running-config startup-config`	(Optional) Saves this configuration change.

You can configure the following optional commands in virtual link configuration mode:

Command	Purpose
dead-interval *seconds* **Example**: `switch(config-router-vlink)# dead-interval 50`	(Optional) Configures the OSPFv3 dead interval, in seconds. The range is from 1 to 65535. The default is four times the hello interval, in seconds.
hello-interval *seconds* **Example:** `switch(config-router-vlink)# hello-interval 25`	(Optional) Configures the OSPFv3 hello interval, in seconds. The range is from 1 to 65535. The default is 10 seconds.
retransmit-interval *seconds* **Example**: `switch(config-router-vlink)# retransmit-interval 50`	(Optional) Configures the OSPFv3 retransmit interval, in seconds. The range is from 1 to 65535. The default is 5.
transmit-delay *seconds* **Example:** `switch(config-router-vlink)# transmit-delay 2`	(Optional) Configures the OSPFv3 transmit-delay, in seconds. The range is from 1 to 450. The default is 1.

These examples show how to create a simple virtual link between two ABRs:

Configuration for ABR 1 (router ID 2001:0DB8::1) is as follows:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# area 0.0.0.10 virtual-link 2001:0DB8::10
switch(config-router)# copy running-config startup-config
```

Configuration for ABR 2 (router ID 2001:0DB8::10) is as follows:

```
switch# configure terminal
switch(config)# router ospf 101
switch(config-router)# area 0.0.0.10 virtual-link 2001:0DB8::1
switch(config-router)# copy running-config startup-config
```

Configuring Redistribution

You can redistribute routes learned from other routing protocols into an OSPFv3 autonomous system through the ASBR.

You can configure the following optional parameters for route redistribution in OSPF:

- Default information originate—Generates an AS External (type 5) LSA for a default route to the external autonomous system.

Note Default information originate ignores **match** statements in the optional route map.

- Default metric—Sets all redistributed routes to the same cost metric.

Note If you redistribute static routes, Cisco NX-OS also redistributes the default static route.

BEFORE YOU BEGIN

Create the necessary route maps used for redistribution.

You must enable OSPF (see the "Enabling OSPFv3" section on page 6-16).

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **address-family ipv6 unicast**
4. **redistribute** {**bgp** *id* | **direct** | **isis** *id* | **rip** *id* | **static**} **route-map** *map-name*
5. **default-information originate** [**always**] [**route-map** *map-name*]
6. **default-metric** *cost*
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**address-family ipv6 unicast** **Example:** `switch(config-router)# address-family ipv6 unicast` `switch(config-router-af)#`	Enters IPv6 unicast address family mode.
Step 4	**redistribute** {**bgp** *id* | **direct** | **isis** *id* | **rip** *id* | **static**} **route-map** *map-name* **Example:** `switch(config-router-af)# redistribute bgp route-map FilterExternalBGP`	Redistributes the selected protocol into OSPFv3 through the configured route map. **Note** If you redistribute static routes, Cisco NX-OS also redistributes the default static route.

	Command	Purpose
Step 5	**default-information originate** [**always**] [**route-map** map-name] **Example:** switch(config-router-af)# default-information-originate route-map DefaultRouteFilter	Creates a default route into this OSPFv3 domain if the default route exists in the RIB. Use the following optional keywords: • **always** —Always generates the default route of 0.0.0. even if the route does not exist in the RIB. • **route-map**—Generates the default route if the route map returns true. **Note** This command ignores **match** statements in the route map.
Step 6	**default-metric** *cost* **Example:** switch(config-router-af)# default-metric 25	Sets the cost metric for the redistributed routes. The range is from 1 to 16777214. This command does not apply to directly connected routes. Use a route map to set the default metric for directly connected routes.
Step 7	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to redistribute the Border Gateway Protocol (BGP) into OSPFv3:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# address-family ipv6 unicast
switch(config-router-af)# redistribute bgp route-map FilterExternalBGP
switch(config-router-af)# copy running-config startup-config
```

Limiting the Number of Redistributed Routes

Route redistribution can add many routes to the OSPFv3 route table. You can configure a maximum limit to the number of routes accepted from external protocols. OSPFv3 provides the following options to configure redistributed route limits:

- Fixed limit—Logs a message when OSPFv3 reaches the configured maximum. OSPFv3 does not accept any more redistributed routes. You can optionally configure a threshold percentage of the maximum where OSPFv3 logs a warning when that threshold is passed.
- Warning only—Logs a warning only when OSPFv3 reaches the maximum. OSPFv3 continues to accept redistributed routes.
- Withdraw—Starts the configured timeout period when OSPFv3 reaches the maximum. After the timeout period, OSPFv3 requests all redistributed routes if the current number of redistributed routes is less than the maximum limit. If the current number of redistributed routes is at the maximum limit, OSPFv3 withdraws all redistributed routes. You must clear this condition before OSPFv3 accepts more redistributed routes. You can optionally configure the timeout period.

BEFORE YOU BEGIN

You must enable OSPF (see the "Enabling OSPFv3" section on page 6-16).

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **address-family ipv6 unicast**
4. **redistribute** {**bgp** *id* | **direct** | **isis** *id* | **rip** *id* | **static**} **route-map** *map-name*
5. **redistribute maximum-prefix** *max* [*threshold*] [**warning-only** | **withdraw** [*num-retries timeout*]]
6. (Optional) **show running-config ospfv3**
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**address-family ipv6 unicast** **Example:** `switch(config-router)# address-family ipv6 unicast` `switch(config-router-af)#`	Enters IPv6 unicast address family mode.
Step 4	**redistribute** {**bgp** *id* | **direct** | **isis** *id* | **rip** *id* | **static**} **route-map** *map-name* **Example:** `switch(config-router-af)# redistribute bgp route-map FilterExternalBGP`	Redistributes the selected protocol into OSPFv3 through the configured route map.
Step 5	**redistribute maximum-prefix** *max* [*threshold*] [**warning-only** | **withdraw** [*num-retries timemout*]] **Example:** `switch(config-router)# redistribute maximum-prefix 1000 75 warning-only`	Specifies a maximum number of prefixes that OSPFv2 distributes. The range is from 1 to 65535. Optionally, specifies the following: • *threshold*—Percentage of maximum prefixes that triggers a warning message. • **warning-only**—Logs an warning message when the maximum number of prefixes is exceeded. • **withdraw**—Withdraws all redistributed routes and optionally tries to retrieve the redistributed routes. The *num-retries* range is from 1 to 12. The *timeout* range is from 60 to 600 seconds. The default is 300 seconds.

	Command	Purpose
Step 6	**show running-config ospfv3** **Example:** switch(config-router)# show running-config ospf	(Optional) Displays the OSPFv3 configuration.
Step 7	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to limit the number of redistributed routes into OSPF:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# address-family ipv6 unicast
switch(config-router-af)# redistribute bgp route-map FilterExternalBGP
switch(config-router-af)# redistribute maximum-prefix 1000 75
```

Configuring Route Summarization

You can configure route summarization for inter-area routes by configuring an address range that is summarized. You can also configure route summarization for external, redistributed routes by configuring a summary address for those routes on an ASBR. For more information, see the "Route Summarization" section on page 6-12.

BEFORE YOU BEGIN

You must enable OSPF (see the "Enabling OSPFv3" section on page 6-16).

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **address-family ipv6 unicast**
4. **area** *area-id* **range** *ipv6-prefix/length* [**no-advertise**] [**cost** *cost*]

   or
5. **summary-address** *ipv6-prefix/length* [**no-advertise**] [**tag** *tag*]
6. (Optional) **show ipv6 ospfv3 summary-address**
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** switch(config)# router ospfv3 201 switch(config-router)#	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**address-family ipv6 unicast** **Example:** switch(config-router)# address-family ipv6 unicast switch(config-router-af)#	Enters IPv6 unicast address family mode.
Step 4	**area** *area-id* **range** *ipv6-prefix/length* [**no-advertise**] [**cost** *cost*] **Example:** switch(config-router-af)# area 0.0.0.10 range 2001:0DB8::/48 advertise	Creates a summary address on an ABR for a range of addresses and optionally advertises this summary address in a Inter-Area Prefix (type 3) LSA. The *cost* range is from 0 to 16777215.
Step 5	**summary-address** *ipv6-prefix/length* [**no-advertise**][**tag** *tag*] **Example:** switch(config-router-af)# summary-address 2001:0DB8::/48 tag 2	Creates a summary address on an ASBR for a range of addresses and optionally assigns a tag for this summary address that can be used for redistribution with route maps.
Step 6	**show ipv6 ospfv3 summary-address** **Example**: switch(config-router)# show ipv6 ospfv3 summary-address	(Optional) Displays information about OSPFv3 summary addresses.
Step 7	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create summary addresses between areas on an ABR:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# address-family ipv6 unicast
switch(config-router)# area 0.0.0.10 range 2001:0DB8::/48
switch(config-router)# copy running-config startup-config
```

This example shows how to create summary addresses on an ASBR:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# address-family ipv6 unicast
switch(config-router)# summary-address 2001:0DB8::/48
switch(config-router)# no discard route internal
switch(config-router)# copy running-config startup-config
```

Configuring the Administrative Distance of Routes

You can set the administrative distance of routes added by OSPFv3 into the RIB.

The administrative distance is a rating of the trustworthiness of a routing information source. A higher value indicates a lower trust rating. Typically, a route can be learned through more than one routing protocol. The administrative distance is used to discriminate between routes learned from more than one routing protocol. The route with the lowest administrative distance is installed in the IP routing table.

BEFORE YOU BEGIN

Ensure that you have enabled OSPF (see the "Enabling OSPFv3" section on page 6-16).

See the guidelines and limitations for this feature in the "Guidelines and Limitations for OSPFv3" section on page 6-14.

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **address-family ipv6 unicast**
4. [**no**] **table-map** *map-name*
5. **exit**
6. **exit**
7. **route-map** *map-name* [**permit** | **deny**] [*seq*]
8. **match route-type** *route-type*
9. **match ip route-source prefix-list** *name*
10. **match ipv6 address prefix-list** *name*
11. **set distance** *value*
12. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** `switch(config)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.

	Command	Purpose
Step 3	**address-family ipv6 unicast** **Example:** `switch(config-router)# address-family ipv6 unicast` `switch(config-router-af)#`	Enters IPv6 unicast address family mode.
Step 4	[**no**] **table-map** *map-name* **Example:** `switch(config-router-af)# table-map foo`	Configures the policy for filtering or modifying OSPFv3 routes before sending them to the RIB. You can enter up to 63 alphanumeric characters for the map name.
Step 5	**exit** **Example:** `switch(config-router-af)# exit` `switch(config-router)#`	Exits router address-family configuration mode.
Step 6	**exit** **Example:** `switch(config-router)# exit` `switch(config)#`	Exits router configuration mode.
Step 7	**route-map** *map-name* [**permit** | **deny**] [*seq*] **Example:** `switch(config)# route-map foo permit 10` `switch(config-route-map)#`	Creates a route map or enters route-map configuration mode for an existing route map. Use *seq* to order the entries in a route map. **Note** The **permit** option enables you to set the distance. If you use the **deny** option, the default distance is applied.
Step 8	**match route-type** *route-type* **Example:** `switch(config-route-map)# match route-type external`	Matches against one of the following route types: • external—The external route (BGP, EIGRP, and OSPF type 1 or 2) • inter-area—OSPF inter-area route • internal—The internal route (including the OSPF intra- or inter-area) • intra-area—OSPF intra-area route • nssa-external—The NSSA external route (OSPF type 1 or 2) • type-1—The OSPF external type 1 route • type-2—The OSPF external type 2 route
Step 9	**match ip route-source prefix-list** *name* **Example:** `switch(config-route-map)# match ip route-source prefix-list p1`	Matches the IPv6 route source address or router ID of a route to one or more IP prefix lists. Use the **ip prefix-list** command to create the prefix list. **Note** For OSPFv3, the router ID is 4 bytes.
Step 10	**match ipv6 address prefix-list** *name* **Example:** `switch(config-route-map)# match ipv6 address prefix-list p1`	Matches against one or more IPv6 prefix lists. Use the **ip prefix-list** command to create the prefix list.

	Command	Purpose
Step 11	**set distance** *value* **Example:** `switch(config-route-map)# set distance 150`	Sets the administrative distance of routes for OSPFv3. The range is from 1 to 255.
Step 12	**copy running-config startup-config** **Example:** `switch(config-route-map)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to configure the OSPFv3 administrative distance for inter-area routes to 150, for external routes to 200, and for all prefixes in prefix list p1 to 190:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# address-family ipv6 unicast
switch(config-router-af)# table-map foo
switch(config-router)# exit
switch(config)# exit
switch(config)# route-map foo permit 10
switch(config-route-map)# match route-type inter-area
switch(config-route-map)# set distance 150
switch(config)# route-map foo permit 20
switch(config-route-map)# match route-type external
switch(config-route-map)# set distance 200
switch(config)# route-map foo permit 30
switch(config-route-map)# match ip route-source prefix-list p1
switch(config-route-map)# match ipv6 address prefix-list p1
switch(config-route-map)# set distance 190
```

Modifying the Default Timers

OSPFv3 includes a number of timers that control the behavior of protocol messages and shortest path first (SPF) calculations. OSPFv3 includes the following optional timer parameters:

- LSA arrival time—Sets the minimum interval allowed between LSAs arriving from a neighbor. LSAs that arrive faster than this time are dropped.
- Pacing LSAs—Sets the interval at which LSAs are collected into a group and refreshed, checksummed, or aged. This timer controls how frequently LSA updates occur and optimizes how many are sent in an LSA update message (see the "Flooding and LSA Group Pacing" section on page 6-7).
- Throttle LSAs—Sets rate limits for generating LSAs. This timer controls how frequently LSAs are generated after a topology change occurs.
- Throttle SPF calculation—Controls how frequently the SPF calculation is run.

At the interface level, you can also control the following timers:

- Retransmit interval—Sets the estimated time between successive LSAs.
- Transmit delay—Sets the estimated time to transmit an LSA to a neighbor.

See the "Configuring Networks in OSPFv3" section on page 6-19 for information on the hello interval and dead timer.

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **timers lsa-arrival** *msec*
4. **timers lsa-group-pacing** *seconds*
5. **timers throttle lsa** *start-time hold-interval max-time*
6. **address-family ipv6 unicast**
7. **timers throttle spf** *delay-time hold-time*
8. **interface** *type slot/port*
9. **ospfv3 retransmit-interval** *seconds*
10. **ospfv3 transmit-delay** *seconds*
11. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**timers lsa-arrival** *msec* **Example:** `switch(config-router)# timers lsa-arrival 2000`	Sets the LSA arrival time in milliseconds. The range is from 10 to 600000. The default is 1000 milliseconds.
Step 4	**timers lsa-group-pacing** *seconds* **Example:** `switch(config-router)# timers lsa-group-pacing 200`	Sets the interval in seconds for grouping LSAs. The range is from 1 to 1800. The default is 10 seconds.
Step 5	**timers throttle lsa** *start-time hold-interval max-time* **Example:** `switch(config-router)# timers throttle lsa network 350 5000 6000`	Sets the rate limit in milliseconds for generating LSAs. You can configure the following timers: *start-time*—The range is from 50 to 5000 milliseconds. The default value is 50 milliseconds. *hold-interval*—The range is from 50 to 30,000 milliseconds. The default value is 5000 milliseconds. *max-time*—The range is from 50 to 30,000 milliseconds. The default value is 5000 milliseconds.

	Command	Purpose
Step 6	**address-family ipv6 unicast** **Example:** `switch(config-router)# address-family ipv6 unicast` `switch(config-router-af)#`	Enters IPv6 unicast address family mode.
Step 7	**timers throttle spf** *delay-time hold-time* **Example:** `switch(config-router)# timers throttle spf 3000 2000`	Sets the SPF best-path schedule initial delay time and the minimum hold time in seconds between SPF best-path calculations. The range is from 1 to 600000. The default is no delay time and 5000 millisecond hold time.
Step 8	**interface** *type slot/port* **Example**: `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 9	**ospfv3 retransmit-interval** *seconds* **Example:** `switch(config-if)# ospfv3 retransmit-interval 30`	Sets the estimated time in seconds between LSAs transmitted from this interface. The range is from 1 to 65535. The default is 5.
Step 10	**ospfv3 transmit-delay** *seconds* **Example:** `switch(config-if)# ospfv3 transmit-delay 600` `switch(config-if)#`	Sets the estimated time in seconds to transmit an LSA to a neighbor. The range is from 1 to 450. The default is 1.
Step 11	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to control LSA flooding with the lsa-group-pacing option:

```
switch# configure terminal
switch(config)# router ospf 201
switch(config-router)# timers lsa-group-pacing 300
switch(config-router)# copy running-config startup-config
```

Configuring Graceful Restart

Graceful restart is enabled by default. You can configure the following optional parameters for graceful restart in an OSPFv3 instance:

- Grace period—Configures how long neighbors should wait after a graceful restart has started before tearing down adjacencies.
- Helper mode disabled—Disables helper mode on the local OSPFv3 instance. OSPFv3 does not participate in the graceful restart of a neighbor.
- Planned graceful restart only—Configures OSPFv3 to support graceful restart only in the event of a planned restart.

BEFORE YOU BEGIN

You must enable OSPFv3 (see the "Enabling OSPFv3" section on page 6-16).

Ensure that all neighbors are configured for graceful restart with matching optional parameters set.

SUMMARY STEPS

1. **configure terminal**
2. **router ospfv3** *instance-tag*
3. **graceful-restart**
4. **graceful-restart grace-period** *seconds*
5. **graceful-restart helper-disable**
6. **graceful-restart planned-only**
7. (Optional) **show ipv6 ospfv3** *instance-tag*
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.
Step 3	**graceful-restart** **Example:** `switch(config-router)# graceful-restart`	Enables graceful restart. A graceful restart is enabled by default.
Step 4	**graceful-restart grace-period** *seconds* **Example:** `switch(config-router)# graceful-restart grace-period 120`	Sets the grace period, in seconds. The range is from 5 to 1800. The default is 60 seconds.
Step 5	**graceful-restart helper-disable** **Example:** `switch(config-router)# graceful-restart helper-disable`	Disables helper mode. Enabled by default.
Step 6	**graceful-restart planned-only** **Example:** `switch(config-router)# graceful-restart planned-only`	Configures graceful restart for planned restarts only.

	Command	Purpose
Step 7	**show ipv6 ospfv3** *instance-tag* **Example:** switch(config-if)# show ipv6 ospfv3 201	(Optional) Displays OSPFv3 information.
Step 8	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to enable graceful restart if it has been disabled and set the grace period to 120 seconds:

```
switch# configure terminal
switch(config)# router ospfv3 201
switch(config-router)# graceful-restart
switch(config-router)# graceful-restart grace-period 120
switch(config-router)# copy running-config startup-config
```

Restarting an OSPFv3 Instance

You can restart an OSPv3 instance. This action clears all neighbors for the instance.

To restart an OSPFv3 instance and remove all associated neighbors, use the following command:

Command	Purpose
restart ospfv3 instance-tag **Example:** switch(config)# restart ospfv3 201	Restarts the OSPFv3 instance and removes all neighbors.

Configuring OSPFv3 with Virtualization

You can configure multiple OSPFv3 instances. You can also create multiple VRFs and use the same or multiple OSPFv3 instances in each VRF. You assign an OSPFv3 interface to a VRF.

Note Configure all other parameters for an interface after you configure the VRF for an interface. Configuring a VRF for an interface deletes all the configuration for that interface.

BEFORE YOU BEGIN

You must enable OSPF (see the "Enabling OSPFv3" section on page 6-16).

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf_name*
3. **router ospfv3** *instance-tag*

4. **vrf** *vrf-name*
5. (Optional) **maximum-paths** *paths*
6. **interface** *type slot/port*
7. **vrf member** *vrf-name*
8. **ipv6 address** *ipv6-prefix/length*
9. **ipv6 ospfv3** *instance-tag* **area** *area-id*
10. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** `switch(config)# vrf context RemoteOfficeVRF` `switch(config-vrf)#`	Creates a new VRF and enters VRF configuration mode.
Step 3	**router ospfv3** *instance-tag* **Example:** `switch(config)# router ospfv3 201` `switch(config-router)#`	Creates a new OSPFv3 instance with the configured instance tag.
Step 4	**vrf** *vrf-name* **Example:** `switch(config-router)# vrf RemoteOfficeVRF` `switch(config-router-vrf)#`	Enters VRF configuration mode.
Step 5	**maximum-paths** *paths* **Example:** `switch(config-router-vrf)# maximum-paths 4`	(Optional) Configures the maximum number of equal OSPFv3 paths to a destination in the route table for this VRF. Use this command for load balancing.
Step 6	**interface** *type slot/port* **Example**: `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 7	**vrf member** *vrf-name* **Example:** `switch(config-if)# vrf member RemoteOfficeVRF`	Adds this interface to a VRF.
Step 8	**ipv6 address** *ipv6-prefix/length* **Example:** `switch(config-if)# ipv6 address 2001:0DB8::1/48`	Configures an IP address for this interface. You must do this step after you assign this interface to a VRF.

	Command	Purpose
Step 9	**ipv6 ospfv3** *instance-tag* **area** *area-id* **Example:** `switch(config-if)# ipv6 ospfv3 201 area 0`	Assigns this interface to the OSPFv3 instance and area configured.
Step 10	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to create a VRF and add an interface to the VRF:

```
switch# configure terminal
switch(config)# vrf context NewVRF
switch(config-vrf)# exit
switch(config)# router ospfv3 201
switch(config-router)# exit
switch(config)# interface ethernet 1/2
switch(config-if)# vrf member NewVRF
switch(config-if)# ipv6 address 2001:0DB8::1/48
switch(config-if)# ipv6 ospfv3 201 area 0
switch(config-if)# copy running-config startup-config
```

Verifying the OSPFv3 Configuration

To display the OSPFv3 configuration, perform one of the following tasks:

Command	Purpose
show ipv6 ospfv3 [*instance-tag*] [**vrf** *vrf-name*]	Displays information about one or more OSPFv3 routing instances. The output includes the following area-level counts: • Interfaces in this area—A count of all interfaces added to this area (configured interfaces). • Active interfaces—A count of all interfaces considered to be in router link states and SPF (UP interfaces). • Passive interfaces—A count of all interfaces considered to be OSPF passive (no adjacencies will be formed). • Loopback interfaces—A count of all local loopback interfaces.
show ipv6 ospfv3 border-routers	Displays the internal OSPF routing table entries to an ABR and ASBR.
show ipv6 ospfv3 database	Displays lists of information related to the OSPFv3 database for a specific router.

Command	Purpose
show ipv6 ospfv3 interface *type number* [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays OSPFv3-related interface information.
show ipv6 ospfv3 neighbors	Displays the neighbor information. Use the **clear ospfv3 neighbors** command to remove adjacency with all neighbors.
show ipv6 ospfv3 request-list	Displays a list of LSAs requested by a router.
show ipv6 ospfv3 retransmission-list	Displays a list of LSAs waiting to be retransmitted.
show ipv6 ospfv3 summary-address	Displays a list of all summary address redistribution information configured under an OSPFv3 instance.
show ospfv3 *process*	Displays the OSPFv3 authentication configuration at the process level.
show ospfv3 interface *interface-type slot/port*	Displays the OSPFv3 authentication configuration at the interface level.
show running-configuration ospfv3	Displays the current running OSPFv3 configuration.

Monitoring OSPFv3

To display OSPFv3 statistics, use the following commands:

Command	Purpose
show ipv6 ospfv3 memory	Displays the OSPFv3 memory usage statistics.
show ipv6 ospfv3 policy statistics area *area-id* **filter-list** {**in** | **out**} [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv3 route policy statistics for an area.
show ipv6 ospfv3 policy statistics redistribute {**bgp** *id*| **direct** | **isis** *id* | **rip** *id* | **static**} **vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv3 route policy statistics.
show ipv6 ospfv3 statistics [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv3 event counters.
show ipv6 ospfv3 traffic [*interface-type number*] [**vrf** {*vrf-name* | **all** | **default** | **management**}]	Displays the OSPFv3 packet counters.

Configuration Examples for OSPFv3

This example shows how to configure OSPFv3:

```
feature ospfv3
router ospfv3 201
 router-id 290.0.2.1

interface ethernet 1/2
 ipv6 address 2001:0DB8::1/48
 ipv6 ospfv3 201 area 0.0.0.10
```

Related Topics

The following topics can give more information on OSPF:

- Chapter 5, “Configuring OSPFv2”
- Chapter 15, “Configuring Route Policy Manager”

Additional References

For additional information related to implementing OSPF, see the following sections:

- MIBs, page 6-49

MIBs

MIBs	MIBs Link
MIBs related to OSPFv3	To locate and download supported MIBs, go to the following URL: ftp://ftp.cisco.com/pub/mibs/supportlists/nexus9000/Nexus9000MIBSupportList.html

Configuring EIGRP

This chapter describes how to configure the Enhanced Interior Gateway Routing Protocol (EIGRP) on the Cisco NX-OS device.

This chapter includes the following sections:

About EIGRP

EIGRP combines the benefits of distance vector protocols with the features of link-state protocols. EIGRP sends out periodic Hello messages for neighbor discovery. Once EIGRP learns a new neighbor, it sends a one-time update of all the local EIGRP routes and route metrics. The receiving EIGRP router calculates the route distance based on the received metrics and the locally assigned cost of the link to that neighbor. After this initial full route table update, EIGRP sends incremental updates to only those neighbors affected by the route change. This process speeds convergence and minimizes the bandwidth used by EIGRP.

This section includes the following topics:

EIGRP Components

EIGRP has the following basic components:

Reliable Transport Protocol

The Reliable Transport Protocol guarantees ordered delivery of EIGRP packets to all neighbors. (See the "Neighbor Discovery and Recovery" section on page 7-2.) The Reliable Transport Protocol supports an intermixed transmission of multicast and unicast packets. The reliable transport can send multicast packets quickly when unacknowledged packets are pending. This provision helps to ensure that the convergence time remains low for various speed links. See the "Configuring Advanced EIGRP" section on page 7-15 for details about modifying the default timers that control the multicast and unicast packet transmissions.

The Reliable Transport Protocol includes the following message types:

- Hello—Used for neighbor discovery and recovery. By default, EIGRP sends a periodic multicast Hello message on the local network at the configured hello interval. By default, the hello interval is 5 seconds.
- Acknowledgement—Verify reliable reception of Updates, Queries, and Replies.
- Updates—Send to affected neighbors when routing information changes. Updates include the route destination, address mask, and route metrics such as delay and bandwidth. The update information is stored in the EIGRP topology table.
- Queries and Replies—Sent as part of the Diffusing Update Algorithm used by EIGRP.

Neighbor Discovery and Recovery

EIGRP uses the Hello messages from the Reliable Transport Protocol to discover neighboring EIGRP routers on directly attached networks. EIGRP adds neighbors to the neighbor table. The information in the neighbor table includes the neighbor address, the interface it was learned on, and the hold time, which indicates how long EIGRP should wait before declaring a neighbor unreachable. By default, the hold time is three times the hello interval or 15 seconds.

EIGRP sends a series of Update messages to new neighbors to share the local EIGRP routing information. This route information is stored in the EIGRP topology table. After this initial transmission of the full EIGRP route information, EIGRP sends Update messages only when a routing change occurs. These Update messages contain only the new or changed information and are sent only to the neighbors affected by the change. See the "EIGRP Route Updates" section on page 7-3.

EIGRP also uses the Hello messages as a keepalive to its neighbors. As long as Hello messages are received, Cisco NX-OS can determine that a neighbor is alive and functioning.

Diffusing Update Algorithm

The Diffusing Update Algorithm (DUAL) calculates the routing information based on the destination networks in the topology table. The topology table includes the following information:

- IPv4 or IPv6 address/mask—The network address and network mask for this destination.

- Successors—The IP address and local interface connection for all feasible successors or neighbors that advertise a shorter distance to the destination than the current feasible distance.
- Feasibility distance (FD)—The lowest calculated distance to the destination. The feasibility distance is the sum of the advertised distance from a neighbor plus the cost of the link to that neighbor.

DUAL uses the distance metric to select efficient, loop-free paths. DUAL selects routes to insert into the unicast Routing Information Base (RIB) based on feasible successors. When a topology change occurs, DUAL looks for feasible successors in the topology table. If there are feasible successors, DUAL selects the feasible successor with the lowest feasible distance and inserts that into the unicast RIB, avoiding unnecessary recomputation.

When there are no feasible successors but there are neighbors advertising the destination, DUAL transitions from the passive state to the active state and triggers a recomputation to determine a new successor or next-hop router to the destination. The amount of time required to recompute the route affects the convergence time. EIGRP sends Query messages to all neighbors, searching for feasible successors. Neighbors that have a feasible successor send a Reply message with that information. Neighbors that do not have feasible successors trigger a DUAL recomputation.

EIGRP Route Updates

When a topology change occurs, EIGRP sends an Update message with only the changed routing information to affected neighbors. This Update message includes the distance information to the new or updated network destination.

The distance information in EIGRP is represented as a composite of available route metrics, including bandwidth, delay, load utilization, and link reliability. Each metric has an associated weight that determines if the metric is included in the distance calculation. You can configure these metric weights. You can fine-tune link characteristics to achieve optimal paths, but we recommend that you use the default settings for most configurable metrics.

This section includes the following topics:

Internal Route Metrics

Internal routes are routes that occur between neighbors within the same EIGRP autonomous system. These routes have the following metrics:

- Next hop—The IP address of the next-hop router.
- Delay—The sum of the delays configured on the interfaces that make up the route to the destination network. The delay is configured in tens of microseconds.
- Bandwidth—The calculation from the lowest configured bandwidth on an interface that is part of the route to the destination.

Note We recommend that you use the default bandwidth value. This bandwidth parameter is also used by EIGRP.

- MTU—The smallest maximum transmission unit value along the route to the destination.
- Hop count—The number of hops or routers that the route passes through to the destination. This metric is not directly used in the DUAL computation.
- Reliability—An indication of the reliability of the links to the destination.
- Load—An indication of how much traffic is on the links to the destination.

By default, EIGRP uses the bandwidth and delay metrics to calculate the distance to the destination. You can modify the metric weights to include the other metrics in the calculation.

Wide Metrics

EIGRP supports wide (64-bit) metrics to improve route selection on higher-speed interfaces or bundled interfaces. Routers supporting wide metrics can interoperate with routers that do not support wide metrics as follows:

- A router that supports wide metrics—Adds local wide metrics values to the received values and sends the information on.
- A router that does not support wide metrics— Sends any received metrics on without changing the values.

EIGRP uses the following equation to calculate path cost with wide metrics:

metric = [k1 x bandwidth + (k2 x bandwidth)/(256 – load) + k3 x delay + k6 x extended attributes] x [k5/(reliability + k4)]

Since the unicast RIB cannot support 64-bit metric values, EIGRP wide metrics use the following equation with a RIB scaling factor to convert the 64-bit metric value to a 32-bit value:

RIB Metric = (Wide Metric / RIB scale value).

where the RIB scale value is a configurable parameter.

EIGRP wide metrics introduce the following two new metric values represented as k6 in the EIGRP metrics configuration:

- Jitter—(Measured in microseconds) accumulated across all links in the route path. Routes lower jitter values are preferred for EIGRP path selection.
- Energy—(Measured in watts per kilobit) accumulated across all links in the route path. Routes lower energy values are preferred for EIGRP path selection.

EIGRP prefers a path with no jitter or energy metric values or lower jitter or metric values over a path with higher values.

Note EIGRP wide metrics are sent with a TLV version of 2. For more information, see the "Enabling Wide Metrics" section on page 7-27.

External Route Metrics

External routes are routes that occur between neighbors in different EIGRP autonomous systems. These routes have the following metrics:

- Next hop—The IP address of the next-hop router.
- Router ID—The router ID of the router that redistributed this route into EIGRP.
- AS number—The autonomous system number of the destination.

- Protocol ID—A code that represents the routing protocol that learned the destination route.
- Tag—An arbitrary tag that can be used for route maps.
- Metric—The route metric for this route from the external routing protocol.

EIGRP and the Unicast RIB

EIGRP adds all learned routes to the EIGRP topology table and the unicast RIB. When a topology change occurs, EIGRP uses these routes to search for a feasible successor. EIGRP also listens for notifications from the unicast RIB for changes in any routes redistributed to EIGRP from another routing protocol.

Advanced EIGRP

You can use the advanced features of EIGRP to optimize your EIGRP configuration.

This section includes the following topics:

Address Families

EIGRP supports both IPv4 and IPv6 address families. For backward compatibility, you can configure EIGRPv4 in route configuration mode or in IPV4 address family mode. You must configure EIGRP for IPv6 in address family mode.

Address family configuration mode includes the following EIGRP features:

- Authentication
- AS number
- Default route
- Metrics
- Distance
- Graceful restart
- Logging
- Load balancing

- Redistribution
- Router ID
- Stub router
- Timers

You cannot configure the same feature in more than one configuration mode. For example, if you configure the default metric in router configuration mode, you cannot configure the default metric in address family mode.

Authentication

You can configure authentication on EIGRP messages to prevent unauthorized or invalid routing updates in your network. EIGRP authentication supports MD5 authentication digest.

You can configure the EIGRP authentication per virtual routing and forwarding (VRF) instance or interface using keychain management for the authentication keys. Keychain management allows you to control changes to the authentication keys used by MD5 authentication digest. See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide* for more details about creating keychains.

For MD5 authentication, you configure a password that is shared at the local router and all remote EIGRP neighbors. When an EIGRP message is created, Cisco NX-OS creates an MD5 one-way message digest based on the message itself and the encrypted password and sends this digest along with the EIGRP message. The receiving EIGRP neighbor validates the digest using the same encrypted password. If the message has not changed, the calculation is identical and the EIGRP message is considered valid.

MD5 authentication also includes a sequence number with each EIGRP message that is used to ensure that no message is replayed in the network.

Stub Routers

You can use the EIGRP stub routing feature to improve network stability, reduce resource usage, and simplify stub router configuration. Stub routers connect to the EIGRP network through a remote router. See the "Stub Routing" section on page 1-7.

When using EIGRP stub routing, you need to configure the distribution and remote routers to use EIGRP and configure only the remote router as a stub. EIGRP stub routing does not automatically enable summarization on the distribution router. In most cases, you need to configure summarization on the distribution routers.

Without EIGRP stub routing, even after the routes that are sent from the distribution router to the remote router have been filtered or summarized, a problem might occur. For example, if a route is lost somewhere in the corporate network, EIGRP could send a query to the distribution router. The distribution router could then send a query to the remote router even if routes are summarized. If a problem communicating over the WAN link between the distribution router and the remote router occurs, EIGRP could get stuck in an active condition and cause instability elsewhere in the network. EIGRP stub routing allows you to prevent queries to the remote router.

Route Summarization

You can configure a summary aggregate address for a specified interface. Route summarization simplifies route tables by replacing a number of more-specific addresses with an address that represents all the specific addresses. For example, you can replace 10.1.1.0/24, 10.1.2.0/24, and 10.1.3.0/24 with one summary address, 10.1.0.0/16.

If more specific routes are in the routing table, EIGRP advertises the summary address from the interface with a metric equal to the minimum metric of the more specific routes.

Note EIGRP does not support automatic route summarization.

Route Redistribution

You can use EIGRP to redistribute static routes, routes learned by other EIGRP autonomous systems, or routes from other protocols. You must configure a route map with the redistribution to control which routes are passed into EIGRP. A route map allows you to filter routes based on attributes such as the destination, origination protocol, route type, route tag, and so on. See Chapter 15, "Configuring Route Policy Manager."

You also configure the default metric that is used for all imported routes into EIGRP.

You use distribute lists to filter routes from routing updates. These filtered routes are applied to each interface with the **ip distribute-list eigrp** command.

Load Balancing

You can use load balancing to allow a router to distribute traffic over all the router network ports that are the same distance from the destination address. Load balancing increases the usage of network segments, which increases effective network bandwidth.

Cisco NX-OS supports the Equal Cost Multiple Paths (ECMP) feature with up to 16 equal-cost paths in the EIGRP route table and the unicast RIB. You can configure EIGRP to load balance traffic across some or all of those paths.

Note EIGRP in Cisco NX-OS does not support unequal cost load balancing.

Split Horizon

You can use split horizon to ensure that EIGRP never advertises a route out of the interface where it was learned.

Split horizon is a method that controls the sending of EIGRP update and query packets. When you enable split horizon on an interface, Cisco NX-OS does not send update and query packets for destinations that were learned from this interface. Controlling update and query packets in this manner reduces the possibility of routing loops.

Split horizon with poison reverse configures EIGRP to advertise a learned route as unreachable back through that the interface that EIGRP learned the route from.

EIGRP uses split horizon or split horizon with poison reverse in the following scenarios:

- Exchanging topology tables for the first time between two routers in startup mode.
- Advertising a topology table change.
- Sending a Query message.

By default, the split horizon feature is enabled on all interfaces.

BFD

This feature supports bidirectional forwarding detection (BFD) for IPv4 and IPv6. BFD is a detection protocol designed to provide fast forwarding-path failure detection times. BFD provides subsecond failure detection between two adjacent devices and can be less CPU-intensive than protocol hello messages because some of the BFD load can be distributed onto the data plane on supported modules. See the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide* for more information.

Virtualization Support

EIGRP supports Virtual Routing and Forwarding instances (VRFs).

Graceful Restart and High Availability

Cisco NX-OS supports nonstop forwarding and graceful restart for EIGRP.

You can use nonstop forwarding for EIGRP to forward data packets along known routes in the FIB while the EIGRP routing protocol information is being restored following a failover. With nonstop forwarding (NSF), peer networking devices do not experience routing flaps. During failover, data traffic is forwarded through intelligent modules while the standby supervisor becomes active.

If a Cisco NX-OS system experiences a cold reboot, the device does not forward traffic to the system and removes the system from the network topology. In this scenario, EIGRP experiences a stateless restart, and all neighbors are removed. Cisco NX-OS applies the startup configuration, and EIGRP rediscovers the neighbors and shares the full EIGRP routing information again.

A dual supervisor platform that runs Cisco NX-OS can experience a stateful supervisor switchover. Before the switchover occurs, EIGRP uses a graceful restart to announce that EIGRP will be unavailable for some time. During a switchover, EIGRP uses nonstop forwarding to continue forwarding traffic based on the information in the FIB, and the system is not taken out of the network topology.

The graceful restart-capable router uses Hello messages to notify its neighbors that a graceful restart operation has started. When a graceful restart-aware router receives a notification from a graceful restart-capable neighbor that a graceful restart operation is in progress, both routers immediately exchange their topology tables. The graceful restart-aware router performs the following actions to assist the restarting router as follows:

- The router expires the EIGRP Hello hold timer to reduce the time interval set for Hello messages. This process allows the graceful restart-aware router to reply to the restarting router more quickly and reduces the amount of time required for the restarting router to rediscover neighbors and rebuild the topology table.
- The router starts the route-hold timer. This timer sets the period of time that the graceful restart-aware router will hold known routes for the restarting neighbor. The default time period is 240 seconds.
- The router notes in the peer list that the neighbor is restarting, maintains adjacency, and holds known routes for the restarting neighbor until the neighbor signals that it is ready for the graceful restart-aware router to send its topology table or the route-hold timer expires. If the route-hold timer expires on the graceful restart-aware router, the graceful restart-aware router discards held routes and treats the restarting router as a new router that joins the network and reestablishes adjacency.

After the switchover, Cisco NX-OS applies the running configuration, and EIGRP informs the neighbors that it is operational again.

Multiple EIGRP Instances

Cisco NX-OS supports multiple instances of the EIGRP protocol that run on the same system. Every instance uses the same system router ID. You can optionally configure a unique router ID for each instance. For the number of supported EIGRP instances, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

Licensing Requirements for EIGRP

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	EIGRP requires an Enterprise Services license. For a complete explanation of the Cisco NX-OS licensing scheme and how to obtain and apply licenses, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for EIGRP

EIGRP has the following prerequisites:

- You must enable EIGRP (see the "Enabling the EIGRP Feature" section on page 7-11).

Guidelines and Limitations for EIGRP

EIGRP has the following configuration guidelines and limitations:

- A metric configuration (either through the default-metric configuration option or through a route map) is required for redistribution from any other protocol, connected routes, or static routes (see Chapter 15, "Configuring Route Policy Manager").
- For graceful restart, an NSF-aware router must be up and completely converged with the network before it can assist an NSF-capable router in a graceful restart operation.
- For graceful restart, neighboring devices participating in the graceful restart must be NSF-aware or NSF-capable.
- Cisco NX-OS EIGRP is compatible with EIGRP in the Cisco IOS software.
- Do not change the metric weights without a good reason. If you change the metric weights, you must apply the change to all EIGRP routers in the same autonomous system.
- A mix of standard metrics and wide metrics in an EIGRP network with interface speeds of 1 Gigabit or greater may result in suboptimal routing.
- Consider using stubs for larger networks.
- Avoid redistribution between different EIGRP autonomous systems because the EIGRP vector metric will not be preserved.
- The **no** {**ip** | **ipv6**} **next-hop-self** command does not guarantee reachability of the next hop.
- The {**ip** | **ipv6**} **passive-interface eigrp** command suppresses neighbors from forming.
- Cisco NX-OS does not support IGRP or connecting IGRP and EIGRP clouds.

- Autosummarization is disabled by default and cannot be enabled.
- Cisco NX-OS supports only IP.
- High availability is not supported with EIGRP aggressive timers.

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Default Settings

Table 7-1 lists the default settings for EIGRP parameters.

Table 7-1 Default EIGRP Parameters

Parameters	Default
Administrative distance	• Internal routes—90 • External routes—170
Bandwidth percent	50 percent
Default metric for redistributed routes	• Bandwidth—100000 Kb/s • Delay—100 (10 microsecond units) • Reliability—255 • Loading—1 • MTU—1500
EIGRP feature	Disabled
Hello interval	5 seconds
Hold time	15 seconds
Equal-cost paths	8
Metric weights	1 0 1 0 0 0
Next-hop address advertised	IP address of local interface
NSF convergence time	120
NSF route-hold time	240
NSF signal time	20
Redistribution	Disabled
Split horizon	Enabled

Configuring Basic EIGRP

This section includes the following topics:

Enabling the EIGRP Feature

You must enable EIGRP before you can configure EIGRP.

SUMMARY STEPS

1. **configure terminal**
2. **feature eigrp**
3. (Optional) **show feature**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**feature eigrp** **Example:** `switch(config)# feature eigrp`	Enables the EIGRP feature.
Step 3	**show feature** **Example:** `switch(config)# show feature`	(Optional) Displays information about enabled features.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

To disable the EIGRP feature and remove all associated configuration, use the following command in configuration mode:

Command	Purpose
no feature eigrp **Example:** `switch(config)# no feature eigrp`	Disables the EIGRP feature and removes all associated configuration.

Creating an EIGRP Instance

You can create an EIGRP instance and associate an interface with that instance. You assign a unique autonomous system number for this EIGRP process (see the "Autonomous Systems" section on page 1-5). Routes are not advertised or accepted from other autonomous systems unless you enable route redistribution.

BEFORE YOU BEGIN

You must enable EIGRP (see the "Enabling the EIGRP Feature" section on page 7-11).

EIGRP must be able to obtain a router ID (for example, a configured loopback address) or you must configure the router ID option.

If you configure an instance tag that does not qualify as an AS number, you must configure the AS number explicitly or this EIGRP instance remains in the shutdown state. For IPv6, this number must be configured under address family.

SUMMARY STEPS

1. **configure terminal**
2. **router eigrp** *instance-tag*
3. (Optional) **autonomous-system** *as-number*
4. (Optional) **log-adjacency-changes**
5. (Optional) **log-neighbor-warnings** [*seconds*]
6. **interface** *interface-type slot/port*
7. {**ip** | **ipv6**} **router eigrp** *instance-tag*
8. (Optional) **show** {**ip** | **ipv6**} **eigrp interfaces**
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router eigrp** *instance-tag* **Example:** `switch(config)# router eigrp Test1` `switch(config-router)#`	Creates a new EIGRP process with the configured instance tag. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. If you configure an *instance-tag* that does not qualify as an AS number, you must use the **autonomous-system** command to configure the AS number explicitly or this EIGRP instance will remain in the shutdown state.

	Command	Purpose
Step 3	**autonomous-system** *as-number* **Example:** `switch(config-router)# autonomous-system 33`	(Optional) Configures a unique AS number for this EIGRP instance. The range is from 1 to 65535.
Step 4	**log-adjacency-changes** **Example:** `switch(config-router)# log-adjacency-changes`	(Optional) Generates a system message whenever an adjacency changes state. This command is enabled by default.
Step 5	**log-neighbor-warnings** [*seconds*] **Example**: `switch(config-router)# log-neighbor-warnings`	(Optional) Generates a system message whenever a neighbor warning occurs. You can configure the time between warning messages, from 1 to 65535, in seconds. The default is 10 seconds. This command is enabled by default.
Step 6	**interface** *interface-type slot/port* **Example:** `switch(config-router)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode. Use **?** to determine the slot and port ranges.
Step 7	{**ip** | **ipv6**} **router eigrp** *instance-tag* **Example**: `switch(config-if)# ip router eigrp Test1`	Associates this interface with the configured EIGRP process. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters.
Step 8	**show** {**ip** | **ipv6**} **eigrp interfaces** **Example**: `switch(config-if)# show ip eigrp interfaces`	(Optional) Displays information about EIGRP interfaces.
Step 9	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

To remove the EIGRP process and the associated configuration, use the following command in the configuration mode:

Command	Purpose
no router eigrp *instance-tag* **Example:** `switch(config)# no router eigrp Test1`	Deletes the EIGRP process and all associated configuration.

Note You should also remove any EIGRP commands configured in interface mode if you remove the EIGRP process.

This example shows how to create an EIGRP process and configure an interface for EIGRP:

```
switch# configure terminal
switch(config)# router eigrp Test1
switch(config)# interface ethernet 1/2
switch(config-if)# ip router eigrp Test1
switch(config-if)# no shutdown
switch(config-if)# copy running-config startup-config
```

For more information about other EIGRP parameters, see the "Configuring Advanced EIGRP" section on page 7-15.

Restarting an EIGRP Instance

You can restart an EIGRP instance. This action clears all neighbors for the instance.

To restart an EIGRP instance and remove all associated neighbors, use the following commands:

Command	Purpose
flush-routes **Example:** switch(config)# flush-routes	(Optional) Flushes all EIGRP routes in the unicast RIB when this EIGRP instance restarts.
restart eigrp instance-tag **Example:** switch(config)# restart eigrp Test1	Restarts the EIGRP instance and removes all neighbors. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters.

Shutting Down an EIGRP Instance

You can gracefully shut down an EIGRP instance. This action removes all routes and adjacencies but preserves the EIGRP configuration.

To disable an EIGRP instance, use the following command in router configuration mode:

Command	Purpose
switch(config-router)# **shutdown** **Example:** switch(config-router)# shutdown	Disables this instance of EIGRP. The EIGRP router configuration remains.

Configuring a Passive Interface for EIGRP

You can configure a passive interface for EIGRP. A passive interface does not participate in EIGRP adjacency, but the network address for the interface remains in the EIGRP topology table.

To configure a passive interface for EIGRP, use the following command in interface configuration mode:

Command	Purpose
{**ip** | **ipv6**} **passive-interface eigrp** *instance-tag* **Example:** `switch(config-if)# ip passive-interface eigrp tag10`	Suppresses EIGRP hellos, which prevents neighbors from forming and sending routing updates on an EIGRP interface. The *instance-tag* argument can be any case-sensitive, alphanumeric string up to 20 characters.

Shutting Down EIGRP on an Interface

You can gracefully shut down EIGRP on an interface. This action removes all adjacencies and stops EIGRP traffic on this interface but preserves the EIGRP configuration.

To disable EIGRP on an interface, use the following command in interface configuration mode:

Command	Purpose
`switch(config-if)#` {**ip** | **ipv6**} **eigrp** *instance-tag* **shutdown** **Example:** `switch(config-router)# ip eigrp Test1 shutdown`	Disables EIGRP on this interface. The EIGRP interface configuration remains. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters.

Configuring Advanced EIGRP

This section includes the following topics:

Configuring Authentication in EIGRP

You can configure authentication between neighbors for EIGRP. See the "Authentication" section on page 7-6.

You can configure EIGRP authentication for the EIGRP process or for individual interfaces. The interface EIGRP authentication configuration overrides the EIGRP process-level authentication configuration.

BEFORE YOU BEGIN

You must enable EIGRP (see the "Enabling the EIGRP Feature" section on page 7-11).

Ensure that all neighbors for an EIGRP process share the same authentication configuration, including the shared authentication key.

Create the keychain for this authentication configuration. For more information, see the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide.*

SUMMARY STEPS

1. **configure terminal**
2. **router eigrp** *instance-tag*
3. **address-family** {**ipv4** | **ipv6**} **unicast**
4. **authentication key-chain** *key-chain*
5. **authentication mode md5**
6. **interface** *interface-type slot/port*
7. {**ip** | **ipv6**} **router eigrp** *instance-tag*
8. {**ip** | **ipv6**} **authentication key-chain eigrp** *instance-tag key-chain*
9. {**ip** | **ipv6**} **authentication mode eigrp** *instance-tag* **md5**
10. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router eigrp** *instance-tag* **Example:** `switch(config)# router eigrp Test1` `switch(config-router)#`	Creates a new EIGRP process with the configured instance tag. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. If you configure an *instance-tag* that does not qualify as an AS number, you must use the **autonomous-system** command to configure the AS number explicitly or this EIGRP instance will remain in the shutdown state.

	Command	Purpose
Step 3	**address-family** {**ipv4** | **ipv6**} **unicast** **Example:** `switch(config-router)# address-family ipv4 unicast` `switch(config-router-af)#`	Enters the address-family configuration mode. This command is optional for IPv4.
Step 4	**authentication key-chain** *key-chain* **Example:** `switch(config-router-af)# authentication key-chain routeKeys`	Associates a keychain with this EIGRP process for this VRF. The keychain can be any case-sensitive, alphanumeric string up to 20 characters.
Step 5	**authentication mode md5** **Example:** `switch(config-router-af)# authentication mode md5`	Configures MD5 message digest authentication mode for this VRF.
Step 6	**interface** *interface-type slot/port* **Example:** `switch(config-router-af) interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode. Use **?** to find the supported interfaces.
Step 7	{**ip** | **ipv6**} **router eigrp** *instance-tag* **Example**: `switch(config-if)# ip router eigrp Test1`	Associates this interface with the configured EIGRP process. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters.
Step 8	{**ip** | **ipv6**} **authentication key-chain eigrp** *instance-tag key-chain* **Example:** `switch(config-if)# ip authentication key-chain eigrp Test1 routeKeys`	Associates a keychain with this EIGRP process for this interface. This configuration overrides the authentication configuration set in the router VRF mode. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters.
Step 9	{**ip** | **ipv6**} **authentication mode eigrp** *instance-tag* **md5** **Example:** `switch(config-if)# ip authentication mode eigrp Test1 md5`	Configures the MD5 message digest authentication mode for this interface. This configuration overrides the authentication configuration set in the router VRF mode. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters.
Step 10	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to configure MD5 message digest authentication for EIGRP over Ethernet interface 1/2:

```
switch# configure terminal
switch(config)# router eigrp Test1
switch(config-router)# exit
switch(config)# interface ethernet 1/2
switch(config-if)# ip router eigrp Test1
switch(config-if)# ip authentication key-chain eigrp Test1 routeKeys
switch(config-if)# ip authentication mode eigrp Test1 md5
switch(config-if)# copy running-config startup-config
```

Configuring EIGRP Stub Routing

To configure a router for EIGRP stub routing, use the following command in address-family configuration mode:

Command	Purpose
`switch(config-router-af)# stub [direct | receive-only | redistributed [direct] leak-map map-name]` **Example:** `switch(config-router-af)# eigrp stub redistributed`	Configures a remote router as an EIGRP stub router. The map name can be any case-sensitive, alphanumeric string up to 20 characters.

This example shows how to configure a stub router to advertise directly connected and redistributed routes:

```
switch# configure terminal
switch(config)# router eigrp Test1
switch(config-router)# address-family ipv6 unicast
switch(config-router-af)# stub direct redistributed
switch(config-router-af)# copy running-config startup-config
```

Use the **show ip eigrp neighbor detail** command to verify that a router has been configured as a stub router. The last line of the output shows the stub status of the remote or spoke router.

This example shows output from the **show ip eigrp neighbor detail** command:

```
Router# show ip eigrp neighbor detail
IP-EIGRP neighbors for process 201
H   Address                 Interface   Hold Uptime   SRTT   RTO  Q  Seq Type
                                        (sec)         (ms)       Cnt Num
0   10.1.1.2                Se3/1         11 00:00:59    1  4500  0  7
   Version 12.1/1.2, Retrans: 2, Retries: 0
   Stub Peer Advertising ( CONNECTED SUMMARY ) Routes
```

Configuring a Summary Address for EIGRP

You can configure a summary aggregate address for a specified interface. If any more specific routes are in the routing table, EIGRP advertises the summary address out the interface with a metric equal to the minimum of all more specific routes. See the "Route Summarization" section on page 7-6.

To configure a summary aggregate address, use the following command in interface configuration mode:

Command	Purpose
`switch(config-if)# {ip | ipv6} summary-address eigrp` *instance-tag ip-prefix/length* `[`*distance* `|` **leak-map** *map-name*`]` **Example:** `switch(config-if)# ip summary-address eigrp Test1 192.0.2.0/8`	Configures a summary aggregate address as either an IP address and network mask or an IP prefix/length. The instance tag and map name can be any case-sensitive, alphanumeric string up to 20 characters. You can optionally configure the administrative distance for this aggregate address. The default administrative distance is 5 for aggregate addresses.

This example shows how to cause EIGRP to summarize network 192.0.2.0 out Ethernet 1/2 only:

```
switch(config)# interface ethernet 1/2
switch(config-if)# ip summary-address eigrp Test1 192.0.2.0 255.255.255.0
```

Redistributing Routes into EIGRP

You can redistribute routes in EIGRP from other routing protocols.

BEFORE YOU BEGIN

You must enable EIGRP (see the "Enabling the EIGRP Feature" section on page 7-11).

You must configure the metric (either through the default-metric configuration option or through a route map) for routes redistributed from any other protocol.

You must create a route map to control the types of routes that are redistributed into EIGRP. See Chapter 15, "Configuring Route Policy Manager."

SUMMARY STEPS

1. **configure terminal**
2. **router eigrp** *instance-tag*
3. **address-family** {**ipv4** | **ipv6**} **unicast**
4. **redistribute** {**bgp** *as* | {**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **direct** | **static**} **route-map** *name*
5. **default-metric** *bandwidth delay reliability loading mtu*
6. (Optional) **show** {**ip** | **ipv6**} **eigrp route-map statistics redistribute**
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router eigrp** *instance-tag* **Example:** switch(config)# router eigrp Test1 switch(config-router)#	Creates a new EIGRP process with the configured instance tag. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. If you configure an *instance-tag* that does not qualify as an AS number, you must use the **autonomous-system** command to configure the AS number explicitly or this EIGRP instance will remain in the shutdown state.
Step 3	**address-family** {**ipv4** | **ipv6**} **unicast** **Example:** switch(config-router)# address-family ipv4 unicast switch(config-router-af)#	Enters the address-family configuration mode. This command is optional for IPv4.
Step 4	**redistribute** {**bgp** *as*| {**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **direct** | **static**} **route-map** *name* **Example:** switch(config-router-af)# redistribute bgp 100 route-map BGPFilter	Injects routes from one routing domain into EIGRP. The instance tag and map name can be any case-sensitive, alphanumeric string up to 20 characters.
Step 5	**default-metric** *bandwidth delay reliability loading mtu* **Example**: switch(config-router-af)# default-metric 500000 30 200 1 1500	Sets the metrics assigned to routes learned through route redistribution. The default values are as follows: • bandwidth—100000 Kb/s • delay—100 (10 microsecond units) • reliability—255 • loading—1 • MTU—1492
Step 6	**show** {**ip** | **ipv6**} **eigrp route-map statistics redistribute** **Example**: switch(config-router-af)# show ip eigrp route-map statistics redistribute bgp	(Optional) Displays information about EIGRP route map statistics.
Step 7	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

The following example shows how to redistribute BGP into EIGRP for IPv4:

```
switch# configure terminal
switch(config)# router eigrp Test1
switch(config-router)# redistribute bgp 100 route-map BGPFilter
switch(config-router)# default-metric 500000 30 200 1 1500
switch(config-router)# copy running-config startup-config
```

Limiting the Number of Redistributed Routes

Route redistribution can add many routes to the EIGRP route table. You can configure a maximum limit to the number of routes accepted from external protocols. EIGRP provides the following options to configure redistributed route limits:

- Fixed limit—Logs a message when EIGRP reaches the configured maximum. EIGRP does not accept any more redistributed routes. You can optionally configure a threshold percentage of the maximum where EIGRP logs a warning when that threshold is passed.
- Warning only—Logs a warning only when EIGRP reaches the maximum. EIGRP continues to accept redistributed routes.
- Withdraw—Starts the timeout period when EIGRP reaches the maximum. After the timeout period, EIGRP requests all redistributed routes if the current number of redistributed routes is less than the maximum limit. If the current number of redistributed routes is at the maximum limit, EIGRP withdraws all redistributed routes. You must clear this condition before EIGRP accepts more redistributed routes. You can optionally configure the timeout period.

BEFORE YOU BEGIN

You must enable EIGRP (see the "Enabling the EIGRP Feature" section on page 7-11).

SUMMARY STEPS

1. **configure terminal**
2. **router eigrp** *instance-tag*
3. **redistribute** {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} **route-map** *map-name*
4. **redistribute maximum-prefix** *max* [*threshold*] [**warning-only** | **withdraw** [*num-retries timeout*]]
5. (Optional) **show running-config eigrp**
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router eigrp** *instance-tag* **Example:** switch(config)# router eigrp Test1 switch(config-router)#	Creates a new EIGRP instance with the configured instance tag.
Step 3	**redistribute** {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} **route-map** *map-name* **Example:** switch(config-router)# redistribute bgp route-map FilterExternalBGP	Redistributes the selected protocol into EIGRP through the configured route map.
Step 4	**redistribute maximum-prefix** *max* [*threshold*] [**warning-only** | **withdraw** [*num-retries timeout*]] **Example:** switch(config-router)# redistribute maximum-prefix 1000 75 warning-only	Specifies a maximum number of prefixes that EIGRP distributes. The range is from 1 to 65535. Optionally specifies the following: • *threshold*—Percentage of maximum prefixes that triggers a warning message. • **warning-only**—Logs an warning message when the maximum number of prefixes is exceeded. • **withdraw**—Withdraws all redistributed routes. Optionally tries to retrieve the redistributed routes. The *num-retries* range is from 1 to 12. The *timeout* is from 60 to 600 seconds. The default is 300 seconds. Use the **clear ip eigrp redistribution** command if all routes are withdrawn.
Step 5	**show running-config eigrp** **Example:** switch(config-router)# show running-config eigrp	(Optional) Displays the EIGRP configuration.
Step 6	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to limit the number of redistributed routes into EIGRP:

```
switch# configure terminal
switch(config)# router eigrp Test1
switch(config-router)# redistribute bgp route-map FilterExternalBGP
switch(config-router)# redistribute maximum-prefix 1000 75
```

Configuring Load Balancing in EIGRP

You can configure load balancing in EIGRP. You can configure the number of Equal Cost Multiple Path (ECMP) routes using the maximum paths option. See the "Configuring Load Balancing in EIGRP" section on page 7-23.

BEFORE YOU BEGIN

You must enable EIGRP (see the "Enabling the EIGRP Feature" section on page 7-11).

