CHAPTER 15

Managing the Unicast RIB and FIB

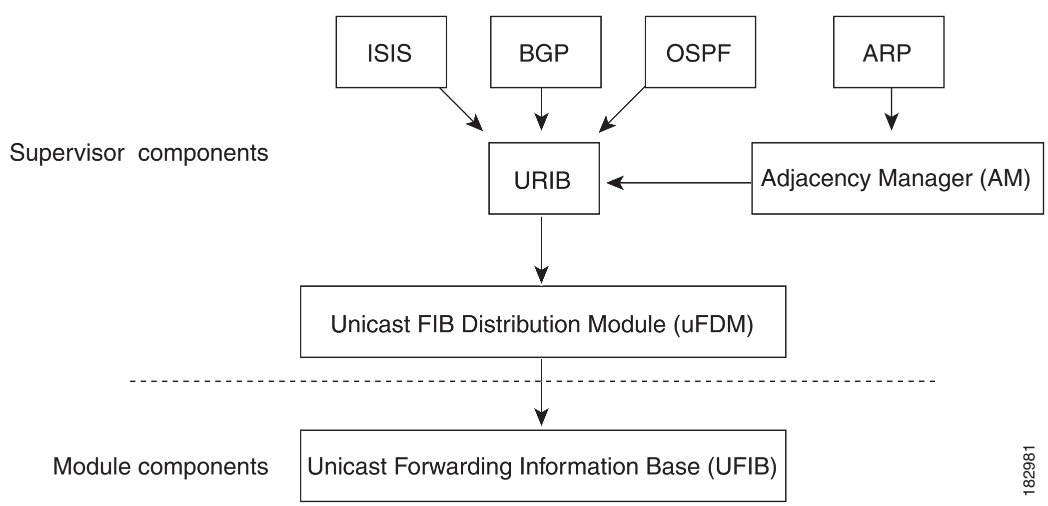
This chapter describes how to manage routes in the unicast Routing Information Base (RIB) and the Forwarding Information Base (FIB) on the Cisco NX-OS device.

This chapter includes the following sections:

Information 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 15-1.

Figure 15-1 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, page 15-2
- Dynamic TCAM Allocation, page 15-2
- Virtualization Support, page 15-3

Layer 3 Consistency Checker

In rare instances, an inconsistency can occur between the unicast RIB and the FIB on each module. In Cisco NX-OS Release 4.0(3) and later releases, 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 15-9.

You can then manually clear any inconsistencies. See the "Clearing Forwarding Information in the FIB" section on page 15-10.

Dynamic TCAM Allocation

Cisco NX-OS divides the FIB to support multiple address families. The FIB TCAM has 128K physical entries.

Table 15-1 describes the default FIB TCAM allocation.

Table 15-1 ***Default FIB TCAM Allocation***

Region	Default Number of Routes	Number of TCAM blocks	Entry size
IPv4 unicast routes	56K	7	72 bits

Table 15-1 *Default FIB TCAM Allocation* (continued)

Region	Default Number of Routes	Number of TCAM blocks	Entry size
IPv4 multicast routes or IPv6 unicast routes	32K	8	144 bits
IPv6 multicast routes	2K	1	288 bits

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

Dynamic TCAM allocation can reallocate unused TCAM blocks to an adjacent region when all existing blocks in that region are full. Dynamic TCAM allocation allows more flexibility in the number of routes that the FIB can allocate for a route type.

Note You may need to disable dynamic TCAM allocation if you downgrade to a release earlier than Cisco NX-OS Release 4.2(1).

Virtualization Support

The Unicast RIB and FIB support Virtual Routing and Forwarding instances (VRFs). VRFs exist within virtual device contexts (VDCs). By default, Cisco NX-OS places you in the default VDC and default VRF unless you specifically configure another VDC and VRF. For more information, see the *Cisco Cisco Nexus 7000 Series NX-OS Virtual Device Context Configuration Guide, Release 4.x* and see Chapter 14, "Configuring Layer 3 Virtualization."

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 Cisco NX-OS system images and is provided at no extra charge to you. For a complete explanation of the NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Guidelines and Limitations

Unicast RIB and FIB have the following guidelines and limitations and restrictions:

- The FIB TCAM has 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)

- Dynamic TCAM allocation is enabled by default.
- You must be in the default VDC to disable dynamic TCAM allocation.

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 ip fib adjacency module *slot* **Example:** switch# show ip fib adjacency module 2	Displays the adjacency information for IPv4.
show forwarding {**ipv4** | **ipv6**} **adjacency module** *slot* **Example:** switch# show forwarding ipv6 adjacency module 2	Displays the adjacency information for IPv4 or IPv6.

