



# CHAPTER 1

## Overview

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

This chapter includes the following sections:

- [Information About Layer 3 Unicast Routing, page 1-1](#)
- [Routing Algorithms, page 1-8](#)
- [Layer 3 Virtualization, page 1-9](#)
- [Cisco NX-OS Forwarding Architecture, page 1-10](#)
- [Summary of Layer 3 Unicast Routing Features, page 1-13](#)
- [Related Topics, page 1-16](#)

## Information 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, page 1-2](#)
- [Packet Switching, page 1-2](#)
- [Routing Metrics, page 1-3](#)
- [Router IDs, page 1-5](#)
- [Autonomous Systems, page 1-5](#)
- [Convergence, page 1-6](#)
- [Load Balancing and Equal Cost Multipath, page 1-6](#)
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- [Administrative Distance, page 1-6](#)
- [Stub Routing, page 1-7](#)

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## 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 and the address of the next router or *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, 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

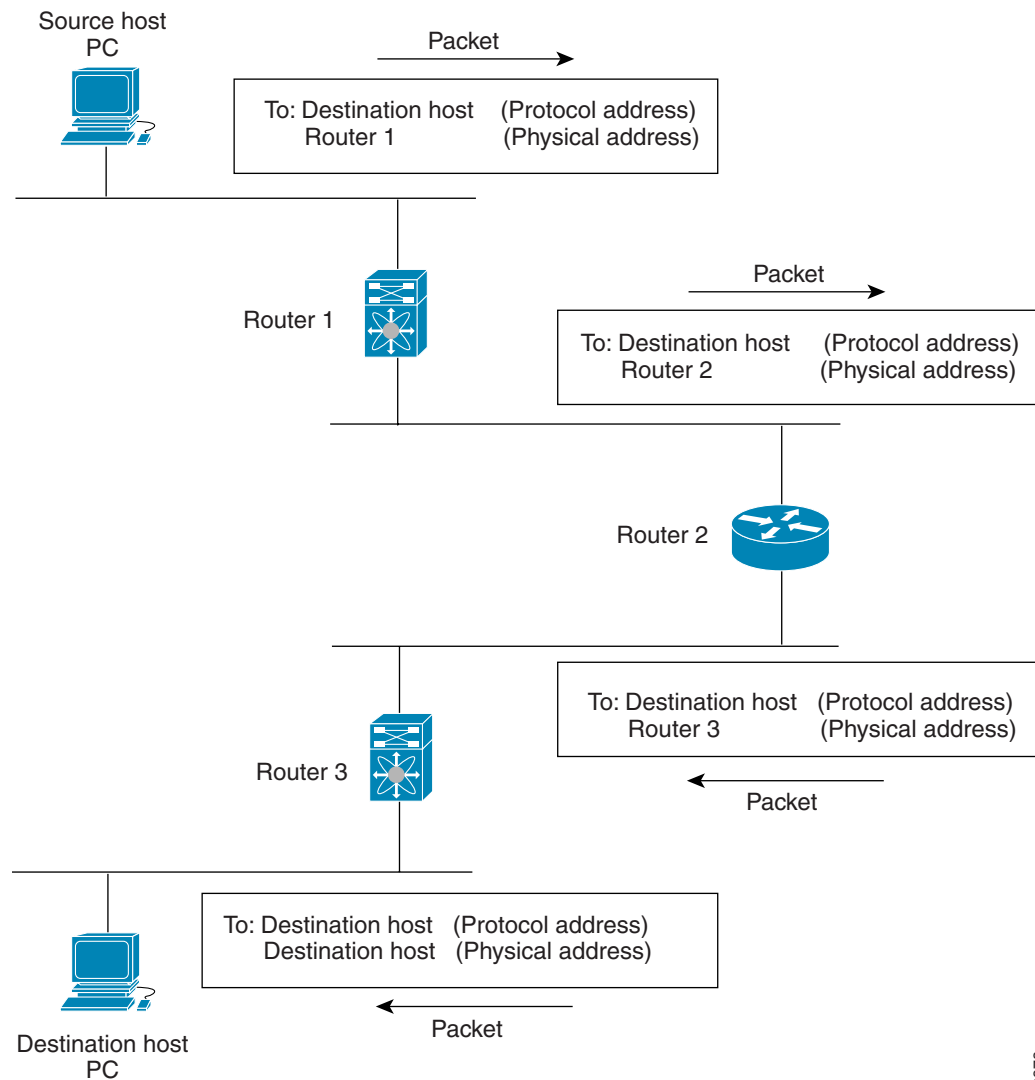
In packet switching, a host determines that it must send a packet to another host. Having acquired a router address by some means, the source host sends a packet addressed specifically to the router physical (Media Access Control [MAC]-layer) address but with the IP (network layer) address of the destination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