SUMMARY STEPS

1. **configure terminal**
2. **router eigrp** *instance-tag*
3. **address-family** {**ipv4** | **ipv6**} **unicast**
4. **maximum-paths** *num-paths*
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router eigrp** *instance-tag* **Example:** `switch(config)# router eigrp Test1` `switch(config-router)#`	Creates a new EIGRP process with the configured instance tag. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. If you configure an *instance-tag* that does not qualify as an AS number, you must use the **autonomous-system** command to configure the AS number explicitly or this EIGRP instance remains in the shutdown state.
Step 3	**address-family** {**ipv4** | **ipv6**} **unicast** **Example:** `switch(config-router)# address-family ipv4 unicast` `switch(config-router-af)#`	Enters the address-family configuration mode. This command is optional for IPv4.
Step 4	**maximum-paths** *num-paths* **Example:** `switch(config-router-af)# maximum-paths 5`	Sets the number of equal cost paths that EIGRP accepts in the route table. The range is from 1 to 32. The default is 8.
Step 5	**copy running-config startup-config** **Example:** `switch(config-router-af)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to configure equal cost load balancing for EIGRP over IPv4 with a maximum of six equal cost paths:

```
switch# configure terminal
switch(config)# router eigrp Test1
switch(config-router)# maximum-paths 6
switch(config-router)# copy running-config startup-config
```

Configuring Graceful Restart for EIGRP

You can configure graceful restart or nonstop forwarding for EIGRP. See the "Graceful Restart and High Availability" section on page 7-8.

Note Graceful restart is enabled by default.

BEFORE YOU BEGIN

You must enable EIGRP (see the "Enabling the EIGRP Feature" section on page 7-11).

An NSF-aware router must be up and completely converged with the network before it can assist an NSF-capable router in a graceful restart operation.

Neighboring devices participating in the graceful restart must be NSF-aware or NSF-capable.

SUMMARY STEPS

1. **configure terminal**
2. **router eigrp** *instance-tag*
3. **address-family** {**ipv4** | **ipv6**} **unicast**
4. **graceful-restart**
5. **timers nsf converge** *seconds*
6. **timers nsf route-hold** *seconds*
7. **timers nsf signal** *seconds*
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router eigrp** *instance-tag* **Example:** `switch(config)# router eigrp Test1` `switch(config-router)#`	Creates a new EIGRP process with the configured instance tag. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. If you configure an *instance-tag* that does not qualify as an AS number, you must use the **autonomous-system** command to configure the AS number explicitly or this EIGRP instance remains in the shutdown state.
Step 3	**address-family** {**ipv4** | **ipv6**} **unicast** **Example:** `switch(config-router)# address-family ipv4 unicast` `switch(config-router-af)#`	Enters the address-family configuration mode. This command is optional for IPv4.
Step 4	**graceful-restart** **Example:** `switch(config-router-af)# graceful-restart`	Enables graceful restart. This feature is enabled by default.
Step 5	**timers nsf converge** *seconds* **Example**: `switch(config-router-af)# timers nsf converge 100`	Sets the time limit for the convergence after a switchover. The range is from 60 to 180 seconds. The default is 120.
Step 6	**timers nsf route-hold** *seconds* **Example**: `switch(config-router-af)# timers nsf route-hold 200`	Sets the hold time for routes learned from the graceful restart-aware peer. The range is from 20 to 300 seconds. The default is 240.
Step 7	**timers nsf signal** *seconds* **Example**: `switch(config-router-af)# timers nsf signal 15`	Sets the time limit for signaling a graceful restart. The range is from 10 to 30 seconds. The default is 20.
Step 8	**copy running-config startup-config** **Example:** `switch(config-router-af)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to configure graceful restart for EIGRP over IPv6 using the default timer values:

```
switch# configure terminal
switch(config)# router eigrp Test1
switch(config-router)# address-family ipv6 unicast
switch(config-router-af)# graceful-restart
switch(config-router-af)# copy running-config startup-config
```

Adjusting the Interval Between Hello Packets and the Hold Time

You can adjust the interval between Hello messages and the hold time.

By default, Hello messages are sent every 5 seconds. The hold time is advertised in Hello messages and indicates to neighbors the length of time that they should consider the sender valid. The default hold time is three times the hello interval, or 15 seconds.

To change the interval between hello packets, use the following command in interface configuration mode:

Command	Purpose
`switch(config-if)# {ip | ipv6} hello-interval eigrp` *instance-tag seconds* **Example:** `switch(config-if)# ip hello-interval eigrp Test1 30`	Configures the hello interval for an EIGRP routing process. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. The range is from 1 to 65535 seconds. The default is 5.

On very congested and large networks, the default hold time might not be sufficient time for all routers to receive hello packets from their neighbors. In this case, you might want to increase the hold time.

To change the hold time, use the following command in interface configuration mode:

Command	Purpose
`switch(config-if)# {ip | ipv6} hold-time eigrp` *instance-tag seconds* **Example:** `switch(config-if)# ipv6 hold-time eigrp Test1 30`	Configures the hold time for an EIGRP routing process. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. The range is from 1 to 65535.

Use the **show ip eigrp interface detail** command to verify the timer configuration.

Disabling Split Horizon

You can use split horizon to block route information from being advertised by a router out of any interface from which that information originated. Split horizon usually optimizes communications among multiple routing devices, particularly when links are broken.

By default, split horizon is enabled on all interfaces.

To disable split horizon, use the following command in interface configuration mode:

Command	Purpose
`switch(config-if)# no {ip | ipv6} split-horizon eigrp` *instance-tag* **Example:** `switch(config-if)# no ip split-horizon eigrp Test1`	Disables split horizon.

Enabling Wide Metrics

To enable wide metrics, use the following command in router or address family configuration mode:

Command	Purpose
`switch(config-router)# metrics version 64bit` **Example:** `switch(config-router)# metrics version 64bit`	Enables 64-bit metric values.

To optionally configure a scaling factor for the RIB, use the following commands in router or address family configuration mode:

Command	Purpose
`switch(config-router)# metrics rib-scale` *value* **Example:** `switch(config-router)# metrics rib-scale 128`	(Optional) Configures the scaling factor used to convert the 64-bit metric values to 32 bit in the RIB. The range is from 1 to 255. The default is 128.

Tuning EIGRP

You can configure optional parameters to tune EIGRP for your network.

You can configure the following optional parameters in address-family configuration mode:

Command	Purpose
default-information originate [**always** | **route-map** *map-name*] **Example:** `switch(config-router-af)# default-information originate always`	Originates or accepts the default route with prefix 0.0.0.0/0. When a route-map is supplied, the default route is originated only when the route map yields a true condition. The map name can be any case-sensitive, alphanumeric string up to 20 characters.
distance *internal external* **Example**: `switch(config-router-af)# distance 25 100`	Configures the administrative distance for this EIGRP process. The range is from 1 to 255. The internal value sets the distance for routes learned from within the same autonomous system (the default value is 90). The external value sets the distance for routes learned from an external autonomous system (the default value is 170).
metric max-hops *hop-count* **Example:** `switch(config-router-af)# metric max-hops 70`	Sets the maximum allowed hops for an advertised route. Routes over this maximum are advertised as unreachable. The range is from 1 to 255. The default is 100.

Command	Purpose
metric weights *tos k1 k2 k3 k4 k5 k6* **Example:** `switch(config-router-af)# metric weights 0 1 3 2 1 0`	Adjusts the EIGRP metric or K value. EIGRP uses the following formula to determine the total metric to the network: metric = [k1 x bandwidth + (k2 x bandwidth)/(256 – load) + k3 x delay + k6 x extended attributes] * [k5/(reliability + k4)] Default values and ranges are as follows: • TOS—0. The range is from 0 to 8. • k1—1. The range is from 0 to 255. • k2—0. The range is from 0 to 255. • k3—1. The range is from 0 to 255. • k4—0. The range is from 0 to 255. • k5—0. The range is from 0 to 255. • k6—0. The range is from 0 to 255.
nsf await-redist-proto-convergence **Example**: `switch(config-router-af)# nsf await-redist-proto-convergence`	Causes EIGRP to wait for the convergence of redistributed protocols before installing its own routes in the Routing Information Base (RIB) during nonstop forwarding (NSF). This command is useful in switchover scenarios when NSF is in progress and you want EIGRP to wait for BGP to converge and install its routes. It prevents EIGRP from installing transient routes and modifying the Forwarding Information Base (FIB) entries before BGP converges and EIGRP finds an alternate path to a destination. **Note** If you use this command when mutual redistribution is configured between EIGRP and BGP (for example, in a PE-CE environment), some traffic loss might occur because the provider-edge (PE) router will not install EIGRP routes into the RIB until BGP routes are available. This behavior delays the routes that the customer-edge (CE) router learns from EIGRP and advertises to the peer PE router.
timers active-time {*time-limit* | **disabled**} **Example**: `switch(config-router-af)# timers active-time 200`	Sets the time the router waits in minutes (after sending a query) before declaring the route to be stuck in the active (SIA) state. The range is from 1 to 65535. The default is 3.

You can configure the following optional parameters in interface configuration mode:

Command	Purpose
{**ip** | **ipv6**} **bandwidth eigrp** *instance-tag bandwidth* **Example:** `switch(config-if)# ip bandwidth eigrp Test1 30000`	Configures the bandwidth metric for EIGRP on an interface. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. The bandwidth range is from 1 to 2,560,000,000 Kb/s.
{**ip** | **ipv6**} **bandwidth-percent eigrp** *instance-tag percent* **Example:** `switch(config-if)# ip bandwidth-percent eigrp Test1 30`	Configures the percentage of bandwidth that EIGRP might use on an interface. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. The percent range is from 0 to 100. The default is 50.
no {**ip** | **ipv6**} **delay eigrp** *instance-tag delay* **Example:** `switch(config-if)# ip delay eigrp Test1 100`	Configures the delay metric for EIGRP on an interface. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. The delay range is from 1 to 16777215 (in tens of microseconds).
{**ip** | **ipv6**} **distribute-list eigrp** *instance-tag* {**prefix-list** *name*| **route-map** name} {**in** | **out**} **Example:** `switch(config-if)# ip distribute-list eigrp Test1 route-map EigrpTest in`	Configures the route filtering policy for EIGRP on this interface. The instance tag, prefix list name, and route map name can be any case-sensitive, alphanumeric string up to 20 characters.
no {**ip** | **ipv6**} **next-hop-self eigrp** *instance-tag* **Example:** `switch(config-if)# ipv6 next-hop-self eigrp Test1`	Configures EIGRP to use the received next-hop address rather than the address for this interface. The default is to use the IP address of this interface for the next-hop address. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters.
{**ip** | **ipv6**} **offset-list eigrp** *instance-tag* {**prefix-list** *name*| **route-map** name} {**in** | **out**} *offset* **Example:** `switch(config-if)# ip offset-list eigrp Test1 prefix-list EigrpList in`	Adds an offset to incoming and outgoing metrics to routes learned by EIGRP. The instance tag, prefix list name, and route map name can be any case-sensitive, alphanumeric string up to 20 characters.
{**ip** | **ipv6**} **passive-interface eigrp** *instance-tag* **Example:** `switch(config-if)# ip passive-interface eigrp Test1`	Suppresses EIGRP hellos, which prevents neighbors from forming and sending routing updates on an EIGRP interface. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters.

Configuring Virtualization for EIGRP

You can configure multiple EIGRP processes, create multiple VRFs, and use the same or multiple EIGRP processes in each VRF. You assign an interface to a VRF.

Note Configure all other parameters for an interface after you configure the VRF for an interface. Configuring a VRF for an interface deletes all other configuration for that interface.

BEFORE YOU BEGIN

You must enable EIGRP (see the "Enabling the EIGRP Feature" section on page 7-11).

Create the VRFs.

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf-name*
3. **router eigrp** *instance-tag*
4. **interface ethernet** *slot/port*
5. **vrf member** *vrf-name*
6. {**ip** | **ipv6**} **router eigrp** *instance-tag*
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** `switch(config)# vrf context RemoteOfficeVRF` `switch(config-vrf)#`	Creates a new VRF and enters VRF configuration mode. The VRF name can be any case-sensitive, alphanumeric string up to 20 characters.
Step 3	**router eigrp** *instance-tag* **Example:** `switch(config)# router eigrp Test1` `switch(config-router)#`	Creates a new EIGRP process with the configured instance tag. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters. If you configure an *instance-tag* that does not qualify as an AS number, you must use the **autonomous-system** command to configure the AS number explicitly or this EIGRP instance remains in the shutdown state.

	Command	Purpose
Step 4	**interface ethernet** *slot/port* **Example**: switch(config)# interface ethernet 1/2 switch(config-if)#	Enters interface configuration mode. Use **?** to find the slot and port ranges.
Step 5	**vrf member** *vrf-name* **Example:** switch(config-if)# vrf member RemoteOfficeVRF	Adds this interface to a VRF. The VRF name can be any case-sensitive, alphanumeric string up to 20 characters.
Step 6	{**ip** | **ipv6**} **router eigrp** *instance-tag* **Example**: switch(config-if)# ip router eigrp Test1	Adds this interface to the EIGRP process. The instance tag can be any case-sensitive, alphanumeric string up to 20 characters.
Step 7	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create a VRF and add an interface to the VRF:

```
switch# configure terminal
switch(config)# vrf context NewVRF
switch(config-vrf)# router eigrp Test1
switch(config-router)# interface ethernet 1/2
switch(config-if)# ip router eigrp Test1
switch(config-if)# vrf member NewVRF
switch(config-if)# copy running-config startup-config
```

Verifying the EIGRP Configuration

To display the EIGRP configuration, perform one of the following tasks:

Command	Purpose
show {**ip** | **ipv6**} **eigrp** [*instance-tag*]	Displays a summary of the configured EIGRP processes.
show {**ip** | **ipv6**} **eigrp** [*instance-tag*] **interfaces** [*type number*] [**brief**] [**detail**]	Displays information about all configured EIGRP interfaces.
show {**ip** | **ipv6**} **eigrp** *instance-tag* **neighbors** [*type number*] [**detail**]	Displays information about all the EIGRP neighbors. Use this command to verify the EIGRP neighbor configuration.
show {**ip** | **ipv6**} **eigrp** [*instance-tag*] **route** [*ip-prefix/length*] [**active**] [**all-links**] [**detail-links**] [**pending**] [**summary**] [**zero-successors**] [**vrf** *vrf-name*]	Displays information about all the EIGRP routes.

Command	Purpose
show {**ip** | **ipv6**} **eigrp** [*instance-tag*] **topology** [*ip-prefix/length*] [**active**] [**all-links**] [**detail-links**] [**pending**] [**summary**] [**zero-successors**] [**vrf** *vrf-name*]	Displays information about the EIGRP topology table.
show running-configuration eigrp	Displays the current running EIGRP configuration.

Monitoring EIGRP

To display EIGRP statistics, use the following commands:

Command	Purpose
show {**ip** | **ipv6**} **eigrp** [*instance-tag*] **accounting** [**vrf** *vrf-name*]	Displays accounting statistics for EIGRP.
show {**ip** | **ipv6**} **eigrp** [*instance-tag*] **route-map statistics redistribute**	Displays redistribution statistics for EIGRP.
show {**ip** | **ipv6**} **eigrp** [*instance-tag*] **traffic** [**vrf** *vrf-name*]	Displays traffic statistics for EIGRP.

Configuration Examples for EIGRP

This example shows how to configure EIGRP:

```
feature eigrp
interface ethernet 1/2
 ip address 192.0.2.55/24
 ip router eigrp Test1
  no shutdown
router eigrp Test1
  router-id 192.0.2.1
```

The following example shows how to use a route map with the **distribute-list** command to filter routes that are dynamically received from (or advertised to) EIGRP peers. The example configures a route map to match an EIGRP external protocol metric route with an allowable deviation of 100, a source protocol of BGP, and an autonomous system number of 45000. When the two match clauses are true, the tag value of the destination routing protocol is set to 5. The route map is used to distribute incoming packets for an EIGRP process.

```
switch(config)# route-map metric-range
switch(config-route-map)# match metric external 500 +- 100
switch(config-route-map)# match source-protocol bgp 45000
switch(config-route-map)# set tag 5
switch(config-route-map)# exit
switch(config)# router eigrp 1
switch(config-router)# exit
switch(config)# interface ethernet 1/2
switch(config-if)# ip address 172.16.0.0
switch(config-if)# ip router eigrp 1
```

```
switch(config-if)# ip distribute-list eigrp 1 route-map metric-range in
```

The following example shows how to use a route map with the **redistribute** command to allow routes that are redistributed from the routing table to be filtered with a route map before being admitted into an EIGRP topology table. The example shows how to configure a route map to match EIGRP routes with a metric of 110, 200, or an inclusive range of 700 to 800. When the match clause is true, the tag value of the destination routing protocol is set to 10. The route map is used to redistribute EIGRP packets.

```
switch(config)# route-map metric-eigrp
switch(config-route-map)# match metric 110 200 750 +- 50
switch(config-route-map)# set tag 10
switch(config-route-map)# exit
switch(config)# router eigrp 1
switch(config-router)# redistribute eigrp route-map metric-eigrp
switch(config-router)# exit
switch(config)# interface ethernet 1/2
switch(config-if)# ip address 172.16.0.0
switch(config-if)# ip router eigrp 1
```

Related Topics

See Chapter 15, "Configuring Route Policy Manager," for more information on route maps.

Additional References

For additional information related to implementing EIGRP, see the following sections:

- Related Documents, page 7-33
- MIBs, page 7-33

Related Documents

Related Topic	Document Title
http://www.cisco.com/warp/public/103/1.html	*Introduction to EIGRP Tech Note*
http://www.cisco.com/en/US/tech/tk365/technologies_q_and_a_item09186a008012dac4.shtml	EIGRP Frequently Asked Questions

MIBs

MIBs	MIBs Link
MIBs related to EIGRP	To locate and download supported MIBs, go to the following URL: ftp://ftp.cisco.com/pub/mibs/supportlists/nexus9000/Nexus9000MIBSupportList.html

Configuring IS-IS

This chapter describes how to configure Integrated Intermediate System-to-Intermediate System (IS-IS) on the Cisco NX-OS device.

This chapter includes the following sections:

About IS-IS

IS-IS is an Interior Gateway Protocol (IGP) based on Standardization (ISO)/International Engineering Consortium (IEC) 10589. Cisco NX-OS supports Internet Protocol version 4 (IPv4) and IPv6. IS-IS is a dynamic link-state routing protocol that can detect changes in the network topology and calculate loop-free routes to other nodes in the network. Each router maintains a link-state database that describes the state of the network and sends packets on every configured link to discover neighbors. IS-IS floods the link-state information across the network to each neighbor. The router also sends advertisements and updates on the link-state database through all the existing neighbors.

This section includes the following topics:

IS-IS Overview

IS-IS sends a hello packet out every configured interface to discover IS-IS neighbor routers. The hello packet contains information, such as the authentication, area, and supported protocols, which the receiving interface uses to determine compatibility with the originating interface. The hello packets are also padded to ensure that IS-IS establishes adjacencies only with interfaces that have matching maximum transmission unit (MTU) settings. Compatible interfaces form adjacencies, which update routing information in the link-state database through link-state update messages (LSPs). By default, the router sends a periodic LSP refresh every 10 minutes and the LSPs remain in the link-state database for 20 minutes (the LSP lifetime). If the router does not receive an LSP refresh before the end of the LSP lifetime, the router deletes the LSP from the database.

The LSP interval must be less than the LSP lifetime or the LSPs time out before they are refreshed.

IS-IS sends periodic hello packets to adjacent routers. If you configure transient mode for hello packets, these hello packets do not include the excess padding used before IS-IS establishes adjacencies. If the MTU value on adjacent routers changes, IS-IS can detect this change and send padded hello packets for a period of time. IS-IS uses this feature to detect mismatched MTU values on adjacent routers. For more information, see the "Configuring the Transient Mode for Hello Padding" section on page 8-18.

IS-IS Areas

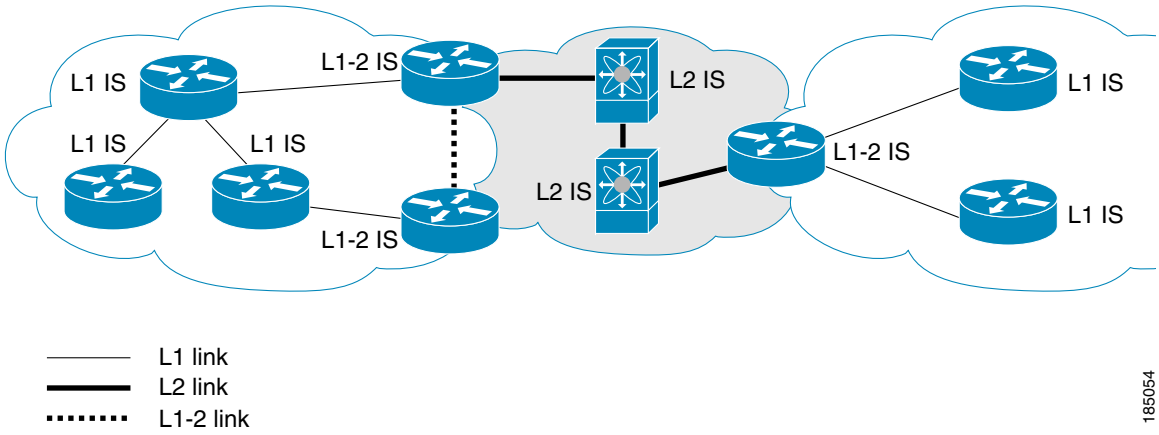
You can design IS-IS networks as a single area that includes all routers in the network or as multiple areas that connect into a backbone or Level 2 area. Routers in a nonbackbone area are Level 1 routers that establish adjacencies within a local area (intra-area routing). Level 2 area routers establish adjacencies to other Level 2 routers and perform routing between Level 1 areas (inter-area routing). A router can have both Level 1 and Level 2 areas configured. These Level 1/Level 2 routers act as area border routers that route information from the local area to the Level 2 backbone area (see Figure 8-1).

Within a Level 1 area, routers know how to reach all other routers in that area. The Level 2 routers know how to reach other area border routers and other Level 2 routers. Level 1/Level 2 routers straddle the boundary between two areas, routing traffic to and from the Level 2 backbone area. Level1/Level2 routers use the attached (ATT) bit signal Level 1 routers to set a default route to this Level1/Level2 router to connect to the Level 2 area.

In some instances, such as when you have two or more Level1/Level 2 routers in an area, you may want to control which Level1/Level2 router that the Level 1 routers use as the default route to the Level 2 area. You can configure which Level1/Level2 router sets the attached bit. For more information, see the "Verifying the IS-IS Configuration" section on page 8-30.

Each IS-IS instance in Cisco NX-OS supports either a single Level 1 or Level 2 area, or one of each. By default, all IS-IS instances automatically support Level 1 and Level 2 routing.

Figure 8-1 IS-IS Network Divided into Areas



An autonomous system boundary router (ASBR) advertises external destinations throughout the IS-IS autonomous system. External routes are the routes redistributed into IS-IS from any other protocol.

NET and System ID

Each IS-IS instance has an associated network entity title (NET). The NET is comprised of the IS-IS system ID, which uniquely identifies this IS-IS instance in the area and the area ID. For example, if the NET is 47.0004.004d.0001.0001.0c11.1111.00, the system ID is 0000.0c11.1111.00 and the area is ID 47.0004.004d.0001.

Designated Intermediate System

IS-IS uses a designated intermediate system (DIS) in broadcast networks to prevent each router from forming unnecessary links with every other router on the broadcast network. IS-IS routers send LSPs to the DIS, which manages all the link-state information for the broadcast network. You can configure the IS-IS priority that IS-IS uses to select the DIS in an area.

Note No DIS is required on a point-to-point network.

IS-IS Authentication

You can configure authentication to control adjacencies and the exchange of LSPs. Routers that want to become neighbors must exchange the same password for their configured level of authentication. IS-IS blocks a router that does not have the correct password. You can configure IS-IS authentication globally or for an individual interface for Level 1, Level 2, or both Level 1/Level 2 routing.

IS-IS supports the following authentication methods:

- Clear text—All packets exchanged carry a cleartext 128-bit password.
- MD5 digest—All packets exchanged carry a message digest that is based on a 128-bit key.

To provide protection against passive attacks, IS-IS never sends the MD5 secret key as cleartext through the network. In addition, IS-IS includes a sequence number in each packet to protect against replay attacks.

You can use also keychains for hello and LSP authentication. See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide* for information on keychain management.

Mesh Groups

A mesh group is a set of interfaces in which all routers reachable over the interfaces have at least one link to every other router. Many links can fail without isolating one or more routers from the network.

In normal flooding, an interface receives a new LSP and floods the LSP out over all other interfaces on the router. With mesh groups, when an interface that is part of a mesh group receives a new LSP, the interface does not flood the new LSP over the other interfaces that are part of that mesh group.

Note You may want to limit LSPs in certain mesh network topologies to improve network scalability. Limiting LSP floods might also reduce the reliability of the network (in case of failures). For this reason, we recommend that you use mesh groups only if specifically required, and then only after you make a careful network design.

You can also configure mesh groups in block mode for parallel links between routers. In this mode, all LSPs are blocked on that interface in a mesh group after the routers initially exchange their link-state information.

Overload Bit

IS-IS uses the overload bit to tell other routers not to use the local router to forward traffic but to continue routing traffic destined for that local router.

You may want to use the overload bit in these situations:

- The router is in a critical condition.
- Graceful introduction and removal of the router to/from the network.
- Other (administrative or traffic engineering) reasons such as waiting for BGP convergence.

Route Summarization

You can configure a summary aggregate address. Route summarization simplifies route tables by replacing a number of more-specific addresses with an address that represents all the specific addresses. For example, you can replace 10.1.1.0/24, 10.1.2.0/24, and 10.1.3.0/24 with one summary address, 10.1.0.0/16.

If more specific routes are in the routing table, IS-IS advertises the summary address with a metric equal to the minimum metric of the more specific routes.

Note Cisco NX-OS does not support automatic route summarization.

Route Redistribution

You can use IS-IS to redistribute static routes, routes learned by other IS-IS autonomous systems, or routes from other protocols. You must configure a route map with the redistribution to control which routes are passed into IS-IS. A route map allows you to filter routes based on attributes such as the destination, origination protocol, route type, route tag, and so on. For more information, see Chapter 15, "Configuring Route Policy Manager."

Whenever you redistribute routes into an IS-IS routing domain, Cisco NX-OS does not, by default, redistribute the default route into the IS-IS routing domain. You can generate a default route into IS-IS, which can be controlled by a route policy.

You also configure the default metric that is used for all imported routes into IS-IS.

Load Balancing

You can use load balancing to allow a router to distribute traffic over all the router network ports that are the same distance from the destination address. Load balancing increases the utilization of network segments and increases the effective network bandwidth.

Cisco NX-OS supports the Equal Cost Multiple Paths (ECMP) feature with up to 16 equal-cost paths in the IS-IS route table and the unicast RIB. You can configure IS-IS to load balance traffic across some or all of those paths.

BFD

This feature supports bidirectional forwarding detection (BFD) for IPv4 and IPv6. BFD is a detection protocol designed to provide fast forwarding-path failure detection times. BFD provides subsecond failure detection between two adjacent devices and can be less CPU-intensive than protocol hello messages because some of the BFD load can be distributed onto the data plane on supported modules. See the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide* for more information.

Virtualization Support

Cisco NX-OS supports multiple process instances for IS-IS. Each IS-IS instance can support multiple virtual routing and forwarding (VRF) instances, up to the system limit. For the number of supported IS-IS instances, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

High Availability and Graceful Restart

Cisco NX-OS provides a multilevel high-availability architecture. IS-IS supports stateful restart, which is also referred to as non-stop routing (NSR). If IS-IS experiences problems, it attempts to restart from its previous run-time state. The neighbors would not register any neighbor event in this case. If the first restart is not successful and another problem occurs, IS-IS attempts a graceful restart as per RFC 3847. A graceful restart, or non-stop forwarding (NSF), allows IS-IS to remain in the data forwarding path through a process restart. When the restarting IS-IS interface is operational again, it rediscovers its neighbors, establishes adjacency, and starts sending its updates again. At this point, the NSF helpers recognize that the graceful restart has finished.

A stateful restart is used in the following scenarios:

- First recovery attempt after process experiences problems
- User-initiated switchover using the **system switchover** command

A graceful restart is used in the following scenarios:

- Second recovery attempt after the process experiences problems within a 4-minute interval
- Manual restart of the process using the **restart isis** command
- Active supervisor removal
- Active supervisor reload using the **reload module** *active-sup* command

Note Graceful restart is on by default, and we strongly recommend that you do not disable it.

Multiple IS-IS Instances

Cisco NX-OS supports multiple instances of the IS-IS protocol that run on the same node. You cannot configure multiple instances over the same interface. Every instance uses the same system router ID. For the number of supported IS-IS instances, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

Licensing Requirements for IS-IS

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	IS-IS requires an Enterprise Services license. For a complete explanation of the Cisco NX-OS licensing scheme and how to obtain and apply licenses, see the *Cisco NX-OS Licensing Guide.*

Prerequisites for IS-IS

IS-IS has the following prerequisites:

- You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

Guidelines and Limitations for IS-IS

IS-IS has the following configuration guidelines and limitations:

- Because the default reference bandwidth is different for Cisco NX-OS and Cisco IOS, the advertised tunnel IS-IS metric is different for these two operating systems.

Default Settings

Table 8-1 lists the default settings for IS-IS parameters.

Table 8-1 Default IS-IS Parameters

Parameters	Default
Administrative distance	115
Area level	Level-1-2
DIS priority	64
Graceful restart	Enabled
Hello multiplier	3
Hello padding	Enabled
Hello time	10 seconds
IS-IS feature	Disabled
LSP interval	33
LSP MTU	1492
Maximum LSP lifetime	1200 seconds
Maximum paths	8
Metric	40
Reference bandwidth	40 Gbps

Configuring IS-IS

To configure IS-IS, follow these steps:

Step 1 Enable the IS-IS feature (see the "Enabling the IS-IS Feature" section on page 8-9).

Step 2 Create an IS-IS instance (see the "Creating an IS-IS Instance" section on page 8-9).

Step 3 Add an interface to the IS-IS instance (see the "Configuring IS-IS on an Interface" section on page 8-12).

Step 4 Configure optional features, such as authentication, mesh groups, and dynamic host exchange.

This section contains the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

IS-IS Configuration Modes

The following sections show how to enter each of the configuration modes. From a mode, you can enter the **?** command to display the commands available in that mode.

This section includes the following topics:

Router Configuration Mode

This example shows how to enter router configuration mode:

```
switch#: configure terminal
switch(config)# router isis isp
switch(config-router)#
```

Router Address Family Configuration Mode

This example shows how to enter router address family configuration mode:

```
switch(config)# router isis isp
switch(config-router)# address-family ipv4 unicast
switch(config-router-af)#
```

Enabling the IS-IS Feature

You must enable the IS-IS feature before you can configure IS-IS.

SUMMARY STEPS

1. **configure terminal**
2. **feature isis**
3. (Optional) **show feature**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**feature isis** **Example:** `switch(config)# feature isis`	Enables the IS-IS feature.
Step 3	**show feature** **Example:** `switch(config)# show feature`	(Optional) Displays enabled and disabled features.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

To disable the IS-IS feature and remove all associated configuration, use the following command in configuration mode:

Command	Purpose
no feature isis **Example:** `switch(config)# no feature isis`	Disables the IS-IS feature and removes all associated configurations.

Creating an IS-IS Instance

You can create an IS-IS instance and configure the area level for that instance.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

SUMMARY STEPS

1. **configure terminal**
2. **router isis** *instance-tag*
3. **net** *network-entity-title*
4. (Optional) **is-type** {**level-1 | level-2 | level-1-2**}
5. (Optional) **show isis** [**vrf** *vrf-name*] **process**
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router isis** *instance-tag* **Example:** `switch(config)# router isis Enterprise` `switch(config-router)#`	Creates a new IS-IS instance with the configured *instance tag*.
Step 3	**net** *network-entity-title* **Example:** `switch(config-router)# net` `47.0004.004d.0001.0001.0c11.1111.00`	Configures the NET for this IS-IS instance.
Step 4	**is-type** {**level-1** | **level-2** | **level-1-2**} **Example:** `switch(config-router)# is-type level-2`	(Optional) Configures the area level for this IS-IS instance. The default is level-1-2.
Step 5	**show isis** [**vrf** *vrf-name*] **process** **Example**: `switch(config)# show isis process`	(Optional) Displays a summary of IS-IS information for all IS-IS instances.
Step 6	**copy running-config startup-config** **Example:** `switch(config)# copy running-config` `startup-config`	(Optional) Saves this configuration change.

To remove the IS-IS instance and the associated configuration, use the following command in configuration mode:

Command	Purpose
no router isis *instance-tag* **Example:** `switch(config)# no router isis Enterprise`	Deletes the IS-IS instance and all associated configurations.

Note You must also remove any IS-IS commands that are configured in interface mode to completely remove all configurations for the IS-IS instance.

You can configure the following optional parameters for IS-IS:

Command	Purpose
distance *value* **Example:** switch(config-router)# distance 30	Sets the administrative distance for IS-IS. The range is from 1 to 255. The default is 115.
log-adjacency-changes **Example:** switch(config-router)# log-adjacency-changes	Sends a system message whenever an IS-IS neighbor changes the state.
lsp-mtu *size* **Example:** switch(config-router)# lsp-mtu 600	Sets the MTU for LSPs in this IS-IS instance. The range is from 128 to 4352 bytes. The default is 1492.
maximum-paths *number* **Example:** switch(config-router)# maximum-paths 6	Configures the maximum number of equal-cost paths that IS-IS maintains in the route table. The range is from 1 to 64. The default is 8.
reference-bandwidth *bandwidth-value* {**Mbps** | **Gbps**} **Example:** switch(config-router)# reference-bandwidth 100 Gbps	Sets the default reference bandwidth used for calculating the IS-IS cost metric. The range is from 1 to 4000 Gbps. The default is 40 Gbps.

This example shows how to create an IS-IS instance in a level 2 area:

```
switch# configure terminal
switch(config)# router isis Enterprise
switch(config-router)# net 47.0004.004d.0001.0001.0c11.1111.00
switch(config-router)# is-type level 2
switch(config-router)# copy running-config startup-config
```

To clear neighbor statistics and remove adjacencies, use the following command in router configuration mode:

Command	Purpose
clear isis [*instance-tag*] **adjacency** [***** | *system-id* | *interface*] **Example**: switch(config-if)# clear isis adjacency *	Clears neighbor statistics and removed adjacencies for this IS-IS instance.

Restarting an IS-IS Instance

You can restart an IS-IS instance. This action clears all neighbors for the instance.

To restart an IS-IS instance and remove all associated neighbors, use the following command:

Command	Purpose
restart isis instance-tag **Example:** switch(config)# restart isis Enterprise	Restarts the IS-IS instance and removes all neighbors.

Shutting Down IS-IS

You can shut down the IS-IS instance. This action disables this IS-IS instance and retains the configuration.

To shut down the IS-IS instance, use the following command in router configuration mode:

Command	Purpose
shutdown **Example:** switch(config-router)# shutdown	Disables the IS-IS instance.

Configuring IS-IS on an Interface

You can add an interface to an IS-IS instance.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. (Optional) **medium** {**broadcast** | **p2p**}
4. {**ip** | **ipv6**} **router isis** *instance-tag*
5. (Optional) **show isis** [**vrf** *vrf-name*] [*instance-tag*] **interface** [*interface-type slot/port*]
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** switch(config)# interface ethernet 1/2 switch(config-if)#	Enters interface configuration mode.
Step 3	**medium** {**broadcast** | **p2p**} **Example**: switch(config-if)# medium p2p	(Optional) Configures the broadcast or point-to-point mode for the interface. IS-IS inherits this mode.
Step 4	{**ip** | **ipv6**} **router isis** *instance-tag* **Example**: switch(config-if)# ip router isis Enterprise	Associates this IPv4 or IPv6 interface with an IS-IS instance.
Step 5	**show isis** [**vrf** *vrf-name*] [*instance-tag*] **interface** [*interface-type slot/port*] **Example**: switch(config)# show isis Enterprise ethernet 1/2	(Optional) Displays IS-IS information for an interface.
Step 6	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

You can configure the following optional parameters for IS-IS in interface mode:

Command	Purpose
isis circuit-type {**level-1** | **level-2** | **level-1-2**} **Example**: switch(config-if)# isis circuit-type level-2	Sets the type of adjacency that this interface participates in. Use this command only for routers that participate in both Level 1 and Level 2 areas.
isis metric *value* {**level-1** | **level-2**} **Example:** switch(config-if)# isis metric 30	Sets the IS-IS metric for this interface. The range is from 1 to 16777214. The default is 10.
isis passive {**level-1** | **level-2** | **level-1-2**} **Example:** switch(config-if)# isis passive level-2	Prevents the interface from forming adjacencies but still advertises the prefix associated with the interface.

This example shows how to add Ethernet 1/2 interface to an IS-IS instance:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# ip router isis Enterprise
switch(config-if)# copy running-config startup-config
```

Shutting Down IS-IS on an Interface

You can gracefully shut down IS-IS on an interface. This action removes all adjacencies and stops IS-IS traffic on this interface but preserves the IS-IS configuration.

To disable IS-IS on an interface, use the following command in interface configuration mode:

Command	Purpose
`switch(config-if)# isis shutdown` **Example:** `switch(config-router)# isis shutdown`	Disables IS-IS on this interface. The IS-IS interface configuration remains.

Configuring IS-IS Authentication in an Area

You can configure IS-IS to authenticate LSPs in an area.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

SUMMARY STEPS

1. **configure terminal**
2. **router isis** *instance-tag*
3. **authentication-type** {**cleartext** | **md5**} {**level-1** | **level-2**}
4. **authentication key-chain** *key* {**level-1** | **level-2**}
5. (Optional) **authentication-check** {**level-1** | **level-2**}
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router isis** *instance-tag* **Example:** switch(config)# router isis Enterprise switch(config-router)#	Creates a new IS-IS instance with the configured *instance tag*.
Step 3	**authentication-type** {**cleartext** | **md5**} {**level-1** | **level-2**} **Example**: switch(config-router)# authentication-type cleartext level-2	Sets the authentication method used for a Level 1 or Level 2 area as cleartext or as an MD5 authentication digest.
Step 4	**authentication key-chain** *key* {**level-1** | **level-2**} **Example**: switch(config-router)# authentication key-chain ISISKey level-2	Configures the authentication key used for an IS-IS area-level authentication.
Step 5	**authentication-check** {**level-1** | **level-2**} **Example**: switch(config-router)# authentication-check level-2	(Optional) Enables checking the authentication parameters in a received packet.
Step 6	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to configure cleartext authentication on an IS-IS instance:

```
switch# configure terminal
switch(config)# router isis Enterprise
switch(config-router)# authentication-type cleartext level-2
switch(config-router)# authentication key-chain ISISKey level-2
switch(config-router)# copy running-config startup-config
```

Configuring IS-IS Authentication on an Interface

You can configure IS-IS to authenticate Hello packets on an interface.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

SUMMARY STEPS

1. **configure terminal**

2. **interface** *interface-type slot/port*
3. **isis authentication-type** {**cleartext** | **md5**} {**level-1** | **level-2**}
4. **isis authentication key-chain** *key* {**level-1** | **level-2**}
5. (Optional) **isis authentication-check** {**level-1** | **level-2**}
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** switch(config)# interface ethernet 1/2 switch(config-if)#	Enters interface configuration mode.
Step 3	**isis authentication-type** {**cleartext** | **md5**} {**level-1** | **level-2**} **Example**: switch(config-if)# isis authentication-type cleartext level-2	Sets the authentication type for IS-IS on this interface as cleartext or as an MD5 authentication digest.
Step 4	**isis authentication key-chain** *key* {**level-1** | **level-2**} **Example**: switch(config-if)# isis authentication-key ISISKey level-2	Configures the authentication key used for IS-IS on this interface.
Step 5	**isis authentication-check** {**level-1** | **level-2**} **Example**: switch(config-if)# isis authentication-check	(Optional) Enables checking the authentication parameters in a received packet.
Step 6	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to configure cleartext authentication on an IS-IS instance:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# isis authentication-type cleartext level-2
switch(config-if)# isis authentication key-chain ISISKey
switch(config-if)# copy running-config startup-config
```

Configuring a Mesh Group

You can add an interface to a mesh group to limit the amount of LSP flooding for interfaces in that mesh group. You can optionally block all LSP flooding on an interface in a mesh group.

To add an interface to a mesh group, use the following command in interface configuration mode:

Command	Purpose
isis mesh-group {**blocked** | *mesh-id*} **Example**: `switch(config-if)# isis mesh-group 1`	Adds this interface to a mesh group. The range is from 1 to 4294967295.

Configuring a Designated Intermediate System

You can configure a router to become the designated intermediate system (DIS) for a multiaccess network by setting the interface priority.

To configure the DIS, use the following command in interface configuration mode:

Command	Purpose
isis priority *number* {**level-1** | **level-2**} **Example**: `switch(config-if)# isis priority 100 level-1`	Sets the priority for DIS selection. The range is from 0 to 127. The default is 64.

Configuring Dynamic Host Exchange

You can configure IS-IS to map between the system ID and the hostname for a router using dynamic host exchange.

To configure dynamic host exchange, use the following command in router configuration mode:

Command	Purpose
hostname dynamic **Example**: `switch(config-router)# hostname dynamic`	Enables dynamic host exchange.

Setting the Overload Bit

You can configure the router to signal other routers not to use this router as an intermediate hop in their shortest path first (SPF) calculations. You can optionally configure the overload bit temporarily on startup, until BGP converges.

In addition to setting the overload bit, you might also want to suppress certain types of IP prefix advertisements from LSPs for Level 1 or Level 2 traffic.

To set the overload bit, use the following command in router configuration mode:

Command	Purpose
set-overload-bit {**always** | **on-startup** {*seconds* | **wait-for bgp** *as-number*}} [**suppress** [**interlevel** | **external**]] **Example:** switch(config-router)# set-overload-bit on-startup 30	Sets the overload bit for IS-IS. The *seconds* range is from 5 to 86400.

Configuring the Attached Bit

You can configure the attached bit to control which Level 1/Level 2 router that the Level 1 routers use as the default route to the Level 2 area. If you disable setting the attached bit, the Level 1 routers do not use this Level 1/Level 2 router to reach the Level 2 area.

To configure the attached bit for a Level 1/Level 2 router, use the following command in router configuration mode:

Command	Purpose
[**no**] **attached-bit** **Example:** switch(config-router)# no attached-bit	Configures the Level 1/Level 2 router to set the attached bit. This feature is enabled by default.

Configuring the Transient Mode for Hello Padding

You can configure the transient mode for hello padding to pad hello packets when IS-IS establishes adjacency and remove that padding after IS-IS establishes adjacency.

To configure the mode for hello padding, use the following command in router configuration mode:

Command	Purpose
[**no**] **isis hello-padding** **Example:** switch(config-if)# no isis hello-padding	Pads the hello packet to the full maximum transmission unit (MTU). The default is enabled. Use the **no** form of this command to configure the transient mode of hello padding.

Configuring a Summary Address

You can create aggregate addresses that are represented in the routing table by a summary address. One summary address can include multiple groups of addresses for a given level. Cisco NX-OS advertises the smallest metric of all the more-specific routes.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

SUMMARY STEPS

1. **configure terminal**
2. **router isis** *instance-tag*
3. **address-family** {**ipv4** | **ipv6**} **unicast**
4. **summary-address** *ip-prefix/mask-len* {**level-1** | **level-2** | **level-1-2**}
5. (Optional) **show isis** [**vrf** *vrf-name*] {**ip** | **ipv6**} **summary-address** *ip-prefix* [**longer-prefixes**]
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router isis** *instance-tag* **Example:** `switch(config)# router isis Enterprise` `switch(config-router)#`	Creates a new IS-IS instance with the configured *instance tag*.
Step 3	**address-family** {**ipv4** | **ipv6**} **unicast** **Example**: `switch(config-router)# address-family ipv4 unicast` `switch(config-router-af)#`	Enters address family configuration mode.
Step 4	**summary-address** *ip-prefix/mask-len* {**level-1** | **level-2** | **level-1-2**} **Example**: `switch(config-router-af)# summary-address 192.0.2.0/24 level-2`	Configures a summary address for an IS-IS area for IPv4 or IPv6 addresses.
Step 5	**show isis** [**vrf** *vrf-name*] {**ip** | **ipv6**} **summary-address** *ip-prefix* [**longer-prefixes**] **Example**: `switch(config-if)# show isis ip summary-address`	(Optional) Displays IS-IS IPv4 or IPv6 summary address information.
Step 6	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to configure an IPv4 unicast summary address for IS-IS:

```
switch# configure terminal
switch(config)# router isis Enterprise
switch(config-router)# address-family ipv4 unicast
switch(config-router-af)# summary-address 192.0.2.0/24 level-2
switch(config-router-af)# copy running-config startup-config
```

Configuring Redistribution

You can configure IS-IS to accept routing information from another routing protocol and redistribute that information through the IS-IS network. You can optionally assign a default route for redistributed routes.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

SUMMARY STEPS

1. **configure terminal**
2. **router isis** *instance-tag*
3. **address-family** {**ipv4** | **ipv6**} **unicast**
4. **redistribute** {**bgp** *as* | **direct** |{**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **static**} **route-map** *map-name*
5. (Optional) **default-information originate** [**always**] [**route-map** *map-name*]
6. (Optional) **distribute** {**level-1** | **level-2**} **into** {**level-1** | **level-2**} {**route-map** *route-map* | **all**}
7. (Optional) **show isis** [**vrf** *vrf-name*] {**ip** | **ipv6**} **route** *ip-prefix* [*detail* | **longer-prefixes** [**summary** | **detail**]]
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router isis** *instance-tag* **Example:** `switch(config)# router isis Enterprise` `switch(config-router)#`	Creates a new IS-IS instance with the configured *instance tag*.
Step 3	**address-family** {**ipv4** | **ipv6**} **unicast** **Example:** `switch(config-router)# address-family ipv4 unicast` `switch(config-router-af)#`	Enters address family configuration mode.
Step 4	**redistribute** {**bgp** *as* | {**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **static** | **direct**} **route-map** *map-name* **Example:** `switch(config-router-af)# redistribute eigrp 201 route-map ISISmap`	Redistributes routes from other protocols into IS-IS. See the "Configuring Route Maps" section on page 15-12 for more information about route maps.

	Command	Purpose
Step 5	**default-information originate** [**always**] [**route-map** *map-name*] **Example**: switch(config-router-af)# default-information originate always	(Optional) Generates a default route into IS-IS.
Step 6	**distribute** {**level-1** | **level-2**} **into** {**level-1** | **level-2**} {**route-map** *route-map* | **all**} **Example**: switch(config-router-af)# distribute level-1 into level-2 all	(Optional) Redistributes routes from one IS-IS level to the other IS-IS level.
Step 7	**show isis** [**vrf** *vrf-name*] {**ip** | **ipv6**} **route** *ip-prefix* [*detail* | **longer-prefixes** [**summary** | **detail**]] **Example:** switch(config-router-af)# show isis ip route	(Optional) Shows the IS-IS routes.
Step 8	**copy running-config startup-config** **Example:** switch(config-router-af)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to redistribute EIGRP into IS-IS:

```
switch# configure terminal
switch(config)# router isis Enterprise
switch(config-router)# address-family ipv4 unicast
switch(config-router-af)# redistribute eigrp 201 route-map ISISmap
switch(config-router-af)# copy running-config startup-config
```

Limiting the Number of Redistributed Routes

Route redistribution can add many routes to the IS-IS route table. You can configure a maximum limit to the number of routes accepted from external protocols. IS-IS provides the following options to configure redistributed route limits:

- Fixed limit—Logs a message when IS-IS reaches the configured maximum. IS-IS does not accept any more redistributed routes. You can optionally configure a threshold percentage of the maximum where IS-IS logs a warning when that threshold is passed.
- Warning only—Logs a warning only when IS-IS reaches the maximum. IS-IS continues to accept redistributed routes.
- Withdraw—Starts the timeout period when IS-IS reaches the maximum. After the timeout period, IS-IS requests all redistributed routes if the current number of redistributed routes is less than the maximum limit. If the current number of redistributed routes is at the maximum limit, IS-IS withdraws all redistributed routes. You must clear this condition before IS-IS accepts more redistributed routes. You can optionally configure the timeout period.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

SUMMARY STEPS

1. **configure terminal**
2. **router isis** *instance-tag*
3. **redistribute** {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} **route-map** *map-name*
4. **redistribute maximum-prefix** *max* [*threshold*] [**warning-only** | **withdraw** [*num-retries timeout*]]
5. (Optional) **show running-config isis**
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router isis** *instance-tag* **Example:** `switch(config)# router isis Enterprise` `switch(config-router)#`	Creates a new IS-IS instance with the configured instance tag.
Step 3	**redistribute** {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} **route-map** *map-name* **Example:** `switch(config-router)# redistribute bgp route-map FilterExternalBGP`	Redistributes the selected protocol into IS-IS through the configured route map.
Step 4	**redistribute maximum-prefix** *max* [*threshold*] [**warning-only** | **withdraw** [*num-retries timeout*]] **Example:** `switch(config-router)# redistribute maximum-prefix 1000 75 warning-only`	Specifies a maximum number of prefixes that IS-IS distributes. The range is from 1 to 65535. You can optionally specify the following: • *threshold*—Percentage of maximum prefixes that triggers a warning message. • **warning-only**—Logs a warning message when the maximum number of prefixes is exceeded. • **withdraw**—Withdraws all redistributed routes. You can optionally try to retrieve the redistributed routes. The *num-retries* range is from 1 to 12. The *timeout* is 60 to 600 seconds. The default is 300 seconds. Use the **clear isis redistribution** command if all routes are withdrawn.

	Command	Purpose
Step 5	**show running-config isis** **Example:** switch(config-router)# show running-config isis	(Optional) Displays the IS-IS configuration.
Step 6	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to limit the number of redistributed routes into IS-IS:

```
switch# configure terminal
switch(config)# router eigrp isis Enterprise
switch(config-router)# redistribute bgp route-map FilterExternalBGP
switch(config-router)# redistribute maximum-prefix 1000 75
```

Disabling Strict Adjacency Mode

When both IPv4 and IPv6 address families are enabled, strict adjacency mode is enabled by default. In this mode, the device does not form an adjacency with any router that does not have both address families enabled. You can disable strict adjacency mode using the **no adjacency-check** command.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

SUMMARY STEPS

1. **configure terminal**
2. **router isis** *instance-tag*
3. **address-family ipv4 unicast**
4. **no adjacency-check**
5. **exit**
6. **address-family ipv6 unicast**
7. **no adjacency-check**
8. (Optional) **show running-config isis**
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router isis** *instance-tag* **Example:** `switch(config)# router isis Enterprise` `switch(config-router)#`	Creates a new IS-IS instance with the configured instance tag.
Step 3	**address-family ipv4 unicast** **Example**: `switch(config-router)# address-family ipv4 unicast` `switch(config-router-af)#`	Enters address family configuration mode.
Step 4	**no adjacency-check** **Example:** `switch(config-router-af)# no adjacency-check`	Disables strict adjacency mode for the IPv4 address family.
Step 5	**exit** **Example:** `switch(config-router-af)# exit` `switch(config-router)#`	Exits address family configuration mode.
Step 6	**address-family ipv6 unicast** **Example**: `switch(config-router)# address-family ipv6 unicast` `switch(config-router-af)#`	Enters address family configuration mode.
Step 7	**no adjacency-check** **Example:** `switch(config-router-af)# no adjacency-check`	Disables strict adjacency mode for the IPv6 address family.
Step 8	**show running-config isis** **Example:** `switch(config-router-af)# show running-config isis`	(Optional) Displays the IS-IS configuration.
Step 9	**copy running-config startup-config** **Example:** `switch(config-router-af)# copy running-config startup-config`	(Optional) Saves this configuration change.

Configuring a Graceful Restart

You can configure a graceful restart for IS-IS.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

Create the VRFs.

SUMMARY STEPS

1. **configure terminal**
2. **router isis** *instance-tag*
3. **graceful-restart**
4. **graceful-restart t3 manual** *time*
5. (Optional) **show running-config isis**
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router isis** *instance-tag* **Example:** `switch(config)# router isis Enterprise` `switch(config-router)#`	Creates a new IS-IS process with the configured name.
Step 3	**graceful-restart** **Example:** `switch(config-router)# graceful-restart`	Enables a graceful restart and the graceful restart helper functionality. Enabled by default.
Step 4	**graceful-restart t3 manual** *time* **Example:** `switch(config-router)# graceful-restart t3 manual 300`	Configures the graceful restart T3 timer. The range is from 30 to 65535 seconds. The default is 60.
Step 5	**show running-config isis** **Example:** `switch(config-router)# show running-config isis`	(Optional) Displays the IS-IS configuration.
Step 6	**copy running-config startup-config** **Example:** `switch(config-router)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to enable a graceful restart:

```
switch# configure terminal
switch(config)# router isis Enterprise
switch(config-router)# graceful-restart
switch(config-router)# copy running-config startup-config
```

Configuring Virtualization

You can configure multiple IS-IS instances and multiple VRFs and use the same or multiple IS-IS instances in each VRF. You assign an IS-IS interface to a VRF.

You must configure a NET for the configured VRF.

Note Configure all other parameters for an interface after you configure the VRF for an interface. Configuring a VRF for an interface deletes all the configuration for that interface.

BEFORE YOU BEGIN

You must enable IS-IS (see the "Enabling the IS-IS Feature" section on page 8-9).

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf_name*
3. **exit**
4. **router isis** *instance-tag*
5. (Optional) **vrf** *vrf_name*
6. **net** *network-entity-title*
7. **exit**
8. **interface** *type slot/port*
9. **vrf member** *vrf-name*
10. {**ip** | **ipv6**} **address** *ip-prefix/length*
11. {**ip** | **ipv6**} **router isis** *instance-tag*
12. (Optional) **show isis** [**vrf** *vrf-name*] [*instance-tag*] **interface** [*interface-type slot/port*]
13. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** `switch(config)# vrf context RemoteOfficeVRF` `switch(config-vrf)#`	Creates a new VRF and enters VRF configuration mode.

	Command	Purpose
Step 3	**exit** **Example:** switch(config-vrf)# exit switch(config)#	Exits VRF configuration mode.
Step 4	**router isis** *instance-tag* **Example:** switch(config)# router isis Enterprise switch(config-router)#	Creates a new IS-IS instance with the configured instance tag.
Step 5	**vrf** *vrf-name* **Example:** switch(config-router)# vrf RemoteOfficeVRF switch(config-router-vrf)#	(Optional) Enters VRF configuration mode.
Step 6	**net** *network-entity-title* **Example:** switch(config-router-vrf)# net 47.0004.004d.0001.0001.0c11.1111.00	Configures the NET for this IS-IS instance.
Step 7	**exit** **Example:** switch(config-router-vrf)# exit switch(config-router)#	Exits router VRF configuration mode.
Step 8	**interface ethernet** *slot/port* **Example**: switch(config)# interface ethernet 1/2 switch(config-if)#	Enters interface configuration mode.
Step 9	**vrf member** *vrf-name* **Example:** switch(config-if)# vrf member RemoteOfficeVRF	Adds this interface to a VRF.
Step 10	{**ip** | **ipv6**} **address** *ip-prefix/length* **Example:** switch(config-if)# ip address 192.0.2.1/16	Configures an IP address for this interface. You must do this step after you assign this interface to a VRF.
Step 11	{**ip** | **ipv6**} **router isis** *instance-tag* **Example**: switch(config-if)# ip router isis Enterprise	Associates this IPv4 or IPv6 interface with an IS-IS instance.
Step 12	**show isis** [**vrf** *vrf-name*] [*instance-tag*] **interface** [*interface-type slot/port*] **Example**: switch(config-if)# show isis Enterprise ethernet 1/2	(Optional) Displays IS-IS information for an interface. in a VRF.
Step 13	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create a VRF and add an interface to the VRF:

```
switch# configure terminal
switch(config)# vrf context NewVRF
switch(config-vrf)# exit
switch(config)# router isis Enterprise
switch(config-router)# vrf NewVRF
switch(config-router-vrf)# net 47.0004.004d.0001.0001.0c11.1111.00
switch(config-router-vrf)# interface ethernet 1/2
switch(config-if)# vrf member NewVRF
switch(config-if)# ip address 192.0.2.1/16
switch(config-if)# ip router isis Enterprise
switch(config-if)# copy running-config startup-config
```

Tuning IS-IS

You can tune IS-IS to match your network requirements.

You can use the following optional commands in router configuration mode to tune IS-IS:

Command	Purpose
lsp-gen-interval [**level-1** | **level-2**] *lsp-max-wait* [*lsp-initial-wait* *lsp-second-wait*] **Example**: `switch(config-router)# lsp-gen-interval level-1 500 500 500`	Configures the IS-IS throttle for LSP generation. The optional parameters are as follows: • lsp-max-wait—The maximum wait between the trigger and LSP generation. The range is from 500 to 65535 milliseconds. • lsp-initial-wait—The initial wait between the trigger and LSP generation. The range is from 50 to 65535 milliseconds. • lsp-second-wait—The second wait used for LSP throttle during backoff. The range is from 50 to 65535 milliseconds.
max-lsp-lifetime *lifetime* **Example:** `switch(config-router)# max-lsp-lifetime 500`	Sets the maximum LSP lifetime in seconds. The range is from 1 to 65535. The default is 1200.
metric-style transition **Example:** `switch(config-router)# metric-style transition`	Enables IS-IS to generate and accept both narrow metric-style Type Length Value (TLV) objects and wide metric-style TLV objects. The default is disabled.

Command	Purpose
spf-interval [**level-1** | **level-2**] *spf-max-wait* [*spf-initial-wait spf-second-wait*] **Example**: switch(config-router)# spf-interval level-2 500 500 500	Configures the interval between LSA arrivals. The optional parameters are as follows: • lsp-max-wait—The maximum wait between the trigger and SPF computation. The range is from 500 to 65535 milliseconds. • lsp-initial-wait—The initial wait between the trigger and SPF computation. The range is from 50 to 65535 milliseconds. • lsp-second-wait—The second wait used for SPF computation during backoff. The range is from 50 to 65535 milliseconds.

You can use the following optional command in router address configuration mode:

Command	Purpose
adjacency-check **Example**: switch(config-router-af)# adjacency-check	Performs an adjacency check to verify that an IS-IS instance forms an adjacency only with a remote IS-IS entity that supports the same address family. This command is enabled by default.

You can use the following optional commands in interface configuration mode to tune IS-IS:

Command	Purpose
isis csnp-interval *seconds* [**level-1** | **level-2**] **Example**: switch(config-if)# isis csnp-interval 20	Sets the complete sequence number PDU (CNSP) interval in seconds for IS-IS. The range is from 1 to 65535. The default is 10.
isis hello-interval *seconds* [**level-1** | **level-2**] **Example**: switch(config-if)# isis hello-interval 20	Sets the hello interval in seconds for IS-IS. The range is from 1 to 65535. The default is 10.
isis hello-multiplier *num* [**level-1** | **level-2**] **Example**: switch(config-if)# isis hello-multiplier 20	Specifies the number of IS-IS hello packets that a neighbor must miss before the router tears down an adjacency. The range is from 3 to 1000. The default is 3.
isis lsp-interval *milliseconds* **Example:** switch(config-if)# isis lsp-interval 20	Sets the interval in milliseconds between LSPs sent on this interface during flooding. The range is from 10 to 65535. The default is 33.