Command	Purpose
show ip fib interfaces module *slot* **Example:** `switch# show ip fib interfaces module 2`	Displays the FIB interface information for IPv4.
show ip fib route module *slot* **Example:** `switch# show ip fib route module 2`	Displays the route table for IPv4.
show forwarding {**ipv4** | **ipv6**} **route module** *slot* **Example:** `switch# show forwarding ipv6 route module 2`	Displays the route table for IPv4 or IPv6.

This example shows the FIB contents on a module:

```
switch# show ip fib route module 2

IPv4 routes for table default/base

------------------+------------------+---------------------
Prefix            | Next-hop         | Interface
------------------+------------------+---------------------
0.0.0.0/32          Drop               Null0
255.255.255.255/32  Receive            sup-eth1
```

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 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 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.

You can globally configure the following load-sharing settings:

- load-share mode—Selects the best path based on the destination address and port or the source and the destination address and port.
- Universal ID—Sets the random seed for the hash algorithm. You do not need to configure the Universal ID. Cisco NX-OS chooses the Universal ID if you do not configure it.

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*] **Example:** `switch(config)# ip load-sharing address source-destination`	Configures the unicast FIB load-sharing algorithm for data traffic. The *universal-id* range is from 1 to 4294967295.

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 the route selected for a source/destination pair:

```
switch# show routing hash 10.0.0.5 30.0.0.2
  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 *20.0.0.2 (hash: 0x0e), for route:
```

Configuring Per-Packet Load Sharing

You can use per-packet load sharing to evenly distribute data traffic in an IP network over multiple equal-cost connections. Per-packet load sharing allows the router to send successive data packets over paths on a packet-by-packet basis rather than on a per-flow basis.

Note Using per-packet load sharing can result in out-of-order packets. Packets for a given pair of source-destination hosts might take different paths and arrive at the destination out of order. Make sure you understand the implications of out-of-order packets to your network and applications. Per-packet load sharing is not appropriate for all networks. Per-flow load sharing ensures packets always arrive in the order that they were sent.

Per-packet load sharing uses the round-robin method to determine which path each packet takes to the destination. With per-packet load sharing enabled on interfaces, the router sends one packet for destination1 over the first path, the second packet for (the same) destination1 over the second path, and so on. Per-packet load sharing ensures balancing over multiple links.

Use per-packet load sharing to ensure that a path for a single source-destination pair does not get overloaded. If most of the traffic passing through parallel links is for a single pair, per-destination load sharing will overload a single link while other links will have very little traffic. Enabling per-packet load sharing allows you to use alternate paths to the same busy destination.

Note Per-packet load sharing on an interface overrides the global load-sharing configuration.

You configure per-packet load sharing on the input interface. This configuration determines the output interface that Cisco NX-OS chooses for the packet.

For example, if you have ECMP paths on two output interfaces, Cisco NX-OS uses the following load-sharing methods for input packets on Ethernet 1/1:

- Per-packet load sharing if you configure per-packet load sharing on Ethernet 1/1.
- Per-flow load sharing.

The configuration for the other interfaces have no effect on the load-sharing method used for Ethernet 1/1 in this example.

To configure per-packet load sharing, use the following command in interface configuration mode:

Command	Purpose
ip load-sharing per-packet **Example:** `switch(config-if)# ip load-sharing per-packet`	Configures per-packet load sharing on an interface.

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.
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 displays 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 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 [**ip** | **ipv4** | **ipv6**] [**unicast**]**forwarding 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 10.

To stop the Layer 3 consistency checker, use the following commands in global configuration mode:

Command	Purpose
test forwarding [**ip** | **ipv4** | **ipv6**] [**unicast**] **inconsistency** [**vrf** *vrf-name*] [**module** {*slot*| **all**}] **stop** **Example:** `switch(config)# 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 10.

To display the Layer 3 inconsistencies, use the following commands in any mode:

Command	Purpose
show forwarding [**ip** | **ipv4** | **ipv6**] **inconsistency** [**vrf** *vrf-name*] [**module** {*slot*| **all**}] **Example:** `switch(config)# 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 10.

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 {**ip** | **ipv4** | **ipv6**} **route** {* | *prefix*} [**vrf** *vrf-name*] [**module** {*slot*| **all**}] **Example:** `switch(config)# clear forwarding ip route *`	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 10.

Enabling Dynamic TCAM Allocation

You can enable dynamic TCAM allocation.

Note You must be in the default VDC to configure dynamic TCAM allocation.

To enable dynamic TCAM allocation, use the following command in any mode:

Command	Purpose
hardware forwarding dynamic-allocation enable **Example:** `switch# hardware forwarding dynamic-allocation enable`	Enables dynamic TCAM allocation. The default is enabled.

Disabling Dynamic TCAM Allocation

You can disable dynamic TCAM allocation.

Note You can disable dynamic TCAM allocation only if the current TCAM usage is below the default allocation. See the "Returning the TCAM to Default Settings" section on page 15-11 for more information.