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**Figure 1-1 Packet Header Updates Through a Network**



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## 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](#)

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## 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 hop count, 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 needs to 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 would be 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 utilization 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.

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## 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 no loopback interfaces, 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 later 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 assign a unique number to each public autonomous system that directly connects to the Internet. This unique number identifies both the routing process and the autonomous system. [Table 1-1](#) lists the autonomous system number (AS number) ranges.

**Table 1-1 Autonomous System Numbers**

16-bit Numbers	32-bit Numbers	Purpose
1 to 64511	0.1 to 0.64511	Public AS (assigned by RIR) <sup>1</sup>
64512 to 65534	0.64512 to 0.65534	Private AS (assigned by local administrator)
65535	0.65535	Reserved
N/A	1.0 to 65535.65535	Public AS (assigned by RIR)

1. RIR=Regional Internet Registries

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, refer to the following URL:

<http://www.iana.org/>

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## 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, 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. Cisco NX-OS supports up to 16 paths to a destination.

The Enhanced Interior Gateway Routing Protocol (EIGRP) also supports unequal cost load-balancing. For more information, see [Chapter 7, “Configuring EIGRP.”](#)

## 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 Open Shortest Path First (OSPF) 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. This avoids the problem of 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.

Route redistribution also uses an administrative distance (see the [“Administrative Distance” section on page 1-6](#)) 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. The higher the value, the lower the 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.

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## Stub Routing

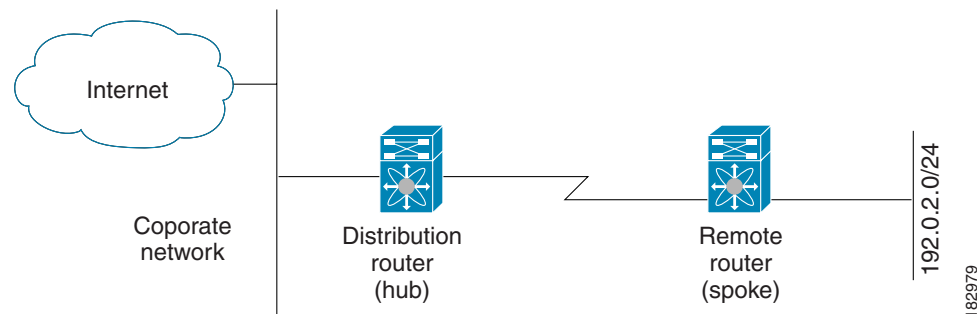
You can use stub routing in a hub-and-spoke network topology, where one or more end (stub) networks are connected to a remote router (the spoke) that is connected to one or more distribution routers (the hub). The remote router is adjacent only to one or more distribution routers. The only route for 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 informing it of the stub status does not query the stub router for any routes, and a router that has a stub peer does not query that peer. The stub router depends on the distribution router to send the proper updates to all peers.

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 would always be through the distribution router. A larger route table would reduce 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 EIGRP supports stub routers.

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## 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, page 1-8](#)
- [Interior and Exterior Gateway Protocols, page 1-8](#)
- [Distance Vector Protocols, page 1-8](#)
- [Link-State Protocols, page 1-9](#)

### 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 today's large, constantly changing networks. Most routing protocols today use dynamic routing algorithms, which 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 unroutable 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. 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.