Verifying the IS-IS Configuration

To display the IS-IS configuration, perform one of the following tasks:

Command	Purpose
show isis [*instance-tag*] **adjacency** [*interface*] [**detail** | **summary**] [**vrf** *vrf-name*]	Displays the IS-IS adjacencies. Use the **clear isis adjacency** command to clear these statistics.
show isis [*instance-tag*] **database** [**level-1** | **level-2**] [**detail** | **summary**] [*LSP ID*] [{**ip** | **ipv6**} **prefix** *ip-prefix*] | [**router-id** *router-id*] | [**adjacency** *node-id*] | [**zero-sequence**]} [**vrf** *vrf-name*]	Displays the IS-IS LSP database.
show isis [*instance-tag*] *hostname* [**vrf** *vrf-name*]	Displays the dynamic host exchange information.
show isis [*instance-tag*] **interface** [**brief** | *interface*] [**level-1** | **level-2**] [**vrf** *vrf-name*]	Displays the IS-IS interface information.
show isis [*instance-tag*] **mesh-group** [*mesh-id*] [**vrf** *vrf-name*]	Displays the mesh group information.
show isis [*instance-tag*] **protocol** [**vrf** *vrf-name*]	Displays information about the IS-IS protocol.
show isis [*instance-tag*] {**ip** | **ipv6**} **redistribute route** [*ip-address* | **summary**] [[*ip-prefix*] [**longer-prefixes** [**summary**]] [**vrf** *vrf-name*]	Displays the IS-IS route redistribution information.
show isis [*instance-tag*] {**ip** | **ipv6**} **route** [*ip-address* | **summary**] [*ip-prefix* [**longer-prefixes** [**summary**]] [**detail**] [**vrf** *vrf-name*]	Displays the IS-IS route table.
show isis [*instance-tag*] **rrm** [*interface*] [**vrf** *vrf-name*]	Displays the IS-IS interface retransmission information.
show isis [*instance-tag*] **srm** [*interface*] [**vrf** *vrf-name*]	Displays the IS-IS interface flooding information.
show isis [*instance-tag*] **ssn** [*interface*] [**vrf** *vrf-name*]	Displays the IS-IS interface PSNP information.
show isis [*instance-tag*] {**ip** | **ipv6**} **summary-address** [*ip-address*] | [*ip-prefix*] [**vrf** *vrf-name*]	Displays the IS-IS summary address information.
show running-configuration isis	Displays the current running IS-IS configuration.
show tech-support isis [**detail**]	Displays the technical support details for IS-IS.

Monitoring IS-IS

To display IS-IS statistics, use the following commands:

Command	Purpose
show isis [*instance-tag*] **adjacency** [*interface*] [**system-ID**] [**detail**] [**summary**] [**vrf** *vrf-name*]	Displays the IS-IS adjacency statistics.
show isis [*instance-tag*] **database** [**level-1** | **level-2**] [**detail** | **summary**] [*lsip*] {[**adjacency** *id*] {**ip** | **ipv6**} **prefix** *prefix*] [**router-id** *id*] [zero-sequence]} [**vrf** *vrf-name*]	Displays the IS-IS database statistics.
show isis [*instance-tag*] **statistics** [*interface*] [**vrf** *vrf-name*]	Displays the IS-IS interface statistics.
show isis {**ip** | **ipv6**} **route-map statistics redistribute** {**bgp** *id* | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} [**vrf** *vrf-name*]	Displays the IS-IS redistribution statistics.
show isis route-map statistics distribute {**level-1** | **level-2**} **into** {**level-1** | **level-2**}} [**vrf** *vrf-name*]	Displays IS-IS distribution statistics for routes distributed between levels.
show isis [*instance-tag*] **spf-log** [**detail**] [**vrf** *vrf-name*]	Displays the IS-IS SPF calculation statistics.
show isis [*instance-tag*] **traffic** [*interface*] [**vrf** *vrf-name*]	Displays the IS-IS traffic statistics.

To clear IS-IS configuration statistics, perform one of the following tasks:

Command	Purpose
clear isis [*instance-tag*] **adjacency** [***** | [*interface*] [**system-id** *id*]] [**vrf** *vrf-name*]	Clears the IS-IS adjacency statistics.
clear isis {**ip** | **ipv6**} **route-map statistics redistribute** {**bgp** *id* | **direct** | **eigrp** *id* | **isis** *id* | **ospf** *id* | **rip** *id* | **static**} [**vrf** *vrf-name*]	Clears the IS-IS redistribution statistics.
clear isis route-map statistics distribute {**level-1** | **level-2**} **into** {**level-1** | **level-2**} [**vrf** *vrf-name*]	Clears IS-IS distribution statistics for routes distributed between levels.
clear isis [*instance-tag*] **statistics** [***** | *interface*] [**vrf** *vrf-name*]	Clears the IS-IS interface statistics.
clear isis [*instance-tag*] **traffic** [***** | *interface*] [**vrf** *vrf-name*]	Clears the IS-IS traffic statistics.

Configuration Examples for IS-IS

This example shows how to configure IS-IS:

```
router isis Enterprise
 is-type level-1
 net 49.0001.0000.0000.0003.00
 graceful-restart
 address-family ipv4 unicast
  default-information originate

interface ethernet 2/1
 ip address 192.0.2.1/24
 isis circuit-type level-1
 ip router isis Enterprise
```

Related Topics

See the Chapter 15, "Configuring Route Policy Manager," for more information on route maps.

Configuring Basic BGP

This chapter describes how to configure Border Gateway Protocol (BGP) on the Cisco NX-OS device.

This chapter includes the following sections:

About Basic BGP

Cisco NX-OS supports BGP version 4, which includes multiprotocol extensions that allow BGP to carry routing information for IP multicast routes and multiple Layer 3 protocol address families. BGP uses TCP as a reliable transport protocol to create TCP sessions with other BGP-enabled devices.

BGP uses a path-vector routing algorithm to exchange routing information between BGP-enabled networking devices or BGP speakers. Based on this information, each BGP speaker determines a path to reach a particular destination while detecting and avoiding paths with routing loops. The routing information includes the actual route prefix for a destination, the path of autonomous systems to the destination, and additional path attributes.

BGP selects a single path, by default, as the best path to a destination host or network. Each path carries well-known mandatory, well-known discretionary, and optional transitive attributes that are used in BGP best-path analysis. You can influence BGP path selection by altering some of these attributes by configuring BGP policies. See the "Route Policies and Resetting BGP Sessions" section on page 10-3 for more information.

BGP also supports load balancing or equal-cost multipath (ECMP). See the "Load Sharing and Multipath" section on page 10-6 for more information.

This section includes the following topics:

BGP Autonomous Systems

An autonomous system (AS) is a network controlled by a single administration entity. An autonomous system forms a routing domain with one or more interior gateway protocols (IGPs) and a consistent set of routing policies. BGP supports 16-bit and 32-bit autonomous system numbers. For more information, see the "Autonomous Systems" section on page 1-5.

Separate BGP autonomous systems dynamically exchange routing information through external BGP (eBGP) peering sessions. BGP speakers within the same autonomous system can exchange routing information through internal BGP (iBGP) peering sessions.

4-Byte AS Number Support

BGP supports 2-byte autonomous system (AS) numbers in plain-text notation or as.dot notation and 4-byte AS numbers in plain-text notation.

When BGP is configured with a 4-byte AS number, the **route-target auto** VXLAN command cannot be used because the AS number along with the VNI (which is already a 3-byte value) is used to generate the route target. For more information, see the *Cisco Nexus 9000 Series NX-OS VXLAN Configuration Guide*.

Administrative Distance

An administrative distance is a rating of the trustworthiness of a routing information source. By default, BGP uses the administrative distances shown in Table 9-1.

Table 9-1 BGP Default Administrative Distances

Distance	Default Value	Function
External	20	Applied to routes learned from eBGP.
Internal	200	Applied to routes learned from iBGP.
Local	220	Applied to routes originated by the router.

Note The administrative distance does not influence the BGP path selection algorithm, but it does influence whether BGP-learned routes are installed in the IP routing table.

For more information, see the "Administrative Distance" section on page 1-7.

BGP Peers

A BGP speaker does not discover another BGP speaker automatically. You must configure the relationships between BGP speakers. A BGP peer is a BGP speaker that has an active TCP connection to another BGP speaker.

BGP Sessions

BGP uses TCP port 179 to create a TCP session with a peer. When a TCP connection is established between peers, each BGP peer initially exchanges all of its routes—the complete BGP routing table—with the other peer. After this initial exchange, the BGP peers send only incremental updates when a topology change occurs in the network or when a routing policy change occurs. In the periods of inactivity between these updates, peers exchange special messages called keepalives. The hold time is the maximum time limit that can elapse between receiving consecutive BGP update or keepalive messages.

Cisco NX-OS supports the following peer configuration options:

- Individual IPv4 or IPv4 address—BGP establishes a session with the BGP speaker that matches the remote address and AS number.
- IPv4 or IPv6 prefix peers for a single AS number—BGP establishes sessions with BGP speakers that match the prefix and the AS number.
- Dynamic AS number prefix peers—BGP establishes sessions with BGP speakers that match the prefix and an AS number from a list of configured AS numbers.

Dynamic AS Numbers for Prefix Peers

Cisco NX-OS accepts a range or list of AS numbers to establish BGP sessions. For example, if you configure BGP to use IPv4 prefix 192.0.2.0/8 and AS numbers 33, 66, and 99, BGP establishes a session with 192.0.2.1 with AS number 66 but rejects a session from 192.0.2.2 with AS number 50.

Cisco NX-OS does not associate prefix peers with dynamic AS numbers as either interior BGP (iBGP) or external BGP (eBGP) sessions until after the session is established. See Chapter 10, "Configuring Advanced BGP" for more information on iBGP and eBGP.

Note The dynamic AS number prefix peer configuration overrides the individual AS number configuration that is inherited from a BGP template. For more information, see Chapter 10, "Configuring Advanced BGP."

BGP Router Identifier

To establish BGP sessions between peers, BGP must have a router ID, which is sent to BGP peers in the OPEN message when a BGP session is established. The BGP router ID is a 32-bit value that is often represented by an IPv4 address. You can configure the router ID. By default, Cisco NX-OS sets the router ID to the IPv4 address of a loopback interface on the router. If no loopback interface is configured on the router, the software chooses the highest IPv4 address configured to a physical interface on the router to represent the BGP router ID. The BGP router ID must be unique to the BGP peers in a network.

If BGP does not have a router ID, it cannot establish any peering sessions with BGP peers.

BGP Path Selection

BGP supports sending and receiving multiple paths per prefix and advertising such paths. For information on configuring additional BGP paths, see Chapter 10, "Configuring Advanced BGP."

The best-path algorithm runs each time that a path is added or withdrawn for a given network. The best-path algorithm also runs if you change the BGP configuration. BGP selects the best path from the set of valid paths available for a given network.

Cisco NX-OS implements the BGP best-path algorithm in the following steps:

Step 1 Compares two paths to determine which is better (see the "Step 1—Comparing Pairs of Paths" section on page 9-5).

Step 2 Explores all paths and determines in which order to compare the paths to select the overall best path (see the "Step 2—Determining the Order of Comparisons" section on page 9-6).

Step 3 Determines whether the old and new best paths differ enough so that the new best path should be used (see the "Step 3—Determining the Best-Path Change Suppression" section on page 9-6).

Note The order of comparison determined in Step 2 is important. Consider the case where you have three paths, A, B, and C. When Cisco NX-OS compares A and B, it chooses A. When Cisco NX-OS compares B and C, it chooses B. But when Cisco NX-OS compares A and C, it might not choose A because some BGP metrics apply only among paths from the same neighboring autonomous system and not among all paths.

The path selection uses the BGP AS-path attribute. The AS-path attribute includes the list of autonomous system numbers (AS numbers) traversed in the advertised path. If you subdivide your BGP autonomous system into a collection or confederation of autonomous systems, the AS-path contains confederation segments that list these locally defined autonomous systems.

Note VXLAN deployments use a BGP path selection process that differs from the normal selection of local over remote paths. For the EVPN address family, BGP compares the sequence number in the MAC Mobility attribute (if present) and selects the path with the higher sequence number. If both paths being compared have the attribute and the sequence numbers are the same, BGP prefers the path that is learned from the remote peer over a locally originated path. For more information, see the *Cisco Nexus 9000 Series NX-OS VXLAN Configuration Guide*.

Step 1—Comparing Pairs of Paths

This first step in the BGP best-path algorithm compares two paths to determine which path is better. The following sequence describes the basic steps that Cisco NX-OS uses to compare two paths to determine the better path:

1. Cisco NX-OS chooses a valid path for comparison. (For example, a path that has an unreachable next hop is not valid.)
2. Cisco NX-OS chooses the path with the highest weight.
3. Cisco NX-OS chooses the path with the highest local preference.
4. If one of the paths is locally originated, Cisco NX-OS chooses that path.
5. Cisco NX-OS chooses the path with the shorter AS-path.

Note When calculating the length of the AS-path, Cisco NX-OS ignores confederation segments and counts AS sets as 1. See the "AS Confederations" section on page 10-4 for more information.

6. Cisco NX-OS chooses the path with the lower origin. The Interior Gateway Protocol (IGP) is considered lower than EGP.
7. Cisco NX-OS chooses the path with the lower multiexit discriminator (MED).

   You can configure a number of options that affect whether or not this step is performed. In general, Cisco NX-OS compares the MED of both paths if the paths were received from peers in the same autonomous system; otherwise, Cisco NX-OS skips the MED comparison.

   You can configure Cisco NX-OS to always perform the best-path algorithm MED comparison, regardless of the peer autonomous system in the paths. See the "Tuning the Best-Path Algorithm" section on page 10-10 for more information. Otherwise, Cisco NX-OS performs a MED comparison that depends on the AS-path attributes of the two paths being compared:

   a. If a path has no AS-path or the AS-path starts with an AS_SET, the path is internal and Cisco NX-OS compares the MED to other internal paths.
   b. If the AS-path starts with an AS_SEQUENCE, the peer autonomous system is the first AS number in the sequence and Cisco NX-OS compares the MED to other paths that have the same peer autonomous system.
   c. If the AS-path contains only confederation segments or starts with confederation segments followed by an AS_SET, the path is internal and Cisco NX-OS compares the MED to other internal paths.
   d. If the AS-path starts with confederation segments that are followed by an AS_SEQUENCE, the peer autonomous system is the first AS number in the AS_SEQUENCE and Cisco NX-OS compares the MED to other paths that have the same peer autonomous system.

   Note If Cisco NX-OS receives no MED attribute with the path, Cisco NX-OS considers the MED to be 0 unless you configure the best-path algorithm to set a missing MED to the highest possible value. See the "Tuning the Best-Path Algorithm" section on page 10-10 for more information.

   e. If the nondeterministic MED comparison feature is enabled, the best-path algorithm uses the Cisco IOS style of MED comparison. See the "Tuning the Best-Path Algorithm" section on page 10-10 for more information.

8. If one path is from an internal peer and the other path is from an external peer, Cisco NX-OS chooses the path from the external peer.
9. If the paths have different IGP metrics to their next-hop addresses, Cisco NX-OS chooses the path with the lower IGP metric.
10. Cisco NX-OS uses the path that was selected by the best-path algorithm the last time that it was run.

If all path parameters in Step 1 through Step 9 are the same, you can configure the best-path algorithm to compare the router IDs. See the "Tuning the Best-Path Algorithm" section on page 10-10 for more information. If the path includes an originator attribute, Cisco NX-OS uses that attribute as the router ID to compare to; otherwise, Cisco NX-OS uses the router ID of the peer that sent the path. If the paths have different router IDs, Cisco NX-OS chooses the path with the lower router ID.

Note When using the attribute originator as the router ID, it is possible that two paths have the same router ID. It is also possible to have two BGP sessions with the same peer router, so you could receive two paths with the same router ID.

11. Cisco NX-OS selects the path with the shorter cluster length. If a path was not received with a cluster list attribute, the cluster length is 0.
12. Cisco NX-OS chooses the path received from the peer with the lower IP address. Locally generated paths (for example, redistributed paths) have a peer IP address of 0.

Note Paths that are equal after Step 9 can be used for multipath if you configure multipath. See the "Load Sharing and Multipath" section on page 10-6 for more information.

Step 2—Determining the Order of Comparisons

The second step of the BGP best-path algorithm implementation is to determine the order in which Cisco NX-OS compares the paths:

1. Cisco NX-OS partitions the paths into groups. Within each group, Cisco NX-OS compares the MED among all paths. Cisco NX-OS uses the same rules as in the "Step 1—Comparing Pairs of Paths" section on page 9-5 to determine whether MED can be compared between any two paths. Typically, this comparison results in one group being chosen for each neighbor autonomous system. If you configure the **bgp bestpath med always** command, Cisco NX-OS chooses just one group that contains all the paths.
2. Cisco NX-OS determines the best path in each group by iterating through all paths in the group and keeping track of the best one so far. Cisco NX-OS compares each path with the temporary best path found so far and if the new path is better, it becomes the new temporary best path and Cisco NX-OS compares it with the next path in the group.
3. Cisco NX-OS forms a set of paths that contain the best path selected from each group in Step 2. Cisco NX-OS selects the overall best path from this set of paths by going through them as in Step 2.

Step 3—Determining the Best-Path Change Suppression

The next part of the implementation is to determine whether Cisco NX-OS uses the new best path or suppresses the new best path. The router can continue to use the existing best path if the new one is identical to the old path (if the router ID is the same). Cisco NX-OS continues to use the existing best path to avoid route changes in the network.

You can turn off the suppression feature by configuring the best-path algorithm to compare the router IDs. See the "Tuning the Best-Path Algorithm" section on page 10-10 for more information. If you configure this feature, the new best path is always preferred to the existing one.

You cannot suppress the best-path change if any of the following conditions occur:

- The existing best path is no longer valid.
- Either the existing or new best paths were received from internal (or confederation) peers or were locally generated (for example, by redistribution).
- The paths were received from the same peer (the paths have the same router ID).
- The paths have different weights, local preferences, origins, or IGP metrics to their next-hop addresses.
- The paths have different MEDs.

BGP and the Unicast RIB

BGP communicates with the unicast Routing Information Base (unicast RIB) to store IPv4 routes in the unicast routing table. After selecting the best path, if BGP determines that the best path change needs to be reflected in the routing table, it sends a route update to the unicast RIB.

BGP receives route notifications regarding changes to its routes in the unicast RIB. It also receives route notifications about other protocol routes to support redistribution.

BGP also receives notifications from the unicast RIB regarding next-hop changes. BGP uses these notifications to keep track of the reachability and IGP metric to the next-hop addresses.

Whenever the next-hop reachability or IGP metrics in the unicast RIB change, BGP triggers a best-path recalculation for affected routes.

BGP communicates with the IPv6 unicast RIB to perform these operations for IPv6 routes.

BGP Prefix Independent Convergence Core

The BGP prefix independent convergence (PIC) core feature allows for faster convergence for traffic destined to BGP prefixes that share the same remote next hop in case of a failure in the core of the network. Pure IP traffic can benefit from this feature. It is enabled by default and cannot be disabled.

BGP Virtualization

BGP supports virtual routing and forwarding (VRF) instances.

Licensing Requirements for Basic BGP

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	BGP requires an Enterprise Services license. For a complete explanation of the Cisco NX-OS licensing scheme and how to obtain and apply licenses, see the *Cisco NX-OS Licensing Guide.*

Prerequisites for BGP

BGP has the following prerequisites:

- You must enable BGP (see the "Enabling BGP" section on page 9-11).
- You should have a valid router ID configured on the system.
- You must have an AS number, either assigned by a Regional Internet Registry (RIR) or locally administered.
- You must configure at least one IGP that is capable of recursive next-hop resolution.
- You must configure an address family under a neighbor for the BGP session establishment.

Guidelines and Limitations for BGP

BGP has the following configuration guidelines and limitations:

- The dynamic AS number prefix peer configuration overrides the individual AS number configuration inherited from a BGP template.
- If you configure a dynamic AS number for prefix peers in an AS confederation, BGP establishes sessions with only the AS numbers in the local confederation.
- BGP sessions created through a dynamic AS number prefix peer ignore any configured eBGP multihop time-to-live (TTL) value or a disabled check for directly connected peers.
- Configure a router ID for BGP to avoid automatic router ID changes and session flaps.
- Use the maximum-prefix configuration option per peer to restrict the number of routes received and system resources used.
- Configure the update source to establish a session with BGP/eBGP multihop sessions.
- Specify a BGP policy if you configure redistribution.
- Define the BGP router ID within a VRF.
- For IPv6 neighbors, Cisco recommends that you configure a router ID per VRF. If a VRF does not have any IPv4 interfaces, the IPv6 BGP neighbor will not come up because its router ID must be an IPv4 address. The numerically lowest loopback IPv4 address is elected to be the router ID. If a loopback address does not exist, the lowest IP address from the VRF interfaces is elected. If that does not exist, the BGP neighbor relationship is not established.
- If you decrease the keepalive and hold timer values, you might experience BGP session flaps.
- The BGP minimum route advertisement interval (MRAI) value for all iBGP and eBGP sessions is zero and is not configurable.
- If you configure VRFs, install the Advanced Services license and enter the desired VRF (see Chapter 13, "Configuring Layer 3 Virtualization").
- Although the **show ip bgp** commands are available for verifying the BGP configuration, Cisco recommends using the **show bgp** commands instead.

Default Settings

Table 9-2 lists the default settings for BGP parameters.

Table 9-2 Default BGP Parameters

Parameters	Default
BGP feature	Disabled
Keep alive interval	60 seconds
Hold timer	180 seconds
BGP PIC core	Enabled
Auto-summary	Always disabled
Synchronization	Always disabled

CLI Configuration Modes

The following sections describe how to enter each of the CLI configuration modes for BGP. From a mode, you can enter the **?** command to display the commands available in that mode.

Global Configuration Mode

Use global configuration mode to create a BGP process and configure advanced features such as AS confederation and route dampening. For more information, see Chapter 10, "Configuring Advanced BGP."

This example shows how to enter router configuration mode:

```
switch# configuration
switch(config)# router bgp 64496
switch(config-router)#
```

BGP supports VRF. You can configure BGP within the appropriate VRF if you are using VRFs in your network. See the "Configuring Virtualization" section on page 10-50 for more information.

This example shows how to enter VRF configuration mode:

```
switch(config)# router bgp 64497
switch(config-router)# vrf vrf_A
switch(config-router-vrf)#
```

Address Family Configuration Mode

You can optionally configure the address families that BGP supports. Use the **address-family** command in router configuration mode to configure features for an address family. Use the **address-family** command in neighbor configuration mode to configure the specific address family for the neighbor.

You must configure the address families if you are using route redistribution, address aggregation, load balancing, and other advanced features.

This example shows how to enter address family configuration mode from the router configuration mode:

```
switch(config)# router bgp 64496
switch(config-router)# address-family ipv6 unicast
switch(config-router-af)#
```

This example shows how to enter VRF address family configuration mode if you are using VRFs:

```
switch(config)# router bgp 64497
switch(config-router)# vrf vrf_A
switch(config-router-vrf)# address-family ipv6 unicast
switch(config-router-vrf-af)#
```

Neighbor Configuration Mode

Cisco NX-OS provides the neighbor configuration mode to configure BGP peers. You can use neighbor configuration mode to configure all parameters for a peer.

This example shows how to enter neighbor configuration mode:

```
switch(config)# router bgp 64496
switch(config-router)# neighbor 192.0.2.1
switch(config-router-neighbor)#
```

This example shows how to enter VRF neighbor configuration mode:

```
switch(config)# router bgp 64497
switch(config-router)# vrf vrf_A
switch(config-router-vrf)# neighbor 192.0.2.1
switch(config-router-vrf-neighbor)#
```

Neighbor Address Family Configuration Mode

An address family configuration submode inside the neighbor configuration submode is available for entering address family-specific neighbor configuration and enabling the address family for the neighbor. Use this mode for advanced features such as limiting the number of prefixes allowed for this neighbor and removing private AS numbers for eBGP.

With the introduction of RFC 5549 in Cisco NX-OS Release 7.0(3)I2(1), you can configure an IPv4 address family for a neighbor with an IPv6 address.

This example shows how to enter the IPv4 neighbor address family configuration mode for a neighbor with an IPv4 address:

```
switch(config)# router bgp 64496
switch(config-router# neighbor 192.0.2.1
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)#
```

This example shows how to enter the IPv4 neighbor address family configuration mode for a neighbor with an IPv6 address:

```
switch(config)# router bgp 64496
switch(config-router# neighbor 2001:db8::/64 eui64
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)#
```

This example shows how to enter the VRF IPv4 neighbor address family configuration mode or a neighbor with an IPv4 address:

```
switch(config)# router bgp 64497
switch(config-router)# vrf vrf_A
switch(config-router-vrf)# neighbor 209.165.201.1
switch(config-router-vrf-neighbor)# address-family ipv4 unicast
switch(config-router-vrf-neighbor-af)#
```

This example shows how to enter the VRF IPv4 neighbor address family configuration mode for a neighbor with an IPv6 address:

```
switch(config)# router bgp 64497
switch(config-router)# vrf vrf_A
switch(config-router-vrf)# neighbor 2001:db8::/64 eui64
switch(config-router-vrf-neighbor)# address-family ipv4 unicast
switch(config-router-vrf-neighbor-af)#
```

Configuring Basic BGP

To configure a basic BGP, you must enable BGP and configure a BGP peer. Configuring a basic BGP network consists of a few required tasks and many optional tasks. You must configure a BGP routing process and BGP peers.

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Enabling BGP

You must enable BGP before you can configure BGP.

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. (Optional) **show feature**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**feature bgp** **Example:** switch(config)# feature bgp	Enables BGP.
Step 3	**show feature** **Example:** switch(config)# show feature	(Optional) Displays enabled and disabled features.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

Use the **no feature bgp** command to disable BGP and remove all associated configuration.

Command	Purpose
no feature bgp **Example:** switch(config)# no feature bgp	Disables BGP and removes all associated configuration.

Creating a BGP Instance

You can create a BGP instance and assign a router ID to the BGP instance. For more information, see the "BGP Router Identifier" section on page 9-4.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

BGP must be able to obtain a router ID (for example, a configured loopback address).

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. (Optional) **router-id** *ip-address*
4. (Optional) **address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**}
5. (Optional) **network** {*ip-address/length* | *ip-address* **mask** *mask*} [**route-map** *map-name*]
6. (Optional) **show bgp all**

7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example:** switch(config)# router bgp 64496 switch(config-router)#	Enables BGP and assigns the AS number to the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
Step 3	**router-id** *ip-address* **Example:** switch(config-router)# router-id 192.0.2.255	(Optional) Configures the BGP router ID. This IP address identifies this BGP speaker.
Step 4	**address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **Example:** switch(config-router)# address-family ipv4 unicast switch(config-router-af)#	(Optional) Enters global address family configuration mode for the IPv4 or IPv6 address family.
Step 5	**network** {*ip-address*/*length* | *ip-address* **mask** *mask*} [**route-map** *map-name*] **Example**: switch(config-router-af)# network 10.10.10.0/24 **Example**: switch(config-router-af)# network 10.10.10.0 mask 255.255.255.0	(Optional) Specifies a network as local to this autonomous system and adds it to the BGP routing table. For exterior protocols, the network command controls which networks are advertised. Interior protocols use the **network** command to determine where to send updates.
Step 6	**show bgp all** **Example**: switch(config-router-af)# show bgp all	(Optional) Displays information about all BGP address families.
Step 7	**copy running-config startup-config** **Example:** switch(config-router-af)# copy running-config startup-config	(Optional) Saves this configuration change.

Use the **no router bgp** command to remove the BGP process and the associated configuration.

Command	Purpose
no router bgp *autonomous-system-number* **Example:** switch(config)# no router bgp 201	Deletes the BGP process and the associated configuration.

This example shows how to enable BGP with the IPv4 unicast address family and manually add one network to advertise:

```
switch# configure terminal
switch(config)# router bgp 64496
switch(config-router)# address-family ipv4 unicast
switch(config-router-af)# network 192.0.2.0
switch(config-router-af)# copy running-config startup-config
```

Restarting a BGP Instance

You can restart a BGP instance and clear all peer sessions for the instance.

To restart a BGP instance and remove all associated peers, use the following command:

Command	Purpose
restart bgp instance-tag **Example:** switch(config)# restart bgp 201	Restarts the BGP instance and resets or reestablishes all peering sessions.

Shutting Down BGP

You can shut down the BGP and gracefully disable BGP while retaining the configuration.

To shut down BGP, use the following command in router configuration mode:

Command	Purpose
shutdown **Example:** switch(config-router)# shutdown	Gracefully shuts down BGP.

Configuring BGP Peers

You can configure a BGP peer within a BGP process. Each BGP peer has an associated keepalive timer and hold timers. You can set these timers either globally or for each BGP peer. A peer configuration overrides a global configuration.

Note You must configure the address family under neighbor configuration mode for each peer.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

SUMMARY STEPS

1. **configure terminal**

2. **router bgp** *autonomous-system-number*
3. **neighbor** {*ip-address* | *ipv6-address*} **remote-as** *as-number*
4. (Optional) **description** *text*
5. (Optional) **timers** *keepalive-time hold-time*
6. (Optional) **shutdown**
7. **address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**}
8. (Optional) **weight** *value*
9. (Optional) **show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **neighbors**
10. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example:** `switch(config)# router bgp 64496` `switch(config-router)#`	Enables BGP and assigns the AS number to the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
Step 3	**neighbor** {*ip-address* | *ipv6-address*} **remote-as** *as-number* **Example:** `switch(config-router)# neighbor 209.165.201.1 remote-as 64497` `switch(config-router-neighbor)#`	Configures the IPv4 or IPv6 address and AS number for a remote BGP peer. The *ip-address* format is x.x.x.x. The *ipv6-address* format is A:B::C:D.
Step 4	**description** *text* **Example:** `switch(config-router-neighbor)# description Peer Router B` `switch(config-router-neighbor)#`	(Optional) Adds a description for the neighbor. The description is an alphanumeric string up to 80 characters.
Step 5	**timers** *keepalive-time hold-time* **Example:** `switch(config-router-neighbor)# timers 30 90`	(Optional) Adds the keepalive and hold time BGP timer values for the neighbor. The range is from 0 to 3600 seconds. The default is 60 seconds for the keepalive time and 180 seconds for the hold time.
Step 6	**shutdown** **Example:** `switch(config-router-neighbor)# shutdown`	(Optional). Administratively shuts down this BGP neighbor. This command triggers an automatic notification and session reset for the BGP neighbor sessions.

	Command	Purpose
Step 7	**address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **Example:** `switch(config-router-neighbor)# address-family ipv4 unicast` `switch(config-router-neighbor-af)#`	Enters neighbor address family configuration mode for the IPv4 or IPv6 address family.
Step 8	**weight** *value* **Example**: `switch(config-router-neighbor-af)# weight 100`	(Optional) Sets the default weight for routes from this neighbor. The range is from 0 to 65535. All routes learned from this neighbor have the assigned weight initially. The route with the highest weight is chosen as the preferred route when multiple routes are available to a particular network. The weights assigned with the **set weight route-map** command override the weights assigned with this command. If you specify a BGP peer policy template, all the members of the template inherit the characteristics configured with this command.
Step 9	**show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **neighbors** **Example**: `switch(config-router-neighbor-af)# show bgp ipv4 unicast neighbors`	(Optional) Displays information about BGP peers.
Step 10	**copy running-config startup-config** **Example:** `switch(config-router-neighbor-af) copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to configure a BGP peer:

```
switch# configure terminal
switch(config)# router bgp 64496
switch(config-router)# neighbor 192.0.2.1 remote-as 64497
switch(config-router-neighbor)# description Peer Router B
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)# weight 100
switch(config-router-neighbor-af)# copy running-config startup-config
```

Configuring Dynamic AS Numbers for Prefix Peers

You can configure multiple BGP peers within a BGP process. You can limit BGP session establishment to a single AS number or multiple AS numbers in a route map.

BGP sessions configured through dynamic AS numbers for prefix peers ignore the **ebgp-multihop** command and the **disable-connected-check** command.

You can change the list of AS numbers in the route map, but you must use the **no neighbor** command to change the route-map name. Changes to the AS numbers in the configured route map affect only new sessions.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **neighbor** *prefix* **remote-as route-map** *map-name*
4. (Optional) **show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **neighbors**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example:** `switch(config)# router bgp 64496` `switch(config-router)#`	Enables BGP and assigns the AS number to the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
Step 3	**neighbor** *prefix* **remote-as route-map** *map-name* **Example:** `switch(config-router)# neighbor 192.0.2.0/8 remote-as routemap BGPPeers` `switch(config-router-neighbor)#`	Configures the IPv4 or IPv6 prefix and a route map for the list of accepted AS numbers for the remote BGP peers. The *prefix* format for IPv4 is x.x.x.x/length. The length range is from 1 to 32. The *prefix* format for IPv6 is A:B::C:D/length. The length range is from 1 to 128. The *map-name* can be any case-sensitive, alphanumeric string up to 63 characters.
Step 4	**show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **neighbors** **Example**: `switch(config-router-neighbor-af)# show bgp ipv4 unicast neighbors`	(Optional) Displays information about BGP peers.
Step 5	**copy running-config startup-config** **Example:** `switch(config-router-neighbor-af)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to configure dynamic AS numbers for a prefix peer:

```
switch# configure terminal
switch(config)# route-map BGPPeers
switch(config-route-map)# match as-number 64496, 64501-64510
switch(config-route-map)# match as-number as-path-list List1, List2
switch(config-route-map)# exit
switch(config)# router bgp 64496
switch(config-router)# neighbor 192.0.2.0/8 remote-as route-map BGPPeers
switch(config-router-neighbor)# description Peer Router B
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)# copy running-config startup-config
```

See Chapter 15, "Configuring Route Policy Manager." for information on route maps.

Clearing BGP Information

To clear BGP information, use the following commands:

Command	Purpose
clear bgp all {*neighbor* | * | *as-number* | **peer-template** *name* | *prefix*} [**vrf** *vrf-name*]	Clears one or more neighbors from all address families. * clears all neighbors in all address families. The arguments are as follows: • *neighbor*—IPv4 or IPv6 address of a neighbor. • *as-number*—Autonomous system number. The AS number can be a 16-bit integer or a 32-bit integer in the form of higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format. • *name*—Peer template name. The name can be any case-sensitive, alphanumeric string up to 64 characters. • *prefix*—IPv4 or IPv6 prefix. All neighbors within that prefix are cleared. • *vrf-name*—VRF name. All neighbors in that VRF are cleared. The name can be any case-sensitive, alphanumeric string up to 64 characters.
clear bgp all dampening [**vrf** *vrf-name*]	Clears route flap dampening networks in all address families. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters.
clear bgp all flap-statistics [**vrf** *vrf-name*]	Clears route flap statistics in all address families. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters.

Command	Purpose
clear bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} **dampening** [**vrf** *vrf-name*]	Clears route flap dampening networks in the selected address family. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters.
clear bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} **flap-statistics** [**vrf** *vrf-name*]	Clears route flap statistics in the selected address family. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters.
clear bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} {*neighbor* | ***** | *as-number* | **peer-template** *name* | *prefix*} [**vrf** *vrf-name*]	Clears one or more neighbors from the selected address family. * clears all neighbors in the address family. The arguments are as follows: • *neighbor*—The IPv4 or IPv6 address of a neighbor. • *as-number*— Autonomous system number. The AS number can be a 16-bit integer or a 32-bit integer in the form of higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format. • *name*—Peer template name. The name can be any case-sensitive, alphanumeric string up to 64 characters. • *prefix*—IPv4 or IPv6 prefix. All neighbors within that prefix are cleared. • *vrf-name*—VRF name. All neighbors in that VRF are cleared. The name can be any case-sensitive, alphanumeric string up to 64 characters.
clear ip bgp {**ip** {**unicast** | **multicast**}} {*neighbor* | ***** | *as-number* | **peer-template** *name* | *prefix*} [**vrf** *vrf-name*]	Clears one or more neighbors. * clears all neighbors in the address family. The arguments are as follows: • *neighbor*—IPv4 or IPv6 address of a neighbor. • *as-number*— Autonomous system number. The AS number can be a 16-bit integer or a 32-bit integer in the form of higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format. • *name*—Peer template name. The name can be any case-sensitive, alphanumeric string up to 64 characters. • *prefix*—IPv4 or IPv6 prefix. All neighbors within that prefix are cleared. • *vrf-name*—VRF name. All neighbors in that VRF are cleared. The name can be any case-sensitive, alphanumeric string up to 64 characters.

Command	Purpose
clear ip bgp dampening [*ip-neighbor* | *ip-prefix*] [**vrf** *vrf-name*]	Clears route flap dampening in one or more networks. The arguments are as follows: • *ip-neighbor*—IPv4 address of a neighbor. • *ip-prefix*—IPv4. All neighbors within that prefix are cleared. • *vrf-name*—VRF name. All neighbors in that VRF are cleared. The name can be any case-sensitive, alphanumeric string up to 64 characters.
clear ip bgp flap-statistics [*ip-neighbor* | *ip-prefix*] [**vrf** *vrf-name*]	Clears route flap statistics in one or more networks. The arguments are as follows: • *ip-neighbor*—IPv4 address of a neighbor. • *ip-prefix*—IPv4. All neighbors within that prefix are cleared. • *vrf-name*—VRF name. All neighbors in that VRF are cleared. The name can be any case-sensitive, alphanumeric string up to 64 characters.
clear ip mbgp {**ip** {**unicast** | **multicast**}} {*neighbor* | ***** | *as-number* | **peer-template** *name* | *prefix*} [**vrf** *vrf-name*]	Clears one or more neighbors. ***** clears all neighbors in the address family. The arguments are as follows: • *neighbor*—IPv4 or IPv6 address of a neighbor. • *as-number*— Autonomous system number. The AS number can be a 16-bit integer or a 32-bit integer in the form of higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format. • *name*—Peer template name. The name can be any case-sensitive, alphanumeric string up to 64 characters. • *prefix*—IPv4 or IPv6 prefix. All neighbors within that prefix are cleared. • *vrf-name*—VRF name. All neighbors in that VRF are cleared. The name can be any case-sensitive, alphanumeric string up to 64 characters.

Command	Purpose
clear ip mbgp dampening [*ip-neighbor* | *ip-prefix*] [**vrf** *vrf-name*]	Clears route flap dampening in one or more networks. The arguments are as follows: • *ip-neighbor*—IPv4 address of a neighbor. • *ip-prefix*—IPv4. All neighbors within that prefix are cleared. • *vrf-name*—VRF name. All neighbors in that VRF are cleared. The name can be any case-sensitive, alphanumeric string up to 64 characters.
clear ip mbgp flap-statistics [*ip-neighbor* | *ip-prefix*] [**vrf** *vrf-name*]	Clears route flap statistics one or more networks. The arguments are as follows: • *ip-neighbor*—IPv4 address of a neighbor. • *ip-prefix*—IPv4. All neighbors within that prefix are cleared. • *vrf-name*—VRF name. All neighbors in that VRF are cleared. The name can be any case-sensitive, alphanumeric string up to 64 characters.

Verifying the Basic BGP Configuration

To display the BGP configuration, perform one of the following tasks:

Command	Purpose
show bgp all [**summary**] [**vrf** *vrf-name*]	Displays the BGP information for all address families.
show bgp convergence [**vrf** *vrf-name*]	Displays the BGP information for all address families.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **community** {**regexp** *expression* | [**community**] [**no-advertise**] [**no-export**] [**no-export-subconfed**]} [**vrf** *vrf-name*]	Displays the BGP routes that match a BGP community.
show bgp [**vrf** *vrf-name*] {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **community-list** *list-name* [**vrf** *vrf-name*]	Displays the BGP routes that match a BGP community list.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **extcommunity** {**regexp** *expression* | **generic** [**non-transitive** | **transitive**] *aa4:nn* [**exact-match**]} [**vrf** *vrf-name*]	Displays the BGP routes that match a BGP extended community.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **extcommunity-list** *list-name* [**exact-match**]} [**vrf** *vrf-name*]	Displays the BGP routes that match a BGP extended community list.

Command	Purpose
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] {**dampening dampened-paths** [**regexp** *expression*]} [**vrf** *vrf-name*]	Displays the information for BGP route dampening. Use the **clear bgp dampening** command to clear the route flap dampening information.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **history-paths** [**regexp** *expression*] [**vrf** *vrf-name*]	Displays the BGP route history paths.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **filter-list** *list-name* [**vrf** *vrf-name*]	Displays the information for the BGP filter list.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [i*p-address* | *ipv6-prefix*] **neighbors** [*ip-address* | *ipv6-prefix*] [**vrf** *vrf-name*]	Displays the information for BGP peers. Use the **clear bgp neighbors** command to clear these neighbors.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] {**nexthop** | **nexthop-database**} [**vrf** *vrf-name*]	Displays the information for the BGP route next hop.
show bgp paths	Displays the BGP path information.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **policy** *name* [**vrf** *vrf-name*]	Displays the BGP policy information. Use the **clear bgp policy** command to clear the policy information.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **prefix-list** *list-name* [**vrf** *vrf-name*]	Displays the BGP routes that match the prefix list.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **received-paths** [**vrf** *vrf-name*]	Displays the BGP paths stored for soft reconfiguration.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **regexp** *expression* [**vrf** *vrf-name*]	Displays the BGP routes that match the AS_path regular expression.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **route-map** *map-name* [**vrf** *vrf-name*]	Displays the BGP routes that match the route map.
show bgp peer-policy *name* [**vrf** *vrf-name*]	Displays the information about BGP peer policies.
show bgp peer-session *name* [**vrf** *vrf-name*]	Displays the information about BGP peer sessions.
show bgp peer-template *name* [**vrf** *vrf-name*]	Displays the information about BGP peer templates. Use the **clear bgp peer-template** command to clear all neighbors in a peer template.
show bgp process	Displays the BGP process information.
show {**ip** | **ipv6**} **bgp** *options*	Displays the BGP status and configuration information.

Command	Purpose
show {**ip** | **ipv6**} **mbgp** *options*	Displays the BGP status and configuration information.
show running-configuration bgp	Displays the current running BGP configuration.

Monitoring BGP Statistics

To display BGP statistics, use the following commands:

Command	Purpose
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **flap-statistics** [**vrf** *vrf-name*]	Displays the BGP route flap statistics. Use the **clear bgp flap-statistics** command to clear these statistics.
show bgp sessions [**vrf** *vrf-name*]	Displays the BGP sessions for all peers. Use the **clear bgp sessions** command to clear these statistics.
show bgp statistics	Displays the BGP statistics.

Configuration Examples for Basic BGP

This example shows a basic BGP configuration:

```
switch(config)# feature bgp
switch(config)# router bgp 64496
switch(config-router)# neighbor 2001:DB8:0:1::55 remote-as 64496
switch(config-router-neighbor)# address-family ipv6 unicast
switch(config-router-af)# next-hop-self
```

Related Topics

The following topics relate to BGP:

- Chapter 10, “Configuring Advanced BGP”
- Chapter 15, “Configuring Route Policy Manager”

Where to Go Next

See Chapter 10, “Configuring Advanced BGP,” for details on the following features:

- Peer templates
- Route redistribution
- Route maps

Additional References

For additional information related to implementing BGP, see the following sections:

- MIBs, page 9-24

MIBs

MIBs	MIBs Link
MIBs related to BGP	To locate and download supported MIBs, go to the following URL: ftp://ftp.cisco.com/pub/mibs/supportlists/nexus9000/Nexus9000MIBSupportList.html

Configuring Advanced BGP

This chapter describes how to configure advanced features of the Border Gateway Protocol (BGP) on the Cisco NX-OS device.

This chapter includes the following sections:

About Advanced BGP

BGP is an interdomain routing protocol that provides loop-free routing between organizations or autonomous systems. Cisco NX-OS supports BGP version 4. BGP version 4 includes multiprotocol extensions that allow BGP to carry routing information for IP multicast routes and multiple Layer 3 protocol address families. BGP uses TCP as a reliable transport protocol to create TCP sessions with other BGP-enabled devices called BGP peers. When connecting to an external organization, the router creates external BGP (eBGP) peering sessions. BGP peers within the same organization exchange routing information through internal BGP (iBGP) peering sessions.

This section includes the following topics:

Peer Templates

BGP peer templates allow you to create blocks of common configuration that you can reuse across similar BGP peers. Each block allows you to define a set of attributes that a peer then inherits. You can choose to override some of the inherited attributes as well, making it a very flexible scheme for simplifying the repetitive nature of BGP configurations.

Cisco NX-OS implements three types of peer templates:

- The peer-session template defines BGP peer session attributes, such as the transport details, remote autonomous system number of the peer, and session timers. A peer-session template can also inherit attributes from another peer-session template (with locally defined attributes that override the attributes from an inherited peer-session).
- A peer-policy template defines the address-family dependent policy aspects for a peer including the inbound and outbound policy, filter lists, and prefix lists. A peer-policy template can inherit from a set of peer-policy templates. Cisco NX-OS evaluates these peer-policy templates in the order specified by the preference value in the inherit configuration. The lowest number is preferred over higher numbers.
- The peer template can inherit the peer-session and peer-policy templates to allow for simplified peer definitions. It is not mandatory to use a peer template but it can simplify the BGP configuration by providing reusable blocks of configuration.

Authentication

You can configure authentication for a BGP neighbor session. This authentication method adds an MD5 authentication digest to each TCP segment sent to the neighbor to protect BGP against unauthorized messages and TCP security attacks.

Note The MD5 password must be identical between BGP peers.

Route Policies and Resetting BGP Sessions

You can associate a route policy to a BGP peer. Route policies use route maps to control or modify the routes that BGP recognizes. You can configure a route policy for inbound or outbound route updates. The route policies can match on different criteria, such as a prefix or AS_path attribute, and selectively accept or deny the routes. Route policies can also modify the path attributes.

When you change a route policy applied to a BGP peer, you must reset the BGP sessions for that peer. Cisco NX-OS supports the following mechanisms to reset BGP peering sessions:

- Hard reset—A hard reset tears down the specified peering sessions, including the TCP connection, and deletes routes coming from the specified peer. This option interrupts packet flow through the BGP network. Hard reset is disabled by default.
- Soft reconfiguration inbound—A soft reconfiguration inbound triggers routing updates for the specified peer without resetting the session. You can use this option if you change an inbound route policy. Soft reconfiguration inbound saves a copy of all routes received from the peer before processing the routes through the inbound route policy. If you change the inbound route policy, Cisco NX-OS passes these stored routes through the modified inbound route policy to update the route table without tearing down existing peering sessions. Soft reconfiguration inbound can use significant memory resources to store the unfiltered BGP routes. Soft reconfiguration inbound is disabled by default.
- Route Refresh—A route refresh updates the inbound routing tables dynamically by sending route refresh requests to supporting peers when you change an inbound route policy. The remote BGP peer responds with a new copy of its routes that the local BGP speaker processes with the modified route policy. Cisco NX-OS automatically sends an outbound route refresh of prefixes to the peer.
- BGP peers advertise the route refresh capability as part of the BGP capability negotiation when establishing the BGP peer session. Route refresh is the preferred option and enabled by default.

Note BGP also uses route maps for route redistribution, route aggregation, route dampening, and other features. See Chapter 15, “Configuring Route Policy Manager,” for more information on route maps.

eBGP

External BGP (eBGP) allows you to connect BGP peers from different autonomous systems to exchange routing updates. Connecting to external networks enables traffic from your network to be forwarded to other networks and across the Internet.

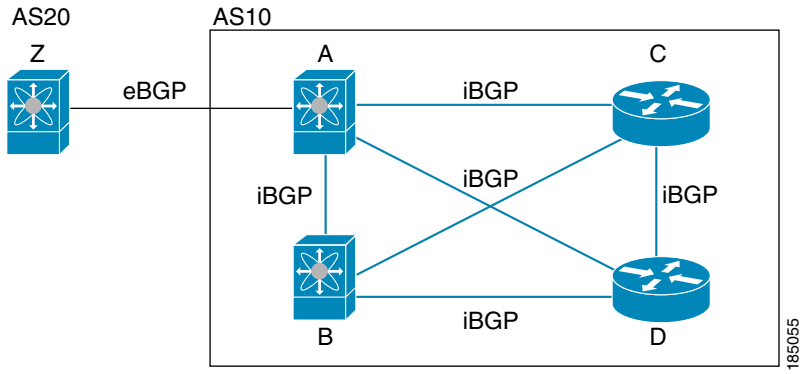
Typically eBGP peerings need to be over directly connected interfaces so that convergence will be faster when the interface goes down.

iBGP

Internal BGP (iBGP) allows you to connect BGP peers within the same autonomous system. You can use iBGP for multihomed BGP networks (networks that have more than one connection to the same external autonomous system).

Figure 10-1 shows an iBGP network within a larger BGP network.

Figure 10-1 iBGP Network



iBGP networks are fully meshed. Each iBGP peer has a direct connection to all other iBGP peers to prevent network loops.

For single-hop iBGP peers with update-source configured under neighbor configuration mode, the peer supports fast external fallover.

You should use loopback interfaces for establishing eBGP peering sessions because loopback interfaces are less susceptible to interface flapping. An interface flap occurs when the interface is administratively brought up or down because of a failure or maintenance issue. See the "Configuring eBGP" section on page 10-29 for information on multihop, fast external fallovers, and limiting the size of the AS_path attribute.

Note You should configure a separate interior gateway protocol in the iBGP network.

This section includes the following topics:

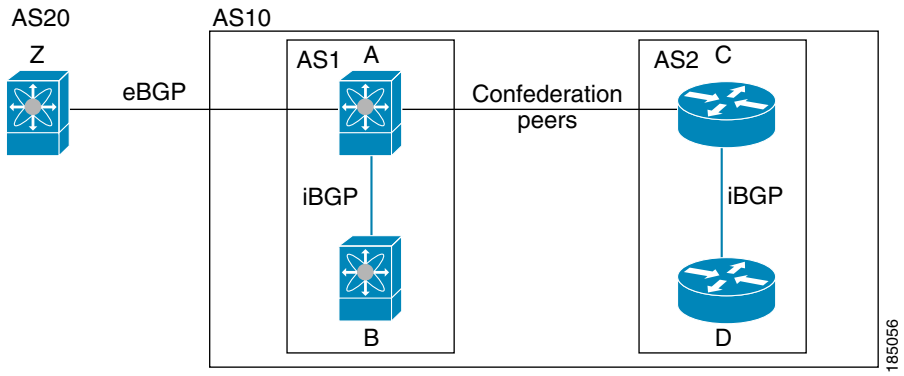
- AS Confederations, page 10-4
- Route Reflector, page 10-5

AS Confederations

A fully meshed iBGP network becomes complex as the number of iBGP peers grows. You can reduce the iBGP mesh by dividing the autonomous system into multiple subautonomous systems and grouping them into a single confederation. A confederation is a group of iBGP peers that use the same autonomous system number to communicate to external networks. Each subautonomous system is fully meshed within itself and has a few connections to other subautonomous systems in the same confederation.

Figure 10-2 shows the BGP network from Figure 10-1, split into two subautonomous systems and one confederation.

Figure 10-2 AS Confederation



In this example, AS10 is split into two subautonomous systems, AS1 and AS2. Each subautonomous system is fully meshed, but there is only one link between the subautonomous systems. By using AS confederations, you can reduce the number of links compared to the fully meshed autonomous system in Figure 10-1.

Route Reflector

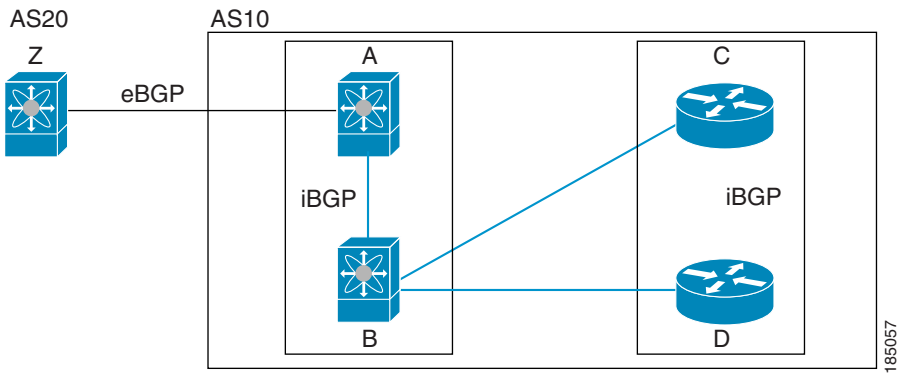
You can alternately reduce the iBGP mesh by using a route reflector configuration where route reflectors pass learned routes to neighbors so that all iBGP peers do not need to be fully meshed.

Figure 10-1 shows a simple iBGP configuration with four meshed iBGP speakers (routers A, B, C, and D). Without route reflectors, when router A receives a route from an external neighbor, it advertises the route to all three iBGP neighbors.

When you configure an iBGP peer to be a route reflector, it becomes responsible for passing iBGP learned routes to a set of iBGP neighbors.

In Figure 10-3, router B is the route reflector. When the route reflector receives routes advertised from router A, it advertises (reflects) the routes to routers C and D. Router A no longer has to advertise to both routers C and D.

Figure 10-3 Route Reflector



The route reflector and its client peers form a cluster. You do not have to configure all iBGP peers to act as client peers of the route reflector. You must configure any nonclient peer as fully meshed to guarantee that complete BGP updates reach all peers.

Capabilities Negotiation

A BGP speaker can learn about BGP extensions that are supported by a peer by using the capabilities negotiation feature. Capabilities negotiation allows BGP to use only the set of features supported by both BGP peers on a link.

If a BGP peer does not support capabilities negotiation, Cisco NX-OS attempts a new session to the peer without capabilities negotiation if you have configured the address family as IPv4. Any other multiprotocol configuration (such as IPv6) requires capabilities negotiation.

Route Dampening

Route dampening is a BGP feature that minimizes the propagation of flapping routes across an internetwork. A route flaps when it alternates between the available and unavailable states in rapid succession.

For example, consider a network with three BGP autonomous systems: AS1, AS2, and AS3. Suppose that a route in AS1 flaps (it becomes unavailable). Without route dampening, AS1 sends a withdraw message to AS2. AS2 propagates the withdrawal message to AS3. When the flapping route reappears, AS1 sends an advertisement message to AS2, which sends the advertisement to AS3. If the route repeatedly becomes unavailable, and then available, AS1 sends many withdrawal and advertisement messages that propagate through the other autonomous systems.

Route dampening can minimize flapping. Suppose that the route flaps. AS2 (in which route dampening is enabled) assigns the route a penalty of 1000. AS2 continues to advertise the status of the route to neighbors. Each time that the route flaps, AS2 adds to the penalty value. When the route flaps so often that the penalty exceeds a configurable suppression limit, AS2 stops advertising the route, regardless of how many times that it flaps. The route is now dampened.

The penalty placed on the route decays until the reuse limit is reached. At that time, AS2 advertises the route again. When the reuse limit is at 50 percent, AS2 removes the dampening information for the route.

Note The router does not apply a penalty to a resetting BGP peer when route dampening is enabled, even though the peer reset withdraws the route.

Load Sharing and Multipath

BGP can install multiple equal-cost eBGP or iBGP paths into the routing table to reach the same destination prefix. Traffic to the destination prefix is then shared across all the installed paths.

The BGP best-path algorithm considers the paths as equal-cost paths if the following attributes are identical:

- Weight
- Local preference
- AS_path
- Origin code
- Multi-exit discriminator (MED)
- IGP cost to the BGP next hop

BGP supports sending and receiving multiple paths per prefix and advertising such paths. For more information, see the "BGP Additional Paths" section.

Note Paths that are received from different AS confederations are considered as equal-cost paths if the external AS_path values and the other attributes are identical.

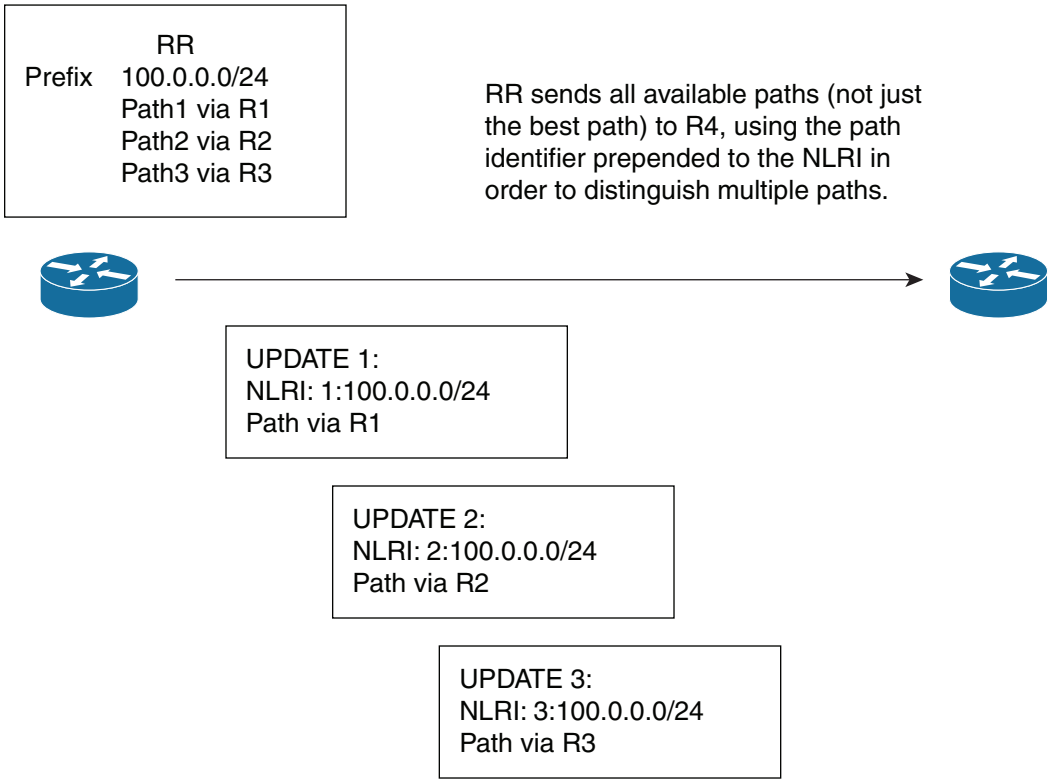
Note When you configure a route reflector for iBGP multipath, and the route reflector advertises the selected best path to its peers, the next hop for the path is not modified.

BGP Additional Paths

Only one BGP best path is advertised, and the BGP speaker accepts only one path for a given prefix from a given peer. If a BGP speaker receives multiple paths for the same prefix within the same session, it uses the most recent advertisement.

BGP supports the additional paths feature, which allows the BGP speaker to propagate and accept multiple paths for the same prefix without the new paths replacing any previous ones. This feature allows BGP speaker peers to negotiate whether they support advertising and receiving multiple paths per prefix and advertising such paths. A special 4-byte path ID is added to the network layer reachability information (NLRI) to differentiate multiple paths for the same prefix sent across a peer session. Figure 10-4 illustrates the BGP additional paths capability.

Figure 10-4 BGP Route Advertisement with the Additional Paths Capability



For information on configuring BGP additional paths, see the "Configuring BGP Additional Paths" section on page 10-26.

Route Aggregation

You can configure aggregate addresses. Route aggregation simplifies route tables by replacing a number of more specific addresses with an address that represents all the specific addresses. For example, you can replace these three more specific addresses, 10.1.1.0/24, 10.1.2.0/24, and 10.1.3.0/24 with one aggregate address, 10.1.0.0/16.

Aggregate prefixes are present in the BGP route table so that fewer routes are advertised.

Note Cisco NX-OS does not support automatic route aggregation.

Route aggregation can lead to forwarding loops. To avoid this problem, when BGP generates an advertisement for an aggregate address, it automatically installs a summary discard route for that aggregate address in the local routing table. BGP sets the administrative distance of the summary discard to 220 and sets the route type to discard. BGP does not use discard routes for next-hop resolution.

BGP Conditional Advertisement

BGP conditional advertisement allows you to configure BGP to advertise or withdraw a route based on whether or not a prefix exists in the BGP table. This feature is useful, for example, in multihomed networks, in which you want BGP to advertise some prefixes to one of the providers only if information from the other provider is not present.

Consider an example network with three BGP autonomous systems: AS1, AS2, and AS3, where AS1 and AS3 connect to the Internet and to AS2. Without conditional advertisement, AS2 propagates all routes to both AS1 and AS3. With conditional advertisement, you can configure AS2 to advertise certain routes to AS3 only if routes from AS1 do not exist (if for example, the link to AS1 fails).

BGP conditional advertisement adds an exist or not-exist test to each route that matches the configured route map. See the "Configuring BGP Conditional Advertisement" section on page 10-38 for more information.

BGP Next-Hop Address Tracking

BGP monitors the next-hop address of installed routes to verify next-hop reachability and to select, install, and validate the BGP best path. BGP next-hop address tracking speeds up this next-hop reachability test by triggering the verification process when routes change in the Routing Information Base (RIB) that may affect BGP next-hop reachability.

BGP receives notifications from the RIB when the next-hop information changes (event-driven notifications). BGP is notified when any of the following events occurs:

- The next hop becomes unreachable.
- The next hop becomes reachable.
- The fully recursed Interior Gateway Protocol (IGP) metric to the next hop changes.
- The first hop IP address or first hop interface changes.