Note You must be in the default VDC to configure dynamic TCAM allocation.

To disable dynamic TCAM allocation, use the following command in any mode:

Command	Purpose
hardware forwarding dynamic-allocation disable **Example:** `switch# hardware forwarding dynamic-allocation disable`	Disables dynamic TCAM allocation. This command returns the TCAM to the default allocation only if there are no route entries in the reallocated The default is enabled.

If Cisco NX-OS sucessfully disables dynamic TCAM allocation, you should see the following message:

```
switch# re-alloc is underway: TCAM re-allocation is underway. Check status for completion.
```

If Cisco NX-OS cannot disable dynamic TCAM allocation, you should see the following message:

```
switch# static is not possible: Current usage exceeds static allocation limits.
```

See the "Returning the TCAM to Default Settings" section on page 15-11 for guidelins on how to lower TCAM usage below the default allocation limits.

Returning the TCAM to Default Settings

You must return the TCAM to default settings before you can start a nondisruptive downgrade to Cisco NX-OS release earlier than Cisco NX-OS 4.2(1).

If you attempt a nondisruptive downgrade, the downgrade may fail with the following error:

TCAM allocation has changed.

You need to return the TCAM to default settings to continue the nondisruptive downgrade.

Note Use these steps as a guideline. You must plan for reducing the route updates to the TCAM from neighbor routers.

BEFORE YOU BEGIN

Ensure that you are in the default VDC (or use the **switchto vdc** command).

SUMMARY STEPS

1. **show hardware forwarding dynamic-allocation status**
2. **show hardware capacity | begin TCAM**
3. Reduce route updates from neighbor routers until TCAM usage is below the default allocation.
4. **hardware forwarding dynamic-allocation disable**

DETAILED STEPS

	Command	Purpose

Step 1	**show hardware forwarding dynamic-allocation status**
	
	Example:
	`switch# show hardware forwarding dynamic-allocation status`
	`Num 288 bit blocks : 1 (Same as default setting)`
	`Num 144 bit blocks : 7 (Different from default setting)`
	`Num  72 bit blocks : 9 (Different from default setting))`
		Displays information about the TCAM allocation.

Step 2	**show hardware capacity | begin TCAM**
	
	Example:
	`switch# show hardware capacity | begin TCAM`
	`Note: IPv4 Multicast/IPv6 Unicast entries share one FIB TCAM entry pool`
	
	`Module 7 usage:`
	`Route Type     Used       %Used       Free       %Free       Total`
	`            (Log/Phys)             (Log/Phys)             (Log/Phys)`
	`------------------------------------------------------------------------`
	`IPv4 Unicast    5/5          0     57339/57339     99     57344/57344`
	`IPv4 Multicast: 4/8          0     16380/32760     99     16384/32768`
	`IPv6 Unicast:   6/12         0     16378/32756     99     16384/32768`
	`IPv6 Multicast: 5/20         0      2043/8172      99      2048/8192`
		Displays information about the number of routes in each TCAM section.

Step 3	`Reduce route updates from neighbor routers until the TCAM usage is below the default allocation.`	You must prevent neighbors from sending more route updates than the TCAM can handle based on the default allocation. The TCAM entries will time out and reduce the TCAM load to below the default allocation.
Step 4	**hardware forwarding dynamic-allocation disable** **Example:** `switch# hardware forwarding dynamic-allocation disable`	Disables dynamic TCAM allocation. Default is enabled.

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 memory estimate routes *num-routes* **next-hops** *num-nexthops* **Example:** `switch# show routing memory estimate routes 5000 next-hops 16`	Displays the memory requirements for routes. The *num-routes* range is from 1000 to 112000. 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 verify the unicast RIB and FIB information, use the following commands:

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.

Command	Purpose
show hardware forwarding dynamic-allocation status	Displays information about the TCAM allocation.
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 15-14
- Feature History for Unicast RIB and FIB, page 15-14

Related Documents

Related Topic	Document Title
Unicast RIB and FIB CLI commands	*Cisco Nexus 7000 Series NX-OS Unicast Routing Command Reference*

Feature History for Unicast RIB and FIB

Table 15-1 lists the release history for this feature.

Table 15-1 Feature History for Unicast RIB and FIB

Feature Name	Releases	Feature Information
IPv6 forwarding inconsistency checker	4.2(1)	Added support to check for inconsistencies in the IPv6 forwarding table.
Dynamic TCAM allocation	4.2(1)	Added support for dynamically allocating TCAM blocks in the FIB.
Per-packet load sharing	4.1(2)	Added support to load balance per packet on an interface.
Unicast RIB and FIB	4.0(3)	Added support to clear individual routes in unicast RIB and FIB.
Unicast RIB and FIB	4.0(1)	This feature was introduced.