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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 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), which 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 received to its neighbors to prevent an LSA update loop. Because the router floods the LSAs immediately after they receive them, 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 its 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 somewhat less prone to routing loops than distance vector algorithms. However, link-state algorithms require more CPU power and memory than distance vector algorithms. Link-state algorithms 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.

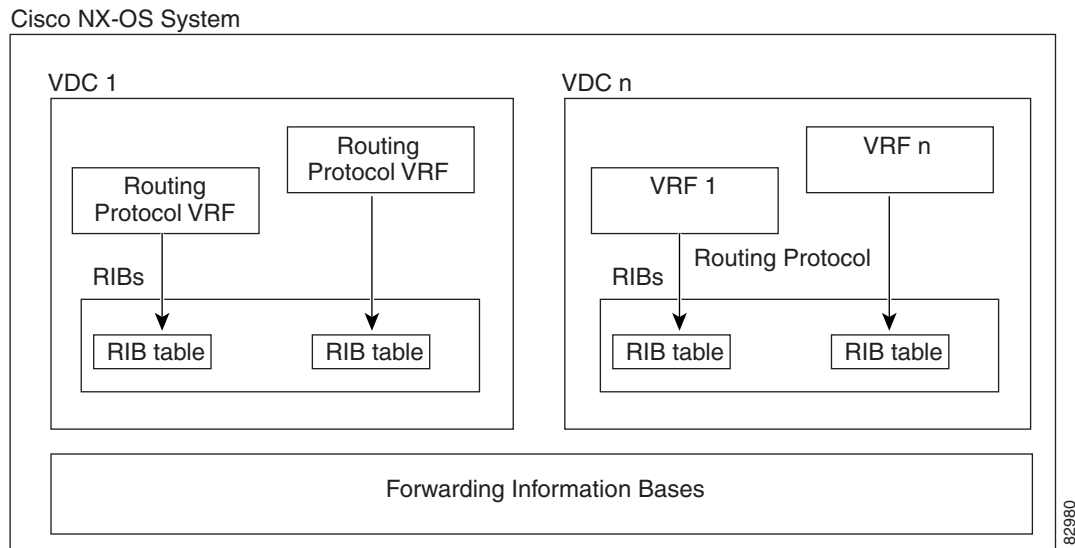
## Layer 3 Virtualization

Cisco NX-OS introduces the virtual device context (VDC), which provides separate management domains per VDC and software fault isolation. Each VDC supports multiple Virtual Routing and Forwarding Instances (VRFs) and multiple routing information bases (*RIBs*) to support multiple address

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domains. Each VRF is associated with a routing information base (RIB) and this information is collected by the Forwarding Information Base (FIB). [Figure 1-3](#) shows the relationship between VDC, VRF, and the Cisco NX-OS system.

**Figure 1-3 Layer 3 Virtualization Example**



A VRF represents a layer 3 addressing domain. Each layer 3 interface (logical or physical) belongs to one VRF. A VRF belongs to one VDC. Each VDC can support multiple VRFs. For more information, see [Chapter 14, “Configuring Layer 3 Virtualization.”](#)

See to the *Cisco Nexus 7000 Series NX-OS Virtual Device Context Configuration Guide, Release 4.0* for details on VDCs.

## Cisco NX-OS Forwarding 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, page 1-10](#)
- [Adjacency Manager, page 1-11](#)
- [Unicast Forwarding Distribution Module, page 1-11](#)
- [FIB, page 1-12](#)
- [Hardware Forwarding, page 1-12](#)
- [Software Forwarding, page 1-13](#)

## Unicast RIB

The Cisco NX-OS forwarding architecture consists of multiple components, as shown in [Figure 1-4](#).

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**Figure 1-4** 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 (FIB) on the supervisors and modules by using the services of 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. See [Chapter 3, “Configuring IPv6.”](#)

## Unicast Forwarding Distribution Module

The unicast forwarding distribution module exists on the active supervisor and distributes the forwarding path information from the unicast RIB and other sources. The unicast RIB generates forwarding information which the unicast FIB programs into the hardware forwarding tables on the standby supervisor and the modules. The unicast forwarding distribution module also downloads the FIB information to newly inserted modules.