- The next hop becomes connected.
- The next hop becomes unconnected.
- The next hop becomes a local address.
- The next hop becomes a nonlocal address.

Note Reachability and recursed metric events trigger a best-path recalculation.

Event notifications from the RIB are classified as critical and noncritical. Notifications for critical and noncritical events are sent in separate batches. However, a noncritical event is sent with the critical events if the noncritical event is pending and there is a request to read the critical events.

- Critical events are related to next-hop reachability, such as the loss of next hops resulting in a switchover to a different path. A change in the IGP metric for a next hop resulting in a switchover to a different path can also be considered a critical event.
- Non-critical events are related to next hops being added without affecting the best path or changing the IGP metric to a single next hop.

See the "Configuring BGP Next-Hop Address Tracking" section on page 10-24 for more information.

Route Redistribution

You can configure BGP to redistribute static routes or routes from other protocols. You must configure a route map with the redistribution to control which routes are passed into BGP. A route map allows you to filter routes based on attributes such as the destination, origination protocol, route type, route tag, and so on. See Chapter 15, "Configuring Route Policy Manager," for more information. iBGP is not redistributed to IGP by default.

You can use route maps to override the default behavior in both scenarios, but be careful when doing so as incorrect use of route maps can result in network loops. The following examples show how to use route maps to change the default behavior.

You can change the default behavior for scenario 1 by modifying the route map as follows:

```
route-map foo permit 10
   match route-type internal
router ospf 1
   redistribute bgp 100 route-map foo
```

Similarly, you can change the default behavior for scenario 2 by modifying the route map as follows:

```
route-map foo deny 10
  match route-type internal
router ospf 1
   vrf bar
     redistribute bgp 100 route-map foo
```

BFD

This feature supports bidirectional forwarding detection (BFD) for IPv4 and IPv6. BFD is a detection protocol designed to provide fast forwarding-path failure detection times. BFD provides subsecond failure detection between two adjacent devices and can be less CPU-intensive than protocol hello messages because some of the BFD load can be distributed onto the data plane on supported modules.

BFD for BGP is supported on eBGP peers and iBGP single-hop peers. Configure the update-source option in neighbor configuration mode for iBGP single-hop peers using BFD.

Note BFD is not supported on other iBGP peers or for multihop eBGP peers.

See the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide* for more information.

Tuning BGP

You can modify the default behavior of BGP through BGP timers and by adjusting the best-path algorithm.

This section includes the following topics:

BGP Timers

BGP uses different types of timers for neighbor session and global protocol events. Each established session has a minimum of two timers for sending periodic keepalive messages and for timing out sessions when peer keepalives do not arrive within the expected time. In addition, there are other timers for handling specific features. Typically, you configure these timers in seconds. The timers include a random adjustment so that the same timers on different BGP peers trigger at different times.

Tuning the Best-Path Algorithm

You can modify the default behavior of the best-path algorithm through optional configuration parameters, including changing how the algorithm handles the multi-exit discriminator (MED) attribute and the router ID.

Multiprotocol BGP

BGP on Cisco NX-OS supports multiple address families. Multiprotocol BGP (MP-BGP) carries different sets of routes depending on the address family. For example, BGP can carry one set of routes for IPv4 unicast routing, one set of routes for IPv4 multicast routing, and one set of routes for IPv6 multicast routing.

Note Because Multicast BGP does not propagate multicast state information, you need a multicast protocol, such as Protocol Independent Multicast (PIM).

Use the router address-family and neighbor address-family configuration modes to support multiprotocol BGP configurations. MP-BGP maintains separate RIBs for each configured address family, such as a unicast RIB and a multicast RIB for BGP.

A multiprotocol BGP network is backward compatible but BGP peers that do not support multiprotocol extensions cannot forward routing information, such as address family identifier information, that the multiprotocol extensions carry.

RFC 5549

Beginning with Cisco NX-OS Release 7.0(3)I2(1), BGP supports RFC 5549, which allows an IPv4 prefix to be carried over an IPv6 next hop. Because BGP is running on every hop and all routers are capable of forwarding IPv4 and IPv6 traffic, there is no need to support IPv6 tunnels between any routers. BGP installs IPv4 over an IPv6 route to the Unicast Route Information Base (URIB).

Graceful Restart and High Availability

Cisco NX-OS supports nonstop forwarding and graceful restart for BGP.

You can use nonstop forwarding (NSF) for BGP to forward data packets along known routes in the Forward Information Base (FIB) while the BGP routing protocol information is being restored following a failover. With NSF, BGP peers do not experience routing flaps. During a failover, the data traffic is forwarded through intelligent modules while the standby supervisor becomes active.

If a Cisco NX-OS router experiences a cold reboot, the network does not forward traffic to the router and removes the router from the network topology. In this scenario, BGP experiences a nongraceful restart and removes all routes. When Cisco NX-OS applies the startup configuration, BGP reestablishes peering sessions and relearns the routes.

A Cisco NX-OS router that has dual supervisors can experience a stateful supervisor switchover. During the switchover, BGP uses nonstop forwarding to forward traffic based on the information in the FIB, and the system is not removed from the network topology. A router whose neighbor is restarting is referred to as a “helper.” After the switchover, a graceful restart operation begins. When it is in progress, both routers reestablish their neighbor relationship and exchange their BGP routes. The helper continues to forward prefixes pointing to the restarting peer, and the restarting router continues to forward traffic to peers even though those neighbor relationships are restarting. When the restarting router has all route updates from all BGP peers that are graceful restart capable, the graceful restart is complete, and BGP informs the neighbors that it is operational again.

For single-hop iBGP peers with update-source configured under neighbor configuration mode, the peer supports fast external fall-over.

With the additional BGP paths feature, if the number of paths advertised for a given prefix is the same before and after restart, the choice of path ID guarantees the final state and removal of stale paths. If fewer paths are advertised for a given prefix after a restart, stale paths can occur on the graceful restart helper peer.

Low Memory Handling

BGP reacts to low memory for the following conditions:

- Minor alert—BGP does not establish any new eBGP peers. BGP continues to establish new iBGP peers and confederate peers. Established peers remain, but reset peers are not reestablished.
- Severe alert—BGP shuts down select established eBGP peers every two minutes until the memory alert becomes minor. For each eBGP peer, BGP calculates the ratio of total number of paths received to the number of paths selected as best paths. The peers with the highest ratio are selected to be shut down to reduce memory usage. You must clear a shutdown eBGP peer before you can bring the eBGP peer back up to avoid oscillation.

Note You can exempt important eBGP peers from this selection process.

- Critical alert—BGP gracefully shuts down all the established peers. You must clear a shutdown BGP peer before you can bring the BGP peer back up.

See the "Tuning BGP" section on page 10-45 for more information on how to exempt a BGP peer from a shutdown due to a low memory condition.

Virtualization Support

You can configure one BGP instance. BGP supports virtual routing and forwarding (VRF) instances.

Licensing Requirements for Advanced BGP

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	BGP requires an Enterprise Services license. For a complete explanation of the Cisco NX-OS licensing scheme and how to obtain and apply licenses, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for Advanced BGP

Advanced BGP has the following prerequisites:

- You must enable BGP (see the "Enabling BGP" section on page 9-11).
- You should have a valid router ID configured on the system.
- You must have an AS number, either assigned by a Regional Internet Registry (RIR) or locally administered.
- You must have reachability (such as an interior gateway protocol [IGP], a static route, or a direct connection) to the peer that you are trying to make a neighbor relationship with.
- You must explicitly configure an address family under a neighbor for the BGP session establishment.

Guidelines and Limitations for Advanced BGP

Advanced BGP has the following configuration guidelines and limitations:

- The dynamic AS number prefix peer configuration overrides the individual AS number configuration inherited from a BGP template.
- If you configure a dynamic AS number for prefix peers in an AS confederation, BGP establishes sessions with only the AS numbers in the local confederation.
- BGP sessions created through a dynamic AS number prefix peer ignore any configured eBGP multihop time-to-live (TTL) value or a disabled check for directly connected peers.
- Configure a router ID for BGP to avoid automatic router ID changes and session flaps.
- Use the maximum-prefix configuration option per peer to restrict the number of routes received and system resources used.

- Configure the update source to establish a session with eBGP multihop sessions.
- Specify a BGP route map if you configure a redistribution.
- Configure the BGP router ID within a VRF.
- If you decrease the keepalive and hold timer values, the network might experience session flaps.
- When you redistribute BGP to IGP, iBGP is redistributed as well. To override this behavior, you must insert an additional deny statement into the route map.
- Cisco NX-OS does not support multi-hop BFD. BFD for BGP has the following limitations:
  - BFD is supported only for eBGP peers and iBGP single-hop peers.
  - To enable BFD for iBGP single-hop peers, you must configure the update-source option on the physical interface.
  - BFD is not supported for multi-hop iBGP peers and multi-hop eBGP peers.
  - BGP supports prefix-based peers, but BFD is not supported for prefix-based peers.
- The following guidelines and limitations apply to the **remove-private-as** command:
  - It applies only to eBGP peers.
  - It can be configured only in neighbor configuration mode and not in neighbor-address-family mode.
  - If the AS-path includes both private and public AS numbers, the private AS numbers are not removed.
  - If the AS-path contains the AS number of the eBGP neighbor, the private AS numbers are not removed.
  - Private AS numbers are removed only if all AS numbers in that AS-path belong to a private AS number range. Private AS numbers are not removed if a peer's AS number or a non-private AS number is found in the AS-path segment.
- If you use the **aggregate-address** command to configure aggregate addresses and the **suppress-fib-pending** command to suppress BGP routes, lossless traffic for aggregates cannot be ensured on BGP or system triggers.
- When you enable FIB suppression on the switch and route programming fails in the hardware, BGP advertises routes that are not programmed locally in the hardware.
- If you disable a command in the neighbor, template peer, template peer-session, or template peer-policy configuration mode (and the **inherit peer** or **inherit peer-session** command is present), you must use the **default** keyword to return the command to its default state. For example, to disable the **update-source loopback 0** command from the running configuration, you must enter the **default update-source loopback 0** command.

Default Settings for Advanced BGP

Table 10-1 lists the default settings for advanced BGP parameters.

Table 10-1 Default BGP Parameters

Parameters	Default
BGP feature	Disabled
BGP additional paths	Disabled

Table 10-1 Default BGP Parameters (continued)

Parameters	Default
Hold timer	180 seconds
Keep alive interval	60 seconds
Dynamic capability	Enabled

Configuring Advanced BGP

This section includes the following topics:

- Tuning BGP, page 10-45
- Configuring a Graceful Restart, page 10-48
- Configuring Virtualization, page 10-50

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Enabling IP Forward on an Interface

To use RFC 5549, you must configure at least one IPv4 address. If you do not want to configure an IPv4 address, you must enable the IP forward feature to use RFC 5549.

1. **configure terminal**
2. **interface** *type slot/port*
3. **ip forward**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip forward** **Example:** `switch(config-if)# ip forward`	Allows IPv4 traffic on the interface even when there is no IP address configuration on that interface.
Step 4	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Saves this configuration change.

Configuring BGP Session Templates

You can use BGP session templates to simplify the BGP configuration for multiple BGP peers with similar configuration needs. BGP templates allow you to reuse common configuration blocks. You configure BGP templates first and then apply these templates to BGP peers.

With BGP session templates, you can configure session attributes such as inheritance, passwords, timers, and security.

A peer-session template can inherit from one other peer-session template. You can configure the second template to inherit from a third template. The first template also inherits this third template. This indirect inheritance can continue for up to seven peer-session templates.

Any attributes configured for the neighbor take priority over any attributes inherited by that neighbor from a BGP template.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

Note When editing a template, you can use the **no** form of a command at either the peer or template level to explicitly override a setting in a template. You must use the **default** form of the command to reset that attribute to the default state.

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **template peer-session** *template-name*
4. (Optional) **password number** *password*
5. (Optional) **timers** *keepalive hold*
6. **exit**
7. **neighbor** *ip-address* **remote-as** *as-number*
8. **inherit peer-session** *template-name*
9. (Optional) **description** *text*
10. (Optional) **show bgp peer-session** *template-name*
11. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example:** `switch(config)# router bgp 65535` `switch(config-router)#`	Enables BGP and assigns the autonomous system number to the local BGP speaker.
Step 3	**template peer-session** *template-name* **Example:** `switch(config-router)# template peer-session BaseSession` `switch(config-router-stmp)#`	Enters peer-session template configuration mode.

	Command	Purpose
Step 4	**password** *number password* **Example**: `switch(config-router-stmp)# password 0 test`	(Optional) Adds the cleartext password *test* to the neighbor. The password is stored and displayed in type 3 encrypted form (3DES).
Step 5	**timers** *keepalive hold* **Example**: `switch(config-router-stmp)# timers 30 90`	(Optional) Adds the BGP keepalive and holdtimer values to the peer-session template. The default keepalive interval is 60. The default hold time is 180.
Step 6	**exit** **Example**: `switch(config-router-stmp)# exit` `switch(config-router)#`	Exits peer-session template configuration mode.
Step 7	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `switch(config-router)# neighbor 192.168.1.2 remote-as 65535` `switch(config-router-neighbor)#`	Places the router in the neighbor configuration mode for BGP routing and configures the neighbor IP address.
Step 8	**inherit peer-session** *template-name* **Example**: `switch(config-router-neighbor)# inherit peer-session BaseSession` `switch(config-router-neighbor)`	Applies a peer-session template to the peer.
Step 9	**description** *text* **Example**: `switch(config-router-neighbor)# description Peer Router A` `switch(config-router-neighbor)`	(Optional) Adds a description for the neighbor.
Step 10	**show bgp peer-session** *template-name* **Example:** `switch(config-router-neighbor)# show bgp peer-session BaseSession`	(Optional) Displays the peer-policy template.
Step 11	**copy running-config startup-config** **Example:** `switch(config-router-neighbor)# copy running-config startup-config`	(Optional) Saves this configuration change.

Use the **show bgp neighbor** command to see the template applied.

This example shows how to configure a BGP peer-session template and apply it to a BGP peer:

```
switch# configure terminal
switch(config)# router bgp 65535
switch(config-router)# template peer-session BaseSession
switch(config-router-stmp)# timers 30 90
switch(config-router-stmp)# exit
switch(config-router)# neighbor 192.168.1.2 remote-as 65535
switch(config-router-neighbor)# inherit peer-session BaseSession
switch(config-router-neighbor)# description Peer Router A
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor)# copy running-config startup-config
```

Configuring BGP Peer-Policy Templates

You can configure a peer-policy template to define attributes for a particular address family. You assign a preference to each peer-policy template and these templates are inherited in the order specified, for up to five peer-policy templates in a neighbor address family.

Cisco NX-OS evaluates multiple peer policies for an address family using the preference value. The lowest preference value is evaluated first. Any attributes configured for the neighbor take priority over any attributes inherited by that neighbor from a BGP template.

Peer-policy templates can configure address family-specific attributes such as AS-path filter lists, prefix lists, route reflection, and soft reconfiguration.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

Note When editing a template, you can use the **no** form of a command at either the peer or template level to explicitly override a setting in a template. You must use the default form of the command to reset that attribute to the default state.

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **template peer-policy** *template-name*
4. (Optional) **advertise-active-only**
5. (Optional) **maximum-prefix** *number*
6. **exit**
7. **neighbor** *ip-address* **remote-as** *as-number*
8. **address-family** {**ipv4** | **ipv6**} {**multicast** | **unicast**}
9. **inherit peer-policy** *template-name preference*
10. (Optional) **show bgp peer-policy** *template-name*
11. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example:** `switch(config)# router bgp 65535` `switch(config-router)#`	Enables BGP and assigns the autonomous system number to the local BGP speaker.

	Command	Purpose
Step 3	**template peer-policy** *template-name* **Example**: switch(config-router)# template peer-policy BasePolicy switch(config-router-ptmp)#	Creates a peer-policy template.
Step 4	**advertise-active-only** **Example**: switch(config-router-ptmp)# advertise-active-only	(Optional) Advertises only active routes to the peer.
Step 5	**maximum-prefix** *number* **Example**: switch(config-router-ptmp)# maximum-prefix 20	(Optional) Sets the maximum number of prefixes allowed from this peer.
Step 6	**exit** **Example**: switch(config-router-ptmp)# exit switch(config-router)#	Exits peer-policy template configuration mode.
Step 7	**neighbor** *ip-address* **remote-as** *as-number* **Example:** switch(config-router)# neighbor 192.168.1.2 remote-as 65535 switch(config-router-neighbor)#	Places the router in neighbor configuration mode for BGP routing and configures the neighbor IP address.
Step 8	**address-family** {**ipv4** | **ipv6**} {**multicast** | **unicast**} **Example**: switch(config-router-neighbor)# address-family ipv4 unicast switch(config-router-neighbor-af)#	Enters global address-family configuration mode for the specified address family.
Step 9	**inherit peer-policy** *template-name preference* **Example**: switch(config-router-neighbor-af)# inherit peer-policy BasePolicy 1	Applies a peer-policy template to the peer address-family configuration and assigns the preference value for this peer policy.
Step 10	**show bgp peer-policy** *template-name* **Example:** switch(config-router-neighbor-af)# show bgp peer-policy BasePolicy	(Optional) Displays the peer-policy template.
Step 11	**copy running-config startup-config** **Example:** switch(config-router-neighbor-af)# copy running-config startup-config	(Optional) Saves this configuration change.

Use the **show bgp neighbor** command to see the template applied.

This example shows how to configure a BGP peer-policy template and apply it to a BGP peer:

```
switch# configure terminal
switch(config)# router bgp 65535
switch(config-router)# template peer-session BasePolicy
switch(config-router-ptmp)# maximum-prefix 20
switch(config-router-ptmp)# exit
switch(config-router)# neighbor 192.168.1.1 remote-as 65535
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)# inherit peer-policy BasePolicy
switch(config-router-neighbor-af)# copy running-config startup-config
```

Configuring BGP Peer Templates

You can configure BGP peer templates to combine session and policy attributes in one reusable configuration block. Peer templates can also inherit peer-session or peer-policy templates. Any attributes configured for the neighbor take priority over any attributes inherited by that neighbor from a BGP template. You configure only one peer template for a neighbor, but that peer template can inherit peer-session and peer-policy templates.

Peer templates support session and address family attributes, such as eBGP multihop time-to-live, maximum prefix, next-hop self, and timers.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

Note When editing a template, you can use the **no** form of a command at either the peer or template level to explicitly override a setting in a template. You must use the default form of the command to reset that attribute to the default state.

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *autonomous-system-number*
3. **template peer** *template-name*
4. **inherit peer-session** *template-name*
5. **address-family** {**ipv4** | **ipv6**} {**multicast** | **unicast**}
6. **inherit peer** *template-name*
7. **exit**
8. **timers** *keepalive hold*
9. **exit**
10. **neighbor** *ip-address* **remote-as** *as-number*
11. **inherit peer** *template-name*
12. **timers** *keepalive hold*
13. (Optional) **show bgp peer-template** *template-name*
14. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example**: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router bgp** *autonomous-system-number* **Example**: switch(config)# router bgp 65535	Enters BGP mode and assigns the autonomous system number to the local BGP speaker.
Step 3	**template peer** *template-name* **Example**: switch(config-router)# template peer BasePeer switch(config-router-neighbor)#	Enters peer template configuration mode.
Step 4	**inherit peer-session** *template-name* **Example**: switch(config-router-neighbor)# inherit peer-session BaseSession	(Optional) Inherits a peer-session template in the peer template.
Step 5	**address-family** {**ipv4** | **ipv6**} {**multicast** | **unicast**} **Example**: switch(config-router-neighbor)# address-family ipv4 unicast switch(config-router-neighbor-af)#	(Optional) Configures the global address-family configuration mode for the specified address family.
Step 6	**inherit peer** *template-name* **Example**: switch(config-router-neighbor-af)# inherit peer BasePolicy	(Optional) Applies a peer template to the neighbor address-family configuration.
Step 7	**exit** **Example**: switch(config-router-neighbor-af)# exit switch(config-router-neighbor)#	Exits BGP neighbor address-family configuration mode.
Step 8	**timers** *keepalive hold* **Example**: switch(config-router-neighbor)# timers 45 100	(Optional) Adds the BGP timer values to the peer. These values override the timer values in the peer-session template, BaseSession.
Step 9	**exit** **Example**: switch(config-router-neighbor)# exit switch(config-router)#	Exits BGP peer template configuration mode.
Step 10	**neighbor** *ip-address* **remote-as** *as-number* **Example:** switch(config-router)# neighbor 192.168.1.2 remote-as 65535 switch(config-router-neighbor)#	Places the router in neighbor configuration mode for BGP routing and configures the neighbor IP address.

	Command	Purpose
Step 11	**inherit peer** *template-name* **Example:** `switch(config-router-neighbor)# inherit peer BasePeer`	Inherits the peer template.
Step 12	**timers** *keepalive hold* **Example:** `switch(config-router-neighbor)# timers 60 120`	(Optional) Adds the BGP timer values to this neighbor. These values override the timer values in the peer template and the peer-session template.
Step 13	**show bgp peer-template** *template-name* **Example:** `switch(config-router-neighbor-af)# show bgp peer-template BasePeer`	(Optional) Displays the peer template.
Step 14	**copy running-config startup-config** **Example:** `switch(config-router-neighbor-af)# copy running-config startup-config`	(Optional) Saves this configuration change.

Use the **show bgp neighbor** command to see the template applied.

This example shows how to configure a BGP peer template and apply it to a BGP peer:

```
switch# configure terminal
switch(config)# router bgp 65535
switch(config-router)# template peer BasePeer
switch(config-router-neighbor)# inherit peer-session BaseSession
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)# inherit peer-policy BasePolicy 1
switch(config-router-neighbor-af)# exit
switch(config-router-neighbor)# exit
switch(config-router)# neighbor 192.168.1.2 remote-as 65535
switch(config-router-neighbor)# inherit peer BasePeer
switch(config-router-neighbor)# copy running-config startup-config
```

Configuring Prefix Peering

BGP supports the definition of a set of peers using a prefix for both IPv4 and IPv6. This feature allows you to not have to add each neighbor to the configuration.

When defining a prefix peering, you must specify the remote AS number with the prefix. BGP accepts any peer that connects from that prefix and autonomous system if the prefix peering does not exceed the configured maximum peers allowed.

When a BGP peer that is part of a prefix peering disconnects, Cisco NX-OS holds its peer structures for a defined prefix peer timeout value. An established peer can reset and reconnect without danger of being blocked because other peers have consumed all slots for that prefix peering.

To configure the BGP prefix peering timeout value, use the following command in neighbor configuration mode:

Command	Purpose
timers prefix-peer-timeout *value* **Example**: switch(config-router-neighbor)# timers prefix-peer-timeout 120	Configures the timeout value for prefix peering. The range is from 0 to 1200 seconds. The default value is 30.

To configure the maximum number of peers, use the following command in neighbor configuration mode:

Command	Purpose
maximum-peers *value* **Example**: switch(config-router-neighbor)# maximum-peers 120	Configures the maximum number of peers for this prefix peering. The range is from 1 to 1000.

This example shows how to configure a prefix peering that accepts up to 10 peers:

```
switch# configure terminal
switch(config)# router bgp 65535
switch(config-router)# timers prefix-peer-timeout 120
switch(config-router)# neighbor 10.100.200.0/24 remote-as 65535
switch(config-router-neighbor)# maximum-peers 10
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)#
```

Use the **show bgp ipv4 unicast neighbors** command to show the details of the configuration for that prefix peering with a list of the currently accepted instances and the counts of active, maximum concurrent, and total accepted peers.

Configuring BGP Authentication

You can configure BGP to authenticate route updates from peers using MD5 digests.

To configure BGP to use MD5 authentication, use the following command in neighbor configuration mode:

Command	Purpose
password [**0** | **3** | **7**] *string* **Example**: switch(config-router-neighbor)# password BGPpassword	Configures an MD5 password for BGP neighbor sessions.

Resetting a BGP Session

If you modify a route policy for BGP, you must reset the associated BGP peer sessions. If the BGP peers do not support route refresh, you can configure a soft reconfiguration for inbound policy changes. Cisco NX-OS automatically attempts a soft reset for the session.

To configure soft reconfiguration inbound, use the following command in neighbor address-family configuration mode:

Command	Purpose
soft-reconfiguration inbound **Example:** `switch(config-router-neighbor-af)# soft-reconfiguration inbound`	Enables soft reconfiguration to store the inbound BGP route updates. This command triggers an automatic soft clear or refresh of BGP neighbor sessions.

To reset a BGP neighbor session, use the following command in any mode:

Command	Purpose
clear bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} *ip-address* **soft** {**in** | **out**} **Example:** `switch# clear bgp ip unicast 192.0.2.1 soft in`	Resets the BGP session without tearing down the TCP session.

Modifying the Next-Hop Address

You can modify the next-hop address used in a route advertisement in the following ways:

- Disable next-hop calculation and use the local BGP speaker address as the next-hop address.
- Set the next-hop address as a third-party address. Use this feature in situations where the original next-hop address is on the same subnet as the peer that the route is being sent to. Using this feature saves an extra hop during forwarding.

To modify the next-hop address, use the following commands in address-family configuration mode:

Command	Purpose
next-hop-self **Example:** `switch(config-router-neighbor-af)# next-hop-self`	Uses the local BGP speaker address as the next-hop address in route updates. This command triggers an automatic soft clear or refresh of BGP neighbor sessions.
next-hop-third-party **Example:** `switch(config-router-neighbor-af)# next-hop-third-party`	Sets the next-hop address as a third-party address. Use this command for single-hop EBGP peers that do not have **next-hop-self** configured.

Configuring BGP Next-Hop Address Tracking

BGP next-hop address tracking is enabled by default and cannot be disabled.

You can modify the delay interval between RIB checks to increase the performance of BGP next-hop tracking.

To modify the BGP next-hop address tracking, use the following commands in address-family configuration mode:

Command	Purpose
nexthop trigger-delay {**critical** | **non-critical**} *milliseconds* **Example**: `switch(config-router-af)# nexthop trigger-delay critical 5000`	Specifies the next-hop address tracking delay timer for critical next-hop reachability routes and for noncritical routes. The range is from 1 to 4294967295 milliseconds. The critical timer default is 3000. The noncritical timer default is 10000.

Configuring Next-Hop Filtering

BGP next-hop filtering allows you to specify that when a next-hop address is checked with the RIB, the underlying route for that next-hop address is passed through the route map. If the route map rejects the route, the next-hop address is treated as unreachable.

BGP marks all next hops that are rejected by the route policy as invalid and does not calculate the best path for the routes that use the invalid next-hop address.

To configure BGP next-hop filtering, use the following command in address-family configuration mode:

Command	Purpose
nexthop route-map *name* **Example**: `switch(config-router-af)# nexthop route-map nextHopLimits`	Specifies a route map to match the BGP next-hop route to. The name can be any case-sensitive, alphanumeric string up to 63 characters.

Shrinking Next-Hop Groups When A Session Goes Down

You can configure BGP to shrink ECMP groups in an accelerated way when a session goes down.

This feature applies to the following BGP path failure events:

- Any single or multiple Layer 3 link failures
- Line card failures
- BFD failure detections for BGP neighbors
- Administrative shutdown of BGP neighbors (using the **shutdown** command)

The accelerated handling of the first two events (Layer 3 link failures and line card failures) is enabled by default and does not require a configuration command to be enabled.

To configure the accelerated handling of the last two events, use the following command in router configuration mode:

Command	Purpose
neighbor-down fib-accelerate **Example:** `switch(config-router)# neighbor-down fib-accelerate`	Withdraws the corresponding next hop from all next-hop groups (ECMP groups and single next-hop routes) whenever a BGP session goes down. **Note** This command applies to both IPv4 and IPv6 address-family routes.

Disabling Capabilities Negotiation

You can disable capabilities negotiations to interoperate with older BGP peers that do not support capabilities negotiation.

To disable capabilities negotiation, use the following command in neighbor configuration mode:

Command	Purpose
dont-capability-negotiate **Example:** `switch(config-router-neighbor)# dont-capability-negotiate`	Disables capabilities negotiation. You must manually reset the BGP sessions after configuring this command.

Disabling Policy Batching

In BGP deployments where prefixes have unique attributes, BGP tries to identify routes with similar attributes to bundle in the same BGP update message. To avoid the overhead of this additional BGP processing, you can disable batching.

Cisco recommends that you disable policy batching for BGP deployments that have a large number of routes with unique next hops.

To disable policy batching, use the following command in router configuration mode:

Command	Purpose
disable-policy-batching **Example:** `switch(config-router)# disable-policy-batching`	Disables the batching evaluation of prefix advertisements to all peers.

Configuring BGP Additional Paths

BGP supports sending and receiving multiple paths per prefix and advertising such paths. This section includes the following topics:

- Configuring Additional Path Selection, page 10-29

Advertising the Capability of Sending and Receiving Additional Paths

You can configure BGP to advertise the capability of sending and receiving additional paths to and from the BGP peers. To do so, use the following commands in neighbor address-family configuration mode:

Command	Purpose
[no] capability additional-paths send [disable] **Example:** `switch(config-router-neighbor-af)# capability additional-paths send`	Advertises the capability to send additional paths to the BGP peer. The **disable** option disables the advertising capability of sending additional paths. The **no** form of this command disables the capability of sending additional paths.
[no] capability additional-paths receive [disable] **Example:** `switch(config-router-neighbor-af)# capability additional-paths receive`	Advertises the capability to receive additional paths from the BGP peer. The **disable** option disables the advertising capability of receiving additional paths. The **no** form of this command disables the capability of receiving additional paths.
show bgp neighbor **Example:** `switch(config-router-neighbor-af)# show bgp neighbor`	Displays whether the local peer has advertised the additional paths send or receive capability to the remote peer.

This example shows how to configure BGP to advertise the capability to send and receive additional paths to the BGP peer:

```
switch# configure terminal
switch(config)# router bgp 100
switch(config-router)# neighbor 10.131.31.2 remote-as 100
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)# capability additional-paths send
switch(config-router-neighbor-af)# capability additional-paths receive
```

Configuring the Sending and Receiving of Additional Paths

You can configure the capability of sending and receiving additional paths to and from the BGP peers. To do so, use the following commands in address-family configuration mode:

Command	Purpose
[no] additional-paths send **Example:** `switch(config-router-af)# additional-paths send`	Enables the send capability of additional paths for all of the neighbors under this address family for which the capability has not been disabled. The **no** form of this command disables the send capability.

Command	Purpose
[**no**] **additional-paths receive** **Example:** `switch(config-router-af)# additional-paths receive`	Enables the receive capability of additional paths for all of the neighbors under this address family for which the capability has not been disabled. The **no** form of this command disables the receive capability.
show bgp neighbor **Example:** `switch(config-router-af)# show bgp neighbor`	Displays whether the local peer has advertised the additional paths send or receive capability to the remote peer.

This example shows how to enable the additional paths send and receive capability for all neighbors under the specified address family for which this capability has not been disabled:

```
switch# configure terminal
switch(config)# router bgp 100
switch(config-router)# address-family ipv4 unicast
switch(config-router-af)# additional-paths send
switch(config-router-af)# additional-paths receive
```

Configuring Advertised Paths

You can specify the paths that are advertised for BGP. To do so, use the following commands in route-map configuration mode:

Command	Purpose
[**no**] **set ip next-hop unchanged** **Example:** `switch(config-route-map)# set ip next-hop unchanged`	Specifies an unchanged next-hop IP address.
[**no**] **set path-selection all advertise** **Example:** `switch(config-route-map)# set path-selection all advertise`	Specifies that all paths be advertised for a given prefix. The **no** form of this command specifies that only the best path be advertised.
show bgp {**ipv4** | **ipv6**} **unicast** [*ip-address* | *ipv6-prefix*] [**vrf** *vrf-name*] **Example:** `switch(config-route-map)# show bgp ipv4 unicast`	Displays the path ID for the additional paths of a prefix and advertisement information for these paths.

This example shows how to specify that all paths be advertised for the specified prefix:

```
switch# configure terminal
switch(config)# route-map PATH_SELECTION_RMAP
switch(config-route-map)# match ip address prefix-list p1
switch(config-route-map)# set path-selection all advertise
```

Configuring Additional Path Selection

You can configure the capability of selecting additional paths for a prefix. To do so, use the following commands in address-family configuration mode:

Command	Purpose
[no] additional-paths selection route-map *map-name* **Example:** `switch(config-router-af)# additional-paths selection route-map map1`	Configures the capability of selecting additional paths for a prefix. The **no** form of this command disables the additional paths selection capability.
show bgp {**ipv4** | **ipv6**} **unicast** [*ip-address* | *ipv6-prefix*] [**vrf** *vrf-name*] **Example:** `switch(config-route-af)# show bgp ipv4 unicast`	Displays the path ID for the additional paths of a prefix and advertisement information for these paths.

This example shows how to configure the additional paths selection under the specified address family:

```
switch# configure terminal
switch(config)# router bgp 100
switch(config-router)# address-family ipv4 unicast
switch(config-router-af)# additional-paths selection route-map PATH_SELECTION_RMAP
```

Configuring eBGP

This section includes the following topics:

Disabling eBGP Single-Hop Checking

You can configure eBGP to disable checking whether a single-hop eBGP peer is directly connected to the local router. Use this option for configuring a single-hop loopback eBGP session between directly connected switches.

To disable checking whether or not a single-hop eBGP peer is directly connected, use the following command in neighbor configuration mode:

Command	Purpose
disable-connected-check **Example:** `switch(config-router-neighbor)# disable-connected-check`	Disables checking whether or not a single-hop eBGP peer is directly connected. You must manually reset the BGP sessions after using this command.

Configuring eBGP Multihop

You can configure the eBGP time-to-live (TTL) value to support eBGP multihop. In some situations, an eBGP peer is not directly connected to another eBGP peer and requires multiple hops to reach the remote eBGP peer. You can configure the eBGP TTL value for a neighbor session to allow these multihop sessions.

To configure eBGP multihop, use the following command in neighbor configuration mode:

Command	Purpose
ebgp-multihop *ttl-value* **Example:** `switch(config-router-neighbor)# ebgp-multihop 5`	Configures the eBGP TTL value for eBGP multihop. The range is from 2 to 255. You must manually reset the BGP sessions after using this command.

Disabling a Fast External Fallover

By default, the Cisco NX-OS device supports fast external fallover for neighbors in all VRFs and address-families (IPv4 or IPv6). Typically, when a BGP router loses connectivity to a directly connected eBGP peer, BGP triggers a fast external fallover by resetting the eBGP session to the peer. You can disable this fast external fallover to limit the instability caused by link flaps.

To disable fast external fallover, use the following command in router configuration mode:

Command	Purpose
no fast-external-fallover **Example:** `switch(config-router)# no fast-external-fallover`	Disables a fast external fallover for eBGP peers. This command is enabled by default.

Limiting the AS-path Attribute

You can configure eBGP to discard routes that have excessive AS numbers in the AS-path attribute.

To discard routes that have excessive AS numbers in the AS-path attribute, use the following command in router configuration mode:

Command	Purpose
maxas-limit *number* **Example:** `switch(config-router)# maxas-limit 50`	Discards eBGP routes that have a number of AS-path segments that exceed the specified limit. The range is from 1 to 2000.

Configuring Local AS Support

The local AS feature allows a router to appear to be a member of a second autonomous system (AS), in addition to its real AS. Local AS allows two ISPs to merge without modifying peering arrangements. Routers in the merged ISP become members of the new autonomous system but continue to use their old AS numbers for their customers.

This feature can only be used for true eBGP peers. You cannot use this feature for two peers that are members of different confederation subautonomous systems.

To configure eBGP local AS support, use the following command in neighbor configuration mode:

Command	Purpose
local-as *number* [**no-prepend** [**replace-as** [**dual-as**]]] **Example**: `switch(config-router-neighbor)# local-as 1.1`	Configures eBGP to prepend the local AS *number* to the AS_PATH attribute.The AS *number* can be a 16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.

This example shows how to configure local AS support on a VRF:

```
switch# configure terminal
switch(config)# router bgp 1
switch(config-router)# vrf test
switch(config-router-vrf)# local-as 1
switch(config-router-vrf)# show running-config bgp
```

Configuring AS Confederations

To configure an AS confederation, you must specify a confederation identifier. To the outside world, the group of autonomous systems within the AS confederation look like a single autonomous system with the confederation identifier as the autonomous system number.

To configure a BGP confederation identifier, use the following command in router configuration mode:

Command	Purpose
confederation identifier *as-number* **Example**: `switch(config-router)# confederation identifier 4000`	Configures a confederation identifier for an AS confederation. This command triggers an automatic notification and session reset for the BGP neighbor sessions.

To configure the autonomous systems that belong to the AS confederation, use the following command in router configuration mode:

Command	Purpose
bgp confederation peers *as-number* [*as-number2...*] **Example**: `switch(config-router)# bgp confederation peers 5 33 44`	Specifies a list of autonomous systems that belong to the confederation. This command triggers an automatic notification and session reset for the BGP neighbor sessions.

Configuring Route Reflector

You can configure iBGP peers as route reflector clients to the local BGP speaker, which acts as the route reflector. Together, a route reflector and its clients form a cluster. A cluster of clients usually has a single route reflector. In such instances, the cluster is identified by the router ID of the route reflector. To increase redundancy and avoid a single point of failure in the network, you can configure a cluster with more than one route reflector. You must configure all route reflectors in the cluster with the same 4-byte cluster ID so that a route reflector can recognize updates from route reflectors in the same cluster.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *as-number*
3. **cluster-id** *cluster-id*
4. **address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**}
5. (Optional) **client-to-client reflection**
6. **exit**
7. **neighbor** *ip-address* **remote-as** *as-number*
8. **address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**}
9. **route-reflector-client**
10. (Optional) **show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **neighbors**
11. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router bgp** *as-number* **Example:** `switch(config)# router bgp 65535` `switch(config-router)#`	Enters BGP mode and assigns the autonomous system number to the local BGP speaker.
Step 3	**cluster-id** *cluster-id* **Example:** `switch(config-router)# cluster-id 192.0.2.1`	Configures the local router as one of the route reflectors that serve the cluster. You specify a cluster ID to identify the cluster. This command triggers an automatic soft clear or refresh of BGP neighbor sessions.

	Command	Purpose
Step 4	**address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **Example**: switch(config-router)# address-family ipv4 unicast switch(config-router-af)#	Enters router address-family configuration mode for the specified address family.
Step 5	**client-to-client reflection** **Example**: switch(config-router-af)# client-to-client reflection	(Optional) Configures client-to-client route reflection. This feature is enabled by default. This command triggers an automatic soft clear or refresh of BGP neighbor sessions.
Step 6	**exit** **Example**: switch(config-router-neighbor)# exit switch(config-router)#	Exits router address configuration mode.
Step 7	**neighbor** *ip-address* **remote-as** *as-number* **Example:** switch(config-router)# neighbor 192.0.2.10 remote-as 65535 switch(config-router-neighbor)#	Configures the IP address and AS number for a remote BGP peer.
Step 8	**address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **Example:** switch(config-router-neighbor)# address-family ipv4 unicast switch(config-router-neighbor-af)#	Enters neighbor address-family configuration mode for the specified address family.
Step 9	**route-reflector-client** **Example**: switch(config-router-neighbor-af)# route-reflector-client	Configures the device as a BGP route reflector and configures the neighbor as its client. This command triggers an automatic notification and session reset for the BGP neighbor sessions.
Step 10	**show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **neighbors** **Example:** switch(config-router-neighbor-af)# show bgp ipv4 unicast neighbors	(Optional) Displays the BGP peers.
Step 11	**copy running-config startup-config** **Example:** switch(config-router-neighbor-af)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to configure the router as a route reflector and add one neighbor as a client:

```
switch# configure terminal
switch(config)# router bgp 65535
switch(config-router)# neighbor 192.0.2.10 remote-as 65535
switch(config-router-neighbor)# address-family ip unicast
switch(config-router-neighbor-af)# route-reflector-client
switch(config-router-neighbor-af)# copy running-config startup-config
```

Configuring Next Hops on Reflected Routes Using an Outbound Route Map

You can change the next hop on reflected routes on a BGP route reflector using an outbound route map. You can configure the outbound route map to specify the peer's local address as the next-hop address.

Note The **next-hop-self** command does not enable this functionality for routes being reflected to clients by a route reflector. This functionality can only be enabled using an outbound route map.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

You must enter the **set next-hop** command to configure an address family specific next-hop address. For example, for the IPv6 address family, you must enter the **set ipv6 next-hop peer-address** command.

- When setting IPv4 next hops using route maps—If **set ip next-hop peer-address** matches the route map, the next hop is set to the peer's local address. If no next hop is set in the route map, the next hop is set to the one stored in the path.
- When setting IPv6 next hops using route maps—If **set ipv6 next-hop peer-address** matches the route map, the next hop is set as follows:
  - For IPv6 peers, the next hop is set to the peer's local IPv6 address.
  - For IPv4 peers, if **update-source** is configured, the next hop is set to the source interface's IPv6 address, if any. If no IPv6 address is configured, no next hop is set.
  - For IPv4 peers, if **update-source** is not configured, the next hop is set to the outgoing interface's IPv6 address, if any. If no IPv6 address is configured, no next hop is set.

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *as-number*
3. **neighbor** *ip-address* **remote-as** *as-number*
4. (Optional) **update-source** *interface number*
5. **address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**}
6. **route-reflector-client**
7. **route-map** *map-name* **out**
8. (Optional) **show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **neighbors**
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example**: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router bgp** *as-number* **Example**: switch(config)# router bgp 200 switch(config-router)#	Enters BGP mode and assigns the autonomous system number to the local BGP speaker.
Step 3	**neighbor** *ip-address* **remote-as** *as-number* **Example:** switch(config-router)# neighbor 192.0.2.12 remote-as 200 switch(config-router-neighbor)#	Configures the IP address and AS number for a remote BGP peer.
Step 4	**update-source** *interface number* **Example:** switch(config-router-neighbor)# update-source loopback 300	(Optional) Specifies and updates the source of the BGP session.
Step 5	**address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **Example:** switch(config-router-neighbor)# address-family ipv4 unicast switch(config-router-neighbor-af)#	Enters router address-family configuration mode for the specified address family.
Step 6	**route-reflector-client** **Example**: switch(config-router-neighbor-af)# route-reflector-client	Configures the device as a BGP route reflector and configures the neighbor as its client. This command triggers an automatic notification and session reset for the BGP neighbor sessions.
Step 7	**route-map** *map-name* **out** **Example**: switch(config-router-neighbor-af)# route-map setrrnh out	Applies the configured BGP policy to outgoing routes.
Step 8	**show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} [**ip-address** | **ipv6-prefix**] **route-map** *map-name* [**vrf** *vrf-name*] **Example:** switch(config-router-neighbor-af)# show bgp ipv4 unicast route-map setrrnh	(Optional) Displays the BGP routes that match the route map.
Step 9	**copy running-config startup-config** **Example:** switch(config-router-neighbor-af)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to configure the next hop on reflected routes on a BGP route reflector using an outbound route map:

```
switch# configure terminal
switch(config)# interface loopback 300
switch(config-if)# ip address 192.0.2.11/32
switch(config-if)# ipv6 address 2001::a0c:1a65/64
switch(config-if)# ip router ospf 1 area 0.0.0.0
switch(config-if)# exit
switch(config)# route-map setrrnh permit 10
switch(config-route-map)# set ip next-hop peer-address
switch(config-route-map)# exit
switch(config)# route-map setrrnhv6 permit 10
switch(config-route-map)# set ipv6 next-hop peer-address
switch(config-route-map)# exit
switch(config)# router bgp 200
switch(config-router)# neighbor 192.0.2.12 remote-as 200
switch(config-router-neighbor)# update-source loopback 300
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)# route-reflector-client
switch(config-router-neighbor-af)# route-map setrrnh out
switch(config-router-neighbor-af)# exit
switch(config-router-neighbor)# address-family ipv6 unicast
switch(config-router-neighbor-af)# route-reflector-client
switch(config-router-neighbor-af)# route-map setrrnhv6 out
```

Configuring Route Dampening

You can configure route dampening to minimize route flaps propagating through your iBGP network.

To configure route dampening, use the following command in address-family or VRF address-family configuration mode:

Command	Purpose
dampening [{*half-life reuse-limit suppress-limit max-suppress-time* | **route-map** *map-name*}] **Example:** `switch(config-router-af)# dampening route-map bgpDamp`	Disables capabilities negotiation. The parameter values are as follows: • half-life—The range is from 1 to 45. • reuse-limit—The range is from 1 to 20000. • suppress-limit—The range is from 1 to 20000. • max-suppress-time—The range is from 1 to 255.

Configuring Load Sharing and ECMP

You can configure the maximum number of paths that BGP adds to the route table for equal-cost multipath load balancing.

To configure the maximum number of paths, use the following command in router address-family configuration mode:

Command	Purpose
maximum-paths [**ibgp**] *maxpaths* **Example**: `switch(config-router-af)# maximum-paths 8`	Configures the maximum number of equal-cost paths for load sharing. The default is 1.

Configuring Maximum Prefixes

You can configure the maximum number of prefixes that BGP can receive from a BGP peer. If the number of prefixes exceeds this value, you can optionally configure BGP to generate a warning message or tear down the BGP session to the peer.

To configure the maximum allowed prefixes for a BGP peer, use the following command in neighbor address-family configuration mode:

Command	Purpose
maximum-prefix *maximum* [*threshold*] [**restart** *time* | **warning-only**] **Example**: `switch(config-router-neighbor-af)# maximum-prefix 12`	Configures the maximum number of prefixes from a peer. The parameter ranges are as follows: • *maximum*—The range is from 1 to 300000. • *Threshold*—The range is from 1 to 100 percent. The default is 75 percent. • *time*—The range is from 1 to 65535 minutes. This command triggers an automatic notification and session reset for the BGP neighbor sessions if the prefix limit is exceeded.

Configuring Dynamic Capability

You can configure dynamic capability for a BGP peer.

To configure dynamic capability, use the following command in neighbor configuration mode:

Command	Purpose
dynamic-capability **Example**: `switch(config-router-neighbor)# dynamic-capability`	Enables dynamic capability. This command triggers an automatic notification and session reset for the BGP neighbor sessions.

Configuring Aggregate Addresses

You can configure aggregate address entries in the BGP route table.

To configure an aggregate address, use the following command in router address-family configuration mode:

Command	Purpose
aggregate-address *ip-prefix/length* [**as-set**] [**summary-only**] [**advertise-map** *map-name*] [**attribute-map** *map-name*] [**suppress-map** *map-name*] **Example:** `switch(config-router-af)# aggregate-address 192.0.2.0/8 as-set`	Creates an aggregate address. The path advertised for this route is an autonomous system set that consists of all elements contained in all paths that are being summarized: • The **as-set** keyword generates autonomous system set path information and community information from contributing paths. • The **summary-only** keyword filters all more-specific routes from updates. • The **advertise-map** keyword and argument specify the route map used to select attribute information from selected routes. • The **attribute-map** keyword and argument specify the route map used to select attribute information from the aggregate. • The **suppress-map** keyword and argument conditionally filter more specific routes.

Suppressing BGP Routes

You can configure Cisco NX-OS to advertise newly learned BGP routes only after these routes are confirmed by the Forwarding Information Base (FIB) and programmed in the hardware. After the routes are programmed, subsequent changes to these routes do not require this hardware-programming check.

To suppress BGP routes, use the following command in router configuration mode:

Command	Purpose
suppress-fib-pending **Example:** `switch(config-router)# suppress-fib-pending`	Suppresses newly learned BGP routes (IPv4 or IPv6) from being advertised to downstream BGP neighbors until the routes have been programmed in the hardware.

Configuring BGP Conditional Advertisement

You can configure BGP conditional advertisement to limit the routes that BGP propagates. You define the following two route maps:

- Advertise map—Specifies the conditions that the route must match before BGP considers the conditional advertisement. This route map can contain any appropriate match statements.

- Exist map or nonexist map—Defines the prefix that must exist in the BGP table before BGP propagates a route that matches the advertise map. The nonexist map defines the prefix that must not exist in the BGP table before BGP propagates a route that matches the advertise map. BGP processes only the permit statements in the prefix list match statements in these route maps.

If the route does not pass the condition, BGP withdraws the route if it exists in the BGP table.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *as-number*
3. **neighbor** *ip-address* **remote-as** *as-number*
4. **address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**}
5. **advertise-map** *adv-map* {**exist-map** *exist-rmap* | **non-exist-map** *nonexist-rmap*}
6. (Optional) **show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **neighbors**
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router bgp** *as-number* **Example:** `switch(config)# router bgp 65535` `switch(config-router)#`	Enters BGP mode and assigns the autonomous system number to the local BGP speaker.
Step 3	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `switch(config-router)# neighbor 192.168.1.2 remote-as 65534` `switch(config-router-neighbor)#`	Places the router in neighbor configuration mode for BGP routing and configures the neighbor IP address.
Step 4	**address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **Example:** `switch(config-router-neighbor)# address-family ipv4 multicast` `switch(config-router-neighbor-af)#`	Enters address-family configuration mode.

	Command	Purpose
Step 5	**advertise-map** *adv-map* {**exist-map** *exist-rmap* | **non-exist-map** *nonexist-rmap*} **Example**: switch(config-router-neighbor-af)# advertise-map advertise exist-map exist	Configures BGP to conditionally advertise routes based on the two configured route maps: • *adv-map*—Specifies a route map with **match** statements that the route must pass before BGP passes the route to the next route map. The *adv-map* is a case-sensitive, alphanumeric string up to 63 characters. • *exist-rmap*—Specifies a route map with match statements for a prefix list. A prefix in the BGP table must match a prefix in the prefix list before BGP advertises the route. The *exist-rmap* is a case-sensitive, alphanumeric string up to 63 characters. • *nonexist-rmap*—Specifies a route map with match statements for a prefix list. A prefix in the BGP table must not match a prefix in the prefix list before BGP advertises the route. The *nonexist-rmap* is a case-sensitive, alphanumeric string up to 63 characters.
Step 6	**show bgp** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **neighbors** **Example:** switch(config-router-neighbor-af)# show bgp ipv4 unicast neighbors	(Optional) Displays information about BGP and the configured conditional advertisement route maps.
Step 7	**copy running-config startup-config** **Example:** switch(config-router-neighbor-af)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to configure BGP conditional advertisement:

```
switch# configure terminal
switch(config)# router bgp 65535
switch(config-router)# neighbor 192.0.2.2 remote-as 65534
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)# advertise-map advertise exist-map exist
switch(config-router-neighbor-af)# exit
switch(config-router-neighbor)# exit
switch(config-router)# exit
switch(config)# route-map advertise
switch(config-route-map)# match as-path pathList
switch(config-route-map)# exit
switch(config)# route-map exit
switch(config-route-map)# match ip address prefix-list plist
switch(config-route-map)# exit
switch(config)# ip prefix-list plist permit 172.16.201.0/27
```

Configuring Route Redistribution

You can configure BGP to accept routing information from another routing protocol and redistribute that information through the BGP network. Optionally, you can assign a default route for redistributed routes.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *as-number*
3. **address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**}
4. **redistribute** {**direct** | {**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **static**} **route-map** *map-name*
5. (Optional) **default-metric** *value*
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router bgp** *as-number* Example: switch(config)# router bgp 65535 switch(config-router)#	Enters BGP mode and assigns the autonomous system number to the local BGP speaker.
Step 3	**address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **Example**: switch(config-router)# address-family ipv4 unicast switch(config-router-af)#	Enters address-family configuration mode.
Step 4	**redistribute** {**direct** | {**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **static**} **route-map** *map-name* **Example**: switch(config-router-af)# redistribute eigrp 201 route-map Eigrpmap	Redistributes routes from other protocols into BGP. See the "Configuring Route Maps" section on page 15-12 for more information about route maps.

	Command	Purpose
Step 5	**default-metric** *value* **Example:** switch(config-router-af)# default-metric 33	(Optional) Generates a default route into BGP.
Step 6	**copy running-config startup-config** **Example:** switch(config-router-af)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to redistribute EIGRP into BGP:

```
switch# configure terminal
switch(config)# router bgp 65535
switch(config-router)# address-family ipv4 unicast
switch(config-router-af)# redistribute eigrp 201 route-map Eigrpmap
switch(config-router-af)# copy running-config startup-config
```

Advertising the Default Route

You can configure BGP to advertise the default route (network 0.0.0.0).

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

SUMMARY STEPS

1. **configure terminal**
2. **route-map allow permit**
3. **exit**
4. **ip route** *ip-address network-mask* **null** *null-interface-number*
5. **router bgp** *as-number*
6. **address-family** {**ipv4** | **ipv6**} **unicast**
7. **default-information originate**
8. **redistribute static route-map allow**
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**route-map allow permit** Example: switch(config)# route-map allow permit switch(config-route-map)#	Enters router map configuration mode and defines the conditions for redistributing routes.
Step 3	**exit** Example: switch(config-route-map)# exit switch(config)#	Exits router map configuration mode.
Step 4	**ip route** *ip-address network-mask* **null** *null-interface-number* **Example**: switch(config)# ip route 192.0.2.1 255.255.255.0 null 0	Configures the IP address.
Step 5	**router bgp** *as-number* **Example**: switch(config)# router bgp 65535 switch(config-router)#	Enters BGP mode and assigns the AS number to the local BGP speaker.
Step 6	**address-family** {**ipv4** | **ipv6**} **unicast** **Example**: switch(config-router)# address-family ipv4 unicast switch(config-router-af)#	Enters address family configuration mode.
Step 7	**default-information originate** **Example**: switch(config-router-af)# default-information originate	Advertises the default route.
Step 8	**redistribute static route-map allow** **Example**: switch(config-router-af)# redistribute static route-map allow	Redistributes the default route.
Step 9	**copy running-config startup-config** **Example:** switch(config-router-af)# copy running-config startup-config	(Optional) Saves this configuration change.

Configuring Multiprotocol BGP

You can configure MP-BGP to support multiple address families, including IPv4 and IPv6 unicast and multicast routes.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *as-number*
3. **neighbor** *ip-address* **remote-as** *as-numbe*r
4. **address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**}
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router bgp** *as-number* **Example:** `switch(config)# router bgp 65535` `switch(config-router)#`	Enters BGP mode and assigns the autonomous system number to the local BGP speaker.
Step 3	**neighbor** *ip-address* **remote-as** *as-number* **Example:** `switch(config-router)# neighbor 192.168.1.2 remote-as 65534` `switch(config-router-neighbor)#`	Places the router in neighbor configuration mode for BGP routing and configures the neighbor IP address.
Step 4	**address-family** {**ipv4** | **ipv6**} {**unicast** | **multicast**} **Example:** `switch(config-router-neighbor)# address-family ipv4 multicast` `switch(config-router-neighbor-af)#`	Enters address family configuration mode.
Step 5	**copy running-config startup-config** **Example:** `switch(config-router-neighbor-af)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to enable advertising and receiving IPv4 and IPv6 routes for multicast RPF for a neighbor:

```
switch# configure terminal
switch(config)# interface ethernet 2/1
switch(config-if)# ipv6 address 2001:0DB8::1
switch(config-if)# router bgp 65535
switch(config-router)# neighbor 192.168.1.2 remote-as 35537
switch(config-router-neighbor)# address-family ipv4 multicast
switch(config-router-neighbor-af)# exit
switch(config-router-neighbor)# address-family ipv6 multicast
switch(config-router-neighbor-af)# copy running-config startup-config
```

Tuning BGP

You can tune BGP characteristics through a series of optional parameters.

To tune BGP, use the following optional commands in router configuration mode:

Command	Purpose
bestpath [**always-compare-med** | **as-path multipath-relax** | **compare-routerid** | **cost-community ignore** | **med** {**confed** | **missing-as-worst** | **non-deterministic**}] **Example**: switch(config-router)# bestpath always-compare-med	Modifies the best-path algorithm. The optional parameters are as follows: • **always-compare-med**—Compares MED on paths from different autonomous systems. • **as-path multipath-relax**—Allows load sharing across the providers with different (but equal-length) AS paths. Without this option, the AS paths must be identical for load sharing. • **compare-routerid**—Compares the router IDs for identical eBGP paths. • **cost-community ignore**—Ignores the cost community for BGP best-path calculations. • **med confed**—Forces bestpath to do a MED comparison only between paths originated within a confederation. • **med missing-as-worst**—Treats a missing MED as the highest MED. • **med non-deterministic**—Does not always pick the best MED path from among the paths from the same autonomous system.
enforce-first-as **Example:** switch(config-router)# enforce-first-as	Enforces the neighbor autonomous system to be the first AS number listed in the AS_path attribute for eBGP.

Command	Purpose
log-neighbor-changes **Example:** `switch(config-router)# log-neighbor-changes`	Generates a system message when any neighbor changes state. **Note** To suppress neighbor status change messages for a specific neighbor, you can use the **log-neighbor-changes disable** command in router address-family configuration mode.
router-id *id* **Example:** `switch(config-router)# router-id 10.165.20.1`	Manually configures the router ID for this BGP speaker.
timers [**bestpath-delay** *delay* | **bgp** *keepalive holdtime* | **prefix-peer-timeout** *timeout*] **Example:** `switch(config-router)# timers bgp 90 270`	Sets the BGP timer values. The optional parameters are as follows: • *delay*—Initial best-path timeout value after a restart. The range is from 0 to 3600 seconds. The default value is 300. • *keepalive*—BGP session keepalive time. The range is from 0 to 3600 seconds. The default value is 60. • *holdtime*—BGP session hold time.The range is from 0 to 3600 seconds. The default value is 180. • *timeout*—Prefix peer timeout value. The range is from 0 to 1200 seconds. The default value is 30. You must manually reset the BGP sessions after configuring this command.

To tune BGP, use the following optional commands in router address-family configuration mode:

Command	Purpose
distance *ebgp-distance ibgp-distance local-distance* **Example:** `switch(config-router-af)# distance 20 100 200`	Sets the administrative distance for BGP. The range is from 1 to 255. The defaults are as follows: • *ebgp-distance*—20. • *ibgp-distance*—200. • *local-distance*—220. Local-distance is the administrative distance used for aggregate discard routes when they are installed in the RIB.
log-neighbor-changes [**disable**] **Example:** `switch(config-router-af)# log-neighbor-changes disable`	Generates a system message when this specific neighbor changes state. The **disable** option suppresses neighbor status change messages for this specific neighbor.

To tune BGP, use the following optional commands in neighbor configuration mode:

Command	Purpose
description *string* **Example**: switch(config-router-neighbor)# description main site	Sets a descriptive string for this BGP peer. The string can be up to 80 alphanumeric characters.
low-memory exempt **Example**: switch(config-router-neighbor)# low-memory exempt	Exempts this BGP neighbor from a possible shutdown due to a low memory condition.
transport connection-mode passive **Example:** switch(config-router-neighbor)# transport connection-mode passive	Allows a passive connection setup only. This BGP speaker does not initiate a TCP connection to a BGP peer. You must manually reset the BGP sessions after configuring this command.
[**no** | **default**] **remove-private-as** [**all** | **replace-as**] **Example**: switch(config-router-neighbor)# remove-private-as	Removes private AS numbers from outbound route updates to an eBGP peer. This command triggers an automatic soft clear or refresh of BGP neighbor sessions. The optional parameters are as follows: • **no**—Disables the command. • **default**—Moves the command to its default mode. • **all**—Removes all private-as numbers from the AS-path. • **replace-as**—Replaces all private AS numbers with the replace-as AS-path value. **Note** See the "Guidelines and Limitations for Advanced BGP" section for additional information on this command.
update-source *interface-type number* **Example**: switch(config-router-neighbor)# update-source ethernet 2/1	Configures the BGP speaker to use the source IP address of the configured interface for BGP sessions to the peer. This command triggers an automatic notification and session reset for the BGP neighbor sessions. Single-hop iBGP peers support fast external fallover when **update-source** is configured.

To tune BGP, use the following optional commands in neighbor address-family configuration mode:

Command	Purpose
allowas in **Example:** `switch(config-router-neighbor-af)# allowas in`	Allows routes that have their own AS in the AS path to be installed in the BRIB.
default-originate [**route-map** *map-name*] **Example:** `switch(config-router-neighbor-af)# default-originate`	Generates a default route to the BGP peer.
disable-peer-as-check **Example:** `switch(config-router-neighbor-af)# disable-peer-as-check`	Disables peer AS-number checking while the device advertises routes learned from one node to another node in the same AS path.
filter-list *list-name* {**in** | **out**} **Example:** `switch(config-router-neighbor-af)# filter-list BGPFilter in`	Applies an AS_path filter list to this BGP peer for inbound or outbound route updates. This command triggers an automatic soft clear or refresh of BGP neighbor sessions.
prefix-list *list-name* {**in** | **out**} **Example:** `switch(config-router-neighbor-af)# prefix-list PrefixFilter in`	Applies a prefix list to this BGP peer for inbound or outbound route updates. This command triggers an automatic soft clear or refresh of BGP neighbor sessions.
send-community **Example:** `switch(config-router-neighbor-af)# send-community`	Sends the community attribute to this BGP peer. This command triggers an automatic soft clear or refresh of BGP neighbor sessions.
send-community extended **Example:** `switch(config-router-neighbor-af)# send-community extended`	Sends the extended community attribute to this BGP peer. This command triggers an automatic soft clear or refresh of BGP neighbor sessions.
suppress-inactive **Example:** `switch(config-router-neighbor-af)# suppress-inactive`	Advertises the best (active) routes only to the BGP peer. This command triggers an automatic soft clear or refresh of BGP neighbor sessions.

Configuring a Graceful Restart

You can configure a graceful restart and enable the graceful restart helper feature for BGP.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

Create the VRFs.

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *as-number*
3. **graceful-restart**
4. **graceful-restart** [**restart-time** *time* | **stalepath-time** *time*]
5. **graceful-restart-helper**
6. (Optional) **show running-config bgp**
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router bgp** *as-number* **Example:** `switch(config)# router bgp 65535` `switch(config-router)#`	Creates a new BGP process with the configured autonomous system number.
Step 3	**graceful-restart** **Example:** `switch(config-router)# graceful-restart`	Enables a graceful restart and the graceful restart helper functionality. This command is enabled by default. This command triggers an automatic notification and session reset for the BGP neighbor sessions.
Step 4	**graceful-restart** [**restart-time** *time* | **stalepath-time** *time*] **Example:** `switch(config-router)# graceful-restart restart-time 300`	Configures the graceful restart timers. The optional parameters are as follows: • **restart-time**—Maximum time for a restart sent to the BGP peer. The range is from 1 to 3600 seconds. The default is 120. • **stalepath-time**—Maximum time that BGP keeps the stale routes from the restarting BGP peer. The range is from 1 to 3600 seconds. The default is 300. This command triggers an automatic notification and session reset for the BGP neighbor sessions.
Step 5	**graceful-restart-helper** **Example:** `switch(config-router)# graceful-restart-helper`	Enables the graceful restart helper functionality. Use this command if you have disabled graceful restart but you still want to enable graceful restart helper functionality. This command triggers an automatic notification and session reset for the BGP neighbor sessions.

	Command	Purpose
Step 6	**show running-config bgp** **Example:** switch(config-router)# show running-config bgp	(Optional) Displays the BGP configuration.
Step 7	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to enable a graceful restart:

```
switch# configure terminal
switch(config)# router bgp 65535
switch(config-router)# graceful-restart
switch(config-router)# copy running-config startup-config
```

Configuring Virtualization

You can configure one BGP process, create multiple VRFs, and use the same BGP process in each VRF.

BEFORE YOU BEGIN

You must enable BGP (see the "Enabling BGP" section on page 9-11).

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf-name*
3. **exit**
4. **router bgp** *as-number*
5. **vrf** *vrf-name*
6. **neighbor** *ip-address* **remote-as** *as-number*
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** switch(config)# vrf context RemoteOfficeVRF switch(config-vrf)#	Creates a new VRF and enters VRF configuration mode.
Step 3	**exit** **Example:** switch(config-vrf)# exit switch(config)#	Exits VRF configuration mode.
Step 4	**router bgp** *as-number* **Example:** switch(config)# router bgp 65535 switch(config-router)#	Creates a new BGP process with the configured autonomous system number.
Step 5	**vrf** *vrf-name* **Example:** switch(config-router)# vrf RemoteOfficeVRF switch(config-router-vrf)#	Enters the router VRF configuration mode and associates this BGP instance with a VRF.
Step 6	**neighbor** *ip-address* **remote-as** *as-number* **Example:** switch(config-router-vrf)# neighbor 209.165.201.1 remote-as 65535 switch(config-router--vrf-neighbor)#	Configures the IP address and AS number for a remote BGP peer.
Step 7	**copy running-config startup-config** **Example:** switch(config-router-vrf-neighbor)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create a VRF and configure the router ID in the VRF:

```
switch# configure terminal
switch(config)# vrf context NewVRF
switch(config-vrf)# exit
switch(config)# router bgp 65535
switch(config-router)# vrf NewVRF
switch(config-router-vrf)# neighbor 209.165.201.1 remote-as 65535
switch(config-router-vrf-neighbor)# copy running-config startup-config
```

Verifying the Advanced BGP Configuration

To display the BGP configuration, perform one of the following tasks:

Command	Purpose
show bgp all [**summary**] [**vrf** *vrf-name*]	Displays the BGP information for all address families.
show bgp convergence [**vrf** *vrf-name*]	Displays the BGP information for all address families.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **community** {**regexp** *expression* | [**community**] [**no-advertise**] [**no-export**] [**no-export-subconfed**]} [**vrf** *vrf-name*]	Displays the BGP routes that match a BGP community.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **community-list** *list-name* [**vrf** *vrf-name*]	Displays the BGP routes that match a BGP community list.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **extcommunity** {**regexp** *expression* | **generic** [**non-transitive** | **transitive**] *aa4:nn* [**exact-match**]} [**vrf** *vrf-name*]	Displays the BGP routes that match a BGP extended community.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **extcommunity-list** *list-name* [**exact-match**]} [**vrf** *vrf-name*]	Displays the BGP routes that match a BGP extended community list.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] {**dampening dampened-paths** [**regexp** *expression*]} [**vrf** *vrf-name*]	Displays the information for BGP route dampening. Use the **clear bgp dampening** command to clear the route flap dampening information.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **history-paths** [**regexp** *expression*] [**vrf** *vrf-name*]	Displays the BGP route history paths.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **filter-list** *list-name* [**vrf** *vrf-name*]	Displays the information for the BGP filter list.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **neighbors** [*ip-address* | *ipv6-prefix*] [**vrf** *vrf-name*]	Displays the information for BGP peers. Use the **clear bgp neighbors** command to clear these neighbors.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] {**nexthop** | **nexthop-database**} [**vrf** *vrf-name*]	Displays the information for the BGP route next hop.
show bgp paths	Displays the BGP path information.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **policy** *name* [**vrf** *vrf-name*]	Displays the BGP policy information. Use the **clear bgp policy** command to clear the policy information.

Command	Purpose
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **prefix-list** *list-name* [**vrf** *vrf-name*]	Displays the BGP routes that match the prefix list.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **received-paths** [**vrf** *vrf-name*]	Displays the BGP paths stored for soft reconfiguration.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **regexp** *expression* [**vrf** *vrf-name*]	Displays the BGP routes that match the AS_path regular expression.
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **route-map** *map-name* [**vrf** *vrf-name*]	Displays the BGP routes that match the route map.
show bgp peer-policy *name* [**vrf** *vrf-name*]	Displays the information about BGP peer policies.
show bgp peer-session *name* [**vrf** *vrf-name*]	Displays the information about BGP peer sessions.
show bgp peer-template *name* [**vrf** *vrf-name*]	Displays the information about BGP peer templates. Use the **clear bgp peer-template** command to clear all neighbors in a peer template.
show bgp process	Displays the BGP process information.
show {**ipv4** | **ipv6**} **bgp** *options*	Displays the BGP status and configuration information.
show {**ipv4** | **ipv6**} **mbgp** *options*	Displays the BGP status and configuration information.
show running-configuration bgp	Displays the current running BGP configuration.

Monitoring BGP Statistics

To display BGP statistics, use the following commands:

Command	Purpose
show bgp {**ipv4** | **ipv6**} {**unicast** | **multicast**} [*ip-address* | *ipv6-prefix*] **flap-statistics** [**vrf** *vrf-name*]	Displays the BGP route flap statistics. Use the **clear bgp flap-statistics** command to clear these statistics.
show bgp {**ipv4** | **ipv6**} **unicast injected-routes**	Displays injected routes in the routing table.
show bgp sessions [**vrf** *vrf-name*]	Displays the BGP sessions for all peers. Use the **clear bgp sessions** command to clear these statistics.
show bgp sessions [**vrf** *vrf-name*]	Displays the BGP sessions for all peers. Use the **clear bgp sessions** command to clear these statistics.
show bgp statistics	Displays the BGP statistics.

Configuration Examples

This example shows how to configure MD5 authentication for prefix-based neighbors:

```
template peer BasePeer-V6
    description BasePeer-V6
    password 3 f4200cfc725bbd28
    transport connection-mode passive
    address-family ipv6 unicast
template peer BasePeer-V4
    bfd
    description BasePeer-V4
    password 3 f4200cfc725bbd28
    address-family ipv4 unicast
--
    neighbor fc00::10:3:11:0/127 remote-as 65006
      inherit peer BasePeer-V6
    neighbor 10.3.11.0/31 remote-as 65006
      inherit peer BasePeer-V4
```

This example shows how to enable neighbor status change messages globally and suppress them for a specific neighbor:

```
router bgp 65100
  log-neighbor-changes
    neighbor 209.165.201.1 remote-as 65535
      description test
      address-family ipv4 unicast
        soft-reconfiguration inbound
         disable log-neighbor-changes
```

Related Topics

The following topics can give more information on BGP:

- Chapter 9, “Configuring Basic BGP”
- Chapter 15, “Configuring Route Policy Manager”

Additional References

For additional information related to implementing BGP, see the following sections:

- MIBs, page 10-54

MIBs

MIBs	MIBs Link
MIBs related to BGP	To locate and download supported MIBs, go to the following URL: ftp://ftp.cisco.com/pub/mibs/supportlists/nexus9000/Nexus9000MIBSupportList.html

Configuring RIP

This chapter describes how to configure the Routing Information Protocol (RIP) on the Cisco NX-OS device.

This chapter includes the following sections:

About RIP

This section includes the following topics:

RIP Overview

RIP uses User Datagram Protocol (UDP) data packets to exchange routing information in small internetworks. RIPv2 supports IPv4 and IPv6. RIPv2 uses an optional authentication feature supported by the RIPv2 protocol (see the "RIPv2 Authentication" section on page 11-2).

RIP uses the following two message types:

- Request—Sent to the multicast address 224.0.0.9 to request route updates from other RIP-enabled routers.
- Response—Sent every 30 seconds by default (see the "Verifying the RIP Configuration" section on page 11-18). The router also sends response messages after it receives a Request message. The response message contains the entire RIP route table. RIP sends multiple response packets for a request if the RIP routing table cannot fit in one response packet.

RIP uses a hop count for the routing metric. The hop count is the number of routers that a packet can traverse before reaching its destination. A directly connected network has a metric of 1; an unreachable network has a metric of 16. This small range of metrics makes RIP an unsuitable routing protocol for large networks.

RIPv2 Authentication

You can configure authentication on RIP messages to prevent unauthorized or invalid routing updates in your network. Cisco NX-OS supports a simple password or an MD5 authentication digest.

You can configure the RIP authentication per interface by using keychain management for the authentication keys. Keychain management allows you to control changes to the authentication keys used by an MD5 authentication digest or simple text password authentication. See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide* for more details about creating keychains.

To use an MD5 authentication digest, you configure a password that is shared at the local router and all remote RIP neighbors. Cisco NX-OS creates an MD5 one-way message digest based on the message itself and the encrypted password and sends this digest with the RIP message (Request or Response). The receiving RIP neighbor validates the digest by using the same encrypted password. If the message has not changed, the calculation is identical and the RIP message is considered valid.

An MD5 authentication digest also includes a sequence number with each RIP message to ensure that no message is replayed in the network.

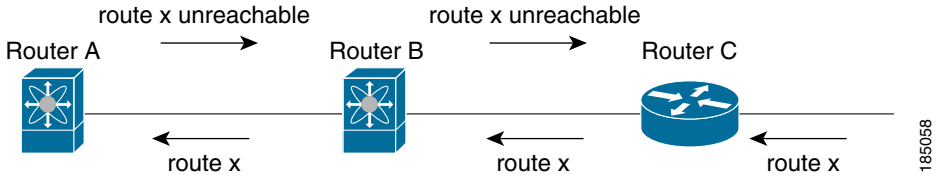
Split Horizon

You can use split horizon to ensure that RIP never advertises a route out of the interface where it was learned.

Split horizon is a method that controls the sending of RIP update and query packets. When you enable split horizon on an interface, Cisco NX-OS does not send update packets for destinations that were learned from this interface. Controlling update packets in this manner reduces the possibility of routing loops.

You can use split horizon with poison reverse to configure an interface to advertise routes learned by RIP as unreachable over the interface that learned the routes. Figure 11-1 shows a sample RIP network with split horizon and poison reverse enabled.

Figure 11-1 RIP with Split Horizon Poison Reverse



Router C learns about route X and advertises that route to Router B. Router B in turn advertises route X to Router A but sends a route X unreachable update back to Router C.

By default, split horizon is enabled on all interfaces.

Route Filtering

You can configure a route policy on a RIP-enabled interface to filter the RIP updates. Cisco NX-OS updates the route table with only those routes that the route policy allows.

Route Summarization

You can configure multiple summary aggregate addresses for a specified interface. Route summarization simplifies route tables by replacing a number of more-specific addresses with an address that represents all the specific addresses. For example, you can replace 10.1.1.0/24, 10.1.2.0/24, and 10.1.3.0/24 with one summary address, 10.1.0.0/16.

If more specific routes are in the routing table, RIP advertises the summary address from the interface with a metric equal to the maximum metric of the more specific routes.

Note Cisco NX-OS does not support automatic route summarization.

Route Redistribution

You can use RIP to redistribute static routes or routes from other protocols. You must configure a route map with the redistribution to control which routes are passed into RIP. A route policy allows you to filter routes based on attributes such as the destination, origination protocol, route type, route tag, and so on. For more information, see Chapter 15, “Configuring Route Policy Manager.”

Whenever you redistribute routes into a RIP routing domain, Cisco NX-OS does not, by default, redistribute the default route into the RIP routing domain. You can generate a default route into RIP, which can be controlled by a route policy.

You also configure the default metric that is used for all imported routes into RIP.

Load Balancing

You can use load balancing to allow a router to distribute traffic over all the router network ports that are the same distance from the destination address. Load balancing increases the usage of network segments and increases effective network bandwidth.

Cisco NX-OS supports the Equal Cost Multiple Path (ECMP) feature with up to 16 equal-cost paths in the RIP route table and the unicast RIB. You can configure RIP to load balance traffic across some or all of those paths.

High Availability

Cisco NX-OS supports stateless restarts for RIP. After a reboot or supervisor switchover, Cisco NX-OS applies the running configuration and RIP immediately sends request packets to repopulate its routing table.

Virtualization Support

Cisco NX-OS supports multiple instances of the RIP protocol that run on the same system. RIP supports virtual routing and forwarding (VRF) instances.

Licensing Requirements for RIP

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	RIP requires no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for RIP

RIP has the following prerequisites:

- You must enable RIP (see the "Enabling RIP" section on page 11-5).

Guidelines and Limitations

RIP has the following configuration guidelines and limitations:

- Cisco NX-OS does not support RIPv1. If Cisco NX-OS receives a RIPv1 packet, it logs a message and drops the packet.
- Cisco NX-OS does not establish adjacencies with RIPv1 routers.

Default Settings

Table 11-1 lists the default settings for RIP parameters.

Table 11-1 Default RIP Parameters

Parameters	Default
Maximum paths for load balancing	16
RIP feature	Disabled
Split horizon	Enabled

Configuring RIP

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Enabling RIP

You must enable RIP before you can configure RIP.

SUMMARY STEPS

1. **configure terminal**
2. **feature rip**
3. (Optional) **show feature**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**feature rip** **Example:** switch(config)# feature rip	Enables the RIP feature.
Step 3	**show feature** **Example:** switch(config)# show feature	(Optional) Displays enabled and disabled features.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

To disable the RIP feature and remove all associated configurations, use the following command in global configuration mode.

Command	Purpose
no feature rip **Example:** switch(config)# no feature rip	Disables the RIP feature and removes all associated configurations.

Creating a RIP Instance

You can create a RIP instance and configure the address family for that instance.

BEFORE YOU BEGIN

You must enable RIP (see the "Enabling RIP" section on page 11-5).

SUMMARY STEPS

1. **configure terminal**
2. **router rip** *instance-tag*
3. **address-family** {**ipv4** | **ipv6**} **unicast**
4. (Optional) **show ip rip** [**instance** *instance-tag*] [**vrf** *vrf-name*]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router rip** *instance-tag* **Example:** switch(config)# router RIP Enterprise switch(config-router)#	Creates a new RIP instance with the configured *instance-tag*.
Step 3	**address-family** {**ipv4** | **ipv6**} **unicast** **Example:** switch(config-router)# address-family ipv4 unicast switch(config-router-af)#	Configures the address family for this RIP instance and enters address-family configuration mode.
Step 4	**show ip rip** [**instance** *instance-tag*] [**vrf** *vrf-name*] **Example**: switch(config-router-af)# show ip rip	(Optional) Displays a summary of RIP information for all RIP instances.
Step 5	**copy running-config startup-config** **Example:** switch(config-router-af)# copy running-config startup-config	(Optional) Saves this configuration change.

To remove the RIP instance and the associated configurations, use the following command in global configuration mode.

Command	Purpose
no router rip *instance-tag* **Example:** switch(config)# no router rip Enterprise	Deletes the RIP instance and all associated configuration.

Note You must also remove any RIP commands configured in interface mode.

You can configure the following optional parameters for RIP in address-family configuration mode:

Command	Purpose
distance *value* **Example:** `switch(config-router-af)# distance 30`	Sets the administrative distance for RIP. The range is from 1 to 255. The default is 120. See the "Administrative Distance" section on page 1-7.
maximum-paths *number* **Example:** `switch(config-router-af)# maximum-paths 6`	Configures the maximum number of equal-cost paths that RIP maintains in the route table. The range is from 1 to 64. The default is 16.

This example shows how to create a RIP instance for IPv4 and set the number of equal-cost paths for load balancing:

```
switch# configure terminal
switch(config)# router rip Enterprise
switch(config-router)# address-family ipv4 unicast
switch(config-router-af)# max-paths 10
switch(config-router-af)# copy running-config startup-config
```

Restarting a RIP Instance

You can restart a RIP instance. This clears all neighbors for the instance.

To restart an RIP instance and remove all associated neighbors, use the following command:

Command	Purpose
restart rip instance-tag **Example:** `switch(config)# restart rip Enterprise`	Restarts the RIP instance and removes all neighbors.

Configuring RIP on an Interface

You can add an interface to a RIP instance.

BEFORE YOU BEGIN

You must enable RIP (see the "Enabling RIP" section on page 11-5).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **ip router rip** *instance-tag*
4. (Optional) **show ip rip** [**instance** *instance-tag*] **interface** [*interface-type slot/port*] [**vrf** *vrf-name*] [**detail**]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** switch(config)# interface ethernet 1/2 switch(config-if)#	Enters interface configuration mode.
Step 3	**ip router rip** *instance-tag* **Example**: switch(config-if)# ip router rip Enterprise	Associates this interface with a RIP instance.
Step 4	**show ip rip** [**instance** *instance-tag*] **interface** [*interface-type slot/port*] [**vrf** *vrf-name*] [**detail**] **Example**: switch(config-if)# show ip rip Enterprise tethernet 1/2	(Optional) Displays RIP information for an interface.
Step 5	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to add Ethernet 1/2 interface to a RIP instance:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# ip router rip Enterprise
switch(config)# copy running-config startup-config
```

Configuring RIP Authentication

You can configure authentication for RIP packets on an interface.

BEFORE YOU BEGIN

You must enable RIP (see the "Enabling RIP" section on page 11-5).

Configure a keychain if necessary before enabling authentication. See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide* for details on implementing keychains.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*

3. **ip rip authentication mode**{**text** | **md5**}
4. **ip rip authentication key-chain** *key*
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** switch(config)# interface ethernet 1/2 switch(config-if)#	Enters interface configuration mode.
Step 3	**ip rip authentication mode** {**text** | **md5**} **Example**: switch(config-if)# ip rip authentication mode md5	Sets the authentication type for RIP on this interface as cleartext or MD5 authentication digest.
Step 4	**ip rip authentication key-chain** *key* **Example**: switch(config-if)# ip rip authentication key-chain RIPKey	Configures the authentication key used for RIP on this interface.
Step 5	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create a keychain and configure MD5 authentication on a RIP interface:

```
switch# configure terminal
switch(config)# key chain RIPKey
switch(config-keychain)# key 2
switch(config-keychain-key)# accept-lifetime 00:00:00 Jan 01 2000 infinite
switch(config-keychain-key)# send-lifetime 00:00:00 Jan 01 2000 infinite
switch(config-keychain-key)# exit
switch(config-keychain)# exit
switch(config)# interface ethernet 1/2
switch(config-if)# ip rip authentication mode md5
switch(config-if)# ip rip authentication key-chain RIPKey
switch(config-if)# copy running-config startup-config
```

Configuring a Passive Interface

You can configure a RIP interface to receive routes but not send route updates by setting the interface to passive mode.

To configure a RIP interface in passive mode, use the following command in interface configuration mode:

Command	Purpose
ip rip passive-interface **Example**: `switch(config-if)# ip rip passive-interface`	Sets the interface into passive mode.

Configuring Split Horizon with Poison Reverse

You can configure an interface to advertise routes learned by RIP as unreachable over the interface that learned the routes by enabling poison reverse.

To configure split horizon with poison reverse on an interface, use the following command in interface configuration mode:

Command	Purpose
ip rip poison-reverse **Example**: `switch(config-if)# ip rip poison-reverse`	Enables split horizon with poison reverse. Split horizon with poison reverse is disabled by default.

Configuring Route Summarization

You can create aggregate addresses that are represented in the routing table by a summary address. Cisco NX-OS advertises the summary address metric that is the smallest metric of all the more-specific routes.

To configure a summary address on an interface, use the following command in interface configuration mode:

Command	Purpose
{**ip** | **ipv6**} **rip summary-address** *ip-prefix/mask-len* **Example**: `switch(config-if)# ip rip summary-address 1.1.1.1/32`	Configures a summary address for RIP for IPv4 or IPv6 addresses.

Configuring Route Redistribution

You can configure RIP to accept routing information from another routing protocol and redistribute that information through the RIP network. Redistributed routes can optionally be assigned a default route.

BEFORE YOU BEGIN

You must enable RIP (see the "Enabling RIP" section on page 11-5).

Configure a route map before configuring redistribution. See the"Configuring Route Maps" section on page 15-12 for details on configuring route maps.

SUMMARY STEPS

1. **configure terminal**
2. **router rip** *instance-tag*
3. **address-family** {**ipv4** | **ipv6**} **unicast**
4. **redistribute** {**bgp** *as* | **direct** | **eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **static**} **route-map** *map-name*
5. (Optional) **default-information originate** [**always**] [**route-map** *map-name*]
6. (Optional) **default-metric** *value*
7. (Optional) **show ip rip route** [{*ip-prefix* [*longer*-**prefixes** | **shorter-prefixes**]] [**vrf** *vrf-name*] [**summary**]
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router rip** *instance-tag* **Example:** `switch(config)# router rip Enterprise` `switch(config-router)#`	Creates a new RIP instance with the configured *instance-tag*.
Step 3	**address-family** {**ipv4** | **ipv6**} **unicast** **Example:** `switch(config-router)# address-family ipv4 unicast` `switch(config-router-af)#`	Enters address-family configuration mode.
Step 4	**redistribute** {**bgp** *as* | **direct** |{**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **static**} **route-map** *map-name* **Example:** `switch(config-router-af)# redistribute eigrp 201 route-map RIPmap`	Redistributes routes from other protocols into RIP. See the "Configuring Route Maps" section on page 15-12 for more information about route maps.
Step 5	**default-information originate** [**always**] [**route-map** *map-name*] **Example:** `switch(config-router-af)# default-information originate always`	(Optional) Generates a default route into RIP, optionally controlled by a route map.

	Command	Purpose
Step 6	**default-metric** *value* **Example:** switch(config-router-af)# default-metric 2	(Optional) Sets the default metric for all redistributed routes. The range is from 1 to 15. The default is 1.
Step 7	**show ip rip route** [*ip-prefix* [**longer-prefixes** | **shorter-prefixes**] [**vrf** *vrf-name] [summary*] **Example:** switch(config-router-af)# show ip rip route	(Optional) Shows the routes in RIP.
Step 8	**copy running-config startup-config** **Example:** switch(config-router-af)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to redistribute EIGRP into RIP:

```
switch# configure terminal
switch(config)# router rip Enterprise
switch(config-router)# address-family ipv4 unicast
switch(config-router-af)# redistribute eigrp 201 route-map RIPmap
switch(config-router-af)# copy running-config startup-config
```

Configuring Cisco NX-OS RIP for Compatibility with Cisco IOS RIP

You can configure Cisco NX-OS RIP to behave like Cisco IOS RIP in the way that routes are advertised and processed.

Directly connected routes are treated with cost 1 in Cisco NX-OS RIP and with cost 0 in Cisco IOS RIP. When routes are advertised in Cisco NX-OS RIP, the receiving device adds a minimum cost of +1 to all received routes and installs the routes in its routing table. In Cisco IOS RIP, this cost increment is done on the sending router, and the receiving router installs the routes without any modification. This difference in behavior can cause issues when both Cisco NX-OS and Cisco IOS devices are working together. You can prevent these compatibility issues by configuring Cisco NX-OS RIP to advertise and process routes like Cisco IOS RIP.

BEFORE YOU BEGIN

You must enable RIP (see the "Enabling RIP" section on page 11-5).

SUMMARY STEPS

1. **configure terminal**
2. **router rip** *instance-tag*
3. [**no**] **metric direct 0**
4. (Optional) **show running-config rip**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**router rip** *instance-tag* **Example:** switch(config)# router rip 100 switch(config-router)#	Creates a new RIP instance with the configured instance tag. You can enter 100, 201, or up to 20 alphanumeric chapters for the instance tag.
Step 3	[**no**] **metric direct 0** **Example:** switch(config-router)# metric direct 0	Configures all directly connected routes with cost 0 instead of the default of cost 1 in order to make Cisco NX-OS RIP compatible with Cisco IOS RIP in the way that routes are advertised and processed. **Note** This command must be configured on all Cisco NX-OS devices that are present in any RIP network that also contains Cisco IOS devices.
Step 4	**show running-config rip** **Example:** switch(config-router)# show running-config rip	(Optional) Displays the current running RIP configuration.
Step 5	**copy running-config startup-config** **Example:** switch(config-router)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to disable Cisco NX-OS RIP compatibility with Cisco IOS RIP by returning all direct routes from cost 0 to cost 1:

```
switch# configure terminal
switch(config)# router rip 100
switch(config-router)# no metric direct 0
switch(config-router)# show running-config rip
switch(config-router)# copy running-config startup-config
```

Configuring Virtualization

You can configure multiple RIP instances, create multiple VRFs, and use the same or multiple RIP instances in each VRF. You assign a RIP interface to a VRF.

Note Configure all other parameters for an interface after you configure the VRF for an interface. Configuring a VRF for an interface deletes all the configurations for that interface.

BEFORE YOU BEGIN

You must enable RIP (see the "Enabling RIP" section on page 11-5).

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf-name*
3. **exit**
4. **router rip** *instance-tag*
5. **vrf** *vrf-name*
6. (Optional) **address-family** {**ipv4** | **ipv6**} **unicast**
7. (Optional) **redistribute** {**bgp** *as* | **direct** | {**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **static**} **route-map** *map-name*
8. **interface ethernet** *slot/port*
9. **vrf member** *vrf-name*
10. **ip-address** *ip-prefix/length*
11. **ip router rip** *instance-tag*
12. (Optional) **show ip rip** [**instance** *instance-tag*] **interface** [*interface-type slot/port*] [**vrf** *vrf-name*]
13. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** `switch(config)# vrf context RemoteOfficeVRF` `switch(config-vrf)#`	Creates a new VRF and enters VRF configuration mode.
Step 3	**exit** **Example:** `switch(config-vrf)# exit` `switch(config)#`	Exits VRF configuration mode.
Step 4	**router rip** *instance-tag* **Example:** `switch(config)# router rip Enterprise` `switch(config-router)#`	Creates a new RIP instance with the configured instance tag.
Step 5	**vrf** *vrf-name* **Example:** `switch(config-router)# vrf RemoteOfficeVRF` `switch(config-router-vrf)#`	Creates a new VRF.

	Command	Purpose
Step 6	**address-family** {**ipv4** | **ipv6**} **unicast** **Example:** switch(config-router-vrf)# address-family ipv4 unicast switch(config-router-vrf-af)#	(Optional) Configures the VRF address family for this RIP instance.
Step 7	**redistribute** {**bgp** *as* | **direct** | {**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **static**} **route-map** *map-name* **Example:** switch(config-router-vrf-af)# redistribute eigrp 201 route-map RIPmap	(Optional) Redistributes routes from other protocols into RIP. See the "Configuring Route Maps" section on page 15-12 for more information about route maps.
Step 8	**interface ethernet** *slot/port* **Example:** switch(config-router-vrf-af)# interface ethernet 1/2 switch(config-if)#	Enters interface configuration mode.
Step 9	**vrf member** *vrf-name* **Example:** switch(config-if)# vrf member RemoteOfficeVRF	Adds this interface to a VRF.
Step 10	**ip address** *ip-prefix/length* **Example:** switch(config-if)# ip address 192.0.2.1/16	Configures an IP address for this interface. You must do this step after you assign this interface to a VRF.
Step 11	**ip router rip** *instance-tag* **Example:** switch(config-if)# ip router rip Enterprise	Associates this interface with a RIP instance.
Step 12	**show ip rip** [**instance** *instance-tag*] **interface** [*interface-type slot/port*] [**vrf** *vrf-name*] **Example:** switch(config-if)# show ip rip Enterprise ethernet 1/2	(Optional) Displays RIP information for an interface in a VRF.
Step 13	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create a VRF and add an interface to the VRF:

```
switch# configure terminal
switch(config)# vrf context RemoteOfficeVRF
switch(config-vrf)# exit
switch(config)# router rip Enterprise
switch(config-router)# vrf RemoteOfficeVRF
switch(config-router-vrf)# address-family ipv4 unicast
switch(config-router-vrf-af)# redistribute eigrp 201 route-map RIPmap
switch(config-router-vrf-af)# interface ethernet 1/2
switch(config-if)# vrf member RemoteOfficeVRF
switch(config-if)# ip address 192.0.2.1/16
switch(config-if)# ip router rip Enterprise
switch(config-if)# copy running-config startup-config
```

Tuning RIP

You can tune RIP to match your network requirements. RIP uses several timers that determine the frequency of routing updates, the length of time before a route becomes invalid, and other parameters. You can adjust these timers to tune routing protocol performance to better suit your internetwork needs.

Note You must configure the same values for the RIP timers on all RIP-enabled routers in your network.

You can use the following optional commands in address-family configuration mode to tune RIP:

Command	Purpose
timers basic *update timeout holddown garbage-collection* **Example:** `switch(config-router-af)# timers basic 40 120 120 100`	Sets the RIP timers in seconds. The parameters are as follows: • *update*—The range is from 5 to any positive integer. The default is 30. • *timeout*—The time that Cisco NX-OS waits before declaring a route as invalid. If Cisco NX-OS does not receive route update information for this route before the timeout interval ends, Cisco NX-OS declares the route as invalid. The range is from 1 to any positive integer. The default is 180. • *holddown*—The time during which Cisco NX-OS ignores better route information for an invalid route. The range is from 0 to any positive integer. The default is 180. • *garbage-collection*—The time from when Cisco NX-OS marks a route as invalid until Cisco NX-OS removes the route from the routing table. The range is from 1 to any positive integer. The default is 120.

You can use the following optional commands in interface configuration mode to tune RIP:

Command	Purpose
ip rip metric-offset *value* **Example:** `switch(config-if)# ip rip metric-offset 10`	Adds a value to the metric for every route received on this interface. The range is from 1 to 15. The default is 1.
ip rip route-filter {**prefix-list** *list-name* | **route-map** *map-name*| [**in** | **out**] **Example:** `switch(config-if)# ip rip route-filter route-map InputMap in`	Specifies a route map to filter incoming or outgoing RIP updates.

Verifying the RIP Configuration

To display RIP configuration, perform one of the following tasks:

Command	Purpose
show ip rip instance [*instance-tag*] [**vrf** *vrf-name*]	Displays the status for an instance of RIP.
show ip rip [**instance** *instance-tag*] **interface** *slot/port* **detail** [**vrf** *vrf-name*]	Displays the RIP status for an interface.
show ip rip [**instance** *instance-tag*] **neighbor** [*interface-type number*] [**vrf** *vrf-name*]	Displays the RIP neighbor table.
show ip rip [**instance** *instance-tag*] **route** [*ip-prefix/lengh* [**longer-prefixes** | **shorter--prefixes]] [summary**] [**vrf** *vrf-name*]	Displays the RIP route table.
show running-configuration rip	Displays the current running RIP configuration.

Displaying RIP Statistics

To display RIP statistics, use the following commands:

Command	Purpose
show ip rip [**instance** *instance-tag*] **policy statistics redistribute** {**bgp** *as* | **direct** | {**eigrp** | **isis** | **ospf** | **ospfv3** | **rip**} *instance-tag* | **static**} [**vrf** *vrf-name*]	Displays the RIP policy statistics.
show ip rip [**instance** *instance-tag*] **statistics** *interface-type number*] [**vrf** *vrf-name*]	Displays the RIP statistics.

Use the **clear ip rip policy statistics redistribute** *protocol process-tag* command to clear policy statistics.

Use the **clear ip rip statistics** command to clear RIP statistics.

Configuration Examples for RIP

This example creates the Enterprise RIP instance in a VRF and adds Ethernet interface 1/2 to this RIP instance. The example also configures authentication for Ethernet interface 1/2 and redistributes EIGRP into this RIP domain.

```
vrf context NewVRF
!
 feature rip
 router rip Enterprise
  vrf NewVRF
   address-family ipv4 unicast
    redistribute eigrp 201 route-map RIPmap
    max-paths 10
!
interface ethernet 1/2
 vrf member NewVRF
 ip address 192.0.2.1/16
 ip router rip Enterprise
 ip rip authentication mode md5
 ip rip authentication key-chain RIPKey
```

Related Topics

See Chapter 15, “Configuring Route Policy Manager” for more information on route maps.

Configuring Static Routing

This chapter describes how to configure static routing on the Cisco NX-OS device.

This chapter includes the following sections:

About Static Routing

Routers forward packets using either route information from route table entries that you manually configure or the route information that is calculated using dynamic routing algorithms.

Static routes, which define explicit paths between two routers, cannot be automatically updated; you must manually reconfigure static routes when network changes occur. Static routes use less bandwidth than dynamic routes. No CPU cycles are used to calculate and analyze routing updates.

You can supplement dynamic routes with static routes where appropriate. You can redistribute static routes into dynamic routing algorithms, but you cannot redistribute routing information calculated by dynamic routing algorithms into the static routing table.

You should use static routes in environments where network traffic is predictable and where the network design is simple. You should not use static routes in large, constantly changing networks because static routes cannot react to network changes. Most networks use dynamic routes to communicate between routers but might have one or two static routes configured for special cases. Static routes are also useful for specifying a gateway of last resort (a default router to which all unroutable packets are sent).

This section includes the following topics:

Administrative Distance

An administrative distance is the metric used by routers to choose the best path when there are two or more routes to the same destination from two different routing protocols. An administrative distance guides the selection of one routing protocol (or static route) over another, when more than one protocol adds the same route to the unicast routing table. Each routing protocol is prioritized in order of most to least reliable using an administrative distance value.

Static routes have a default administrative distance of 1. A router prefers a static route to a dynamic route because the router considers a route with a low number to be the shortest. If you want a dynamic route to override a static route, you can specify an administrative distance for the static route. For example, if you have two dynamic routes with an administrative distance of 120, you would specify an administrative distance that is greater than 120 for the static route if you want the dynamic route to override the static route.

Directly Connected Static Routes

You must specify only the output interface (the interface on which all packets are sent to the destination network) in a directly connected static route. The router assumes the destination is directly attached to the output interface and the packet destination is used as the next-hop address. The next hop can be an interface, only for point-to-point interfaces. For broadcast interfaces, the next hop must be an IPv4/IPv6 address.

Fully Specified Static Routes

You must specify either the output interface (the interface on which all packets are sent to the destination network) or the next-hop address in a fully specified static route. You can use a fully specified static route when the output interface is a multi-access interface and you need to identify the next-hop address. The next-hop address must be directly attached to the specified output interface.

Floating Static Routes

A floating static route is a static route that the router uses to back up a dynamic route. You must configure a floating static route with a higher administrative distance than the dynamic route that it backs up. In this instance, the router prefers a dynamic route to a floating static route. You can use a floating static route as a replacement if the dynamic route is lost.

Note By default, a router prefers a static route to a dynamic route because a static route has a smaller administrative distance than a dynamic route.

Remote Next Hops for Static Routes

You can specify the next-hop address of a neighboring router that is not directly connected to the router for static routes with remote (nondirectly attached) next-hops. If a static route has remote next hops during data forwarding, the next hops are recursively used in the unicast routing table to identify the corresponding directly attached next hops that have reachability to the remote next hops.

BFD

This feature supports bidirectional forwarding detection (BFD) for IPv4. BFD is a detection protocol designed to provide fast forwarding-path failure detection times. BFD provides subsecond failure detection between two adjacent devices and can be less CPU-intensive than protocol hello messages because some of the BFD load can be distributed onto the data plane on supported modules. See the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide* for more information.

Virtualization Support

Static routes support virtual routing and forwarding (VRF) instances.

Licensing Requirements for Static Routing

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	Static routing requires no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for Static Routing

Static routing has the following prerequisites:

- If the next-hop address for a static route is unreachable, the static route is not added to the unicast routing table.

Default Settings

Table 12-1 lists the default settings for static routing parameters.

Table 12-1 Default Static Routing Parameters

Parameters	Default
Administrative distance	1
RIP feature	Disabled

Configuring Static Routing

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Configuring a Static Route

You can configure a static route on the router.

SUMMARY STEPS

1. **configure terminal**
2. **ip route** {*ip-prefix* | *ip-addr/ip-mask*} {[*next-hop* | *nh-prefix*] | [*interface next-hop* | *nh-prefix*]} [**name** *nexthop-name*] [**tag** *tag-value*] [*pref*] [**track** *number*] [**vrf** *name*]

   or

   ipv6 route *ip6-prefix* {*nh-prefix* | *link-local-nh-prefix*} | {*nh-prefix* [*interface*] | *link-local-nh-prefix* [*interface*]} [**name** *nexthop-name*] [**tag** *tag-value*] [*pref*] [**track** *number*] [**vrf** *name*]
3. (Optional) **show** {**ip** | **ipv6**} **static-route**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**ip route** {*ip-prefix* | *ip-addr/ip-mask*} {[*next-hop* | *nh-prefix*] | [*interface next-hop* | *nh-prefix*]} [**name** *nexthop-name*] [**tag** *tag-value*] [*pref*] [**track** *number*] [**vrf** *name*] **Example**: switch(config)# ip route 192.0.2.0/8 ethernet 1/2 192.0.2.4	Configures a static route and the interface for this static route. Use **?** to display a list of supported interfaces. You can specify a null interface by using **null 0**. You can optionally configure the next-hop address. The *preference* value sets the administrative distance. The range is from 1 to 255. The default is 1. The track number specifies the object to be tracked. The range is from 1 to 500. The VRF name specifies the VRF for the next hop, if it is different from the present VRF.
	ipv6 route *ip6-prefix* {*nh-prefix* | *link-local-nh-prefix*} | (*nexthop* [*interface*] | *link-local-nexthop* [*interface*]} [**name** *nexthop-name*] [**tag** *tag-value*] [*pref*] [**track** *number*] [**vrf** *name*] **Example**: switch(config)# ipv6 route 2001:0DB8::/48 6::6 ethernet 2/1	Configures a static route and the interface for this static route. Use **?** to display a list of supported interfaces. You can specify a null interface by using **null 0**. You can optionally configure the next-hop address. The *preference* value sets the administrative distance. The range is from 1 to 255. The default is 1. The track number specifies the object to be tracked. The range is from 1 to 500. The VRF name specifies the VRF for the next hop, if it is different from the present VRF.
Step 3	**show** {**ip** | **ipv6**} **static-route** **Example:** switch(config)# show ip static-route	(Optional) Displays information about static routes.
Step 4	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure a static route for a null interface:

```
switch# configure terminal
switch(config)# ip route 1.1.1.1/32 null 0
switch(config)# copy running-config startup-config
```

Use the **no** {**ip** | **ipv6**} **route** command to remove the static route.

Configuring a Static Route over a VLAN

You can configure a static route without next hop support over a VLAN.

BEFORE YOU BEGIN

Ensure that the access port is part of the VLAN.

SUMMARY STEPS

1. **configure terminal**
2. **feature interface-vlan**
3. **interface vlan** *vlan-id*
4. **ip address** *ip-addr/length*
5. **ip route** *ip-addr/length vlan-id*
6. (Optional) **show ip route**
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**feature interface vlan** **Example:** `switch(config)# feature interface-vlan`	Enables VLAN interface mode.
Step 3	**interface-vlan** *vlan-id* **Example:** `switch(config)# interface-vlan 10`	Creates an SVI and enters interface configuration mode. The range for the *vlan-id* argument is from 1 to 4094, except for the VLANs reserved for the internal switch.
Step 4	**ip address** *ip-addr/length* **Example:** `switch(config)# ip address 192.0.2.1/8`	Configures an IP address for the VLAN.
Step 5	**ip route** *ip-addr/length vlan-id* **Example:** `switch(config)# ip route 209.165.200.224/27 vlan 10`	Adds an interface static route without a next hop on the switch virtual interface (SVI). The IP address is the address that is configured on the interface that is connected to the switch.

	Command	Purpose
Step 6	**show ip route** **Example:** switch(config)# show ip route	(Optional) Displays routes from the Unicast Route Information Base (URIB).
Step 7	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure a static route without a next hop over an SVI:

```
switch# configure terminal
switch(config)# feature interface-vlan
swicth(config)# interface vlan 10
switch(config-if)# ip address 192.0.2.1/8
switch(config-if)# ip route 209.165.200.224/27 vlan 10 <===209,165.200.224 is the IP
address of the interface that is configured on the interface that is directly connected to
the switch.
switch(config-if)# copy running-config startup-config
```

Use the **no ip route** command to remove the static route.

Configuring Virtualization

You can configure a static route in a VRF.

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf-name*
3. **ip route** {*ip-prefix* | *ip-addr ip-mask*} {*next-hop* | *nh-prefix* | *interface*} [**name** *nexthop-name*] [**tag** *tag-value*] [*pref*] [**track** *number*] [**vrf** *name*]

   or

   ipv6 route *ip6-prefix* {*nh-prefix* | *link-local-nh-prefix*} | {*next-hop* [*interface*] | *link-local-next-hop* [*interface*]} [**name** *nexthop-name*] [**tag** *tag-value*] [*pref*] [**track** *number*] [**vrf** *name*]
4. (Optional) **show** {**ip** | **ipv6**} **static-route vrf** *vrf-nam*e
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** switch(config)# vrf context StaticVrf	Creates a VRF and enters VRF configuration mode.
Step 3	**ip route** {*ip-prefix* | *ip-addr ip-mask*} {*next-hop* | *nh-prefix* | *interface*} [**name** *nexthop-name*] [**tag** *tag-value*] [*pref*] [**track** *number*] [**vrf** *name*] **Example**: switch(config-vrf)# ip route 192.0.2.0/8 ethernet 1/2	Configures a static route and the interface for this static route. Use **?** to display a list of supported interfaces. You can specify a null interface by using **null 0**. You can optionally configure the next-hop address. The *preference* value sets the administrative distance. The range is from 1 to 255. The default is 1. The track number specifies the object to be tracked. The range is from 1 to 500. The VRF name specifies the VRF for the next hop, if it is different from the present VRF.
	ipv6 route *ip6-prefix* {*nh-prefix* | *link-local-nh-prefix*} | (*nexthop* [*interface*] | *link-local-nexthop* [*interface*]} [**name** *nexthop-name*] [**tag** *tag-value*] [*pref*] [**track** *number*] [**vrf** *name*] **Example**: switch(config)# ipv6 route 2001:0DB8::/48 6::6 ethernet 2/1	Configures a static route and the interface for this static route. Use **?** to display a list of supported interfaces. You can specify a null interface by using **null 0**. You can optionally configure the next-hop address. The *preference* value sets the administrative distance. The range is from 1 to 255. The default is 1. The track number specifies the object to be tracked. The range is from 1 to 500. The VRF name specifies the VRF for the next hop, if it is different from the present VRF.
Step 4	**show** {**ip** | **ipv6**} **static-route vrf** *vrf-name* **Example:** switch(config-vrf)# show ip static-route	(Optional) Displays information on static routes.
Step 5	**copy running-config startup-config** **Example:** switch(config-vrf)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure a static route:

```
switch# configure terminal
switch(config)# vrf context StaticVrf
switch(config-vrf)# ip route 192.0.2.0/8 192.0.2.10
switch(config-vrf)# copy running-config startup-config
```

Verifying the Static Routing Configuration

To display the static routing configuration, perform one of the following tasks:

Command	Purpose
show {**ip** | **ipv6**} **static-route**	Displays the configured static routes.
show ipv6 static-route vrf *vrf-name*	Displays static route information for each VRF.
show {**ip** | **ipv6**} **static-route track-table**	Displays information about the IPv4 or IPv6 static-route track table.

Configuration Example for Static Routing

This example shows how to configure static routing:

```
configure terminal
 ip route 192.0.2.0/8 192.0.2.10
 copy running-config startup-config
```

Configuring Layer 3 Virtualization

This chapter describes how to configure Layer 3 virtualization on the Cisco NX-OS device.

This chapter includes the following sections:

About Layer 3 Virtualization

Cisco NX-OS supports multiple virtual routing and forwarding instances (VRFs). Each VRF contains a separate address space with unicast and multicast route tables for IPv4 and IPv6 and makes routing decisions independent of any other VRF.

Each router has a default VRF and a management VRF:

Management VRF

- The management VRF is for management purposes only.
- Only the mgmt 0 interface can be in the management VRF.
- The mgmt 0 interface cannot be assigned to another VRF.
- No routing protocols can run in the management VRF (static only).

Default VRF

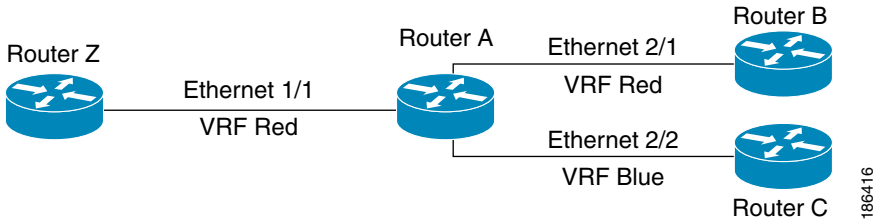
- All Layer 3 interfaces exist in the default VRF until they are assigned to another VRF.
- Routing protocols run in the default VRF context unless another VRF context is specified.
- The default VRF uses the default routing context for all **show** commands.
- The default VRF is similar to the global routing table concept in Cisco IOS.

VRF and Routing

All unicast and multicast routing protocols support VRFs. When you configure a routing protocol in a VRF, you set routing parameters for the VRF that are independent of routing parameters in another VRF for the same routing protocol instance.

You can assign interfaces and route protocols to a VRF to create virtual Layer 3 networks. An interface exists in only one VRF. Figure 13-1 shows one physical network split into two virtual networks with two VRFs. Routers Z, A, and B exist in VRF Red and form one address domain. These routers share route updates that do not include Router C because Router C is configured in a different VRF.

Figure 13-1 VRFs in a Network



By default, Cisco NX-OS uses the VRF of the incoming interface to select which routing table to use for a route lookup. You can configure a route policy to modify this behavior and set the VRF that Cisco NX-OS uses for incoming packets.

VRF Route Leaking

Cisco NX-OS supports route leaking between VRFs.

You can import IP prefixes from the global routing table (the default VRF) into any other VRF by using an import policy or export IP prefixes from a non-default VRF into the default VRF using an export policy. The VRF import and export policies uses a route map to specify the prefixes to be imported or exported into a VRF. The policies can import or export IPv4 and IPv6 unicast prefixes.

Note Routes in the BGP default VRF can be imported directly. Any other routes in the default VRF should be redistributed into BGP first.

IP prefixes are defined as match criteria for the import or export route map through standard route policy filtering mechanisms. For example, you can create an IP prefix list or an as-path filter to define an IP prefix or IP prefix range and use that prefix list or as-path filter in a match clause for the route map. Prefixes that pass through the route map are imported or exported into the specified VRF using the import or export policy. Any route or path that is imported from another VRF cannot be imported or exported again.

For more information, see the "Guidelines and Limitations for VRF Route Leaking" section on page 13-5.

VRF-Aware Services

A fundamental feature of the Cisco NX-OS architecture is that every IP-based feature is VRF aware.

The following VRF-aware services can select a particular VRF to reach a remote server or to filter information based on the selected VRF:

- AAA—See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide* for more information.
- Call Home—See the *Cisco Nexus 9000 Series NX-OS System Management Configuration Guide* for more information.
- DNS—See Chapter 4, "Configuring DNS" for more information.
- HTTP—See the *Cisco Nexus 9000 Series NX-OS Fundamentals Configuration Guide* for more information.
- HSRP—See Chapter 17, "Configuring HSRP," for more information.
- NTP—See the *Cisco Nexus 9000 Series NX-OS System Management Configuration Guide* for more information.
- RADIUS—See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide* for more information.
- Ping and Traceroute —See the *Cisco Nexus 9000 Series NX-OS Fundamentals Configuration Guide* for more information.
- SSH—See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide* for more information.
- SNMP—See the *Cisco Nexus 9000 Series NX-OS System Management Configuration Guide* for more information.
- Syslog—See the *Cisco Nexus 9000 Series NX-OS System Management Configuration Guide* for more information.
- TACACS+—See the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide* for more information.
- TFTP—See the *Cisco Nexus 9000 Series NX-OS Fundamentals Configuration Guide* for more information.
- VRRP—See Chapter 18, "Configuring VRRP," for more information.
- XML—See the *Cisco NX-OS XML Management Interface User Guide* for more information.

See the appropriate configuration guide for each service for more information on configuring VRF support in that service.

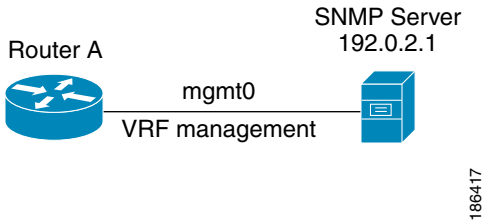
This section contains the following topics:

Reachability

Reachability indicates which VRF contains the routing information needed to get to the server providing the service. For example, you can configure an SNMP server that is reachable on the management VRF. When you configure that server address on the router, you also configure which VRF that Cisco NX-OS must use to reach the server.

Figure 13-2 shows an SNMP server that is reachable over the management VRF. You configure Router A to use the management VRF for the SNMP server host 192.0.2.1.

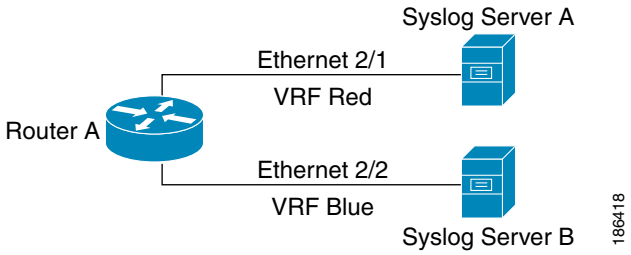
Figure 13-2 Service VRF Reachability



Filtering

Filtering allows you to limit the type of information that goes to a VRF-aware service based on the VRF. For example, you can configure a syslog server to support a particular VRF. Figure 13-3 shows two syslog servers with each server supporting one VRF. syslog server A is configured in VRF Red, so Cisco NX-OS sends only system messages generated in VRF Red to syslog server A.

Figure 13-3 Service VRF Filtering

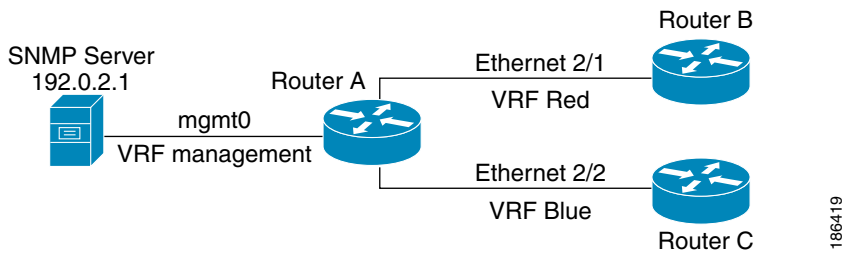


Combining Reachability and Filtering

You can combine reachability and filtering for VRF-aware services. You can configure the VRF that Cisco NX-OS uses to connect to that service as well as the VRF that the service supports. If you configure a service in the default VRF, you can optionally configure the service to support all VRFs.

Figure 13-4 shows an SNMP server that is reachable on the management VRF. You can configure the SNMP server to support only the SNMP notifications from VRF Red, for example.

Figure 13-4 Service VRF Reachability Filtering



Licensing Requirements for VRFs

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	VRFs require no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*. VRF route leaking requires an Enterprise Services license. For a complete explanation of the Cisco NX-OS licensing scheme and how to obtain and apply licenses, see the *Cisco NX-OS Licensing Guide.*

Guidelines and Limitations for VRFs

VRFs have the following configuration guidelines and limitations:

- When you make an interface a member of an existing VRF, Cisco NX-OS removes all Layer 3 configurations. You should configure all Layer 3 parameters after adding an interface to a VRF.
- You should add the mgmt0 interface to the management VRF and configure the mgmt0 IP address and other parameters after you add it to the management VRF.
- If you configure an interface for a VRF before the VRF exists, the interface is operationally down until you create the VRF.
- Cisco NX-OS creates the default and management VRFs by default. You should make the mgmt0 interface a member of the management VRF.
- The **write erase boot** command does not remove the management VRF configurations. You must use the **write erase** command and then the **write erase boot** command.

Guidelines and Limitations for VRF Route Leaking

VRF route leaking has the following configuration guidelines and limitations:

- Route leaking is supported between any two non-default VRFs and from the default VRF to a non-default VRF. Beginning with Cisco NX-OS Release 7.0(3)I2(1), route leaking is also supported from a non-default VRF to the default VRF.
- You can restrict route leaking to specific routes using route map filters to match designated IP addresses.
- By default, the maximum number of IP prefixes that can be imported from the default VRF into a non-default VRF is 1000 routes.
- There is no limit on the number of routes that can be leaked between two non-default VRFs.
- VRF route leaking requires an Enterprise license, and BGP must be enabled.

Default Settings

Table 13-1 lists the default settings for VRF parameters.

Table 13-1 Default VRF Parameters

Parameters	Default
Configured VRFs	Default, management
Routing context	Default VRF
Prefix limit for VRF route leaking	1000

Configuring VRFs

This section contains the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Creating a VRF

You can create a VRF.

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf-name*
3. (Optional) **ip route** {*ip-prefix* | *ip-addr ip-mask*} {[*next-hop* | *nh-prefix*] | [*interface next-hop* | *nh-prefix*]} [**tag** *tag-value* [*pref*]
4. (Optional) **show vrf** [*vrf-name*]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**vrf context** *name* **Example:** `switch(config)# vrf context Enterprise` `switch(config-vrf)#`	Creates a new VRF and enters VRF configuration mode. The *name* can be any case-sensitive, alphanumeric string up to 32 characters.
Step 3	**ip route** {*ip-prefix* | *ip-addr ip-mask*} {[*next-hop* | *nh-prefix*] | [*interface next-hop* | *nh-prefix*]} [**tag** *tag-value* [*pref*] **Example**: `switch(config-vrf)# ip route 192.0.2.0/8 ethernet 1/2 192.0.2.4`	(Optional) Configures a static route and the interface for this static route. You can optionally configure the next-hop address. The *preference* value sets the administrative distance. The range is from 1 to 255. The default is 1.
Step 4	**show vrf** [*vrf-name*] **Example**: `switch(config-vrf)# show vrf Enterprise`	(Optional) Displays VRF information.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

To delete the VRF and the associated configuration, use the following command in global configuration mode:

Command	Purpose
no vrf context *name* **Example:** `switch(config)# no vrf context Enterprise`	Deletes the VRF and all associated configurations.

Any commands available in global configuration mode are also available in VRF configuration mode.

This example shows how to create a VRF and add a static route to the VRF:

```
switch# configure terminal
switch(config)# vrf context Enterprise
switch(config-vrf)# ip route 192.0.2.0/8 ethernet 1/2
switch(config-vrf)# exit
switch(config)# copy running-config startup-config
```

Assigning VRF Membership to an Interface

You can make an interface a member of a VRF.

BEFORE YOU BEGIN

Assign the IP address for an interface after you have configured the interface for a VRF.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **vrf member** *vrf-name*
4. **ip-address** *ip-prefix/length*
5. (Optional) **show vrf** *vrf-name* **interface** *interface-type number*
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**vrf member** *vrf-name* **Example:** `switch(config-if)# vrf member RemoteOfficeVRF`	Adds this interface to a VRF.
Step 4	**ip address** *ip-prefix/length* **Example:** `switch(config-if)# ip address 192.0.2.1/16`	Configures an IP address for this interface. You must do this step after you assign this interface to a VRF.
Step 5	**show vrf** *vrf-name* **interface** *interface-type number* **Example:** `switch(config-vrf)# show vrf Enterprise interface ethernet 1/2`	(Optional) Displays VRF information.
Step 6	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to add an interface to the VRF:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# vrf member RemoteOfficeVRF
switch(config-if)# ip address 192.0.2.1/16
switch(config-if)# copy running-config startup-config
```

Configuring VRF Parameters for a Routing Protocol

You can associate a routing protocol with one or more VRFs. See the appropriate chapter for information on how to configure VRFs for the routing protocol. This section uses OSPFv2 as an example protocol for the detailed configuration steps.

SUMMARY STEPS

1. **configure terminal**
2. **router ospf** *instance-tag*
3. **vrf** *vrf-name*
4. (Optional) **maximum-paths** *paths*
5. **interface** *interface-type slot/port*
6. **vrf member** *vrf-name*
7. **ip address** *ip-prefix/length*
8. **ip router ospf** *instance-tag* **area** *area-id*
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**router ospf** *instance-tag* **Example:** `switch(config-vrf)# router ospf 201` `switch(config-router)#`	Creates a new OSPFv2 instance with the configured instance tag.
Step 3	**vrf** *vrf-name* **Example:** `switch(config-router)# vrf RemoteOfficeVRF` `switch(config-router-vrf)#`	Enters VRF configuration mode.
Step 4	**maximum-paths** *paths* Example: `switch(config-router-vrf)# maximum-paths 4`	(Optional) Configures the maximum number of equal OSPFv2 paths to a destination in the route table for this VRF. Used for load balancing.

	Command	Purpose
Step 5	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 6	**vrf member** *vrf-name* **Example:** `switch(config-if)# vrf member RemoteOfficeVRF`	Adds this interface to a VRF.
Step 7	**ip address** *ip-prefix/length* **Example:** `switch(config-if)# ip address 192.0.2.1/16`	Configures an IP address for this interface. You must do this step after you assign this interface to a VRF.
Step 8	**ip router ospf** *instance-tag* **area** *area-id* **Example:** `switch(config-if)# ip router ospf 201 area 0`	Assigns this interface to the OSPFv2 instance and area configured.
Step 9	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to create a VRF and add an interface to the VRF:

```
switch# configure terminal
switch(config)# vrf context RemoteOfficeVRF
switch(config-vrf)# exit
switch(config)# router ospf 201
switch(config-router)# vrf RemoteOfficeVRF
switch(config-router-vrf)# maximum-paths 4
switch(config-router-vrf)# interface ethernet 1/2
switch(config-if)# vrf member RemoteOfficeVRF
switch(config-if)# ip address 192.0.2.1/16
switch(config-if)# ip router ospf 201 area 0
switch(config-if)# exit
switch(config)# copy running-config startup-config
```

Configuring Global VRF Route Leaking

You can configure route leaking from the default VRF to a non-default VRF or from a non-default VRF to the default VRF.