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The unicast forwarding distribution module 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 Cisco NX-OS divides the FIB to support multiple address families. The FIB TCAM is 128K physical entries, which is divided into the following sections by default:

- 56K IPv4 unicast routes (56K physical entries)
- 32K IPv4 multicast routes or IPv6 unicast routes (64K physical entries)
- 2K IPv6 multicast routes (8K physical entries)



**Note**

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You cannot change the FIB default sections.

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**Note**

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Full IPv4 Internet route tables have more than 256K routes, which is more than the maximum number Cisco NX-OS FIB entries.

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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 forwarding distribution module and sends the information along 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.

The forwarding tables are identical on the supervisor and all the modules.

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

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## Software Forwarding

The software forwarding path in Cisco NX-OS is used mainly to handle features that are not supported in hardware or to handle errors encountered during 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 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 and rate limiters. (see the *Cisco Nexus 7000 Series NX-OS Security Configuration Guide, Release 4.0*).

## 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, page 1-13](#)
- [IP Services, page 1-13](#)
- [OSPF, page 1-14](#)
- [EIGRP, page 1-14](#)
- [IS-IS, page 1-14](#)
- [BGP, page 1-14](#)
- [RIP, page 1-14](#)
- [Static Routing, page 1-15](#)
- [Layer 3 Virtualization, page 1-15](#)
- [Route Policy Manager, page 1-15](#)
- [Policy-Based Routing, page 1-15](#)
- [First-Hop Redundancy Protocols, page 1-15](#)
- [Object Tracking, page 1-15](#)

### IPv4 and IPv6

Layer 3 uses either the IPv4 or IPv6 protocol. IPv6 is a new IP protocol designed to replace IPv4, the Internet protocol that is predominantly deployed and used throughout the world. 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.”](#)

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## OSPF

The 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 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 EIGRP protocol 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, typical to a distance vector routing protocol. 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 International Organization for Standardization (ISO) 10589. The IS-IS routing protocol is a link-state protocol. Features of IS-IS are as follows:

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

For more information, see the [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.”](#)

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## 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 Virtual Device Contexts (VDCs) which allow you to create separate virtual systems within a Cisco NX-OS system. Each VDC is isolated from the others, which means that a problem in one VDC does not affect any other VDCs. VDCs are also secure from the other. You can assign separate network operators to each VDC and these network operators cannot control or view the configuration of a different VDC.

Cisco NX-OS also supports Layer 3 virtualization with VPN Routing and Forwarding (VRF). A VRF provides a separate address domain for configuring layer 3 routing protocols. For more information, see [Chapter 14, “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 such things as protocol types and port numbers. For more information, see [Chapter 16, “Configuring Policy-Based Routing.”](#)

## First-Hop Redundancy Protocols

First-hop redundancy protocols allow you to provide redundant connections to your hosts. In the event that 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 since the address is virtual and shared between each router in the FHRP group. For more information on the Gateway Load Balancing Protocol (GLBP), see [Chapter 17, “Configuring GLBP.”](#)

## 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 recovery time if an object state goes down. For more information, see [Chapter 20, “Configuring Object Tracking.”](#)

***Send document comments to [nexus7k-docfeedback@cisco.com](mailto:nexus7k-docfeedback@cisco.com).***

## Related Topics

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

- *Cisco Nexus 7000 Series NX-OS Multicast Routing Configuration Guide, Release 4.0*
- *Cisco Nexus 7000 Series NX-OS High Availability and Redundancy Guide, Release 4.0*
- *Cisco Nexus 7000 Series NX-OS Virtual Device Context Configuration Guide, Release 4.0*
- Exploring Autonomous System Numbers:  
[http://www.cisco.com/web/about/ac123/ac147/archived\\_issues/ipj\\_9-1/autonomous\\_system\\_numbers.html](http://www.cisco.com/web/about/ac123/ac147/archived_issues/ipj_9-1/autonomous_system_numbers.html)