Route leaking between non-default VRFs is enabled automatically (with route target matching).

BEFORE YOU BEGIN

Make sure that the Enterprise license is installed and BGP is enabled.

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** [*vrf-name*]
3. **address-family** {**ipv4** | **ipv6**} **unicast**
4. {**import** | **export**} **vrf default** [*prefix-limit*] **map** *route-map*
5. (Optional) **show bgp process vrf** [*vrf-name*]
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** switch(config)# vrf context vpn1 switch(config-vrf)#	Creates a new VRF.
Step 3	**address-family** {**ipv4** | **ipv6**} **unicast** **Example:** switch(config-vrf)# address-family ipv4 unicast switch(config-vrf-af-ipv4)#	Enters global address family configuration mode for the IPv4 or IPv6 address family.
Step 4	{**import** | **export**} **vrf default** [*prefix-limit*] **map** *route-map* Example: switch(config-vrf-af-ipv4)# import vrf default map importmap Example: switch(config-vrf-af-ipv4)# export vrf default map exportmap	Configures VRF route leaking. The following options are available: • **import**—Copies a route containing IPv4 or IPv6 unicast prefixes from the global routing table (the default VRF) into any other VRF. • **export**—Copies a route containing IPv4 or IPv6 unicast prefixes from a non-default VRF into the global routing table (the default VRF). • *prefix-limit*—Specifies the maximum number of routes that can be imported or exported. The range is from 1 to 2147483647, and the default value is 1000.
Step 5	**show bgp process vrf** [*vrf-name*] **Example:** switch(config-vrf-af-ipv4)# show bgp process vrf vpn1	(Optional) Displays the BGP process information for the specified VRF.
Step 6	**copy running-config startup-config** **Example:** switch(config)# copy running-config startup-config	(Optional) Saves this configuration change.

Configuring a VRF-Aware Service

You can configure a VRF-aware service for reachability and filtering. See the "VRF-Aware Services" section on page 13-3 for links to the appropriate chapter or configuration guide for information on how to configure the service for VRFs. This section uses SNMP and IP domain lists as example services for the detailed configuration steps.

SUMMARY STEPS

1. **configure terminal**
2. **snmp-server host** *ip-address* [**filter-vrf** *vrf-name*] [**use-vrf** *vrf-name*]
3. **vrf context** [*vrf-name*]
4. **ip domain-list** *domain-name* [**all-vrfs**][**use-vrf** *vrf-name*]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**snmp-server host** *ip-address* [**filter-vrf** *vrf-name*] [**use-vrf** *vrf-name*] **Example:** `switch(config)# snmp-server host 192.0.2.1 use-vrf Red` `switch(config-vrf)#`	Configures a global SNMP server and configures the VRF that Cisco NX-OS uses to reach the service. Use the **filter-vrf** keyword to filter information from the selected VRF to this server.
Step 3	**vrf context** *vrf-name* **Example:** `switch(config)# vrf context Blue` `switch(config-vrf)#`	Creates a new VRF.
Step 4	**ip domain-list** *domain-name* [**all-vrfs**][**use-vrf** *vrf-name*] **Example:** `switch(config-vrf)# ip domain-list List all-vrfs use-vrf Blue` `switch(config-vrf)#`	Configures the domain list in the VRF and optionally configures the VRF that Cisco NX-OS uses to reach the domain name listed.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to send SNMP information for all VRFs to SNMP host 192.0.2.1, reachable on VRF Red:

```
switch# configure terminal
switch(config)# snmp-server host 192.0.2.1 for-all-vrfs use-vrf Red
switch(config)# copy running-config startup-config
```

This example shows how to filter SNMP information for VRF Blue to SNMP host 192.0.2.12, reachable on VRF Red:

```
switch# configure terminal
switch(config)# vrf context Blue
switch(config-vrf)# snmp-server host 192.0.2.12 use-vrf Red
switch(config)# copy running-config startup-config
```

Setting the VRF Scope

You can set the VRF scope for all EXEC commands (for example, **show** commands). This automatically restricts the scope of the output of EXEC commands to the configured VRF. You can override this scope by using the VRF keywords available for some EXEC commands.

To set the VRF scope, use the following command in EXEC mode:

Command	Purpose
routing-context vrf *vrf-name* **Example:** `switch# routing-context vrf red` `switch%red#`	Sets the routing context for all EXEC commands. Default routing context is the default VRF.

To return to the default VRF scope, use the following command in EXEC mode:

Command	Purpose
routing-context vrf default **Example:** `switch%red# routing-context vrf default` `switch#`	Sets the default routing context.

Verifying the VRF Configuration

To display VRF configuration information, perform one of the following tasks:

Command	Purpose
show bgp process vrf [*vrf-name*]	Displays the BGP process information for the specified VRF.
show vrf [*vrf-name*]	Displays the information for all or one VRF.

Command	Purpose
show vrf [*vrf-name*] **detail**	Displays detailed information for all or one VRF.
show vrf [*vrf-name*] [**interface** *interface-type slot/port*]	Displays the VRF status for an interface.

Configuration Examples for VRF

This example shows how to configure VRF Red, add an SNMP server to that VRF, and add an instance of OSPF to VRF Red:

```
configure terminal
vrf context Red
 snmp-server host 192.0.2.12 use-vrf Red
router ospf 201
   vrf Red
interface ethernet 1/2
 vrf member Red
 ip address 192.0.2.1/16
 ip router ospf 201 area 0
```

This example shows how to configure VRF Red and Blue, add an instance of OSPF to each VRF, and create an SNMP context for each OSPF instance in each VRF:

```
configure terminal
!Create the VRFs
vrf context Red
vrf context Blue
vrf context Green
!Create the OSPF instances and associate them with a single VRF or multiple VRFs
(recommended)
feature ospf
router ospf Lab
 vrf Red
!
router ospf Production
 vrf Blue
   router-id 1.1.1.1
vrf Green
   router-id 2.2.2.2
!Configure one interface to use ospf Lab on VRF Red
interface ethernet 1/2
 vrf member Red
 ip address 192.0.2.1/16
 ip router ospf Lab area 0
 no shutdown
!Configure another interface to use ospf Production on VRF Blue
interface ethernet 10/2
 vrf member Blue
 ip address 192.0.2.1/16
 ip router ospf Production area 0
 no shutdown
!
interface ethernet 10/3
 vrf member Green
 ip address 192.0.2.1/16
 ip router ospf Production area 0
 no shutdown

!configure the SNMP server
```

```
snmp-server user admin network-admin auth md5 nbv-12345
snmp-server community public ro
!Create the SNMP contexts for each VRF
snmp-server context lab instance Lab vrf Red
snmp-server context production instance Production vrf Blue
!Use the SNMP context lab to access the OSPF-MIB values for the OSPF instance Lab in VRF
Red in this example.
```

Use the SNMP context **lab** to access the OSPF-MIB values for the OSPF instance Lab in VRF Red in this example.

This example shows how to configure route leaking between two non-default VRFs and from the default VRF to a non-default VRF:

```
feature bgp
vrf context Green
ip route 33.33.33.33/32 35.35.1.254
address-family ipv4 unicast
route-target import 3:3
route-target export 2:2
export map test
import map test
import vrf default map test

interface Ethernet1/7
vrf member Green
ip address 35.35.1.2/24

vrf context Shared
ip route 44.44.44.44/32 45.45.1.254
address-family ipv4 unicast
route-target import 1:1
route-target import 2:2
route-target export 3:3
export map test
import map test
import vrf default map test

interface Ethernet1/11
vrf member Shared
ip address 45.45.1.2/24


router bgp 100
address-family ipv4 unicast
redistribute static route-map test
vrf Green
address-family ipv4 unicast
redistribute static route-map test
vrf Shared
address-family ipv4 unicast
redistribute static route-map test

ip prefix-list test seq 5 permit 0.0.0.0/0 le 32

route-map test permit 10
match ip address prefix-list test

ip route 100.100.100.100/32 55.55.55.1

switch# show ip route vrf all
IP Route Table for VRF "default"
```

```
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

55.55.55.0/24, ubest/mbest: 1/0, attached
*via 55.55.55.5, Lo0, [0/0], 00:07:59, direct
55.55.55.5/32, ubest/mbest: 1/0, attached
*via 55.55.55.5, Lo0, [0/0], 00:07:59, local
100.100.100.100/32, ubest/mbest: 1/0
*via 55.55.55.1, [1/0], 00:07:42, static

IP Route Table for VRF "management"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

0.0.0.0/0, ubest/mbest: 1/0
*via 10.29.176.1, [1/0], 12:53:54, static
10.29.176.0/24, ubest/mbest: 1/0, attached
*via 10.29.176.233, mgmt0, [0/0], 13:11:57, direct
10.29.176.233/32, ubest/mbest: 1/0, attached
*via 10.29.176.233, mgmt0, [0/0], 13:11:57, local

IP Route Table for VRF "Green"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

33.33.33.33/32, ubest/mbest: 1/0
*via 35.35.1.254, [1/0], 00:23:44, static
35.35.1.0/24, ubest/mbest: 1/0, attached
*via 35.35.1.2, Eth1/7, [0/0], 00:26:46, direct
35.35.1.2/32, ubest/mbest: 1/0, attached
*via 35.35.1.2, Eth1/7, [0/0], 00:26:46, local
44.44.44.44/32, ubest/mbest: 1/0
*via 45.45.1.254%Shared, [20/0], 00:12:08, bgp-100, external, tag 100
100.100.100.100/32, ubest/mbest: 1/0
*via 55.55.55.1%default, [20/0], 00:07:41, bgp-100, external, tag 100

IP Route Table for VRF "Shared"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

33.33.33.33/32, ubest/mbest: 1/0
*via 35.35.1.254%Green, [20/0], 00:12:34, bgp-100, external, tag 100
44.44.44.44/32, ubest/mbest: 1/0
*via 45.45.1.254, [1/0], 00:23:16, static
45.45.1.0/24, ubest/mbest: 1/0, attached
*via 45.45.1.2, Eth1/11, [0/0], 00:25:53, direct
45.45.1.2/32, ubest/mbest: 1/0, attached
*via 45.45.1.2, Eth1/11, [0/0], 00:25:53, local
100.100.100.100/32, ubest/mbest: 1/0
*via 55.55.55.1%default, [20/0], 00:07:41, bgp-100, external, tag 100
```

This example shows how to configure route leaking from a non-default VRF to the default VRF:

```
feature bgp
vrf context vpn1
    address-family ipv4 unicast
        import vrf default map importmap
        export vrf default map exportmap

show bgp ipv4 unicast 123.123.123.123/32
BGP routing table information for VRF default, address family IPv4 Unicast
BGP routing table entry for 123.123.123.123/32, version 6
Paths: (1 available, best #1)
Flags: (0x8008001a) on xmit-list, is in urib, is best urib route

  Advertised path-id 1
  Path type: redist, path is valid, is best path
             Imported from 100:1:123.123.123.123/32 (VRF vpn1)
  AS-Path: NONE, path locally originated
    0.0.0.0 (metric 0) from 0.0.0.0 (1.1.1.1)
      Origin incomplete, MED 0, localpref 100, weight 32768
Extcommunity:  RT:100:1

  Path-id 1 not advertised to any peer
  Path-id 1 scheduled to be advertised to peers:
    2.2.2.2

show bgp process vrf vpn1
Information regarding configured VRFs:

BGP Information for VRF vpn1
VRF Id                          : 3
VRF state                       : UP
Router-ID                       : 20.0.0.1
Configured Router-ID            : 0.0.0.0
Confed-ID                       : 0
Cluster-ID                      : 0.0.0.0
No. of configured peers         : 2
No. of pending config peers     : 0
No. of established peers        : 2
VRF RD                          : 100:1

    Information for address family IPv4 Unicast in VRF vpn1
    Table Id                    : 3
    Table state                 : UP
Peers      Active-peers    Routes     Paths      Networks   Aggregates
    1          1               6          6          0          0

    Redistribution
        None

    Export RT list:
        100:1
        1000:1
    Import RT list:
        100:1
    Label mode: per-prefix
    Aggregate label: 492287
    Import default limit       : 1000
    Import default prefix count : 2
    Import default map         : importmap
    Export default limit       : 1000
    Export default prefix count : 3
    Export default map         : exportmap
```

Additional References

For additional information related to implementing virtualization, see the following sections:

Related Documents

Related Topic	Document Title
BGP	*Chapter 9, "Configuring Basic BGP"*
VRFs	*Cisco Nexus 9000 Series NX-OS Fundamentals Configuration Guide* *Cisco Nexus 9000 Series NX-OS System Management Configuration Guide*

Standards

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

Managing the Unicast RIB and FIB

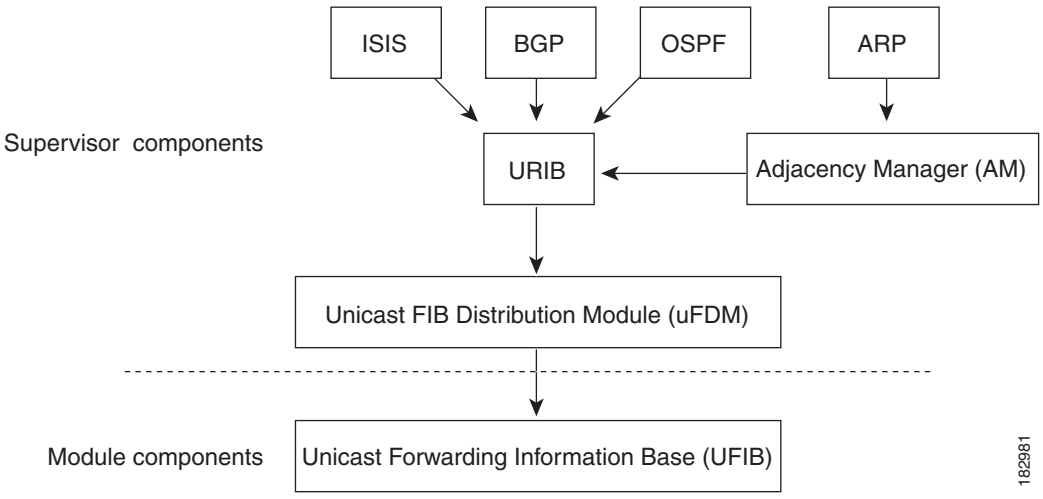
This chapter describes how to manage routes in the unicast Routing Information Base (RIB) and the Forwarding Information Base (FIB) on the Cisco NX-OS device.

This chapter includes the following sections:

About the Unicast RIB and FIB

The unicast RIB (IPv4 RIB and IPv6 RIB) and FIB are part of the Cisco NX-OS forwarding architecture, as shown in Figure 14-1.

Figure 14-1 Cisco NX-OS Forwarding Architecture



The unicast RIB exists on the active supervisor. It maintains the routing table with directly connected routes, static routes, and routes learned from dynamic unicast routing protocols. The unicast RIB also collects adjacency information from sources such as the Address Resolution Protocol (ARP). The

unicast RIB determines the best next hop for a given route and populates the unicast forwarding information bases (FIBs) on the modules by using the services of the unicast FIB distribution module (FDM).

Each dynamic routing protocol must update the unicast RIB for any route that has timed out. The unicast RIB then deletes that route and recalculates the best next hop for that route (if an alternate path is available).

This section includes the following topics:

Layer 3 Consistency Checker

In rare instances, an inconsistency can occur between the unicast RIB and the FIB on each module. Cisco NX-OS supports the Layer 3 consistency checker. This feature detects inconsistencies between the unicast IPv4 RIB on the supervisor module and the FIB on each interface module. Inconsistencies include the following:

- Missing prefix
- Extra prefix
- Wrong next-hop address
- Incorrect Layer 2 rewrite string in the ARP or neighbor discovery (ND) cache

The Layer 3 consistency checker compares the FIB entries to the latest adjacency information from the Adjacency Manager (AM) and logs any inconsistencies. The consistency checker then compares the unicast RIB prefixes to the module FIB and logs any inconsistencies. See the "Triggering the Layer 3 Consistency Checker" section on page 14-7.

You can then manually clear any inconsistencies. See the "Clearing Forwarding Information in the FIB" section on page 14-8.

Licensing Requirements for the Unicast RIB and FIB

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	The unicast RIB and FIB require no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Managing the Unicast RIB and FIB

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Displaying Module FIB Information

You can display the FIB information on a module.

DETAILED STEPS

To display the FIB information on a module, use the following commands in any mode:

Command	Purpose
show forwarding {**ipv4** | **ipv6**} **adjacency module** *slot* **Example:** `switch# show forwarding ipv6 adjacency module 2`	Displays the adjacency information for IPv4 or IPv6.
show forwarding {**ipv4** | **ipv6**} **route module** *slot* **Example:** `switch# show forwarding ipv6 route module 2`	Displays the route table for IPv4 or IPv6.

Configuring Load Sharing in the Unicast FIB

Dynamic routing protocols such as Open Shortest Path First (OSPF) support load balancing with equal-cost multipath (ECMP). The routing protocol determines its best routes based on the metrics configured for the protocol and installs up to the protocol-configured maximum paths in the unicast Routing Information Base (RIB). The unicast RIB compares the administrative distances of all routing protocol paths in the RIB and selects a best path set from all of the path sets installed by the routing protocols. The unicast RIB installs this best path set into the Forwarding Information Base (FIB) for use by the forwarding plane.

The forwarding plane uses a load-sharing algorithm to select one of the installed paths in the FIB to use for a given data packet.

Note Load sharing uses the same path for all packets in a given flow. A flow is defined by the load-sharing method that you configure. For example, if you configure source-destination load sharing, then all packets with the same source IP address and destination IP address pair follow the same path.

To configure the unicast FIB load-sharing algorithm, use the following command in global configuration mode:

Command	Purpose
ip load-sharing address {**destination port destination** | **source-destination** [**port source-destination**]} [**universal-id** *seed*][**rotate** *rotate*] [**concatenation**] **Example:** `switch(config)# ip load-sharing address source-destination`	Configures the unicast FIB load-sharing algorithm for data traffic. • The **universal-id** option sets the random seed for the hash algorithm and shifts the flow from one link to another. You do not need to configure the universal ID. Cisco NX-OS chooses the universal ID if you do not configure it. The *universal-id* range is from 1 to 4294967295. • The **rotate** option causes the hash algorithm to rotate the link picking selection so that it does not continually choose the same link across all nodes in the network. It does so by influencing the bit pattern for the hash algorithm. This option shifts the flow from one link to another and load balances the already load-balanced (polarized) traffic from the first ECMP level across multiple links. If you specify a *rotate* value, the 64-bit stream is interpreted starting from that bit position in a cyclic rotation. The *rotate* range is from 1 to 63, and the default is 32. **Note** With multi-tier Layer 3 topology, polarization is possible. To avoid polarization, use a different rotate bit at each tier of the topology. **Note** To configure a rotation value for port channels, use the **port-channel load-balance src-dst ip-l4port rotate** *rotate* command. For more information on this command, see the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide*. • The **concatenation** option ties together the hash tag values for ECMP and the hash tag values for port channels in order to use a stronger 64-bit hash. If you do not use this option, you can control ECMP load-balancing and port-channel load-balancing independently. The default is disabled.

To display the unicast FIB load-sharing algorithm, use the following command in any mode:

Command	Purpose
show ip load-sharing **Example:** `switch(config)# show ip load-sharing address source-destination`	Displays the unicast FIB load-sharing algorithm for data traffic.

To display the route that the unicast RIB and FIB use for a particular source address and destination address, use the following command in any mode:

Command	Purpose
show routing hash *source-addr dest-addr* [*source-port dest-port*] [**vrf** *vrf-name*] **Example:** `switch# show routing hash 192.0.2.1 10.0.0.1`	Displays the route that the unicast RIB FIB use for a source and destination address pair. The source address and destination address format is x.x.x.x. The source port and destination port range is from 1 to 65535. The VRF name can be any case-sensitive, alphanumeric string up to 64 characters.

This example shows how to display the route selected for a source/destination pair:

```
switch# show routing hash 10.0.0.5 192.0.0.2
  Load-share parameters used for software forwarding:
  load-share mode: address source-destination port source-destination
  Universal-id seed: 0xe05e2e85
  Hash for VRF "default"
  Hashing to path *172.0.0.2 (hash: 0x0e), for route:
```

Displaying Routing and Adjacency Information

You can display the routing and adjacency information.

To display the routing and adjacency information, use the following commands in any mode:

Command	Purpose
show {**ip** | **ipv6**} **route** [*route-type* | **interface** *int-type number* | **next-hop**] **Example:** `switch# show ip route`	Displays the unicast route table. The *route-type* argument can be a single route prefix, direct, static, or a dynamic route protocol. Use the **?** command to see the supported interfaces.

Command	Purpose
show {**ip** | **ipv6**} **adjacency** [*prefix* | *interface-type number* [**summary**]| **non-best**] [**detail**] [**vrf** *vrf-id*] **Example:** switch# show ip adjacency	Displays the adjacency table. The argument ranges are as follows: • *prefix*—Any IPv4 or IPv6 prefix address. • *interface-type number*—Use the **?** command to see the supported interfaces. • *vrf-id*—Any case-sensitive, alphanumeric string up to 64 characters.
show {**ip** | **ipv6**} **routing** [*route-type* | **interface** *int-type number* | **next-hop** | **recursive-next-hop** | **summary** | **updated** {**since** | **until**} *time*] **Example:** switch# show routing summary	Displays the unicast route table. The *route-type* argument can be a single route prefix, direct, static, or a dynamic route protocol. Use the **?** command to see the supported interfaces.

This example shows how to display the unicast route table:

```
switch# show ip route
IP Route Table for Context "default"
'*' denotes best ucast next-hop       '**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]

0.0.0.0/0, 1 ucast next-hops, 0 mcast next-hops
   *via 10.1.1.1, mgmt0, [1/0], 5d21h, static
0.0.0.0/32, 1 ucast next-hops, 0 mcast next-hops
   *via Null0, [220/0], 1w6d, local, discard
10.1.0.0/22, 1 ucast next-hops, 0 mcast next-hops, attached
   *via 10.1.1.55, mgmt0, [0/0], 5d21h, direct
10.1.0.0/32, 1 ucast next-hops, 0 mcast next-hops, attached
   *via 10.1.0.0, Null0, [0/0], 5d21h, local
10.1.1.1/32, 1 ucast next-hops, 0 mcast next-hops, attached
   *via 10.1.1.1, mgmt0, [2/0], 5d16h, am
10.1.1.55/32, 1 ucast next-hops, 0 mcast next-hops, attached
   *via 10.1.1.55, mgmt0, [0/0], 5d21h, local
10.1.1.253/32, 1 ucast next-hops, 0 mcast next-hops, attached
   *via 10.1.1.253, mgmt0, [2/0], 5d20h, am
10.1.3.255/32, 1 ucast next-hops, 0 mcast next-hops, attached
   *via 10.1.3.255, mgmt0, [0/0], 5d21h, local
255.255.255.255/32, 1 ucast next-hops, 0 mcast next-hops
   *via Eth Inband Port, [0/0], 1w6d, local
```

This example shows how to display the adjacency information:

```
switch# show ip adjacency

IP Adjacency Table for context default
Total number of entries: 2
Address         Age       MAC Address     Pref Source     Interface       Best
10.1.1.1        02:20:54  00e0.b06a.71eb  50   arp        mgmt0           Yes
10.1.1.253      00:06:27  0014.5e0b.81d1  50   arp        mgmt0           Yes
```

Triggering the Layer 3 Consistency Checker

You can manually trigger the Layer 3 consistency checker.

To manually trigger the Layer 3 consistency checker, use the following commands in global configuration mode:

Command	Purpose
test forwarding [**ipv4** | **ipv6**] [**unicast**] **inconsistency** [**vrf** *vrf-name*] [**module** {*slot*| **all**}] **Example:** `switch(config)# test forwarding inconsistency`	Starts a Layer 3 consistency check. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters. The *slot* range is from 1 to 26.

To stop the Layer 3 consistency checker, use the following commands in global configuration mode:

Command	Purpose
test forwarding [**ipv4** | **ipv6**] [**unicast**] **inconsistency** [**vrf** *vrf-name*] [**module** {*slot*| **all**}] **stop** **Example:** `switch# test forwarding inconsistency stop`	Stops a Layer 3 consistency check. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters. The *slot* range is from 1 to 26.

To display the Layer 3 inconsistencies, use the following commands in any mode:

Command	Purpose
show forwarding [**ipv4** | **ipv6**] **inconsistency** [**vrf** *vrf-name*] [**module** {*slot*| **all**}] **Example:** `switch# show forwarding inconsistency`	Displays the results of a Layer 3 consistency check. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters. The *slot* range is from 1 to 26.

Clearing Forwarding Information in the FIB

You can clear one or more entries in the FIB. Clearing a FIB entry does not affect the unicast RIB.

Caution The **clear forwarding** command disrupts forwarding on the device.

To clear an entry in the FIB, including a Layer 3 inconsistency, use the following command in any mode:

Command	Purpose
clear forwarding {**ipv4** | **ipv6**} **route** {* | *prefix*} [**vrf** *vrf-name*] **module** {*slot*| **all**} **Example:** `switch# clear forwarding ipv4 route * module 1`	Clears one or more entries from the FIB. The route options are as follows: • *—All routes. • *prefix*—Any IP or IPv6 prefix. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters. The *slot* range is from 1 to 26.

Configuring Maximum Routes for the Unicast RIB

You can configure the maximum number of routes allowed in the routing table.

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf-name*
3. **ipv4 unicast**
4. **maximum routes** *max-routes* [*threshold* [**reinstall** *threshold*] | **warning-only**]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**vrf context** *vrf-name* **Example:** `switch(config)# vrf context Red` `switch(config-vrf)#`	Creates a VRF and enters VRF configuration mode.
Step 3	**ipv4 unicast** **Example**: `switch(config-vrf)# ipv4 unicast` `switch(config-vrf-af-ipv4)#`	Enters address-family configuration mode.

	Command	Purpose
Step 4	**maximum routes** *max-routes* [*threshold* [**reinstall** *threshold*] | **warning-only**] **Example:** `switch(config-vrf-af-ipv4)# maximum routes 250 90`	Configures the maximum number of routes allowed in the routing table. The range is from 1 to 4294967295. You can optionally specify the following: • *threshold*—Percentage of maximum routes that triggers a warning message. The range is from 1 to 100. • **warning-only**—Logs a warning message when the maximum number of routes is exceeded. • **reinstall** *threshold*—Reinstalls routes that previously exceeded the maximum route limit and were rejected and specifies the threshold value at which to reinstall them. The threshold range is from 1 to 100.
Step 5	**copy running-config startup-config** **Example:** `switch(config-vrf-af-ipv4)# copy running-config startup-config`	(Optional) Saves this configuration change.

Estimating Memory Requirements for Routes

You can estimate the memory that a number of routes and next-hop addresses will use.

To estimate the memory requirements for routes, use the following command in any mode:

Command	Purpose
show routing {**ipv6**} **memory estimate routes** *num-routes* **next-hops** *num-nexthops* **Example:** `switch# show routing memory estimate routes 5000 next-hops 2`	Displays the memory requirements for routes. The *num-routes* range is from 1000 to 1000000. The *num-nexthops* range is from 1 to 16.

Clearing Routes in the Unicast RIB

You can clear one or more routes from the unicast RIB.

Caution The * keyword is severely disruptive to routing.

To clear one or more entries in the unicast RIB, use the following commands in any mode:

Command	Purpose
clear {**ip** | **ipv4** | **ipv6**} **route** {* | {*route* | *prefix/length*}[*next-hop interface*]} [**vrf** *vrf-name*] **Example:** switch(config)# clear ip route 10.2.2.2	Clears one or more routes from both the unicast RIB and all the module FIBs. The route options are as follows: • *—All routes. • *route*—An individual IP or IPv6 route. • *prefix/length*—Any IP or IPv6 prefix. • *next-hop*—The next-hop address • *interface*—The interface to reach the next-hop address. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters.
clear routing [**multicast** | **unicast**] [**ip** | **ipv4** | **ipv6**] {* | {*route* | *prefix/length*}[*next-hop interface*]} [**vrf** *vrf-name*] **Example:** switch(config)# clear routing ip 10.2.2.2	Clears one or more routes from the unicast RIB. The route options are as follows: • *—All routes. • *route*—An individual IP or IPv6 route. • *prefix/length*—Any IP or IPv6 prefix. • *next-hop*—The next-hop address • *interface*—The interface to reach the next-hop address. The *vrf-name* can be any case-sensitive, alphanumeric string up to 64 characters.

Verifying the Unicast RIB and FIB

To display the unicast RIB and FIB information, perform one the following tasks:

Command	Purpose
show forwarding adjacency	Displays the adjacency table on a module.
show forwarding distribution {**clients** | **fib-state**}	Displays the FIB distribution information.
show forwarding interfaces module *slot*	Displays the FIB information for a module.
show forwarding {**ip** | **ipv4** | **ipv6**} **route**	Displays routes in the FIB.
show {**ip** | **ipv6**} **adjacency**	Displays the adjacency table.
show {**ip** | **ipv6**} **route**	Displays IPv4 or IPv6 routes from the unicast RIB.
show routing	Displays routes from the unicast RIB.

Additional References

For additional information related to managing unicast RIB and FIB, see the following sections:

- Related Documents, page 14-11

Related Documents

Related Topic	Document Title
Configuring EEM	*Cisco Nexus 9000 Series NX-OS System Management Configuration Guide*

Configuring Route Policy Manager

This chapter describes how to configure the Route Policy Manager on the Cisco NX-OS device.

This chapter includes the following sections:

About Route Policy Manager

Route Policy Manager supports route maps and IP prefix lists. These features are used for route redistribution. A prefix list contains one or more IPv4 or IPv6 network prefixes and the associated prefix length values. You can use a prefix list by itself in features such as Border Gateway Protocol (BGP) templates, route filtering, or redistribution of routes that are exchanged between routing domains.

Route maps can apply to both routes and IP packets. Route filtering and redistribution pass a route through a route map.

This section includes the following topics:

Prefix Lists

You can use prefix lists to permit or deny an address or range of addresses. Filtering by a prefix list involves matching the prefixes of routes or packets with the prefixes listed in the prefix list. An implicit deny is assumed if a given prefix does not match any entries in a prefix list.

You can configure multiple entries in a prefix list and permit or deny the prefixes that match the entry. Each entry has an associated sequence number that you can configure. If you do not configure a sequence number, Cisco NX-OS assigns a sequence number automatically. Cisco NX-OS evaluates prefix lists starting with the lowest sequence number. Cisco NX-OS processes the first successful match for a given prefix. Once a match occurs, Cisco NX-OS processes the permit or deny statement and does not evaluate the rest of the prefix list.

Note An empty prefix list permits all routes.

Prefix List Masks

Cisco NX-OS Release 7.0(3)I4(1) introduces masks for prefix lists. Masking uses the number 1 and the number 0 to specify how the software treats the corresponding IP address bits.

- A mask bit 0 means ignore the corresponding bit value.
- A mask bit 1 means check the corresponding bit value for an exact match.

You can use a prefix list to match the IP address in a route map, which in turn is used in routing protocols during redistribution. The IP address is matched against the prefix list where the bits corresponding to the mask bit 1 are the same as the subnet provided in the prefix list.

By carefully setting masks, you can select one or several IP addresses for permit or deny tests.

The prefix list mask allows noncontiguous bits in the mask. You can thus define a range of even- or odd-numbered IP addresses.

Route Maps

You can use route maps for route redistribution. Route map entries consist of a list of match and set criteria. The match criteria specify match conditions for incoming routes or packets, and the set criteria specify the action taken if the match criteria are met.

You can configure multiple entries in the same route map. These entries contain the same route map name and are differentiated by a sequence number.

You create a route map with one or more route map entries arranged by the sequence number under a unique route map name. The route map entry has the following parameters:

- Sequence number
- Permission—permit or deny
- Match criteria
- Set changes

By default, a route map processes routes or IP packets in a linear fashion, that is, starting from the lowest sequence number. You can configure the route map to process in a different order using the **continue** statement, which allows you to determine which route map entry to process next.

Match Criteria

You can use a variety of criteria to match a route or IP packet in a route map. Some criteria, such as BGP community lists, are applicable only to a specific routing protocol, while other criteria, such as the IP source or the destination address, can be used for any route or IP packet.

When Cisco NX-OS processes a route or packet through a route map, it compares the route or packet to each of the match statements configured. If the route or packet matches the configured criteria, Cisco NX-OS processes it based on the permit or deny configuration for that match entry in the route map and any set criteria configured.

The match categories and parameters are as follows:

- BGP parameters—Match based on AS numbers, AS-path, community attributes, or extended community attributes.
- Prefix lists—Match based on an address or range of addresses.
- Multicast parameters—Match based on a rendezvous point, groups, or sources.
- Other parameters—Match based on an IP next-hop address or packet length.

Set Changes

Once a route or packet matches an entry in a route map, the route or packet can be changed based on one or more configured set statements.

The set changes are as follows:

- BGP parameters—Change the AS-path, tag, community, extended community, dampening, local preference, origin, or weight attributes.
- Metrics—Change the route-metric, the route-tag, or the route-type.
- Other parameters—Change the forwarding address or the IP next-hop address.

Access Lists

IP access lists can match the packet to a number of IP packet fields such as the following:

- Source or destination IPv4 or IPv6 address
- Protocol
- Precedence
- ToS

AS Numbers for BGP

You can configure a list of AS numbers to match against BGP peers. If a BGP peer matches an AS number in the list and matches the other BGP peer configuration, BGP creates a session. If the BGP peer does not match an AS number in the list, BGP ignores the peer. You can configure the AS numbers as a list, a range of AS numbers, or you can use an AS-path list to compare the AS numbers against a regular expression.

AS-Path Lists for BGP

You can configure an AS-path list to filter inbound or outbound BGP route updates. If the route update contains an AS-path attribute that matches an entry in the AS-path list, the router processes the route based on the permit or deny condition configured. You can configure AS-path lists within a route map.

You can configure multiple AS-path entries in an AS-path list by using the same AS-path list name. The router processes the first entry that matches.

Community Lists for BGP

You can filter BGP route updates based on the BGP community attribute by using community lists in a route map. You can match the community attribute based on a community list, and you can set the community attribute using a route map.

A community list contains one or more community attributes. If you configure more than one community attribute in the same community list entry, the BGP route must match all community attributes listed to be considered a match.

You can also configure multiple community attributes as individual entries in the community list by using the same community list name. In this case, the router processes the first community attribute that matches the BGP route, using the permit or deny configuration for that entry.

You can configure community attributes in the community list in one of the following formats:

- A named community attribute, such as **internet** or **no-export.**
- In *aa:nn* format, where the first two bytes represent the two-byte AS number and the last two bytes represent a user-defined network number.
- A regular expression.

Extended Community Lists for BGP

Extended community lists support 4-byte AS numbers. You can configure community attributes in the extended community list in one of the following formats:

- In *aa4:nn* format, where the first four bytes represent the four-byte AS number and the last two bytes represent a a user-defined network number.
- A regular expression.

Cisco NX-OS supports generic specific extended community lists, which provide similar functionality to regular community lists for four-byte AS numbers. You can configure generic specific extended community lists with the following properties:

- Transitive—BGP propagates the community attributes across autonomous systems.
- Nontransitive—BGP removes community attributes before propagating the route to another autonomous system.

Route Redistribution and Route Maps

You can use route maps to control the redistribution of routes between routing domains. Route maps match on the attributes of the routes to redistribute only those routes that pass the match criteria. The route map can also modify the route attributes during this redistribution using the set changes.

The router matches redistributed routes against each route map entry. If there are multiple match statements, the route must pass all of the match criteria. If a route passes the match criteria defined in a route map entry, the actions defined in the entry are executed. If the route does not match the criteria, the router compares the route against subsequent route map entries. Route processing continues until a match is made or the route is processed by all entries in the route map with no match. If the router processes the route against all entries in a route map with no match, the router accepts the route (inbound route maps) or forwards the route (outbound route maps).

Note When you redistribute BGP to IGP, iBGP is redistributed as well. To override this behavior, you must insert an additional deny statement into the route map.

Licensing Requirements for Route Policy Manager

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	Route Policy Manager requires no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Guidelines and Limitations

Route Policy Manager has the following configuration guidelines and limitations:

- An empty route map denies all the routes.
- An empty prefix list permits all the routes.
- Without any match statement in a route-map entry, the permission (permit or deny) of the route-map entry decides the result for all the routes or packets.
- If referred policies (for example, prefix lists) within a match statement of a route-map entry return either a no-match or a deny-match, Cisco NX-OS fails the match statement and processes the next route-map entry.
- When you change a route map, Cisco NX-OS holds all the changes until you exit from the route-map configuration submode. Cisco NX-OS then sends all the changes to the protocol clients to take effect.
- Cisco recommends that you do not have both IPv4 and IPv6 match statements in the same route-map sequence. If both are required, they should be specified in different sequences in the same route-map.
- Because you can use a route map before you define it, verify that all your route maps exist when you finish a configuration change.
- You can view the route-map usage for redistribution and filtering. Each individual routing protocol provides a way to display these statistics.
- When you redistribute BGP to IGP, iBGP is redistributed as well. To override this behavior, you must insert an additional deny statement into the route map.
- Route Policy Manager does not support MAC lists.

Default Settings

Table 15-1 lists the default settings for Route Policy Manager.

Table 15-1 Default Route Policy Manager Parameters

Parameters	Default
Route Policy Manager	Enabled
Administrative distance	115

Configuring Route Policy Manager

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Configuring IP Prefix Lists

IP prefix lists match the IP packet or route against a list of prefixes and prefix lengths. You can create an IP prefix list for IPv4 and create an IPv6 prefix list for IPv6.

You can configure the prefix list entry to match the prefix length exactly or to match any prefix with a length that matches the configured range of prefix lengths.

Use the **ge** and **lt** keywords to create a range of possible prefix lengths. The incoming packet or route matches the prefix list if the prefix matches and if the prefix length is greater than or equal to the **ge** keyword value (if configured) and less than or equal to the **lt** keyword value (if configured).

Use the **mask** keyword to define a range of possible contiguous or non-contiguous routes to be compared to the prefix address.

SUMMARY STEPS

1. **configure terminal**
2. {**ip** | **ipv6**} **prefix-list** *name* **description** *string*
3. **ip prefix-list** *name* [**seq** *number*] [{**permit** | **deny**} *prefix* {[**eq** *prefix-length*] | [**ge** *prefix-length*] [**le** *prefix-length*]}] [**mask** *mask*]

   or

   ipv6 prefix-list *name* [**seq** *number*] [{**permit** | **deny**} *prefix* **{[eq** *prefix-length*] | [**ge** *prefix-length*] [**le** *prefix-length*]}] [**mask** *mask*]
4. (Optional) **show** {**ip** | **ipv6**} **prefix-list** *name*
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	{**ip** | **ipv6**} **prefix-list** *name* **description** *string* **Example**: switch(config)# ip prefix-list AllowPrefix description allows engineering server	(Optional) Adds an information string about the prefix list.
Step 3	**ip prefix-list** *name* [**seq** *number*] [{**permit** | **deny**} *prefix* {[**eq** *prefix-length*] | [**ge** *prefix-length*] [**le** *prefix-length*]}] [**mask** *mask*] **Example:** switch(config)# ip prefix-list AllowPrefix seq 10 permit 192.0.2.0/24 eq 24 **Example:** switch(config)# ip prefix-list even permit 0.0.0.0/32 mask 0.0.0.1	Creates an IPv4 prefix list or adds a prefix to an existing prefix list. The prefix length is matched as follows: • eq—Matches the exact *prefix length*. • ge—Matches a prefix length that is equal to or greater than the configured *prefix length*. • le—Matches a prefix length that is equal to or less than the configured *prefix length*. • mask—Specifies the bits of a prefix address in a prefix list that are compared to the bits of the prefix address used in routing protocols during redistribution.
	ipv6 prefix-list *name* [**seq** *number*] [{**permit** | **deny**} *prefix* {[**eq** *prefix-length*] | [**ge** *prefix-length*] [**le** *prefix-length*]}] [**mask** *mask*] **Example:** switch(config)# ipv6 prefix-list AllowIPv6Prefix seq 10 permit 2001:0DB8:: le 32	Creates an IPv6 prefix list or adds a prefix to an existing prefix list. The prefix length is configured as follows: • eq—Matches the exact *prefix length*. • ge—Matches a prefix length that is equal to or greater than the configured *prefix length*. • le—Matches a prefix length that is equal to or less than the configured *prefix length*. • mask—Specifies the bits of a prefix address in a prefix list that are compared to the bits of the prefix address used in routing protocols during redistribution.
Step 4	**show** {**ip** | **ipv6**} **prefix-list** *name* **Example**: switch(config)# show ip prefix-list AllowPrefix	(Optional) Displays information about prefix lists.
Step 5	**copy running-config startup-config** **Example:** switch# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create an IPv4 prefix list with two entries and apply the prefix list to a BGP neighbor:

```
switch# configure terminal
switch(config)# ip prefix-list allowprefix seq 10 permit 192.0.2.0/24 eq 24
switch(config)# ip prefix-list allowprefix seq 20 permit 209.165.201.0/27 eq 27
switch(config)# router bgp 65535
switch(config-router)# neighbor 192.0.2.1/16 remote-as 65534
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)# prefix-list allowprefix in
```

This example shows how to create an IPv4 prefix list with a match mask for all /24 odd IP addresses:

```
switch# configure terminal
switch(config)# ip prefix-list list1 seq 7 permit 22.1.1.0/24 mask 255.255.1.0
switch(config)# show route-map test
route-map test, permit, sequence 7
  Match clauses:
    ip address prefix-lists: list1
  Set clauses:
    extcommunity COST:igp:10:20
switch(config)# show ip prefix-list list1
ip prefix-list list1: 1 entries
   seq 7 permit 22.1.1.0/24 mask 255.255.1.0
```

This example shows how to create an IPv4 prefix list that matches all subnets of 21.1.0.0/16 where the subnet prefix is 17 or greater. Due to the **mask** option, only those incoming prefixes where the first bit in the third octet is unset (even) will be matched.

```
switch# configure terminal
switch(config)# ip prefix-list list1 seq 10 permit 21.1.0.0/16 ge 17 mask 255.255.1.0
```

Configuring AS-Path Lists

You can specify an AS-path list filter on both inbound and outbound BGP routes. Each filter is an access list based on regular expressions. If the regular expression matches the representation of the AS-path attribute of the route as an ASCII string, the permit or deny condition applies.

SUMMARY STEPS

1. **configure terminal**
2. **ip as-path access-list** *name* {**deny** | **permit**} *expression*
3. (Optional) **show** {**ip** | **ipv6**} **as-path list** *name*
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.

	Command	Purpose
Step 2	**ip as-path access-list** *name* {**deny** | **permit**} *expression* **Example:** switch(config)# ip as-path access-list Allow40 permit 40	Creates a BGP AS-path list using a regular expression.
Step 3	**show** {**ip** | **ipv6**} **as-path-access-list** *name* **Example**: switch(config)# show ip as-path-access-list Allow40	(Optional) Displays information about as-path access lists.
Step 4	**copy running-config startup-config** **Example:** switch# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create an AS-path list with two entries and apply the AS path list to a BGP neighbor:

```
switch# configure terminal
switch(config)# ip as-path access-list AllowAS permit 64510
switch(config)# ip as-path access-list AllowAS permit 64496
switch(config)# copy running-config startup-config
switch(config)# router bgp 65535:20
switch(config-router)# neighbor 192.0.2.1/16 remote-as 65535:20
switch(config-router-neighbor)# address-family ipv4 unicast
switch(config-router-neighbor-af)# filter-list AllowAS in
```

Configuring Community Lists

You can use community lists to filter BGP routes based on the community attribute. The community number consists of a 4-byte value in the *aa:nn* format. The first two bytes represent the autonomous system number, and the last two bytes represent a user-defined network number.

When you configure multiple values in the same community list statement, all community values must match to satisfy the community list filter. When you configure multiple values in separate community list statements, the first list that matches a condition is processed.

Use community lists in a match statement to filter BGP routes based on the community attribute.

SUMMARY STEPS

1. **configure terminal**
2. **ip community-list standard** *list-name* {**deny** | **permit**} [*community-list*] [**internet**] [**local-AS**] [**no-advertise**] [**no-export**]

   or

   ip community-list expanded *list-name* {**deny** | **permit**} *expression*
3. (Optional) **show ip community-list** *name*
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**ip community-list standard** *list-name* {**deny** | **permit**} [*community-list*] [**internet**] [**local-AS**] [**no-advertise**] [**no-export**] **Example:** switch(config)# ip community-list standard BGPCommunity permit no-advertise 65535:20	Creates a standard BGP community list. The *list-name* can be any case-sensitive, alphanumeric string up to 63 characters. The *community-list* can be one or more communities in the *aa:nn* format.
	ip community-list expanded *list-name* {**deny** | **permit**} *expression* **Example:** switch(config)# ip community-list expanded BGPComplex deny 50000:[0-9][0-9]_	Creates an expanded BGP community list using a regular expression.
Step 3	**show ip community-list** *name* **Example**: switch(config)# show ip community-list BGPCommunity	(Optional) Displays information about community lists.
Step 4	**copy running-config startup-config** **Example:** switch# copy running-config startup-config	(Optional) Saves this configuration change.

This example shows how to create a community list with two entries:

```
switch# configure terminal
switch(config)# ip community-list standard BGPCommunity permit no-advertise 65535:20
switch(config)# ip community-list standard BGPCommunity permit local-AS no-export
switch(config)# copy running-config startup-config
```

Configuring Extended Community Lists

You can use extended community lists to filter BGP routes based on the community attribute. The community number consists of a 6-byte value in the *aa4:nn* format. The first four bytes represent the autonomous system number, and the last two bytes represent a user-defined network number.

When you configure multiple values in the same extended community list statement, all extended community values must match to satisfy the extended community list filter. When you configure multiple values in separate extended community list statements, the first list that matches a condition is processed.

Use extended community lists in a match statement to filter BGP routes based on the extended community attribute.

SUMMARY STEPS

1. **configure terminal**
2. **ip extcommunity-list standard** *list-name* {**deny** | **permit**} **4bytegeneric** {**transitive** | **non-transitive**} *aa4:nn*

   or

   ip extcommunity-list expanded *list-name* {**deny** | **permit**} *expression*
3. (Optional) **show ip extcommunity-list** *name*
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**ip extcommunity-list standard** *list-name* {**deny** | **permit**} **4bytegeneric** {**transitive** | **nontransitive**} *community1* [*community2...*] **Example:** `switch(config)# ip extcommunity-list standard BGPExtCommunity permit 4bytegeneric transitive 65535:20`	Creates a standard BGP extended community list. The *community* can be one or more extended communities in the *aa4:nn* format.
	ip extcommunity-list expanded *list-name* {**deny** | **permit**} *expression* **Example:** `switch(config)# ip extcommunity-list expanded BGPExtComplex deny 1.5:[0-9][0-9]_`	Creates an expanded BGP extended community list using a regular expression.
Step 3	**show ip community-list** *name* **Example**: `switch(config)# show ip community-list BGPCommunity`	(Optional) Displays information about extended community lists.
Step 4	**copy running-config startup-config** **Example:** `switch# copy running-config startup-config`	(Optional) Saves this configuration change.

This example shows how to create a generic specific extended community list:

```
switch# configure terminal
switch(config)# ip extcommunity-list standard test1 permit 4bytegeneric transitive
65535:40 65535:60
switch(config)# copy running-config startup-config
```

Configuring Route Maps

You can use route maps for route redistribution or route filtering. Route maps can contain multiple match criteria and multiple set criteria.

Configuring a route map for BGP triggers an automatic soft clear or refresh of BGP neighbor sessions.

SUMMARY STEPS

1. **configure terminal**
2. **route-map** *map-name* [**permit** | **deny**] [*seq*]
3. (Optional) **continue** *seq*
4. (Optional) **exit**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**route-map** *map-name* [**permit** | **deny**] [*seq*] **Example:** `switch(config)# route-map Testmap permit 10` `switch(config-route-map)#`	Creates a route map or enters route-map configuration mode for an existing route map. Use *seq* to order the entries in a route map.
Step 3	**continue** *seq* **Example:** `switch(config-route-map)# continue 10`	(Optional) Determines what sequence statement to process next in the route map. Used only for filtering and redistribution.
Step 4	**exit** **Example:** `switch(config-route-map)# exit`	(Optional) Exits route-map configuration mode.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

You can configure the following optional match parameters for route maps in route-map configuration mode:

Note The **default-information originate** command ignores **match** statements in the optional route map.

Command	Purpose
match as-path *name* [*name...*] **Example:** `switch(config-route-map)# match as-path Allow40`	Matches against one or more AS-path lists. Create the AS-path list with the **ip as-path access-list** command.
match as-number {*number* [*,number...*] | **as-path-list** *name* [*name...*]} **Example:** `switch(config-route-map)# match as-number 33,50-60`	Matches against one or more AS numbers or AS-path lists. Create the AS-path list with the **ip as-path access-list** command. The number range is from 1 to 65535. The AS-path list name can be any case-sensitive, alphanumeric string up to 63 characters.
match community *name* [*name...*][***exact-match***] **Example:** `switch(config-route-map)# match community BGPCommunity`	Matches against one or more community lists. Create the community list with the **ip community-list** command.
match extcommunity *name* [*name...*][***exact-match***] **Example:** `switch(config-route-map)# match extcommunity BGPextCommunity`	Matches against one or more extended community lists. Create the community list with the **ip extcommunity-list** command.
match interface *interface-type number* [*interface-type number...* **Example:** `switch(config-route-map)# match interface e 1/2`	Matches any routes that have their next hop out one of the configured interfaces. Use **?** to find a list of supported interface types.
match ip address prefix-list *name* [*name...*] **Example:** `switch(config-route-map)# match ip address prefix-list AllowPrefix`	Matches against one or more IPv4 prefix lists. Use the **ip prefix-list** command to create the prefix list.
match ipv6 address prefix-list *name* [*name...*] **Example:** `switch(config-route-map)# match ip address prefix-list AllowIPv6Prefix`	Matches against one or more IPv6 prefix lists. Use the **ipv6 prefix-list** command to create the prefix list.
match ip multicast [**source** *ipsource*] [[**group** *ipgroup*] [*rp iprp*]] **Example:** `switch(config-route-map)# match ip multicast rp 192.0.2.1`	Matches an IPv4 multicast packet based on the multicast source, group, or rendezvous point.

Command	Purpose
match ipv6 multicast [**source** *ipsource*] [[**group** *ipgroup*] [*rp iprp*]] **Example:** `switch(config-route-map)# match ip multicast source 2001:0DB8::1`	Matches an IPv6 multicast packet based on the multicast source, group, or rendezvous point.
match ip next-hop prefix-list *name* [*name...*] **Example:** `switch(config-route-map)# match ip next-hop prefix-list AllowPrefix`	Matches the IPv4 next-hop address of a route to one or more IP prefix lists. Use the **ip prefix-list** command to create the prefix list.
match ipv6 next-hop prefix-list *name* [*name...*] **Example:** `switch(config-route-map)# match ipv6 next-hop prefix-list AllowIPv6Prefix`	Matches the IPv6 next-hop address of a route to one or more IP prefix lists. Use the **ipv6 prefix-list** command to create the prefix list.
match ip route-source prefix-list *name* [*name...*] **Example:** `switch(config-route-map)# match ip route-source prefix-list AllowPrefix`	Matches the IPv4 route source address of a route to one or more IP prefix lists. Use the **ip prefix-list** command to create the prefix list.
match ipv6 route-source prefix-list *name* [*name...*] **Example:** `switch(config-route-map)# match ipv6 route-source prefix-list AllowIPv6Prefix`	Matches the IPv6 route-source address of a route to one or more IP prefix lists. Use the **ipv6 prefix-list** command to create the prefix list.
match metric *value* [**+-** *deviation.*] [*value..*] **Example:** `switch(config-route-map)# match metric 50 + 10`	Matches the route metric against one or more metric values or value ranges. Use +- *deviation* argument to set a metric range. The route map matches any route metric that falls within the range: *value* - *deviation* to *value* + *deviation*.
match ospf-area *area-id* **Example:** `switch(config-route-map)# match ospf-area 1`	Matches the OSPFv2 or OSPFv3 area ID. The *area-id* range is from 0 to 4294967295.

Command	Purpose
match route-type *route-type* **Example:** `switch(config-route-map)# match route-type level 1 level 2`	Matches against a type of route. The *route-type* can be one or more of the following: • external—The external route (BGP, EIGRP, and OSPF type 1 or 2) • inter-area—The OSPF inter-area route • internal—The internal route (including the OSPF intra- or inter-area) • intra-area—The OSPF intra-area route • level-1—The IS-IS level 1 route • level-2—The IS-IS level 2 route • local—The locally generated route • nssa-external—The NSSA external route (OSPF type 1 or 2). • type-1—The OSPF external type 1 route • type-2—The OSPF external type 2 route
match tag *tagid* [*tagid...*] **Example:** `switch(config-route-map)# match tag 2`	Matches a route against one or more tags for filtering or redistribution.
match vlan *vlan-id* [*vlan-range*] **Example:** `switch(config-route-map)# match vlan 3, 5-10`	Matches against a VLAN.

You can configure the following optional set parameters for route maps in route-map configuration mode:

Command	Purpose
set as-path {**tag** | **prepend** {**last-as** *number* | *as-1* [*as-2...*]}} **Example:** `switch(config-route-map)# set as-path prepend 10 100 110`	Modifies an AS-path attribute for a BGP route. You can prepend the configured *number* of last AS numbers or a string of particular AS-path values (*as-1 as-2...as-n*).
set comm-list *name* **delete** **Example:** `switch(config-route-map)# set comm-list BGPCommunity delete`	Removes communities from the community attribute of an inbound or outbound BGP route update. Use the **ip community-list** command to create the community list.

Command	Purpose
set community {**none** | **additive** | **local-AS** | **no-advertise** | **no-export** | *community-1* [community-2...]} **Example:** switch(config-route-map)# set community local-AS	Sets the community attribute for a BGP route update. **Note** When you use both the **set community** and **set comm-list delete** commands in the same sequence of a route map attribute, the deletion operation is performed before the set operation. **Note** Use the **send-community** command in BGP neighbor address-family configuration mode to propagate BGP community attributes to BGP peers.
set dampening *halflife reuse suppress duration* **Example:** switch(config-route-map)# set dampening 30 1500 10000 120	Sets the following BGP route dampening parameters: • *halflife*—The range is from 1 to 45 minutes. The default is 15. • *reuse*—The range is from is 1 to 20000 seconds. The default is 750. • *suppress*—The range is from is 1 to 20000. The default is 2000. • *duration*—The range is from is 1 to 255 minutes. The default is 60.
set distance *value* **Example:** switch(config-route-map)# set distance 150	Sets the administrative distance of routes for OSPFv2 or OSPFv3. The range is from 1 to 255.
set extcomm-list *name* **delete** **Example:** switch(config-route-map)# set extcomm-list BGPextCommunity delete	Removes communities from the extended community attribute of an inbound or outbound BGP route update. Use the **ip extcommunity-list** command to create the extended community list.
set extcommunity 4byteas-generic {**transitive** | **nontransitive**} {**none** | **additive**] *community-1* [community-2...]} **Example:** switch(config-route-map)# set extcommunity generic transitive 1.0:30	Sets the extended community attribute for a BGP route update. **Note** When you use both the **set extcommunity** and **set extcomm-list delete** commands in the same sequence of a route map attribute, the deletion operation is performed before the set operation. **Note** Use the **send-community** command in BGP neighbor address-family configuration mode to propagate BGP extended community attributes to BGP peers.

Command	Purpose
set extcommunity cost *community-id1 cost* [**igp** | **pre-bestpath**] [*community-id2...*]} **Example:** switch(config-route-map)# set extcommunity cost 33 1.0:30	Sets the cost community attribute for a BGP route update. This attribute allows you to customize the BGP best-path selection process for a local autonomous system or confederation. The *community-id* range is from 0 to 255. The *cost* range is from 0 to 4294967295. The path with the lowest cost is preferred. For paths with equal cost, the path with the lowest community ID is preferred. The **igp** keyword compares the cost after the IGP cost comparison. The **pre-bestpath** keyword compares before all other steps in the bestpath algorithm.
set extcommunity rt *community-1* [**additive**] [community-2...]} **Example:** switch(config-route-map)# set extcommunity rt 1.0:30	Sets the extended community route target attribute for a BGP route update. The *community* value can be a 2-byte AS number:4-byte network number, a 4-byte AS number:2-byte network number, or an IP address:2-byte network number. Use the **additive** keyword to add a route target to an existing extended community route target attribute.
set forwarding-address **Example:** switch(config-route-map)# set forwarding-address	Sets the forwarding address for OSPF.
set ip next-hop unchanged **Example:** switch(config-route-map)# set ip next-hop unchanged	Specifies an unchanged next-hop IP address. This command is required for BGP IPv6-over-IPv4 peering.
set level {**backbone** | **level-1** | **level-1-2** | **level-2**} **Example:** switch(config-route-map)# set level backbone	Sets what area to import routes to for IS-IS. The options for IS-IS are level-1, level-1-2, or level-2. The default is level-1.
set local-preference *value* **Example:** switch(config-route-map)# set local-preference 4000	Sets the BGP local preference value. The range is from 0 to 4294967295.
set metric [**+** | **-**]*bandwidth-metric* **Example:** switch(config-route-map)# set metric +100	Adds or subtracts from the existing metric value. The metric is in Kb/s. The range is from 0 to 4294967295.

Command	Purpose
set metric *bandwidth* [*delay reliability load mtu*] **Example:** `switch(config-route-map)# set metric 33 44 100 200 1500`	Sets the route metric values. Metrics are as follows: • *metric0*—Bandwidth in Kb/s. The range is from 0 to 4294967295. • *metric1*—Delay in 10-microsecond units. • *metric2*—Reliability. The range is from 0 to 255 (100 percent reliable). • *metric3*—Loading. The range is from 1 to 255 (100 percent loaded). • *metric4*—MTU of the path. The range is from 1 to 16777215.
set metric-type {**external** | **internal** | **type-1** | **type-2**} **Example:** `switch(config-route-map)# set metric-type internal`	Sets the metric type for the destination routing protocol. The options are as follows: external—IS-IS external metric internal— IGP metric as the MED for BGP type-1—OSPF external type 1 metric type-2—OSPF external type 2 metric
set nssa-only **Example:** `switch(config-route-map)# set nssa-only`	Sets Type-7 LSA generated on ASBR with no P bit set. This prevents Type-7 to Type-5 LSA translation in OSPF.
set origin {**egp** *as-number* | **igp** | **incomplete**} **Example:** `switch(config-route-map)# set origin incomplete`	Sets the BGP origin attribute. The EGP *as-number* range is from 0 to 65535.
set tag *name* **Example:** `switch(config-route-map)# set tag 33`	Sets the tag value for the destination routing protocol. The *name* parameter is an unsigned integer.
set weight *count* **Example:** `switch(config-route-map)# set weight 33`	Sets the weight for the BGP route. The range is from 0 to 65535.

The **set metric-type internal** command affects an outgoing policy and an eBGP neighbor only. If you configure both the **metric** and **metric-type internal** commands in the same BGP peer outgoing policy, Cisco NX-OS ignores the **metric-type internal** command.

Verifying the Route Policy Manager Configuration

To display route policy manager configuration information, perform one of the following tasks:

Command	Purpose
show ip community-list [*name*]	Displays information about a community list.
show ip extcommunity-list [*name*]	Displays information about an extended community list.
show [**ip** | **ipv6**] **prefix-list** [*name*]	Displays information about an IPv4 or IPv6 prefix list.
show route-map [*name*]	Displays information about a route map.

Configuration Examples for Route Policy Manager

This example shows how to use an address family to configure Route Policy Manager so that any unicast and multicast routes from neighbor 209.0.2.1 are accepted if they match prefix-list AllowPrefix:

```
router bgp 64496

neighbor 172.16.0.1 remote-as 64497
  address-family ipv4 unicast
    route-map filterBGP in

route-map filterBGP
 match ip address prefix-list AllowPrefix

ip prefix-list AllowPrefix 10 permit 192.0.2.0/24
ip prefix-list AllowPrefix 20 permit 172.16.201.0/27
```

Related Topics

The following topics can give more information on Route Policy Manager:

- Chapter 9, “Configuring Basic BGP”

Configuring Policy-Based Routing

This chapter describes how to configure policy-based routing on the Cisco NX-OS device.

This chapter includes the following sections:

About Policy-Based Routing

With policy-based routing, you can configure a defined policy for IPv4 and IPv6 traffic flows that lessens the reliance on routes derived from routing protocols. All packets received on an interface with policy-based routing enabled are passed through enhanced packet filters or route maps. The route maps dictate the policy that determines where to forward packets.

Policy-based routing includes the following features:

- Source-based routing—Routes traffic that originates from different sets of users through different connections across the policy routers.
- Quality of Service (QoS)—Differentiates traffic by setting the precedence or type of service (ToS) values in the IP packet headers at the periphery of the network and leveraging queuing mechanisms to prioritize traffic in the core or backbone of the network (see the *Cisco Nexus 9000 Series NX-OS Quality of Service Configuration Guide*).
- Load sharing—Distributes traffic among multiple paths based on the traffic characteristics.

Policy Route Maps

Each entry in a route map contains a combination of match and set statements. The match statements define the criteria for whether appropriate packets meet the particular policy (that is, the conditions to be met). The set clauses explain how the packets should be routed once they have met the match criteria.

You can mark the route-map statements as permit or deny. You can interpret the statements as follows:

- If the statement is marked as permit and the packets meet the match criteria, the set clause is applied. One of these actions involves choosing the next hop.
- If a statement is marked as deny, the packets that meet the match criteria are sent back through the normal forwarding channels, and destination-based routing is performed.
- If the statement is marked as permit and the packets do not match any route-map statements, the packets are sent back through the normal forwarding channels, and destination-based routing is performed.

Note Policy-based routing is specified on the interface that receives the packets, not on the interface from which the packets are sent.

Set Criteria for Policy-Based Routing

The Cisco Nexus 9000 Series switches support the following **set** commands for route maps used in policy-based routing:

- **set** {**ip** | **ipv6**} **next-hop** *address1* [*address2...*] [**load-share**]
- **set interface null0**

These **set** commands are mutually exclusive within the route-map sequence.

In the first command, the IP address specifies the adjacent next-hop router in the path toward the destination to which the packets should be forwarded. The first IP address associated with a currently up connected interface is used to route the packets.

Note You can optionally configure this command for next-hop addresses to load balance traffic for up to 32 IP addresses. In this case, Cisco NX-OS sends all traffic for each IP flow to a particular IP next-hop address.

If the packets do not meet any of the defined match criteria, those packets are routed through the normal destination-based routing process.

Route-Map Processing Logic

When a packet is received on an interface that is configured with a route map, the forwarding logic processes each route-map statement according to the sequence number.

If the route-map statement encountered is a **route-map...permit** statement, the packet is matched against the criteria in the **match** command. This command may refer to an ACL that has one or more access control entries (ACEs). If the packet matches the permit ACEs in the ACL, the policy-based routing logic executes the action specified by the **set** command on the packet.

If the route-map statement encountered is a **route-map... deny** statement, the packet is matched against the criteria in the **match** command. This command may refer to an ACL that has one or more ACEs. If the packet matches the permit ACEs in the ACL, policy-based routing processing terminates, and the packet is routed using the default IP routing table.

Note The **set** command has no effect inside a **route-map... deny** statement.

If the route-map configuration does not contain a match statement, the policy-based routing logic executes the action specified by the **set** command on the packet. All packets are routed using policy-based routing.

If the route-map configuration references a match statement but the match statement references a non-existing ACL or an existing ACL without any access control entries (ACEs), the packet is routed using the default routing table.

If the next-hop specified in the **set** {**ip** | **ipv6**} **next-hop** command is down, is not reachable, or is removed, the packet is routed using the default routing table.

Policy-Based Routing Filtering Options

You can identify traffic by using additional options. The following list includes most but not all additional filtering options.

Policy-based routing ACLs support the following additional filtering options:

- Layer 3 source and/or destination address
- TCP and UDP ports
- Precedence level
- Differentiated Services Code Point (DSCP) value
- TCP packets with the ACK, FIN, PSH, RST, SYN, or URG bit set
- Established TCP connections
- Packet length

Licensing Requirements for Policy-Based Routing

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	Policy-based routing requires an Enterprise Services license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for Policy-Based Routing

Policy-based routing has the following prerequisites:

- Install the correct license.
- Enable policy-based routing.
- Assign an IP address on the interface and bring the interface up before you apply a route map on the interface for policy-based routing.

Guidelines and Limitations

Policy-based routing has the following configuration guidelines and limitations:

- A policy-based routing route map can have only one match statement per route-map statement.
- A policy-based routing route map can have only one set statement per route-map statement, unless you are using IP SLA policy-based routing. For information on IP SLA policy-based routing, see the *Cisco Nexus 9000 Series NX-OS IP SLAs Configuration Guide.*
- A **match** command cannot refer to more than one ACL in a route map used for policy-based routing.
- The same route map can be shared among different interfaces for policy-based routing as long as the interfaces belong to the same virtual routing and forwarding (VRF) instance.
- Using a prefix list as a match criteria is not supported. Do not use a prefix list in a policy-based routing route map.
- Policy-based routing supports only unicast traffic. Multicast traffic is not supported.
- Policy-based routing is not supported with inbound traffic on FEX ports.
- Policy-based routing is not supported on FEX ports for Cisco Nexus 9300-EX Series switches.
- Policy-based routing is not supported with Layer 3 port-channel subinterfaces.
- An ACL used in a policy-based routing route map cannot include deny access control entries (ACEs).
- Policy-based routing is supported only in the default system routing mode.
- The Cisco Nexus 9000 Series switches do not support the **set vrf** and **set default next-hop** commands.
- Policy-based routing traffic cannot be balanced if the next hop is recursive over ECMP paths. Instead, use the **set** {**ip** | **ipv6**} **next-hop** *ip-address* **load-share** command to specify the adjacent next hops.

- Beginning with Cisco NX-OS Release 6.1(2)I3(2), the Cisco Nexus 9000 Series switches support policy-based ACLs (PBACLs), also referred to as object-group ACLs. For more information, see the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide*.
- Beginning with Cisco NX-OS 7.0(3)I5(1), Cisco Nexus 9200 and 9300-EX Series switches support IPv4 and IPv6 policy-based routing. Cisco Nexus 9500 Series switches with the X9732C-EX line card support only IPv4 policy-based routing.
- If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Default Settings

Table 16-1 lists the default settings for policy-based routing.

Table 16-1 Default Policy-Based Routing Parameters

Parameters	Default
Policy-based routing	Disabled

Configuring Policy-Based Routing

This section includes the following topics:

Enabling the Policy-Based Routing Feature

You must enable the policy-based routing feature before you can configure a route policy.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **feature pbr**
3. (Optional) **show feature**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	[**no**] **feature pbr** **Example:** `switch(config)# feature pbr`	Enables the policy-based routing feature. Use the **no** form of this command to disable the policy-based routing feature. **Note** The **no feature pbr** command removes the policies applied under the interfaces. It does not remove the ACL or route-map configuration nor does it create a system checkpoint.
Step 3	**show feature** **Example:** `switch(config)# show feature`	(Optional) Displays enabled and disabled features.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

Configuring a Route Policy

You can use route maps in policy-based routing to assign routing policies to the inbound interface. Cisco NX-OS routes the packets as soon as it finds a next hop and an interface.

BEFORE YOU BEGIN

You must configure the IPv6 RACL TCAM region (using TCAM carving) before you apply the policy-based routing policy for IPv6 traffic. For instructions, see the "Configuring ACL TCAM Region Sizes" and "Configuring TCAM Carving - For Cisco NX-OS Release 6.1(2)I2(1) and Later Releases" sections in the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide*.

Note The switch has an IPv4 RACL TCAM region by default for IPv4 traffic.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *type slot/port*
3. {**ip** | **ipv6**} **policy route-map** *map-name*
4. **route-map** *map-name* [**permit** | **deny**] [*seq*]
5. **match** {**ip** | **ipv6**} **address access-list-name** *name* [*name...*]

6. (Optional) **set ip next-hop** *address1* [*address2...*] [**load-share**]
7. (Optional) **set ipv6 next-hop** *address1* [*address2...*] [**load-share**]
8. (Optional) **set interface null0**
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	{**ip** | **ipv6**} **policy route-map** *map-name* **Example**: `switch(config-if)# ip policy route-map Testmap`	Assigns a route map for IPv4 or IPv6 policy-based routing to the interface.
Step 4	**route-map** *map-name* [**permit** | **deny**] [*seq*] **Example:** `switch(config-if)# route-map Testmap` `switch(config-route-map)#`	Creates a route map or enters route-map configuration mode for an existing route map. Use *seq* to order the entries in a route map.
Step 5	**match** {**ip** | **ipv6**} **address access-list-name** *name* [*name...*] **Example**: `switch(config-route-map)# match ip address access-list-name ACL1`	Matches an IPv4 or IPv6 address against one or more IP or IPv6 access control lists (ACLs). This command is used for policy-based routing and is ignored by route filtering or redistribution.
Step 6	**set ip next-hop** *address1* [*address2...*] [**load-share**] **Example**: `switch(config-route-map)# set ip next-hop 192.0.2.1`	(Optional) Sets the IPv4 next-hop address for policy-based routing. This command uses the first valid next-hop address if multiple addresses are configured. Use the optional **load-share** keyword to load balance traffic across a maximum of 32 next-hop addresses.
Step 7	**set ipv6 next-hop** *address1* [*address2...*] [**load-share**] **Example**: `switch(config-route-map)# set ipv6 next-hop 2001:0DB8::1`	(Optional) Sets the IPv6 next-hop address for policy-based routing. This command uses the first valid next-hop address if multiple addresses are configured. Use the optional **load-share** keyword to load balance traffic across a maximum of 32 next-hop addresses.

	Command	Purpose
Step 8	**set interface null0** **Example:** `switch(config-route-map)# set interface null0`	(Optional) Sets the interface used for routing. Use the **null0** interface to drop packets.
Step 9	**copy running-config startup-config** **Example:** `switch(config-route-map)# copy running-config startup-config`	(Optional) Saves this configuration change.

Verifying the Policy-Based Routing Configuration

To display the policy-based routing configuration information, perform one of the following tasks:

Command	Purpose
show [**ip** | **ipv6**] **policy** [*name*]	Displays information about an IPv4 or IPv6 policy.
show route-map [*name*] **pbr-statistics**	Displays policy statistics.

Use the **route-map** *map-name* **pbr-statistics** command to enable policy statistics. Use the **clear route-map** *map-name* **pbr-statistics** command to clear these policy statistics.

Configuration Examples for Policy-Based Routing

This example shows how to configure a simple route policy on an interface:

```
ip access-list pbr-sample
permit tcp host 10.1.1.1 host 192.168.2.1 eq 80
!
route-map pbr-sample
match ip address pbr-sample
set ip next-hop 192.168.1.1
!
route-map pbr-sample pbr-statistics
interface ethernet 1/2
ip policy route-map pbr-sample
```

The following output verifies this configuration:

```
switch# show route-map pbr-sample
route-map pbr-sample, permit, sequence 10
 Match clauses:
  ip address (access-lists): pbr-sample
 Set clauses:
  ip next-hop 192.168.1.1

switch# show route-map pbr-sample pbr-statistics
route-map pbr-sample, permit, sequence 10
 Policy routing matches: 84 packets
Default routing: 233 packets
```

```
switch# show ip policy
Interface   Route-map  Status  VRF-Name
Ethernet1/2 pbr-sample Active  --
```

Related Documents

Related Topic	Document Title
IP SLA PBR object tracking	*Cisco Nexus 9000 Series NX-OS IP SLAs Configuration Guide*
Troubleshooting information	*Cisco Nexus 9000 Series NX-OS Troubleshooting Guide*

Configuring HSRP

This chapter describes how to configure the Hot Standby Router Protocol (HSRP) on the Cisco NX-OS device.

This chapter includes the following sections:

Information About HSRP

HSRP is a first-hop redundancy protocol (FHRP) that allows a transparent failover of the first-hop IP router. HSRP provides first-hop routing redundancy for IP hosts on Ethernet networks configured with a default router IP address. You use HSRP in a group of routers for selecting an active router and a standby router. In a group of routers, the active router is the router that routes packets; the standby router is the router that takes over when the active router fails or when preset conditions are met.

Many host implementations do not support any dynamic router discovery mechanisms but can be configured with a default router. Running a dynamic router discovery mechanism on every host is not practical for many reasons, including administrative overhead, processing overhead, and security issues. HSRP provides failover services to these hosts.

This section includes the following topics:

HSRP Overview

When you use HSRP, you configure the HSRP virtual IP address as the host's default router (instead of the IP address of the actual router). The virtual IP address is an IPv4 or IPv6 address that is shared among a group of routers that run HSRP.

When you configure HSRP on a network segment, you provide a virtual MAC address and a virtual IP address for the HSRP group. You configure the same virtual address on each HSRP-enabled interface in the group. You also configure a unique IP address and MAC address on each interface that acts as the real address. HSRP selects one of these interfaces to be the active router. The active router receives and routes packets destined for the virtual MAC address of the group.

HSRP detects when the designated active router fails. At that point, a selected standby router assumes control of the virtual MAC and IP addresses of the HSRP group. HSRP also selects a new standby router at that time.

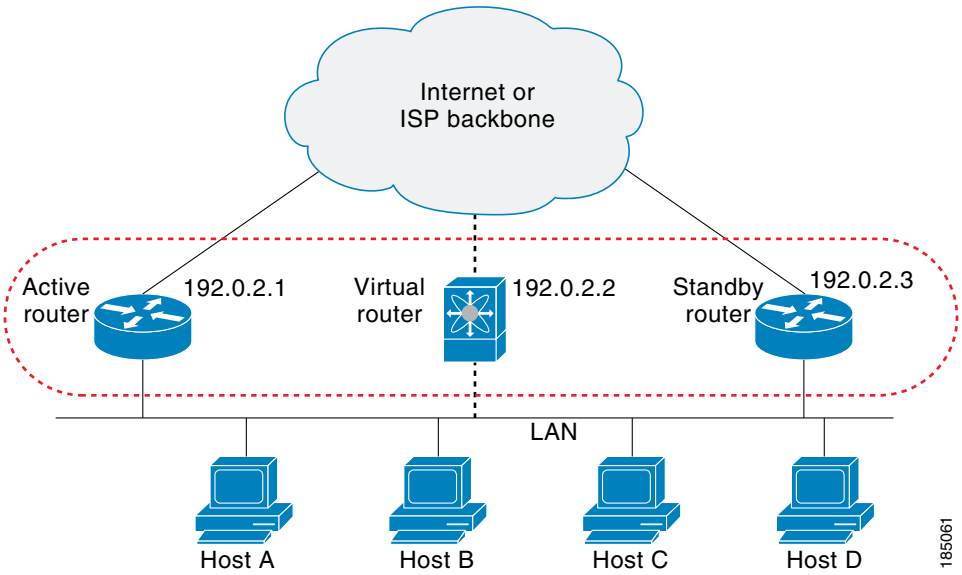
HSRP uses a priority designator to determine which HSRP-configured interface becomes the default active router. To configure an interface as the active router, you assign it with a priority that is higher than the priority of all the other HSRP-configured interfaces in the group. The default priority is 100, so if you configure just one interface with a higher priority, that interface becomes the default active router.

Interfaces that run HSRP send and receive multicast User Datagram Protocol (UDP)-based hello messages to detect a failure and to designate active and standby routers. When the active router fails to send a hello message within a configurable period of time, the standby router with the highest priority becomes the active router. The transition of packet forwarding functions between the active and standby router is completely transparent to all hosts on the network.

You can configure multiple HSRP groups on an interface.

Figure 17-1 shows a network configured for HSRP. By sharing a virtual MAC address and a virtual IP address, two or more interfaces can act as a single virtual router.

Figure 17-1 HSRP Topology with Two Enabled Routers



The virtual router does not physically exist but represents the common default router for interfaces that are configured to provide backup to each other. You do not need to configure the hosts on the LAN with the IP address of the active router. Instead, you configure them with the IP address of the virtual router (virtual IP address) as their default router. If the active router fails to send a hello message within the configurable period of time, the standby router takes over, responds to the virtual addresses, and becomes the active router, assuming the active router duties. From the host perspective, the virtual router remains the same.

Note Packets received on a routed port destined for the HSRP virtual IP address terminate on the local router, regardless of whether that router is the active HSRP router or the standby HSRP router. This process includes ping and Telnet traffic. Packets received on a Layer 2 (VLAN) interface destined for the HSRP virtual IP address terminate on the active router.

HSRP Versions

Cisco NX-OS supports HSRP version 1 by default. You can configure an interface to use HSRP version 2.

HSRP version 2 has the following enhancements to HSRP version 1:

- Expands the group number range. HSRP version 1 supports group numbers from 0 to 255. HSRP version 2 supports group numbers from 0 to 4095.
- For IPv4, uses the IPv4 multicast address 224.0.0.102 or the IPv6 multicast address FF02::66 to send hello packets instead of the multicast address of 224.0.0.2, which is used by HSRP version 1.
- Uses the MAC address range from 0000.0C9F.F000 to 0000.0C9F.FFFF for IPv4 and 0005.73A0.0000 through 0005.73A0.0FFF for IPv6 addresses. HSRP version 1 uses the MAC address range 0000.0C07.AC00 to 0000.0C07.ACFF.
- Adds support for MD5 authentication.

When you change the HSRP version, Cisco NX-OS reinitializes the group because it now has a new virtual MAC address.

HSRP version 2 has a different packet format than HSRP version 1. The packet format uses a type-length-value (TLV) format. HSRP version 2 packets received by an HSRP version 1 router are ignored.

HSRP for IPv4

HSRP routers communicate with each other by exchanging HSRP hello packets. These packets are sent to the destination IP multicast address 224.0.0.2 (reserved multicast address used to communicate to all routers) on UDP port 1985. The active router sources hello packets from its configured IP address and the HSRP virtual MAC address while the standby router sources hellos from its configured IP address and the interface MAC address, which might be the burned-in address (BIA). The BIA is the last six bytes of the MAC address that is assigned by the manufacturer of the network interface card (NIC).

Because hosts are configured with their default router as the HSRP virtual IP address, hosts must communicate with the MAC address associated with the HSRP virtual IP address. This MAC address is a virtual MAC address, 0000.0C07.ACxy, where xy is the HSRP group number in hexadecimal based on the respective interface. For example, HSRP group 1 uses the HSRP virtual MAC address of 0000.0C07.AC01. Hosts on the adjoining LAN segment use the normal Address Resolution Protocol (ARP) process to resolve the associated MAC addresses.

HSRP version 2 uses the new IP multicast address 224.0.0.102 to send hello packets instead of the multicast address of 224.0.0.2, which is used by version 1. HSRP version 2 permits an expanded group number range of 0 to 4095 and uses a new MAC address range of 0000.0C9F.F000 to 0000.0C9F.FFFF.

HSRP for IPv6

IPv6 hosts learn of available IPv6 routers through IPv6 neighbor discovery (ND) router advertisement (RA) messages. These messages are multicast periodically, or might be solicited by hosts, but the time delay for detecting when a default route is down might be 30 seconds or more. HSRP for IPv6 provides a much faster switchover to an alternate default router than the IPv6 ND protocol provides, which is less than a second if the milliseconds timers are used. HSRP for IPv6 provides a virtual first hop for IPv6 hosts.

When you configure an IPv6 interface for HSRP, the periodic RAs for the interface link-local address stop after IPv6 ND sends a final RA with a router lifetime of zero. No restrictions occur for the interface IPv6 link-local address. Other protocols continue to receive and send packets to this address.

IPv6 ND sends periodic RAs for the HSRP virtual IPv6 link-local address when the HSRP group is active. These RAs stop after a final RA is sent with a router lifetime of 0 when the HSRP group leaves the active state. HSRP uses the virtual MAC address for active HSRP group messages only (hello, coup, and resign).

HSRP for IPv6 uses the following parameters:

- HSRP version 2
- UDP port 2029
- Virtual MAC address range from 0005.73A0.0000 through 0005.73A0.0FFF
- Multicast link-local IP destination address of FF02::66
- Hop limit set to 255

HSRP IPv6 Addresses

An HSRP IPv6 group has a virtual MAC address that is derived from the HSRP group number and a virtual IPv6 link-local address that is derived, by default, from the HSRP virtual MAC address. The default virtual MAC address for an HSRP IPv6 group is always used to form the virtual IPv6 link-local address, regardless of the actual virtual MAC address used by the group.

Table 17-1 shows the MAC and IP addresses used for IPv6 neighbor discovery packets and HSRP packets.

Table 17-1 HSRP and IPv6 ND Addresses

Packet	MAC Source Address	IPv6 Source Address	IPv6 Destination Address	Link-layer Address Option
Neighbor solicitation (NS)	Interface MAC address	Interface IPv6 address	—	Interface MAC address
Router solicitation (RS)	Interface MAC address	Interface IPv6 address	—	Interface MAC address
Neighbor advertisement (NA)	Interface MAC address	Interface IPv6 address	Virtual IPv6 address	HSRP virtual MAC address
Route advertisement (RA)	Interface MAC address	Virtual IPv6 address	—	HSRP virtual MAC address
HSRP (inactive)	Interface MAC address	Interface IPv6 address	—	—
HSRP (active)	Virtual MAC address	Interface IPv6 address	—	—

HSRP does not add IPv6 link-local addresses to the Unicast Routing Information Base (URIB). Link-local addresses have no secondary virtual IP addresses.

For global unicast addresses, HSRP adds the virtual IPv6 address to the URIB and IPv6.

HSRP Authentication

HSRP message digest 5 (MD5) algorithm authentication protects against HSRP-spoofing software and uses the industry-standard MD5 algorithm for improved reliability and security. HSRP includes the IPv4 or IPv6 address in the authentication TLVs.

HSRP Messages

Routers that are configured with HSRP exchange the following three types of multicast messages:

- Hello—The hello message conveys the HSRP priority and state information of the router to other HSRP routers.
- Coup—When a standby router wants to assume the function of the active router, it sends a coup message.
- Resign—A router that is the active router sends this message when it is about to shut down or when a router that has a higher priority sends a hello or coup message.

HSRP Load Sharing

HSRP allows you to configure multiple groups on an interface. You can configure two overlapping IPv4 HSRP groups to load share traffic from the connected hosts while providing the default router redundancy expected from HSRP. Figure 17-2 shows an example of a load-sharing HSRP IPv4 configuration.

Figure 17-2 HSRP Load Sharing

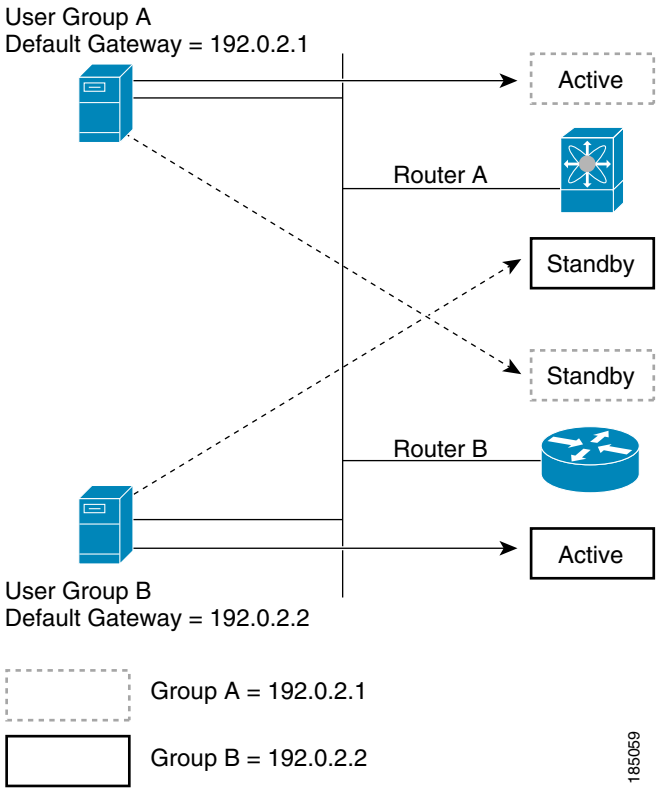


Figure 17-2 shows two routers A and B and two HSRP groups. Router A is the active router for group A but is the standby router for group B. Similarly, router B is the active router for group B and the standby router for group A. If both routers remain active, HSRP load balances the traffic from the hosts across both routers. If either router fails, the remaining router continues to process traffic for both hosts.

Note HSRP for IPv6 load balances by default. If two HSRP IPv6 groups are on the subnet, hosts learn of both groups from their router advertisements and choose to use one so that the load is shared between the advertised routers.

Object Tracking and HSRP

You can use object tracking to modify the priority of an HSRP interface based on the operational state of another interface. Object tracking allows you to route to a standby router if the interface to the main network fails.

Two objects that you can track are the line protocol state of an interface or the reachability of an IP route. If the specified object goes down, Cisco NX-OS reduces the HSRP priority by the configured amount. For more information, see the "Configuring HSRP Object Tracking" section on page 17-18.

vPC and HSRP

HSRP interoperates with virtual port channels (vPCs). vPCs allow links that are physically connected to two different Cisco Nexus 9000 Series devices to appear as a single port channel by a third device. See the *Cisco Nexus 9000 Series NX-OS Layer 2 Switching Configuration Guide* for more information on vPCs.

vPC forwards traffic through both the active HSRP router and the standby HSRP router. For more information, see the "Configuring the HSRP Priority" section on page 17-20 and the "Configuration Examples for HSRP" section on page 17-23.

Note HSRP active can be distributed on both the primary and secondary vPC peers for different SVIs.

vPC Peer Gateway and HSRP

Some third-party devices can ignore the HSRP virtual MAC address and instead use the source MAC address of an HSRP router. In a vPC environment, the packets that use this source MAC address might be sent across the vPC peer link, causing a potential dropped packet. Configure the vPC peer gateway to enable the HSRP routers to directly handle packets sent to the local vPC peer MAC address and the remote vPC peer MAC address, as well as the HSRP virtual MAC address. See the *Cisco Nexus 9000 Series NX-OS Layer 2 Switching Configuration Guide* for more information on the vPC peer gateway.

BFD

This feature supports bidirectional forwarding detection (BFD) for IPv4. BFD is a detection protocol that provides fast-forwarding and path-failure detection times. BFD provides subsecond failure detection between two adjacent devices and can be less CPU-intensive than protocol hello messages because some of the BFD load can be distributed onto the data plane on supported modules. See the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide* for more information.

High Availability and Extended Nonstop Forwarding

HSRP supports stateful restarts and stateful switchovers. A stateful restart occurs when the HSRP process fails and is restarted. A stateful switchover occurs when the active supervisor switches to the standby supervisor. Cisco NX-OS applies the run-time configuration after the switchover.

If HSRP hold timers are configured for short time periods, these timers might expire during a controlled switchover. HSRP supports extended nonstop forwarding (NSF) to temporarily extend these HSRP hold timers during a controlled switchover.

With extended NSF configured, HSRP sends hello messages with the extended timers. HSRP peers update their hold timers with these new values. The extended timers prevent unnecessary HSRP state changes during the switchover. After the switchover, HSRP restores the hold timers to their original configured values. If the switchover fails, HSRP restores the hold timers after the extended hold timer values expire.

See the "Configuring Extended Hold Timers for HSRP" section on page 17-22 for more information.

Virtualization Support

HSRP supports virtual routing and forwarding (VRF) instances.

Licensing Requirements for HSRP

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	HSRP requires no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for HSRP

- You must enable the HSRP feature in a device before you can configure and enable any HSRP groups.

Guidelines and Limitations for HSRP

HSRP has the following configuration guidelines and limitations:

- You must configure an IP address for the interface that you configure HSRP on and enable that interface before HSRP becomes active.
- You must configure HSRP version 2 when you configure an IPv6 interface for HSRP.
- For IPv4, the virtual IP address must be in the same subnet as the interface IP address.
- We recommend that you do not configure more than one first-hop redundancy protocol on the same interface.
- HSRP version 2 does not interoperate with HSRP version 1. An interface cannot operate both version 1 and version 2 because both versions are mutually exclusive. However, the different versions can be run on different physical interfaces of the same router.
- You cannot change from version 2 to version 1 if you have configured groups above the group number range allowed for version 1 (0 to 255).
- HSRP for IPv4 is supported with BFD. HSRP for IPv6 is not supported with BFD.
- If HSRP IPv4 and IPv6 use the same virtual MAC address on an SVI, the HSRP state should be the same for both HSRP IPv4 and IPv6. The priority and preemption should be configured to result in the same state after failovers.
- Cisco NX-OS removes all Layer 3 configurations on an interface when you change the interface VRF membership, port channel membership, or the port mode to Layer 2.

- If you configure virtual MAC addresses with vPC, you must configure the same virtual MAC address on both vPC peers.
- You cannot use the HSRP MAC address burned-in option on a VLAN interface that is a vPC member.
- Starting with Release 7.0(3)I2(1), Cisco NX-OS supports having the same HSRP groups on all nodes in a double-sided vPC.
- If you have not configured authentication, the **show hsrp** command displays the following string:

```
Authentication text "cisco"
```

  The default behavior of HSRP is as defined in RFC 2281:

```
If no authentication data is configured, the RECOMMENDED default
value is 0x63 0x69 0x73 0x63 0x6F 0x00 0x00 0x00.
```

Default Settings

Table 17-2 lists the default settings for HSRP parameters.

Table 17-2 Default HSRP Parameters

Parameters	Default
HSRP	Disabled
Authentication	Enabled as text for version 1, with cisco as the password
HSRP version	Version 1
Preemption	Disabled
Priority	100
Virtual MAC address	Derived from HSRP group number

Configuring HSRP

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Enabling HSRP

You must globally enable HSRP before you can configure and enable any HSRP groups.

DETAILED STEPS

To enable the HSRP feature, use the following command in global configuration mode:

Command	Purpose
feature hsrp **Example:** `switch(config)# feature hsrp`	Enables HSRP.

To disable the HSRP feature and remove all associated configurations, use the following command in global configuration mode:

Command	Purpose
no feature hsrp **Example:** `switch(config)# no feature hsrp`	Disables HSRP for all groups.

Configuring the HSRP Version

You can configure the HSRP version. If you change the version for existing groups, Cisco NX-OS reinitializes HSRP for those groups because the virtual MAC address changes. The HSRP version applies to all groups on the interface.

Note IPv6 HSRP groups must be configured as HSRP version 2.

To configure the HSRP version, use the following command in interface configuration mode:

Command	Purpose
hsrp version {**1** | **2**} **Example:** `switch(config-if)# hsrp version 2`	Configures the HSRP version. Version 1 is the default.

Configuring an HSRP Group for IPv4

You can configure an HSRP group on an IPv4 interface and configure the virtual IP address and virtual MAC address for the HSRP group.

BEFORE YOU BEGIN

Ensure that you have enabled the HSRP feature (see the "Enabling HSRP" section on page 17-10).

Cisco NX-OS enables an HSRP group once you configure its virtual IP address. You should configure HSRP attributes such as authentication, timers, and priority before you enable the HSRP group.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *type number*
3. **ip address** *ip-address/length*
4. **hsrp** *group-number* [**ipv4**]
5. **ip** [*ip-address* [**secondary**]]
6. **exit**
7. **no shutdown**
8. (Optional) **show hsrp [group** *group-number*] [**ipv4**]
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *type number* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip address** *ip-address/length* **Example:** `switch(config-if)# ip 192.0.2.2/8`	Configures the IPv4 address of the interface.
Step 4	**hsrp** *group-number* [**ipv4**] **Example:** `switch(config-if)# hsrp 2` `switch(config-if-hsrp)#`	Creates an HSRP group and enters HSRP configuration mode. The range for HSRP version 1 is from 0 to 255. The range is for HSRP version 2 is from 0 to 4095. The default value is 0.
Step 5	**ip** [*ip-address* [**secondary**]] **Example:** `switch(config-if-hsrp)# ip 192.0.2.1`	Configures the virtual IP address for the HSRP group and enables the group. This address should be in the same subnet as the IPv4 address of the interface.

	Command	Purpose
Step 6	**exit** **Example:** switch(config-if-hsrp)# exit	Exits HSRP configuration mode.
Step 7	**no shutdown** **Example:** switch(config-if)# no shutdown	Enables the interface.
Step 8	**show hsrp** [**group** *group-number*] [**ipv4**] **Example:** switch(config-if)# show hsrp group 2	(Optional) Displays HSRP information.
Step 9	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

Note You should use the **no shutdown** command to enable the interface after you finish the configuration.

This example shows how to configure an HSRP group on Ethernet 1/2:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# ip 192.0.2.2/8
switch(config-if)# hsrp 2
switch(config-if-hsrp)# ip 192.0.2.1
switch(config-if-hsrp)# exit
switch(config-if)# no shutdown
switch(config-if)# copy running-config startup-config
```

Configuring an HSRP Group for IPv6

You can configure an HSRP group on an IPv6 interface and configure the virtual MAC address for the HSRP group.

When you configure an HSRP group for IPv6, HSRP generates a link-local address from the link-local prefix. HSRP also generates a modified EUI-64 format interface identifier in which the EUI-64 interface identifier is created from the relevant HSRP virtual MAC address.

BEFORE YOU BEGIN

You must enable HSRP (see the "Enabling HSRP" section on page 17-10).

Ensure that you have enabled HSRP version 2 on the interface that you want to configure an IPv6 HSRP group on.

Ensure that you have configured HSRP attributes such as authentication, timers, and priority before you enable the HSRP group.

SUMMARY STEPS

1. **configure terminal**

2. **interface** *type number*
3. **ipv6 address** *ipv6-address/length*
4. **hsrp version 2**
5. **hsrp** *group-number* **ipv6**
6. **ip** *ipv6-address*
7. **ip autoconfig**
8. **exit**
9. **no shutdown**
10. (Optional) **show hsrp** [**group** *group-number*] [**ipv6**]
11. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *type number* **Example:** `switch(config)# interface ethernet 3/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ipv6 address** *ipv6-address/length* **Example**: `switch(config-if)# ipv6 address` `2001:0DB8::0001:0001/64`	Configures the IPv6 address of the interface.
Step 4	**hsrp version 2** **Example**: `switch(config-if-hsrp)# hsrp version 2`	Configures this group for HSRP version 2.
Step 5	**hsrp** *group-number* **ipv6** **Example**: `switch(config-if)# hsrp 10 ipv6` `switch(config-if-hsrp)#`	Creates an IPv6 HSRP group and enters HSRP configuration mode. The range for HSRP version 2 is from 0 to 4095. The default value is 0.
Step 6	**ip** *ipv6-address* **Example**: `switch(config-if-hsrp)# ip 2001:DB8::1`	Configures the virtual IPv6 address for the HSRP group and enables the group.
Step 7	**ip autoconfig** **Example**: `switch(config-if-hsrp)# ip autoconfig`	Autoconfigures the virtual IPv6 address for the HSRP group from the calculated link-local virtual IPv6 address and enables the group.
Step 8	**exit** **Example**: `switch(config-if-hsrp)# exit` `switch(config-if)#`	Exits HSRP configuration mode.

	Command	Purpose
Step 9	**no shutdown** **Example**: switch(config-if)# no shutdown	Enables the interface.
Step 10	**show hsrp** [**group** *group-number*] [**ipv6**] **Example**: switch(config-if)# show hsrp group 10	(Optional) Displays HSRP information.
Step 11	**copy running-config startup-config** **Example:** switch(config-if)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

Note You should use the **no shutdown** command to enable the interface after you finish the configuration.

This example shows how to configure an IPv6 HSRP group on Ethernet 3/2:

```
switch# configure terminal
switch(config)# interface ethernet 3/2
switch(config-if)# ipv6 address 2001:0DB8::0001:0001/64
switch(config-if-hsrp)# hsrp version 2
switch(config-if)# hsrp 2 ipv6
switch(config-if-hsrp)# ip 2001:DB8::1
switch(config-if-hsrp)# exit
switch(config-if)# no shutdown
switch(config-if)# copy running-config startup-config
```

Configuring the HSRP Virtual MAC Address

You can override the default virtual MAC address that HSRP derives from the configured group number.

Note You must configure the same virtual MAC address on both vPC peers of a vPC link.

To manually configure the virtual MAC address for an HSRP group, use the following command in hsrp configuration mode:

Command	Purpose
mac-address *string* **Example**: switch(config-if-hsrp)# mac-address 5000.1000.1060	Configures the virtual MAC address for an HSRP group. The string uses the standard MAC address format (xxxx.xxxx.xxxx).

To configure HSRP to use the burned-in MAC address of the interface for the virtual MAC address, use the following command in interface configuration mode:

Command	Purpose
hsrp use-bia [**scope interface**] **Example:** `switch(config-if)# hsrp use-bia`	Configures HSRP to use the burned-in MAC address of the interface for the HSRP virtual MAC address. You can optionally configure HSRP to use the burned-in MAC address for all groups on this interface by using the **scope interface** keyword.

Authenticating HSRP

You can configure HSRP to authenticate the protocol using cleartext or MD5 digest authentication. MD5 authentication uses a key chain (see the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide*).

BEFORE YOU BEGIN

You must enable HSRP (see the "Enabling HSRP" section on page 17-10).

You must configure the same authentication and keys on all members of the HSRP group.

Ensure that you have created the key chain if you are using MD5 authentication.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **hsrp** *group-number* [**ipv4** | **ipv6**]
4. **authentication text** *string*

   or

   authentication md5 {**key-chain** *key-chain* | **key-string** {**0** | **7**} *text* [**timeout** *seconds*]}
5. (Optional) **show hsrp** [**group** *group-number*]
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.

	Command	Purpose
Step 3	**hsrp** *group-number* [**ipv4** | **ipv6**] **Example:** switch(config-if)# hsrp 2 switch(config-if-hsrp)#	Creates an HSRP group and enters HSRP configuration mode.
Step 4	**authentication text** *string* **Example:** switch(config-if-hsrp)# authentication text mypassword	Configures cleartext authentication for HSRP on this interface.
	authentication md5 {**key-chain** *key-chain* | **key-string** {**0** | **7**} *text* [**timeout** *seconds*]} **Example:** switch(config-if-hsrp)# authentication md5 key-chain hsrp-keys	Configures MD5 authentication for HSRP on this interface. You can use a key chain or key string. If you use a key string, you can optionally set the timeout for when HSRP only accepts a new key. The range is from 0 to 32767 seconds.
Step 5	**show hsrp** [**group** *group-number*] **Example:** switch(config-if-hsrp)# show hsrp group 2	(Optional) Displays HSRP information.
Step 6	**copy running-config startup-config** **Example:** switch(config-if-hsrp)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure MD5 authentication for HSRP on Ethernet 1/2 after creating the key chain:

```
switch# configure terminal
switch(config)# key chain hsrp-keys
switch(config-keychain)# key 0
switch(config-keychain-key)# key-string 7 zqdest
switch(config-keychain-key) accept-lifetime 00:00:00 Jun 01 2013 23:59:59 Sep 12 2013
switch(config-keychain-key) send-lifetime 00:00:00 Jun 01 2013 23:59:59 Aug 12 2013
switch(config-keychain-key) key 1
switch(config-keychain-key) key-string 7 uaeqdyito
switch(config-keychain-key) accept-lifetime 00:00:00 Aug 12 2013 23:59:59 Dec 12 2013
switch(config-keychain-key) send-lifetime 00:00:00 Sep 12 2013 23:59:59 Nov 12 2013
switch(config-keychain-key)# interface ethernet 1/2
switch(config-if)# hsrp 2
switch(config-if-hsrp)# authentication md5 key-chain hsrp-keys
switch(config-if-hsrp)# copy running-config startup-config
```

Authenticating HSRP

You can configure HSRP to authenticate the protocol using cleartext or MD5 digest authentication. MD5 authentication uses a key chain (see the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide*).

BEFORE YOU BEGIN

You must enable HSRP (see the "Enabling HSRP" section on page 17-10).

You must configure the same authentication and keys on all members of the HSRP group.

Ensure that you have created the key chain if you are using MD5 authentication.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **hsrp** *group-number* [**ipv4** | **ipv6**]
4. **authentication text** *string*

   or

   authentication md5 {**key-chain** *key-chain* | **key-string** {**0** | **7**} *text* [**timeout** *seconds*]}
5. (Optional) **show hsrp** [**group** *group-number*]
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**hsrp** *group-number* [**ipv4** | **ipv6**] **Example**: `switch(config-if)# hsrp 2` `switch(config-if-hsrp)#`	Creates an HSRP group and enters HSRP configuration mode.
Step 4	**authentication text** *string* **Example**: `switch(config-if-hsrp)# authentication text mypassword`	Configures cleartext authentication for HSRP on this interface.
	authentication md5 {**key-chain** *key-chain* | **key-string** {**0** | **7**} *text* [**timeout** *seconds*]} **Example**: `switch(config-if-hsrp)# authentication md5 key-chain hsrp-keys`	Configures MD5 authentication for HSRP on this interface. You can use a key chain or key string. If you use a key string, you can optionally set the timeout for when HSRP only accepts a new key. The range is from 0 to 32767 seconds.

	Command	Purpose
Step 5	**show hsrp** [**group** *group-number*] **Example**: switch(config-if-hsrp)# show hsrp group 2	(Optional) Displays HSRP information.
Step 6	**copy running-config startup-config** **Example:** switch(config-if-hsrp)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure MD5 authentication for HSRP on Ethernet 1/2 after creating the key chain:

```
switch# configure terminal
switch(config)# key chain hsrp-keys
switch(config-keychain)# key 0
switch(config-keychain-key)# key-string 7 zqdest
switch(config-keychain-key) accept-lifetime 00:00:00 Jun 01 2013 23:59:59 Sep 12 2013
switch(config-keychain-key) send-lifetime 00:00:00 Jun 01 2013 23:59:59 Aug 12 2013
switch(config-keychain-key) key 1
```

Configuring HSRP Object Tracking

You can configure an HSRP group to adjust its priority based on the availability of other interfaces or routes. The priority of an HSRP group can change dynamically if it has been configured for object tracking and the object that is being tracked goes down.

The tracking process periodically polls the tracked objects and notes any value change. The value change triggers HSRP to recalculate the priority. The HSRP interface with the higher priority becomes the active router if you configure the HSRP interface for preemption.

SUMMARY STEPS

1. **configure terminal**
2. **track** *object-id* **interface** *interface-type slot/port* {**line-protocol** | **ip routing** | **ipv6 routing**}
3. **track** *object-id* {**ip** | **ipv6**} **route** *ip-prefix/length* **reachability**
4. **exit**
5. **interface** *interface-type slot/port*
6. **hsrp** *group-number* [**ipv4** | **ipv6**]
7. **priority** [*value*]
8. **track** *object-id* [**decrement** *value*]
9. **preempt** [**delay [minimum** *seconds*] **[reload** *seconds*] **[sync** *seconds*]]
10. (Optional) **show hsrp interface** *interface-type slot/port*
11. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**track** *object-id* **interface** *interface-type slot/port* {**line-protocol** | **ip routing** | **ipv6 routing**} **Example:** `switch(config)# track 1 interface ethernet 2/2 line-protocol` `switch(config-track)#`	Configures the interface that the track object tracks. Changes in the state of the interface affect the track object status as follows: • You configure the interface and corresponding object number that you use with the **track** command in global configuration mode. • The **line-protocol** keyword tracks whether the interface is up. The **ip routing** or **ipv6 routing** keyword also checks that IP routing is enabled on the interface and an IP address is configured.
Step 3	**track** *object-id* {**ip** | **ipv6**} **route** *ip-prefix/length* **reachability** **Example:** `switch(config-track)# track 2 ip route 192.0.2.0/8 reachability`	Creates a tracked object for a route and enters tracking configuration mode. The *object-id* range is from 1 to 500.
Step 4	**exit** **Example:** `switch(config-track)# exit` `switch(config)#`	Exits track configuration mode.
Step 5	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 1/2` `switch(config-if)#`	Enters interface configuration mode.
Step 6	**hsrp** *group-number* [**ipv4** | **ipv6**] **Example**: `switch(config-if)# hsrp 2` `switch(config-if-hsrp)#`	Creates an HSRP group and enters HSRP configuration mode.
Step 7	**priority** [*value*] **Example**: `switch(config-if-hsrp)# priority 254`	Sets the priority level used to select the active router in an HSRP group. The range is from 0 to 255. The default is 100.
Step 8	**track** *object-id* [**decrement** *value*] **Example:** `switch(config-if-hsrp)# track 1 decrement 20`	Specifies an object to be tracked that affects the weighting of an HSRP interface. The value argument specifies a reduction in the priority of an HSRP interface when a tracked object fails. The range is from 1 to 255. The default is 10.

	Command	Purpose
Step 9	**preempt** [**delay** [**minimum** *seconds*] [**reload** *seconds*] [**sync** *seconds*]] **Example**: `switch(config-if-hsrp)# preempt delay minimum 60`	Configures the router to take over as the active router for an HSRP group if it has a higher priority than the current active router. This command is disabled by default. Optionally, a delay can be configured that delays the HSRP group preemption by the configured time. The range is from 0 to 3600 seconds.
Step 10	**show hsrp interface** *interface-type slot/port* **Example**: `switch(config-if-hsrp)# show hsrp interface ethernet 1/2`	(Optional) Displays HSRP information for an interface.
Step 11	**copy running-config startup-config** **Example:** `switch(config-if-hsrp)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure HSRP object tracking on Ethernet interface 1/2:

```
switch# configure terminal
switch(config)# track 1 interface ethernet 2/2 line-protocol
switch(config-track)# track 2 ip route 192.0.2.0/8 reachability
switch(config-track)# exit
switch(config)# interface ethernet 1/2
switch(config-if)# hsrp 2
switch(config-if-hsrp)# priority 254
switch(config-if-hsrp)# track 1 decrement 20
switch(config-if-hsrp)# preempt delay minimum 60
switch(config-if-hsrp)# copy running-config startup-config
```

Configuring the HSRP Priority

You can configure the priority of an HSRP group. HSRP uses the priority to determine which HSRP group member acts as the active router. If you configure HSRP on a vPC-enabled interface, you can optionally configure the upper and lower threshold values to control when to fail over to the vPC trunk. If the standby router priority falls below the lower threshold, HSRP sends all standby router traffic across the vPC trunk to forward through the active HSRP router. HSRP maintains this scenario until the standby HSRP router priority increases above the upper threshold.

For IPv6 HSRP groups, if all group members have the same priority, HSRP selects the active router based on the IPv6 link-local address.

To configure the HSRP priority, use the following command in the HSRP group configuration mode:

Command	Purpose
priority *level* [**forwarding-threshold** ***lower*** *lower-value* **upper** *upper-value*] **Example:** `switch(config-if-hsrp)# priority 60 forwarding-threshold lower 40 upper 50`	Sets the priority level used to select the active router in an HSRP group. The level range is from 0 to 255. The default is 100. Optionally, this command sets the upper and lower threshold values used by vPC to determine when to fail over to the vPC trunk. The lower-value range is from 1 to 255. The default is 1. The upper-value range is from 1 to 255. The default is 255.

Customizing HSRP

You can optionally customize the behavior of HSRP. Be aware that as soon as you enable an HSRP group by configuring a virtual IP address, that group is now operational. If you first enable an HSRP group before customizing HSRP, the router could take control over the group and become the active router before you finish customizing the feature. If you plan to customize HSRP, you should do so before you enable the HSRP group. To customize HSRP, use the following commands in HSRP configuration mode:

Command	Purpose
name *string* **Example:** `switch(config-if-hsrp)# name HSRP-1`	Specifies the IP redundancy name for an HSRP group. The *string* is from 1 to 255 characters. The default string has the following format: *hsrp-interface short-name group-id*. For example, hsrp-Eth2/1-1.
preempt [**delay** [**minimum** *seconds*] [**reload** *seconds*] [**sync** *seconds*]] **Example:** `switch(config-if-hsrp)# preempt delay minimum 60`	Configures the router to take over as an active router for an HSRP group if it has a higher priority than the current active router. This command is disabled by default. Optionally, a delay can be configured that delays the HSRP group preemption by the configured time. The range is from 0 to 3600 seconds.
timers [**msec**] *hellotime* [**msec**] *holdtime* **Example:** `switch(config-if-hsrp)# timers 5 18`	Configures the hello and hold time for this HSRP member as follows: • *hellotime*—The interval between successive hello packets sent. The range is from 1 to 254 seconds. • *holdtime*—The interval before the information in the hello packet is considered invalid. The range is from 3 to 255. The optional **msec** keyword specifies that the argument is expressed in milliseconds instead of the default seconds. The timer ranges for milliseconds are as follows: • *hellotime*—The interval between successive hello packets sent. The range is from 255 to 999 milliseconds. • *holdtime*—The interval before the information in the hello packet is considered invalid. The range is from 750 to 3000 milliseconds.

To customize HSRP, use the following commands in interface configuration mode:

Command	Purpose
hsrp delay minimum *seconds* **Example:** `switch(config-if)# hsrp delay minimum 30`	Specifies the minimum amount of time that HSRP waits after a group is enabled before participating in the group. The range is from 0 to 10000 seconds. The default is 0.
hsrp delay reload *seconds* **Example:** `switch(config-if)# hsrp delay reload 30`	Specifies the minimum amount of time that HSRP waits after a reload and before participating in the group. The range is from 0 to 10000 seconds. The default is 0.

Configuring Extended Hold Timers for HSRP

You can configure HSRP to use extended hold timers to support extended NSF during a controlled (graceful) switchover. You should configure extended hold timers on all HSRP routers (see the "High Availability and Extended Nonstop Forwarding" section on page 17-7).

Note You must configure extended hold timers on all HSRP routers if you configure extended hold timers. If you configure a nondefault hold timer, you should configure the same value on all HSRP routers when you configure HSRP extended hold timers.

Note HSRP extended hold timers are not applied if you configure millisecond hello and hold timers for HSRPv1. This statement does not apply to HSRPv2.

To configure HSRP extended hold timers, use the following command in global configuration mode:

Command	Purpose
hsrp timers extended-hold [*timer*] **Example:** `switch(config)# hsrp timers extended-hold`	Sets the HSRP extended hold timer, in seconds, for both IPv4 and IPv6 groups. The timer range is from 10 to 255. The default is 10.

Use the **show hsrp** command or the **show running-config hsrp** command to display the extended hold time.

Verifying the HSRP Configuration

To display HSRP configuration information, perform one of the following tasks:

Command	Purpose
show hsrp [**group** *group-number*]	Displays the HSRP status for all groups or one group.
show hsrp delay [**interface** *interface-type slot/port*]	Displays the HSRP delay value for all interfaces or one interface.
show hsrp [**interface** *interface-type slot/port*]	Displays the HSRP status for an interface.
show hsrp [**group** *group-number*] [**interface** *interface-type slot/port*] [**active**] [**all**] [**init**] [**learn**] [**listen**] [**speak**] [**standby**]	Displays the HSRP status for a group or interface for virtual forwarders in the active, init, learn, listen, or standby state. Use the **all** keyword to see all states, including disabled.
show hsrp [**group** *group-number*] [**interface** *interface-type slot/port*] **active**] [**all**] [**init**] [**learn**] [**listen**] [**speak**] [**standby**] **brief**	Displays a brief summary of the HSRP status for a group or interface for virtual forwarders in the active, init, learn, listen, or standby state. Use the **all** keyword to see all states, including disabled.

Configuration Examples for HSRP

This example shows how to enable HSRP on an interface with MD5 authentication and interface tracking:

```
key chain hsrp-keys
 key 0
   key-string 7 zqdest
   accept-lifetime 00:00:00 Jun 01 2013 23:59:59 Sep 12 2013
   send-lifetime 00:00:00 Jun 01 2013 23:59:59 Aug 12 2013
  key 1
   key-string 7 uaeqdyito
   accept-lifetime 00:00:00 Aug 12 2013 23:59:59 Nov 12 2013
   send-lifetime 00:00:00 Sep 12 2013 23:59:59 Nov 12 2013
feature hsrp
track 2 interface ethernet 2/2 ip
interface ethernet 1/2
 ip address 192.0.2.2/8
 hsrp 1
  authenticate md5 key-chain hsrp-keys
  priority 90
  track 2 decrement 20
  ip 192.0.2.10
 no shutdown
```

This example shows how to configure the HSRP priority on an interface:

```
interface vlan 1
hsrp 0
    preempt
    priority 100 forwarding-threshold lower 80 upper 90
    ip 192.0.2.2
    track 1 decrement 30
```

Additional References

For additional information related to implementing HSRP, see the following sections:

- Related Documents, page 17-24
- MIBs, page 17-24

Related Documents

Related Topic	Document Title
Configuring the Virtual Router Redundancy Protocol	Chapter 18,“Configuring VRRP”
Configuring high availability	*Cisco Nexus 9000 Series NX-OS High Availability and Redundancy Guide*

MIBs

MIBs	MIBs Link
MIBs related to HSRP	To locate and download supported MIBs, go to the following URL: ftp://ftp.cisco.com/pub/mibs/supportlists/nexus9000/Nexus9000MIBSupportList.html

Configuring VRRP

This chapter describes how to configure the Virtual Router Redundancy Protocol (VRRP) on the Cisco NX-OS device.

This chapter includes the following sections:

Information About VRRP

VRRP allows for transparent failover at the first-hop IP router by configuring a group of routers to share a virtual IP address. VRRP selects a master router in that group to handle all packets for the virtual IP address. The remaining routers are in standby and take over if the master router fails.

This section includes the following topics:

VRRP Operation

A LAN client can determine which router should be the first hop to a particular remote destination by using a dynamic process or static configuration. Examples of dynamic router discovery are as follows:

- Proxy ARP—The client uses the Address Resolution Protocol (ARP) to get the destination it wants to reach, and a router responds to the ARP request with its own MAC address.
- Routing protocol—The client listens to dynamic routing protocol updates (for example, from Routing Information Protocol [RIP]) and forms its own routing table.
- ICMP Router Discovery Protocol (IRDP) client—The client runs an Internet Control Message Protocol (ICMP) router discovery client.

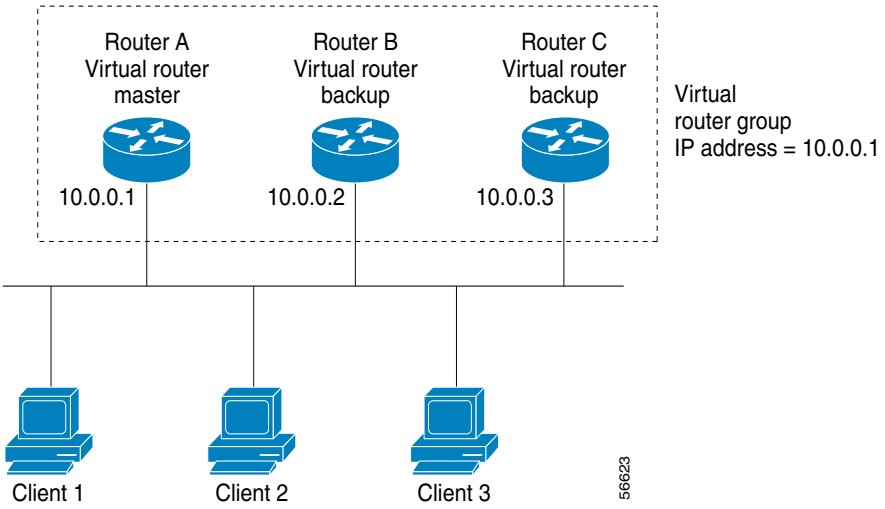
The disadvantage to dynamic discovery protocols is that they incur some configuration and processing overhead on the LAN client. Also, if a router fails, the process of switching to another router can be slow.

An alternative to dynamic discovery protocols is to statically configure a default router on the client. Although, this approach simplifies client configuration and processing, it creates a single point of failure. If the default gateway fails, the LAN client is limited to communicating only on the local IP network segment and is cut off from the rest of the network.

VRRP can solve the static configuration problem by enabling a group of routers (a VRRP group) to share a single virtual IP address. You can then configure the LAN clients with the virtual IP address as their default gateway.

Figure 18-1 shows a basic VLAN topology. In this example, Routers A, B, and C form a VRRP group. The IP address of the group is the same address that was configured for the Ethernet interface of Router A (10.0.0.1).

Figure 18-1 Basic VRRP Topology



Because the virtual IP address uses the IP address of the physical Ethernet interface of Router A, Router A is the master (also known as the IP address owner). As the master, Router A owns the virtual IP address of the VRRP group and forwards packets sent to this IP address. Clients 1 through 3 are configured with the default gateway IP address of 10.0.0.1.

Routers B and C function as backups. If the master fails, the backup router with the highest priority becomes the master and takes over the virtual IP address to provide uninterrupted service for the LAN hosts. When router A recovers, it becomes the master again. For more information, see the "VRRP Router Priority and Preemption" section.

Note Packets received on a routed port destined for the VRRP virtual IP address terminate on the local router, regardless of whether that router is the master VRRP router or a backup VRRP router. These packets include ping and Telnet traffic. Packets received on a Layer 2 (VLAN) interface destined for the VRRP virtual IP address terminate on the master router.

VRRP Benefits

The benefits of VRRP are as follows:

- Redundancy—Enables you to configure multiple routers as the default gateway router, which reduces the possibility of a single point of failure in a network.
- Load sharing—Allows traffic to and from LAN clients to be shared by multiple routers. The traffic load is shared more equitably among available routers.
- Multiple VRRP groups—Supports multiple VRRP groups on a router physical interface if the platform supports multiple MAC addresses. Multiple VRRP groups enable you to implement redundancy and load sharing in your LAN topology.
- Multiple IP addresses—Allows you to manage multiple IP addresses, including secondary IP addresses. If you have multiple subnets configured on an Ethernet interface, you can configure VRRP on each subnet.
- Preemption—Enables you to preempt a backup router that has taken over for a failing master with a higher priority backup router that has become available.

- Advertisement protocol—Uses a dedicated Internet Assigned Numbers Authority (IANA) standard multicast address (224.0.0.18) for VRRP advertisements. This addressing scheme minimizes the number of routers that must service the multicasts and allows test equipment to accurately identify VRRP packets on a segment. IANA has assigned the IP protocol number 112 to VRRP.
- VRRP tracking—Ensures that the best VRRP router is the master for the group by altering VRRP priorities based on interface states.

Multiple VRRP Groups

You can configure multiple VRRP groups on a physical interface. For the number of supported VRRP groups, see the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.

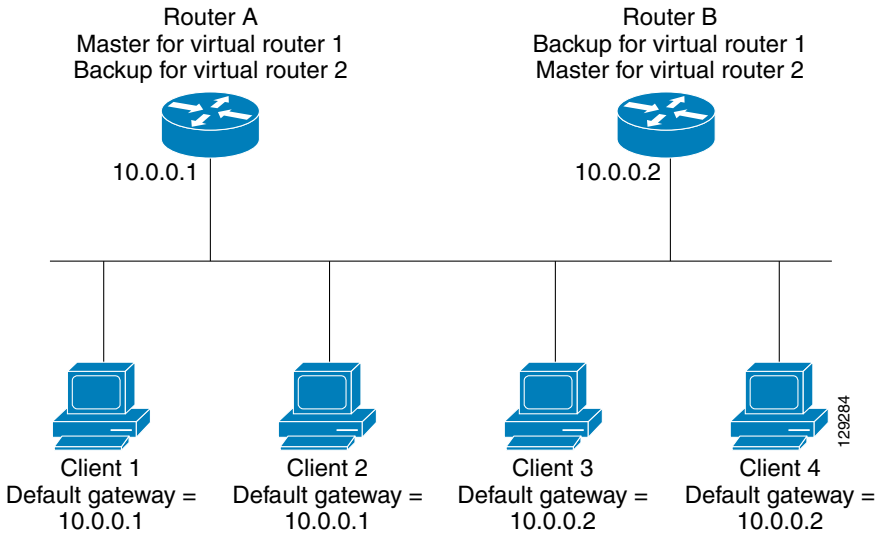
The number of VRRP groups that a router interface can support depends on the following factors:

- Router processing capability
- Router memory capability

In a topology where multiple VRRP groups are configured on a router interface, the interface can act as a master for one VRRP group and as a backup for one or more other VRRP groups.

Figure 18-2 shows a LAN topology in which VRRP is configured so that Routers A and B share the traffic to and from clients 1 through 4. Routers A and B act as backups to each other if either router fails.

Figure 18-2 Load Sharing and Redundancy VRRP Topology



This topology contains two virtual IP addresses for two VRRP groups that overlap. For VRRP group 1, Router A is the owner of IP address 10.0.0.1 and is the master. Router B is the backup to Router A. Clients 1 and 2 are configured with the default gateway IP address of 10.0.0.1.

For VRRP group 2, Router B is the owner of IP address 10.0.0.2 and is the master. Router A is the backup to router B. Clients 3 and 4 are configured with the default gateway IP address of 10.0.0.2.

VRRP Router Priority and Preemption

An important aspect of the VRRP redundancy scheme is the VRRP router priority because the priority determines the role that each VRRP router plays and what happens if the master router fails.

If a VRRP router owns the virtual IP address and the IP address of the physical interface, this router functions as the master. The priority of the master is 255.

The priority also determines if a VRRP router functions as a backup router and the order of ascendancy to becoming a master if the master fails.

For example, if Router A, the master in a LAN topology, fails, VRRP must determine if backups B or C should take over. If you configure Router B with priority 101 and Router C with the default priority of 100, VRRP selects Router B to become the master because it has the higher priority. If you configure Routers B and C with the default priority of 100, VRRP selects the backup with the higher IP address to become the master.

VRRP uses preemption to determine what happens after a VRRP backup router becomes the master. With preemption enabled by default, VRRP switches to a backup if that backup comes online with a priority higher than the new master. For example, if Router A is the master and fails, VRRP selects Router B (next in order of priority). If Router C comes online with a higher priority than Router B, VRRP selects Router C as the new master, even though Router B has not failed.

If you disable preemption, VRRP switches only if the original master recovers or the new master fails.

vPC and VRRP

VRRP interoperates with virtual port channels (vPCs). vPCs allow links that are physically connected to two different Cisco Nexus 9000 Series devices to appear as a single port channel by a third device. See the *Cisco Nexus 9000 Series NX-OS Layer 2 Switching Configuration Guide* for more information on vPCs.

vPC forwards traffic through both the master VRRP router as well as the backup VRRP router. See the "Configuring VRRP Priority" section on page 18-11.

Note You should configure VRRP on the primary vPC peer device as active and VRRP on the vPC secondary device as standby.

VRRP Advertisements

The VRRP master sends VRRP advertisements to other VRRP routers in the same group. The advertisements communicate the priority and state of the master. Cisco NX-OS encapsulates the VRRP advertisements in IP packets and sends them to the IP multicast address assigned to the VRRP group. Cisco NX-OS sends the advertisements once every second by default, but you can configure a different advertisement interval.

VRRP Authentication

VRRP supports the following authentication functions:

- No authentication
- Plain text authentication

VRRP rejects packets in any of the following cases:

- The authentication schemes differ on the router and in the incoming packet.
- Text authentication strings differ on the router and in the incoming packet.

VRRP Tracking

VRRP supports the following options for tracking:

- Native interface tracking— Tracks the state of an interface and uses that state to determine the priority of the VRRP router in a VRRP group. The tracked state is down if the interface is down or if the interface does not have a primary IP address.
- Object tracking—Tracks the state of a configured object and uses that state to determine the priority of the VRRP router in a VRRP group. See Chapter 19,"Configuring Object Tracking" for more information on object tracking.

If the tracked state (interface or object) goes down, VRRP updates the priority based on what you configure the new priority to be for the tracked state. When the tracked state comes up, VRRP restores the original priority for the virtual router group.

For example, you might want to lower the priority of a VRRP group member if its uplink to the network goes down so another group member can take over as master for the VRRP group. See the "Configuring VRRP Interface State Tracking" section on page 18-17 for more information.

Note VRRP does not support Layer 2 interface tracking.

BFD

This feature supports bidirectional forwarding detection (BFD) for IPv4. BFD is a detection protocol that provides fast-forwarding and path-failure detection times. BFD provides subsecond failure detection between two adjacent devices and can be less CPU-intensive than protocol hello messages because some of the BFD load can be distributed onto the data plane on supported modules. See the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide* for more information.

Information About VRRPv3 and VRRS

VRRP version 3 (VRRPv3) enables a group of switches to form a single virtual switch in order to provide redundancy and reduce the possibility of a single point of failure in a network. The LAN clients can then be configured with the virtual switch as their default gateway. The virtual switch, representing a group of switches, is also known as a VRRPv3 group.

Virtual router redundancy service (VRRS) improves the scalability of VRRPv3 by providing a stateless redundancy service to VRRS pathways and VRRS clients by monitoring VRRPv3. VRRPv3 acts as a VRRS server that pushes VRRPv3 status information (such as current and previous redundancy states, active and inactive Layer 2 and Layer 3 addresses, and so on) to VRRS pathways and all registered VRRS clients.

VRRS clients are other Cisco processes or applications that use VRRPv3 to provide or withhold a service or resource dependent upon the state of the group. VRRS pathways are special VRRS clients that use the VRRS database information to provide scaled first-hop gateway redundancy across scaled interface environments.

VRRS by itself is limited to maintaining its own state. Linking a VRRS client to a VRRPv3 group provides a mechanism that allows VRRS to provide a service to client applications so that they can implement stateless or stateful failovers. A stateful failover requires communication with a nominated backup before the failure so that operational data is not lost when the failover occurs.

VRRS pathways operate in a similar way to clients but are integrated with the VRRS architecture. They provide a means to scale first-hop gateway redundancy by allowing you to configure a virtual address across hundreds of interfaces. The virtual gateway state of a VRRS pathway follows the state of a First-Hop Redundancy Protocol (FHRP) VRRS server.

VRRPv3 notifies VRRS of its current state (master, backup, or nonoperational initial state [INIT]) and passes that information to pathways or clients. The VRRPv3 group name activates VRRS and associates the VRRPv3 group with any clients or pathways that are configured as part of VRRS with the same name.

Pathways and clients act on the VRRPv3 server state. When a VRRPv3 group changes states, VRRS pathways and clients alter their behavior (performing tasks such as shutting down interfaces or appending accounting logs) depending on the state received from VRRS.

VRRPv3 Benefits

The benefits of VRRPv3 are as follows:

- Interoperability in multi-vendor environments
- Support for the IPv4 and IPv6 address families
- Improved scalability through the use of VRRS pathways

High Availability

VRRP supports high availability through stateful restarts and stateful switchovers. A stateful restart occurs when the VRRP process fails and is restarted. A stateful switchover occurs when the active supervisor switches to the standby supervisor. Cisco NX-OS applies the run-time configuration after the switchover.

VRRPv3 does not support stateful switchovers.

Virtualization Support

VRRP supports virtual routing and forwarding (VRF) instances.

Licensing Requirements for VRRP

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	VRRP requires no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Guidelines and Limitations for VRRP

VRRP has the following configuration guidelines and limitations:

- You cannot configure VRRP on the management interface.
- When VRRP is enabled, you should replicate the VRRP configuration across devices in your network.
- We recommend that you do not configure more than one first-hop redundancy protocol on the same interface.
- You must configure an IP address for the interface that you configure VRRP on and enable that interface before VRRP becomes active.
- Cisco NX-OS removes all Layer 3 configurations on an interface when you change the interface VRF membership, port channel membership, or when you change the port mode to Layer 2.
- When you configure VRRP to track a Layer 2 interface, you must shut down the Layer 2 interface and reenable the interface to update the VRRP priority to reflect the state of the Layer 2 interface.
- BFD for VRRP can only be configured between two routers.

Guidelines and Limitations for VRRPv3

VRRPv3 has the following configuration guidelines and limitations:

- VRRPv3 is not intended as a replacement for existing dynamic protocols. VRRPv3 is designed for use over multi-access, multicast, or broadcast-capable Ethernet LANs.
- VRRPv3 is supported only on Ethernet and Fast Ethernet interfaces, bridge group virtual interfaces (BVIs), Gigabit Ethernet interfaces, and VLANs.
- When VRRPv3 is in use, VRRPv2 is unavailable. To configure VRRPv3, you must disable any VRRPv2configuration.
- VRRS is currently available only for use with VRRPv3.
- Use VRRPv3 millisecond timers only where absolutely necessary and with careful consideration andtesting. Millisecond values work only under favorable circumstances. The millisecond timer values are compatible with third-party vendors as long as they also support VRRPv3.
- Full network redundancy can be achieved only if VRRPv3 operates over the same network path as the VRRS pathway redundant interfaces. For full redundancy, the following restrictions apply:
  - VRRS pathways should use the same physical interface as the parent VRRPv3 group or be configured on a subinterface with the same physical interface as the parent VRRPv3 group.

  - VRRS pathways can be configured on switch virtual interfaces (SVIs) only if the associated VLAN shares the same trunk as the VLAN on which the parent VRRPv3 group is configured.
- Unlike VRRPv2, VRRPv3 does not support bidirectional forwarding for faster failure detection.
- Unlike VRRPv2, VRRPv3 does not support native and object tracking.

Default Settings for VRRP Parameters

Table 18-1 lists the default settings for VRRP parameters.

Table 18-1 Default VRRP Parameters

Parameters	Default
VRRP	Disabled
Advertisement interval	1 seconds
Authentication	No authentication
Preemption	Enabled
Priority	100

Default Settings for VRRPv3 Parameters

Table 18-1 lists the default settings for VRRPv3 parameters.

Table 18-2 Default VRRPv3 Parameters

Parameters	Default
VRRPv3	Disabled
VRRS	Disabled
VRRPv3 secondary address matching	Enabled
Priority of a VRRPv3 group	100
VRRPv3 advertisement timer	1000 milliseconds

Configuring VRRP

This section includes the following topics:

Note If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Enabling the VRRP Feature

You must globally enable the VRRP feature before you can configure and enable any VRRP groups.

To enable the VRRP feature, use the following command in global configuration mode:

Command	Purpose
feature vrrp **Example:** `switch(config)# feature vrrp`	Enables VRRP.

To disable the VRRP feature and remove all associated configurations, use the following command in global configuration mode:

Command	Purpose
no feature vrrp **Example:** `switch(config)# no feature vrrp`	Disables the VRRP feature.

Configuring VRRP Groups

You can create a VRRP group, assign the virtual IP address, and enable the group.

You can configure one virtual IPv4 address for a VRRP group. By default, the master VRRP router drops the packets addressed directly to the virtual IP address because the VRRP master is only intended as a next-hop router to forward packets. Some applications require that Cisco NX-OS accept packets addressed to the virtual router IP. Use the secondary option to the virtual IP address to accept these packets when the local router is the VRRP master.

Once you have configured the VRRP group, you must explicitly enable the group before it becomes active.

BEFORE YOU BEGIN

Ensure that you configure an IP address on the interface (see the "Configuring IPv4 Addressing" section on page 2-9).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **vrrp** *number*
4. **address** *ip-address* [**secondary**]

5. **no shutdown**
6. (Optional) **show vrrp**
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** switch(config)# interface ethernet 2/1 switch(config-if)#	Enters interface configuration mode.
Step 3	**vrrp** *number* **Example:** switch(config-if)# vrrp 250 switch(config-if-vrrp)#	Creates a virtual router group. The range is from 1 to 255.
Step 4	**address** *ip-address* [**secondary**] **Example:** switch(config-if-vrrp)# address 192.0.2.8	Configures the virtual IPv4 address for the specified VRRP group. This address should be in the same subnet as the IPv4 address of the interface. Use the **secondary** option only if applications require that VRRP routers accept the packets sent to the virtual router's IP address and deliver to applications.
Step 5	**no shutdown** **Example**: switch(config-if-vrrp)# no shutdown switch(config-if-vrrp)#	Enables the VRRP group. Disabled by default.
Step 6	**show vrrp** **Example:** switch(config-if-vrrp)# show vrrp	(Optional) Displays VRRP information.
Step 7	**copy running-config startup-config** **Example:** switch(config-if-vrrp)# copy running-config startup-config	(Optional) Saves this configuration change.

Configuring VRRP Priority

The valid priority range for a virtual router is from 1 to 254 (1 is the lowest priority and 254 is the highest). The default priority value for backups is 100. For devices whose interface IP address is the same as the primary virtual IP address (the master), the default value is 255.

If you configure VRRP on a vPC-enabled interface, you can optionally configure the upper and lower threshold values to control when to fail over to the vPC trunk. If the backup router priority falls below the lower threshold, VRRP sends all backup router traffic across the vPC trunk to forward through the master VRRP router. VRRP maintains this scenario until the backup VRRP router priority increases above the upper threshold.

BEFORE YOU BEGIN

You must enable VRRP (see the "Configuring VRRP" section on page 18-9).

Ensure that you have configured an IP address on the interface (see the "Configuring IPv4 Addressing" section on page 2-9).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **vrrp** *number*
4. **shutdown**
5. **priority** *level* [**forwarding-threshold lower** *lower-value* **upper** *upper-value*]
6. **no shutdown**
7. (Optional) **show vrrp**
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 2/1` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**vrrp** *number* **Example:** `switch(config-if)# vrrp 250` `switch(config-if-vrrp)#`	Creates a virtual router group.
Step 4	**shutdown** **Example:** `switch(config-if-vrrp)# shutdown` `switch(config-if-vrrp)#`	Disables the VRRP group. Disabled by default.

	Command	Purpose
Step 5	**priority** *level* [**forwarding-threshold lower** *lower-value* **upper** *upper-value*] **Example:** `switch(config-if-vrrp)# priority 60 forwarding-threshold lower 40 upper 50`	Sets the priority level used to select the active router in an VRRP group. The *level* range is from 1 to 254. The default is 100 for backups and 255 for a master that has an interface IP address equal to the virtual IP address. Optionally, sets the upper and lower threshold values used by vPC to determine when to fail over to the vPC trunk. The *lower-value* range is from 1 to 255. The default is 1. The *upper-value* range is from 1 to 255. The default is 255.
Step 6	**no shutdown** **Example**: `switch(config-if-vrrp)# no shutdown` `switch(config-if-vrrp)#`	Enables the VRRP group. Disabled by default.
Step 7	**show vrrp** ***Example:*** `switch(config-if-vrrp)# show vrrp`	(Optional) Displays a summary of VRRP information.
Step 8	**copy running-config startup-config** **Example:** `switch(config-if-vrrp)# copy running-config startup-config`	(Optional) Saves this configuration change.

Configuring VRRP Authentication

You can configure simple text authentication for a VRRP group.

BEFORE YOU BEGIN

Ensure that the authentication configuration is identical for all VRRP devices in the network.

Ensure that you have enabled VRRP (see the "Configuring VRRP" section on page 18-9).

Ensure that you have configured an IP address on the interface (see the "Configuring IPv4 Addressing" section on page 2-9).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **vrrp** *number*
4. **shutdown**
5. **authentication text** *password*
6. **no shutdown**
7. (Optional) **show vrrp**
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** switch(config)# interface ethernet 2/1 switch(config-if)#	Enters interface configuration mode.
Step 3	**vrrp** *number* **Example:** switch(config-if)# vrrp 250 switch(config-if-vrrp)#	Creates a virtual router group.
Step 4	**shutdown** **Example:** switch(config-if-vrrp)# shutdown switch(config-if-vrrp)#	Disables the VRRP group. Disabled by default.
Step 5	**authentication text** *password* **Example:** switch(config-if-vrrp)# authentication text aPassword	Assigns the simple text authentication option and specifies the keyname password. The keyname range is from 1 to 255 characters. We recommend that you use at least 16 characters. The text password is up to eight alphanumeric characters.
Step 6	**no shutdown** **Example:** switch(config-if-vrrp)# no shutdown switch(config-if-vrrp)#	Enables the VRRP group. Disabled by default.
Step 7	**show vrrp** **Example:** switch(config-if-vrrp)# show vrrp	(Optional) Displays a summary of VRRP information.
Step 8	**copy running-config startup-config** **Example:** switch(config-if-vrrp)# copy running-config startup-config	(Optional) Saves this configuration change.

Configuring Time Intervals for Advertisement Packets

You can configure the time intervals for advertisement packets.

BEFORE YOU BEGIN

You must enable VRRP (see the "Configuring VRRP" section on page 18-9).

Ensure that you have configured an IP address on the interface (see the "Configuring IPv4 Addressing" section on page 2-9).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **vrrp** *number*
4. **shutdown**
5. **advertisement-interval** *seconds*
6. **no shutdown**
7. (Optional) **show vrrp**
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 2/1` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**vrrp** ***number*** **Example:** `switch(config-if)# vrrp 250` `switch(config-if-vrrp)#`	Creates a virtual router group.
Step 4	**shutdown** **Example**: `switch(config-if-vrrp)# shutdown` `switch(config-if-vrrp)#`	Disables the VRRP group. Disabled by default.
Step 5	**advertisement-interval** *seconds* **Example:** `switch(config-if-vrrp)# advertisement-interval 15`	Sets the interval time in seconds between sending advertisement frames. The range is from 1 to 255. The default is 1 second.
Step 6	**no shutdown** **Example**: `switch(config-if-vrrp)# no shutdown` `switch(config-if-vrrp)#`	Enables the VRRP group. Disabled by default.
Step 7	**show vrrp** **Example:** `switch(config-if-vrrp)# show vrrp`	(Optional) Displays a summary of VRRP information.
Step 8	**copy running-config startup-config** **Example:** `switch(config-if-vrrp)# copy running-config startup-config`	(Optional) Saves this configuration change.

Disabling Preemption

You can disable preemption for a VRRP group member. If you disable preemption, a higher-priority backup router does not take over for a lower-priority master router. Preemption is enabled by default.

BEFORE YOU BEGIN

You must enable VRRP (see the "Configuring VRRP" section on page 18-9).

Ensure that you have configured an IP address on the interface (see the "Configuring IPv4 Addressing" section on page 2-9).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **vrrp** *number*
4. **shutdown**
5. **no preempt**
6. **no shutdown**
7. (Optional) **show vrrp**
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** `switch(config)# interface ethernet 2/1` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**vrrp** *number* **Example:** `switch(config-if)# vrrp 250` `switch(config-if-vrrp)#`	Creates a virtual router group.
Step 4	**no shutdown** **Example:** `switch(config-if-vrrp)# no shutdown`	Enables the VRRP group. Disabled by default.
Step 5	**no preempt** **Example:** `switch(config-if-vrrp)# no preempt`	Disables the preempt option and allows the master to remain when a higher-priority backup appears.

	Command	Purpose
Step 6	**no shutdown** **Example:** switch(config-if-vrrp)# no shutdown	Enables the VRRP group. Disabled by default.
Step 7	**show vrrp** **Example:** switch(config-if-vrrp)# show vrrp	(Optional) Displays a summary of VRRP information.
Step 8	**copy running-config startup-config** **Example:** switch(config-if-vrrp)# copy running-config startup-config	(Optional) Saves this configuration change.

Configuring VRRP Interface State Tracking

Interface state tracking changes the priority of the virtual router based on the state of another interface in the device. When the tracked interface goes down or the IP address is removed, Cisco NX-OS assigns the tracking priority value to the virtual router. When the tracked interface comes up and an IP address is configured on this interface, Cisco NX-OS restores the configured priority to the virtual router (see the"Configuring VRRP Priority" section on page 18-11).

Note For interface state tracking to function, you must enable preemption on the interface.

Note VRRP does not support Layer 2 interface tracking.

BEFORE YOU BEGIN

You must enable VRRP (see the "Configuring VRRP" section on page 18-9).

Ensure that you have configured an IP address on the interface (see the "Configuring IPv4 Addressing" section on page 2-9).

Ensure that you have enabled the virtual router (see the "Configuring VRRP Groups" section on page 18-10).

SUMMARY STEPS

1. **configure terminal**
2. **interface** *interface-type slot/port*
3. **vrrp** *number*
4. **shutdown**
5. **track interface** *type number* **priority** *value*
6. **no shutdown**
7. (Optional) **show vrrp**
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**interface** *interface-type slot/port* **Example:** switch(config)# interface ethernet 2/1 switch(config-if)#	Enters interface configuration mode.
Step 3	**vrrp** *number* **Example:** switch(config-if)# vrrp 250 switch(config-if-vrrp)#	Creates a virtual router group.
Step 4	**shutdown** **Example:** switch(config-if-vrrp)# shutdown switch(config-if-vrrp)#	Disables the VRRP group. Disabled by default.
Step 5	**track interface** type *number* **priority** *value* **Example:** switch(config-if-vrrp)# track interface ethernet 2/10 priority 254	Enables interface priority tracking for a VRRP group. The priority range is from 1 to 254.
Step 6	**no shutdown** **Example:** switch(config-if-vrrp)# no shutdown switch(config-if-vrrp)#	Enables the VRRP group. Disabled by default.
Step 7	**show vrrp** **Example:** switch(config-if-vrrp)# show vrrp	(Optional) Displays a summary of VRRP information.
Step 8	**copy running-config startup-config** **Example:** switch(config-if-vrrp)# copy running-config startup-config	(Optional) Saves this configuration change.

Configuring VRRPv3

This section includes the following topics:

Enabling VRRPv3 and VRRS

You must globally enable VRRPv3 before you can configure and enable any VRRPv3 groups.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **feature vrrpv3**
3. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	[**no**] **feature vrrpv3** **Example:** `switch(config)# feature vrrpv3`	Enables VRRP version 3 and Virtual Router Redundancy Service (VRRS). The **no** form of this command disables VRRPv3 and VRRS. If VRRPv2 is currently configured, use the **no feature vrrp** command in global configuration mode to remove the VRRPv2 configuration and then use the **feature vrrpv3** command to enable VRRPv3.
Step 3	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Saves this configuration change.

Creating VRRPv3 Groups

You can create a VRRPv3 group, assign the virtual IP address, and enable the group.

BEFORE YOU BEGIN

Make sure that VRRPv3 is enabled.

Make sure that you have configured an IP address on the interface.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *slot/port*
3. **vrrpv3** *number* **address-family** [**ipv4** | **ipv6**]
4. (Optional) **address** *ip-address* [**primary** | **secondary**]
5. (Optional) **description** *description*
6. (Optional) **match-address**
7. (Optional) **preempt** [**delay minimum** *seconds*]
8. (Optional) **priority** *level*
9. (Optional) **timers advertise** *interval*
10. (Optional) **vrrp2**
11. (Optional) **vrrs leader** *vrrs-leader-name*
12. (Optional) **shutdown**
13. (Optional) **show fhrp** [*interface-type interface-number*] [**verbose**]
14. (Optional) **show vrrpv3** *interface-type interface-number*
15. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface ethernet** *slot/port* **Example:** `switch(config)# interface ethernet 2/1` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**vrrpv3** *number address-family* [**ipv4** | **ipv6**] **Example:** `switch(config-if)# vrrpv3 5 address-family ipv4` `switch(config-if-vrrpv3-group)#`	Creates a VRRPv3 group and enters VRRPv3 group configuration mode. The range is from 1 to 255.
Step 4	**address** *ip-address* [**primary** | **secondary**] **Example:** `switch(config-if-vrrpv3-group)# address 100.0.1.10 primary`	(Optional) Specifies a primary or secondary IPv4 or IPv6 address for the VRRPv3 group. To utilize secondary IP addresses in a VRRPv3 group, you must first configure a primary IP address on the same group.

	Command	Purpose
Step 5	**description** *description* **Example:** `switch(config-if-vrrpv3-group)# description group3`	(Optional) Specifies a description for the VRRPv3 group. You can enter up to 80 alphanumeric characters.
Step 6	**match-address** **Example:** `switch(config-if-vrrpv3-group)# match-address`	(Optional) Matches the secondary address in the advertisement packet against the configured address.
Step 7	**preempt** [**delay minimum** *seconds*] **Example:** `switch(config-if-vrrpv3-group)# preempt delay minimum 30`	(Optional) Enables preemption of a lower priority master switch with an optional delay. The range is from 0 to 3600.
Step 8	**priority** *level* **Example:** `switch(config-if-vrrpv3-group)# priority 3`	(Optional) Specifies the priority of the VRRPv3 group. The range is from 1 to 254.
Step 9	**timers advertise** *interval* **Example:** `switch(config-if-vrrpv3-group)# timers advertise 1000`	(Optional) Sets the advertisement timer in milliseconds. The range is from 100 to 40950. Cisco recommends that you set this timer to a value greater than or equal to 1 second.
Step 10	**vrrp2** **Example:** `switch(config-if-vrrpv3-group)# vrrp2`	(Optional) Enables support for VRRPv2 simultaneously to ensure interoperability with devices that support only VRRPv2. VRRPv2 compatibility mode is provided to allow an upgrade from VRRPv2 to VRRPv3. This is not a full VRRPv2 implementation and should be used only to perform an upgrade.
Step 11	**vrrs leader** *vrrs-leader-name* **Example:** `switch(config-if-vrrpv3-group)# vrrs leader leader1`	(Optional) Specifies a leader's name to be registered with VRRS.
Step 12	**shutdown** **Example:** `switch(config-if-vrrpv3-group)# shutdown`	(Optional) Disables the VRRP configuration for the VRRPv3 group.
Step 13	**show fhrp** [*interface-type interface-number*] [**verbose**] **Example:** `switch(config-if-vrrpv3-group)# show fhrp ethernet 2/1 verbose`	(Optional) Displays First Hop Redundancy Protocol (FHRP) information. Use the **verbose** keyword to view detailed information.

	Command	Purpose
Step 14	**show vrrpv3** *interface-type interface-number* **Example:** `switch(config-if-vrrpv3-group)# show vrrpv3 ethernet 2/1`	(Optional) Displays the VRRPv3 configuration information for the specified interface.
Step 15	**copy running-config startup-config** **Example:** `switch(config-if-vrrpv3-group)# copy running-config startup-config`	(Optional) Saves this configuration change.

Configuring VRRPv3 Control Groups

You can configure VRRPv3 control groups.

BEFORE YOU BEGIN

Make sure that VRRPv3 is enabled.

Make sure that you have configured an IP address on the interface.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *slot/port*
3. **ip address** *ip-address mask* [**secondary**]
4. **vrrpv3** *number* **address-family** [**ipv4** | **ipv6**]
5. (Optional) **address** *ip-address* [**primary** | **secondary**]
6. (Optional) **shutdown**
7. (Optional) **show fhrp** [*interface-type interface-number*] [**verbose**]
8. (Optional) **show vrrpv3** *interface-type interface-number*
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface ethernet** *slot/port* **Example:** `switch(config)# interface ethernet 2/1` `switch(config-if)#`	Enters interface configuration mode.

	Command	Purpose
Step 3	**ip address** *ip-address mask* [**secondary**] **Example:** switch(config-if)# ip address 209.165.200.230 255.255.255.224	Configures the IP address on the interface. You can use the **secondary** keyword to configure additional IP addresses on the interface.
Step 4	**vrrpv3** *number* **address-family** [**ipv4** | **ipv6**] **Example:** switch(config-if)# vrrpv3 5 address-family ipv4 switch(config-if-vrrpv3-group)#	Creates a VRRPv3 group and enters VRRPv3 group configuration mode. The range is from 1 to 255.
Step 5	**address** *ip-address* [**primary** | **secondary**] **Example:** switch(config-if-vrrpv3-group)# address 209.165.200.227 primary	(Optional) Specifies a primary or secondary IPv4 or IPv6 address for the VRRPv3 group.
Step 6	**shutdown** **Example:** switch(config-if-vrrpv3-group)# shutdown	(Optional) Disables the VRRP configuration for the VRRPv3 group.
Step 7	**show fhrp** [*interface-type interface-number*] [**verbose**] **Example:** switch(config-if-vrrpv3-group)# show fhrp ethernet 2/1 verbose	(Optional) Displays First Hop Redundancy Protocol (FHRP) information. Use the **verbose** keyword to view detailed information.
Step 8	**show vrrpv3** *interface-type interface-number* **Example:** switch(config-if-vrrpv3-group)# show vrrpv3 ethernet 2/1	(Optional) Displays the VRRPv3 configuration information for the specified interface.
Step 9	**copy running-config startup-config** **Example:** switch(config-if-vrrpv3-group)# copy running-config startup-config	(Optional) Saves this configuration change.

Configuring VRRS Pathways

You can configure a Virtual Router Redundancy Service (VRRS) pathway. In scaled environments, VRRS pathways should be used in combination with VRRPv3 control groups.

BEFORE YOU BEGIN

Make sure that VRRPv3 is enabled.

Make sure that you have configured an IP address on the interface.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *slot/port*
3. **ip address** *ip-address mask* [**secondary**]
4. **vrrs pathway** *vrrs-tag*
5. **mac address** {*mac-address* | **inherit**}
6. **address** *ip-address*
7. (Optional) **show vrrs pathway** *interface-type interface-number*
8. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**interface ethernet** *slot/port* **Example:** `switch(config)# interface ethernet 2/1` `switch(config-if)#`	Enters interface configuration mode.
Step 3	**ip address** *ip-address mask* [**secondary**] **Example:** `switch(config-if)# ip address 209.165.200.230 255.255.255.224`	Configures the IP address on the interface. You can use the **secondary** keyword to configure additional IP addresses on the interface.
Step 4	**vrrs pathway** *vrrs-tag* **Example:** `switch(config-if)# vrrs pathway path1` `switch(config-if-vrrs-pw)#`	Defines the VRRS pathway for a VRRS group and enters VRRS pathway configuration mode. The *vrrs-tag* argument specifies the name of the VRRS tag that is being associated with the pathway.
Step 5	**mac address** {*mac-address* | **inherit**} **Example:** `switch(config-if-vrrs-pw)# mac address fe24.fe24.fe24`	Specifies a MAC address for the pathway. The **inherit** keyword causes the pathway to inherit the virtual MAC address of the VRRPv3 group with which the pathway is associated.
Step 6	**address** *ip-address* **Example:** `switch(config-if-vrrs-pw)# address 209.165.201.10`	Defines the virtual IPv4 or IPv6 address for a pathway. A VRRPv3 group is capable of controlling more than tne pathway.

	Command	Purpose
Step 7	**show vrrs pathway** *interface-type interface-number* **Example:** `switch(config-if-vrrs-pw)# show vrrs pathway ethernet 1/2`	(Optional) Displays the VRRS pathway information for different pathway states, such as active, inactive, and not ready.
Step 8	**copy running-config startup-config** **Example:** `switch(config-if-vrrs-pw)# copy running-config startup-config`	(Optional) Saves this configuration change.

Verifying the VRRP Configuration

To display VRRP configuration information, perform one of the following tasks:

Command	Purpose
show vrrp	Displays the VRRP status for all groups.
show fhrp [*interface-type interface-number*] [**verbose**]	Displays First Hop Redundancy Protocol (FHRP) information.
show interface *interface-type*	Displays the virtual router configuration for an interface.

Verifying the VRRPv3 Configuration

To display VRRPv3 configuration information, perform one of the following tasks:

Command	Purpose
show vrrpv3 [**all** | **brief** | **detail**]	Displays the VRRPv3 configuration information.
show vrrpv3 *interface-type interface-number*	Displays the VRRPv3 configuration information for a specific interface.
show vrrs client [*client-name*]	Displays the VRRS client information.
show vrrs pathway [*interface-type interface-number*]	Displays the VRRS pathway information for different pathway states, such as active, inactive, and not ready.
show vrrs server	Displays the VRRS server information.
show vrrs tag [*tag-name*]	Displays the VRRS tag information.

Monitoring and Clearing VRRP Statistics

To display VRRP statistics, use the following commands:

Command	Purpose
show vrrp statistics	Displays the VRRP statistics.

Use the **clear vrrp statistics** command to clear all the VRRP statistics for all interfaces on the device.

Monitoring and Clearing VRRPv3 Statistics

To display VRRPv3 statistics, use the following commands:

Command	Purpose
show vrrpv3 statistics	Displays the VRRPv3 statistics.

Use the **clear vrrpv3 statistics** command to clear the VRRPv3 statistics for all interfaces on the device.

Configuration Examples for VRRP

In this example, Router A and Router B each belong to three VRRP groups. In the configuration, each group has the following properties:

- Group 1:
  - Virtual IP address is 10.1.0.10.
  - Router A will become the master for this group with priority 120.
  - Advertising interval is 3 seconds.
  - Preemption is enabled.
- Group 5:
  - Router B will become the master for this group with priority 200.
  - Advertising interval is 30 seconds.
  - Preemption is enabled.
- Group 100:
  - Router A will become the master for this group first because it has a higher IP address (10.1.0.2).
  - Advertising interval is the default of 1 second.
  - Preemption is disabled.

Router A

```
interface ethernet 1/0
   ip address 10.1.0.2/16
   no shutdown
    vrrp 1
     priority 120
     authentication text cisco
     advertisement-interval 3
     address 10.1.0.10
     no shutdown
    vrrp 5
     priority 100
     advertisement-interval 30
     address 10.1.0.50
     no shutdown
    vrrp 100
     no preempt
     address 10.1.0.100
     no shutdown
```

Router B

```
interface ethernet 1/0
 ip address 10.2.0.1/2
 no shutdown
    vrrp 1
     priority 100
     authentication text cisco
     advertisement-interval 3
     address 10.2.0.10
     no shutdown

    vrrp 5
     priority 200
     advertisement-interval 30
     address 10.2.0.50
     no shutdown
    vrrp 100
     no preempt
     address 10.2.0.100
     no shutdown
```

Configuration Examples for VRRPv3

This example shows how to enable VRRPv3 and create and customize a VRRPv3 group:

```
switch# configure terminal
switch(config)# feature vrrpv3
switch(config)# interface ethernet 4/6
switch(config-if)# vrrpv3 5 address-family ipv4
switch(config-if-vrrp3-group)# address 209.165.200.225 primary
switch(config-if-vrrp3-group)# description group3
switch(config-if-vrrp3-group)# match-address
switch(config-if-vrrp3-group)# preempt delay minimum 30
switch(config-if-vrrpv3-group)# show fhrp ethernet 4/6 verbose
switch(config-if-vrrpv3-group)# show vrrpv3 ethernet 4/6
```

This example shows how to configure a VRRPv3 control group:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# ip address 209.165.200.230 255.255.255.224
switch(config-if)# vrrpv3 5 address-family ipv4
```

```
switch(config-if-vrrpv3-group)# address 209.165.200.227 primary
switch(config-if-vrrpv3-group)# vrrs leader leader1
switch(config-if-vrrpv3-group)# shutdown
switch(config-if-vrrpv3-group)# show fhrp ethernet 1/2 verbose
switch(config-if-vrrpv3-group)# show vrrpv3 ethernet 1/2
```

This example shows how to configure VRRS pathways:

```
switch# configure terminal
switch(config)# interface ethernet 1/2
switch(config-if)# ip address 209.165.200.230 255.255.255.224
switch(config-if)# vrrs pathway path1
switch(config-if-vrrs-pw)# mac address inherit
switch(config-if-vrrs-pw)# address 209.165.201.10
switch(config-if-vrrs-pw)# show vrrs pathway ethernet 1/2
```

Additional References

Related Documents

Related Topic	Document Title
Configuring the Hot Standby Routing Protocol (HSRP)	Chapter 17,“Configuring HSRP”
Configuring high availability	*Cisco Nexus 9000 Series NX-OS High Availability and Redundancy Guide*

Configuring Object Tracking

This chapter describes how to configure object tracking on the Cisco NX-OS device.

This chapter includes the following sections:

Information About Object Tracking

Object tracking allows you to track specific objects on the device, such as the interface line protocol state, IP routing, and route reachability, and to take action when the tracked object's state changes. This feature allows you to increase the availability of the network and shorten recovery time if an object state goes down.

This section includes the following topics:

Object Tracking Overview

The object tracking feature allows you to create a tracked object that multiple clients can use to modify the client behavior when a tracked object changes. Several clients register their interest with the tracking process, track the same object, and take different actions when the object state changes.

Clients include the following features:

- Embedded Event Manager (EEM)
- Hot Standby Redundancy Protocol (HSRP)
- Virtual port channel (vPC)
- Virtual Router Redundancy Protocol (VRRP)

The object tracking monitors the status of the tracked objects and communicates any changes made to interested clients. Each tracked object is identified by a unique number that clients can use to configure the action to take when a tracked object changes state.

Cisco NX-OS tracks the following object types:

- Interface line protocol state—Tracks whether the line protocol state is up or down.
- Interface IP routing state—Tracks whether the interface has an IPv4 or IPv6 address and if IPv4 or IPv6 routing is enabled and active.
- IP route reachability—Tracks whether an IPv4 or IPv6 route exists and is reachable from the local device.

For example, you can configure HSRP to track the line protocol of the interface that connects one of the redundant routers to the rest of the network. If that link protocol goes down, you can modify the priority of the affected HSRP router and cause a switchover to a backup router that has better network connectivity.

Object Track List

An object track list allows you to track the combined states of multiple objects. Object track lists support the following capabilities:

- Boolean "and" function—Each object defined within the track list must be in an up state so that the track list object can become up.
- Boolean "or" function—At least one object defined within the track list must be in an up state so that the tracked object can become up.
- Threshold percentage—The percentage of up objects in the tracked list must be greater than the configured up threshold for the tracked list to be in the up state. If the percentage of down objects in the tracked list is above the configured track list down threshold, the tracked list is marked as down.
- Threshold weight—Assign a weight value to each object in the tracked list, and a weight threshold for the track list. If the combined weights of all up objects exceeds the track list weight up threshold, the track list is in an up state. If the combined weights of all the down objects exceeds the track list weight down threshold, the track list is in the down state.

Other entities, such as virtual port channels (vPCs) can use an object track list to modify the state of a vPC based on the state of the multiple peer links that create the vPC. See the *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide* for more information on vPCs.

See the "Configuring an Object Track List with a Boolean Expression" section on page 19-7 for more information on track lists.

High Availability

Object tracking supports high availability through stateful restarts. A stateful restart occurs when the object tracking process crashes. Object tracking also supports a stateful switchover on a dual supervisor system. Cisco NX-OS applies the runtime configuration after the switchover.

You can also use object tracking to modify the behavior of a client to improve overall network availability.

Virtualization Support

Object tracking supports virtual routing and forwarding (VRF) instances. By default, Cisco NX-OS tracks the route reachability state of objects in the default VRF. If you want to track objects in another VRF, you must configure the object to be a member of that VRF (see the "Configuring Object Tracking for a Nondefault VRF" section on page 19-13).

Licensing Requirements for Object Tracking

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	Object tracking requires no license. Any feature not included in a license package is bundled with the nx-os image and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Guidelines and Limitations

Object tracking has the following configuration guidelines and limitations:

- Supports Ethernet, subinterfaces, port channels, loopback interfaces, and VLAN interfaces.
- Supports one tracked object per HSRP group.

Default Settings

Table 19-1 lists the default settings for object tracking parameters.

Table 19-1 Default Object Tracking Parameters

Parameters	Default
Tracked object VRF	Member of default VRF

Configuring Object Tracking

This section includes the following topics:

Note For information on configuring IP SLA object tracking, see the Cisco Nexus 9000 Series NX-OS IP SLAs Configuration Guide.

Configuring Object Tracking for an Interface

You can configure Cisco NX-OS to track the line protocol or IPv4 or IPv6 routing state of an interface.

SUMMARY STEPS

1. **configure terminal**
2. **track** *object-id* **interface** *interface-type number* {**ip** | **ipv6** | **routing** | **line-protocol**}
3. (Optional) **show track** [*object-id*]
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**track** *object-id* **interface** *interface-type number* {**ip routing** | **ipv6 routing** | **line-protocol**} **Example:** `switch(config)# track 1 interface ethernet 1/2 line-protocol` `switch(config-track)#`	Creates a tracked object for an interface and enters tracking configuration mode. The *object-id* range is from 1 to 500.

	Command	Purpose
Step 3	**show track** [*object-id*] **Example**: switch(config-track)# show track 1	(Optional) Displays object tracking information.
Step 4	**copy running-config startup-config** **Example:** switch(config-track)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure object tracking for the line protocol state on Ethernet 1/2:

```
switch# configure terminal
switch(config)# track 1 interface ethernet 1/2 line-protocol
switch(config-track)# copy running-config startup-config
```

This example shows how to configure object tracking for the IPv4 routing state on Ethernet 1/2:

```
switch# configure terminal
switch(config)# track 2 interface ethernet 1/2 ip routing
switch(config-track)# copy running-config startup-config
```

This example shows how to configure object tracking for the IPv6 routing state on Ethernet 1/2:

```
switch# configure terminal
switch(config)# track 3 interface ethernet 1/2 ipv6 routing
switch(config-track)# copy running-config startup-config
```

Deleting a Tracked Object

You can delete a tracked object.

SUMMARY STEPS

1. **configure terminal**
2. **no track** *object-id*

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**no track** *object-id* **Example:** switch(config)# no track 1 switch(config-track)#	Deletes a tracked object for an interface. The *object-id* range is from 1 to 500.

This example shows how to delete a tracked object:

```
switch# configure terminal
switch(config)# no track 1
switch(config-track)# copy running-config startup-config
```

Configuring Object Tracking for Route Reachability

You can configure Cisco NX-OS to track the existence and reachability of an IP route or IPv6 route.

SUMMARY STEPS

1. **configure terminal**
2. **track** *object-id* {**ip** | **ipv6**} **route** *prefix/length* **reachability**
3. (Optional) **show track** [*object-id*]
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**track** *object-id* {**ip** | **ipv6**} **route** *prefix/length* **reachability** **Example:** `switch(config)# track 3 ipv6 route 2::5/64 reachability` `switch(config-track)#`	Creates a tracked object for a route and enters tracking configuration mode. The *object-id* range is from 1 to 500. The prefix format for IPv4 is A.B.C.D/length, where the length range is from 1 to 32. The prefix format for IPv6 is A:B::C:D/length, where the length range is from 1 to 128.
Step 3	**show track** [*object-id*] **Example**: `switch(config-track)# show track 1`	(Optional) Displays object tracking information.
Step 4	**copy running-config startup-config** **Example:** `switch(config-track)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure object tracking for an IPv4 route in the default VRF:

```
switch# configure terminal
switch(config)# track 4 ip route 192.0.2.0/8 reachability
switch(config-track)# copy running-config startup-config
```

This example shows how to configure object tracking for an IPv6 route in the default VRF:

```
switch# configure terminal
switch(config)# track 5 ipv6 route 10::10/128 reachability
switch(config-track)# copy running-config startup-config
```

Configuring an Object Track List with a Boolean Expression

You can configure an object track list that contains multiple tracked objects. A tracked list contains one or more objects. The Boolean expression enables two types of calculation by using either "and" or "or" operators. For example, when tracking two interfaces using the "and" operator, up means that both interfaces are up, and down means that either interface is down.

SUMMARY STEPS

1. **configure terminal**
2. **track** *track-number* **list boolean** {**and** | **or**}
3. **object** *object-id* [**not**]
4. (Optional) **show track** [*object-id*]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**track** *track-number* **list boolean** {**and** | **or**} **Example:** `switch(config)# track 1 list boolean and` `switch(config-track)#`	Configures a tracked list object and enters tracking configuration mode. Specifies that the state of the tracked list is based on a Boolean calculation. The keywords are as follows: • **and**—Specifies that the list is up if all objects are up or down if one or more objects are down. For example, when tracking two interfaces, up means that both interfaces are up, and down means that either interface is down. • **or**—Specifies that the list is up if at least one object is up. For example, when tracking two interfaces, up means that either interface is up, and down means that both interfaces are down. The *track-number* range is from 1 to 500.
Step 3	**object** *object-id* [**not**] **Example:** `switch(config-track)# object 10`	Adds a tracked object to the track list. The *object-id* range is from 1 to 500. The **not** keyword optionally negates the tracked object state. **Note** The example means that when object 10 is up, the tracked list detects object 10 as down.

	Command	Purpose
Step 4	**show track** [*object-id*] **Example:** switch(config-track)# show track	(Optional) Displays object tracking information.
Step 5	**copy running-config startup-config** **Example:** switch(config-track)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure a track list with multiple objects as a Boolean "and":

```
switch# configure terminal
switch(config)# track 1 list boolean and
switch(config-track)# object 10
switch(config-track)# object 20 not
```

Configuring an Object Track List with a Percentage Threshold

You can configure an object track list that contains a percentage threshold. A tracked list contains one or more objects. The percentage of up objects must exceed the configured track list up percent threshold before the track list is in an up state. For example, if the tracked list has three objects and you configure an up threshold of 60 percent, two of the objects must be in the up state (66 percent of all objects) for the track list to be in the up state.

SUMMARY STEPS

1. **configure terminal**
2. **track** *track-number* **list threshold percentage**
3. **threshold percentage up** *up-value* **down** *down-value*
4. **object** *object-id*
5. (Optional) **show track** [*object-id*]
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**track** *track-number* **list threshold percentage** **Example:** switch(config)# track 1 list threshold percentage switch(config-track)#	Configures a tracked list object and enters tracking configuration mode. Specifies that the state of the tracked list is based on a configured threshold percent. The *track-number* range is from 1 to 500.

	Command	Purpose
Step 3	**threshold percentage up** *up-value* **down** *down-value* **Example:** `switch(config-track)# threshold percentage up 70 down 30`	Configures the threshold percentage for the tracked list. The range from 0 to 100 percent.
Step 4	**object** *object-id* **Example:** `switch(config-track)# object 10`	Adds a tracked object to the track list. The *object-id* range is from 1 to 500.
Step 5	**show track** [*object-id*] **Example**: `switch(config-track)# show track`	(Optional) Displays object tracking information.
Step 6	**copy running-config startup-config** **Example:** `switch(config-track)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure a track list with an up threshold of 70 percent and a down threshold of 30 percent:

```
switch# configure terminal
switch(config)# track 1 list threshold percentage
switch(config-track)# threshold percentage up 70 down 30
switch(config-track)# object 10
switch(config-track)# object 20
switch(config-track)# object 30
```

Configuring an Object Track List with a Weight Threshold

You can configure an object track list that contains a weight threshold. A tracked list contains one or more objects. The combined weight of up objects must exceed the configured track list up weight threshold before the track list is in an up state. For example, if the tracked list has three objects with the default weight of 10 each and you configure an up threshold of 15, two of the objects must be in the up state (combined weight of 20) for the track list to be in the up state.

SUMMARY STEPS

1. **configure terminal**
2. **track** *track-number* **list threshold weight**
3. **threshold weight up** *up-value* **down** *down-value*
4. **object** *object-id* **weight** *value*
5. (Optional) **show track** [*object-id*]
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**track** *track-number* **list threshold weight** **Example:** `switch(config)# track 1 list threshold weight` `switch(config-track)#`	Configures a tracked list object and enters tracking configuration mode. Specifies that the state of the tracked list is based on a configured threshold weight. The *track-number* range is from 1 to 500.
Step 3	**threshold weight up** *up-value* **down** *down-value* **Example:** `switch(config-track)# threshold weight up 30 down 10`	Configures the threshold weight for the tracked list. The range from 1 to 255.
Step 4	**object** *object-id* **weight** *value* **Example:** `switch(config-track)# object 10 weight 15`	Adds a tracked object to the track list. The *object-id* range is from 1 to 500. The *value* range is from 1 to 255. The default weight value is 10.
Step 5	**show track** [*object-id*] **Example:** `switch(config-track)# show track`	(Optional) Displays object tracking information.
Step 6	**copy running-config startup-config** **Example:** `switch(config-track)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure a track list with an up weight threshold of 30 and a down threshold of 10:

```
switch# configure terminal
switch(config)# track 1 list threshold weight
switch(config-track)# threshold weight up 30 down 10
switch(config-track)# object 10 weight 15
switch(config-track)# object 20 weight 15
switch(config-track)# object 30
```

In this example, the track list is up if object 10 and object 20 are up, and the track list goes to the down state if all three objects are down.

Configuring an Object Tracking Delay

You can configure a delay for a tracked object or an object track list that delays when the object or list triggers a stage change. The tracked object or track list starts the delay timer when a state change occurs but does not recognize a state change until the delay timer expires. At that point, Cisco NX-OS checks the object state again and records a state change only if the object or list currently has a changed state. Object tracking ignores any intermediate state changes before the delay timer expires.

For example, for an interface line-protocol tracked object that is in the up state with a 20-second down delay, the delay timer starts when the line protocol goes down. The object is not in the down state unless the line protocol is down 20 seconds later.

You can configure an independent up delay and down delay for a tracked object or track list. When you delete the delay, object tracking deletes both the up and down delay.

You can change the delay at any point. If the object or list is already counting down the delay timer from a triggered event, the new delay is computed as follows:

- If the new configuration value is less than the old configuration value, the timer starts with the new value.
- If the new configuration value is more than the old configuration value, the timer is calculated as the new configuration value minus the current timer countdown minus the old configuration value.

SUMMARY STEPS

1. **configure terminal**
2. **track** *object-id* {*parameters*}
3. **track** *track-number* **list** {*parameters*}
4. **delay** {**up** *up-time* [**down** *down-time*] | **down** *down-time* [**up** *up-time*]}
5. (Optional) **show track** [*object-id*]
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	**track** *object-id* {*parameters*} **Example:** switch(config)# track 2 ip route 192.0.2.0/8 reachability switch(config-track)#	Creates a tracked object for a route and enters tracking configuration mode. The *object-id* range is from 1 to 500. The prefix format for IPv4 is A.B.C.D/length, where the length range is from 1 to 32. The prefix format for IPv6 is A:B::C:D/length, where the length range is from 1 to 128.
Step 3	**track** *track-number* **list** {*parameters*} **Example:** switch(config)# track 1 list threshold weight switch(config-track)#	Configures a tracked list object and enters tracking configuration mode. Specifies that the state of the tracked list is based on a configured threshold weight. The *track-number* range is from 1 to 500.

	Command	Purpose
Step 4	**delay** {**up** *up-time* [**down** *down-time*] | **down** *down-time* [**up** *up-time*]} **Example:** switch(config-track)# delay up 20 down 30	Configures the object delay timers. The range is from 0 to 180 seconds.
Step 5	**show track** [*object-id*] **Example:** switch(config-track)# show track 3	(Optional) Displays object tracking information.
Step 6	**copy running-config startup-config** **Example:** switch(config-track)# copy running-config startup-config	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure object tracking for a route and use delay timers:

```
switch# configure terminal
switch(config)# track 2 ip route 209.165.201.0/8 reachability
switch(config-track)# delay up 20 down 30
switch(config-track)# copy running-config startup-config
```

This example shows how to configure a track list with an up weight threshold of 30 and a down threshold of 10 with delay timers:

```
switch# configure terminal
switch(config)# track 1 list threshold weight
switch(config-track)# threshold weight up 30 down 10
switch(config-track)# object 10 weight 15
switch(config-track)# object 20 weight 15
switch(config-track)# object 30
switch(config-track)# delay up 20 down 30
```

This example shows the delay timer in the **show track** command output before and after an interface is shut down:

```
switch(config-track)# show track
Track 1
  Interface loopback1 Line Protocol
  Line Protocol is UP
  1 changes, last change 00:00:13
  Delay down 10 secs

switch(config-track)# interface loopback 1
switch(config-if)# shutdown
switch(config-if)# show track
Track 1
  Interface loopback1 Line Protocol
  Line Protocol is delayed DOWN (8 secs remaining)<------- delay timer counting down
  1 changes, last change 00:00:22
  Delay down 10 secs
```

Configuring Object Tracking for a Nondefault VRF

You can configure Cisco NX-OS to track an object in a specific VRF.

BEFORE YOU BEGIN

Ensure that nondefault VRFs are created first.

SUMMARY STEPS

1. **configure terminal**
2. **track** *object-id* {**ip** | **ipv6**} **route** *prefix/length* **reachability**
3. **vrf member** *vrf-name*
4. (Optional) **show track** [*object-id*]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal` `switch(config)#`	Enters global configuration mode.
Step 2	**track** *object-id* {**ip** | **ipv6**} **route** *prefix/length* **reachability** **Example:** `switch(config)# track 3 ipv6 route 1::2/64 reachability` `switch(config-track)#`	Creates a tracked object for a route and enters tracking configuration mode. The *object-id* range is from 1 to 500. The prefix format for IPv4 is A.B.C.D/length, where the length range is from 1 to 32. The prefix format for IPv6 is A:B::C:D/length, where the length range is from 1 to 128.
Step 3	**vrf member** *vrf-name* **Example**: `switch(config-track)# vrf member Red`	Configures the VRF to use for tracking the configured object.
Step 4	**show track** [*object-id*] **Example**: `switch(config-track)# show track 3`	(Optional) Displays object tracking information.
Step 5	**copy running-config startup-config** **Example:** `switch(config-track)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

This example shows how to configure object tracking for a route and use VRF Red to look up reachability information for this object:

```
switch# configure terminal
switch(config)# track 2 ip route 209.165.201.0/8 reachability
switch(config-track)# vrf member Red
switch(config-track)# copy running-config startup-config
```

This example shows how to configure object tracking for an IPv6 route and use VRF Red to look up reachability information for this object:

```
switch# configure terminal
switch(config)# track 3 ipv6 route 1::2/64 reachability
switch(config-track)# vrf member Red
switch(config-track)# copy running-config startup-config
```

This example shows how to modify tracked object 2 to use VRF Blue instead of VRF Red to look up reachability information for this object:

```
switch# configure terminal
switch(config)# track 2
switch(config-track)# vrf member Blue
switch(config-track)# copy running-config startup-config
```

Verifying the Object Tracking Configuration

To display object tracking configuration information, perform one of the following tasks:

Command	Purpose
show track [*object-id*] [**brief**]	Displays the object tracking information for one or more objects.
show track [*object-id*] **interface** [**brief**]	Displays the interface-based object tracking information.
show track [*object-id*] {**ip** | **ipv6**} **route** [**brief**]	Displays the IPv4 or IPv6 route-based object tracking information.

Configuration Examples for Object Tracking

This example shows how to configure object tracking for route reachability and use VRF Red to look up reachability information for this route:

```
switch# configure terminal
switch(config)# track 2 ip route 209.165.201.0/8 reachability
switch(config-track)# vrf member Red
switch(config-track)# copy running-config startup-config
```

Related Topics

See the following topics for information related to object tracking:

- Chapter 13, “Configuring Layer 3 Virtualization”
- Chapter 17, “Configuring HSRP”

Additional References

For additional information related to implementing object tracking, see the following sections:

- Related Documents, page 19-15

Related Documents

Related Topic	Document Title
Configuring the Embedded Event Manager	*Cisco Nexus 9000 Series NX-OS System Management Configuration Guide*
Configuring IP SLA Object Tracking	*Cisco Nexus 9000 Series NX-OS IP SLAs Configuration Guide*

IETF RFCs Supported by Cisco NX-OS Unicast Features

This appendix lists the IETF RFCs supported in Cisco NX-OS.

BGP RFCs

RFCs	Title
RFC 1997	*BGP Communities Attribute*
RFC 2385	*Protection of BGP Sessions via the TCP MD5 Signature Option*
RFC 2439	*BGP Route Flap Damping*
RFC 2519	*A Framework for Inter-Domain Route Aggregation*
RFC 2545	*Use of BGP-4 Multiprotocol Extensions for IPv6 Inter-Domain Routing*
RFC 2858	*Multiprotocol Extensions for BGP-4*
RFC 2918	*Route Refresh Capability for BGP-4*
RFC 3065	*Autonomous System Confederations for BGP*
RFC 3392	*Capabilities Advertisement with BGP-4*
RFC 4271	*A Border Gateway Protocol 4 (BGP-4)*
RFC 4273	*Definitions of Managed Objects for BGP-4*
RFC 4456	*BGP Route Reflection: An Alternative to Full Mesh Internal BGP (IBGP)*
RFC 4486	*Subcodes for BGP Cease Notification Message*
RFC 4724	*Graceful Restart Mechanism for BGP*
RFC 4893	*BGP Support for Four-octet AS Number Space*
RFC 5004	*Avoid BGP Best Path Transitions from One External to Another*
RFC 5396[1]	*Textual Representation of Autonomous System (AS) Numbers*
RFC 5549	*Advertising IPv4 Network Layer Reachability Information with an IPv6 Next Hop*
RFC 5668	*4-Octet AS Specific BGP Extended Community*
draft-ietf-idr-add-paths-08.txt	*Advertisement of Multiple Paths in BGP*

RFCs	Title
draft-ietf-idr-bgp4-mib-15.txt	*BGP4-MIB*
draft-kato-bgp-ipv6-link-local-00.txt	*BGP4+ Peering Using IPv6 Link-local Address*

1. RFC 5396 is partially supported. The asplain and asdot notations are supported, but the asdot+ notation is not.

First-Hop Redundancy Protocol RFCs

RFCs	Title
RFC 2281	*Hot Standby Redundancy Protocol*
RFC 3768	*Virtual Router Redundancy Protocol*

IP Services RFCs

RFCs	Title
RFC 786	*UDP*
RFC 791	*IP*
RFC 792	*ICMP*
RFC 793	*TCP*
RFC 826	*ARP*
RFC 1027	*Proxy ARP*
RFC 1591	*DNS Client*
RFC 1812	*IPv4 routers*
RFC 4022	*TCP-MIB*
RFC 4292	*IP-FORWARDING-TABLE-MIB*
RFC 4293	*IP-MIB*

IPv6 RFCs

RFCs	Title
RFC 1981	*Path MTU Discovery for IP version 6*
RFC 2373	*IP Version 6 Addressing Architecture*
RFC 2374	*An Aggregatable Global Unicast Address Format*
RFC 2460	*Internet Protocol, Version 6 (IPv6) Specification*
RFC 2461	*Neighbor Discovery for IP Version 6 (IPv6)*
RFC 2462	*IPv6 Stateless Address Autoconfiguration*
RFC 2464	*Transmission of IPv6 Packets over Ethernet Networks*
RFC 3152	*Delegation of IP6.ARPA*
RFC 3162	*RADIUS and IPv6*

RFCs	Title
RFC 3513	*Internet Protocol Version 6 (IPv6) Addressing Architecture*
RFC 3596	*DNS Extensions to Support IP version 6*
RFC 4193	*Unique Local IPv6 Unicast Addresses*

IS-IS RFCs

RFCs	Title
RFC 1142	*OSI 10589 Intermediate system to intermediate system intra-domain routing exchange protocol*
RFC 1195	*Use of OSI IS-IS for routing in TCP/IP and dual environment*
RFC 2763, RFC 5301	*Dynamic Hostname Exchange Mechanism for IS-IS*
RFC 2966, RFC 5302	*Domain-wide Prefix Distribution with Two-Level IS-IS*
RFC 2972	*IS-IS Mesh Groups*
RFC 3277	*IS-IS Transient Blackhole Avoidance*
RFC 3373, RFC 5303	*Three-Way Handshake for IS-IS Point-to-Point Adjacencies*
RFC 3567, RFC 5304	*IS-IS Cryptographic Authentication*
RFC 3784, RFC 5305	*IS-IS Extensions for Traffic Engineering*
RFC 3847, RFC 5306	*Restart Signaling for IS-IS*
draft-ietf-isis-igp-p2p-over-lan-06.txt	*Internet Draft Point-to-point operation over LAN in link-state routing protocols*

OSPF RFCs

RFCs	Title
RFC 2328	*OSPF Version 2*
RFC 2370	*The OSPF Opaque LSA Option*
RFC 2740	*OSPF for IPv6*
RFC 3101	*The OSPF Not-So-Stubby Area (NSSA) Option*
RFC 3137	*OSPF Stub Router Advertisement*
RFC 3623	*Graceful OSPF Restart*
RFC 4552 (partial support)	*Authentication/Confidentiality for OSPFv3*
RFC 5709	*OSPFv2 HMAC-SHA Cryptographic Authentication*
draft-ietf-ospf-ospfv3-graceful-restart-04.txt	*OSPFv3 Graceful Restart*

RIP RFCs

RFCs	Title
RFC 2082	*RIP-2 MD5 Authentication*
RFC 2453	*RIP Version 2*

Configuration Limits for Cisco NX-OS Layer 3 Unicast Features

The configuration limits are documented in the *Cisco Nexus 9000 Series NX-OS Verified Scalability Guide*.