



Implementing Cisco Express Forwarding

Cisco Express Forwarding (CEF) is advanced, Layer 3 IP switching technology. CEF optimizes network performance and scalability for networks with large and dynamic traffic patterns, such as the Internet, on networks characterized by intensive web-based applications, or interactive sessions.

This module describes the tasks required to implement CEF on your Cisco ASR 9000 Series Aggregation Services Router.



Note

For complete descriptions of the CEF commands listed in this module, refer to the *Cisco ASR 9000 Series Aggregation Services Router IP Addresses and Services Command Reference*. To locate documentation for other commands that might appear in the course of executing a configuration task, search online in the master command index.

Feature History for Implementing CEF

Release	Modification
Release 3.7.2	This feature was introduced.

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Prerequisites for Implementing Cisco Express Forwarding

The following prerequisites are required to implement Cisco Express Forwarding:

- You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Information About Implementing Cisco Express Forwarding Software

To implement Cisco Express Forwarding features in this document you must understand the following concepts:

Key Features Supported in the Cisco Express Forwarding Implementation

The following features are supported for CEF on Cisco IOS XR software:

- Border Gateway Protocol (BGP) policy accounting
- Reverse path forwarding (RPF)
- Virtual interface support
- Multipath support
- Route consistency
- High availability features such as packaging, restartability, and Out of Resource (OOR) handling
- OSPFv2 SPF prefix prioritization
- BGP attributes download

Benefits of CEF

CEF offers the following benefits:

- Improved performance—CEF is less CPU-intensive than fast-switching route caching. More CPU processing power can be dedicated to Layer 3 services such as quality of service (QoS) and encryption.
- Scalability—CEF offers full switching capacity at each line card.
- Resilience—CEF offers an unprecedented level of switching consistency and stability in large dynamic networks. In dynamic networks, fast-switched cache entries are frequently invalidated due to routing changes. These changes can cause traffic to be process switched using the routing table, rather than fast switched using the route cache. Because the Forwarding Information Base (FIB) lookup table contains all known routes that exist in the routing table, it eliminates route cache maintenance and the fast-switch or process-switch forwarding scenario. CEF can switch traffic more efficiently than typical demand caching schemes.

CEF Components

Cisco IOS XR software CEF always operates in CEF mode with two distinct components: a Forwarding Information Base (FIB) database and adjacency table—a protocol-independent adjacency information base (AIB).

CEF is a primary IP packet-forwarding database for Cisco IOS XR software. CEF is responsible for the following functions:

- Software switching path
- Maintaining forwarding table and adjacency tables (which are maintained by the AIB) for software and hardware forwarding engines

The following CEF forwarding tables are maintained in Cisco IOS XR software:

- IPv4 CEF database
- IPv6 CEF database
- MPLS LFD database
- Multicast Forwarding Table (MFD)

The protocol-dependent FIB process maintains the forwarding tables for IPv4 and IPv6 unicast in the Route Switch Processor (RSP) and each MSC.

The FIB on each node processes Routing Information Base (RIB) updates, performing route resolution and maintaining FIB tables independently in the RSP and each MSC. FIB tables on each node can be slightly different. Adjacency FIB entries are maintained only on a local node, and adjacency entries linked to FIB entries could be different.

Border Gateway Protocol Policy Accounting

Border Gateway Protocol (BGP) policy accounting measures and classifies IP traffic that is sent to, or received from, different peers. Policy accounting is enabled on an individual input or output interface basis, and counters based on parameters such as community list, autonomous system number, or autonomous system path are assigned to identify the IP traffic.

**Note**

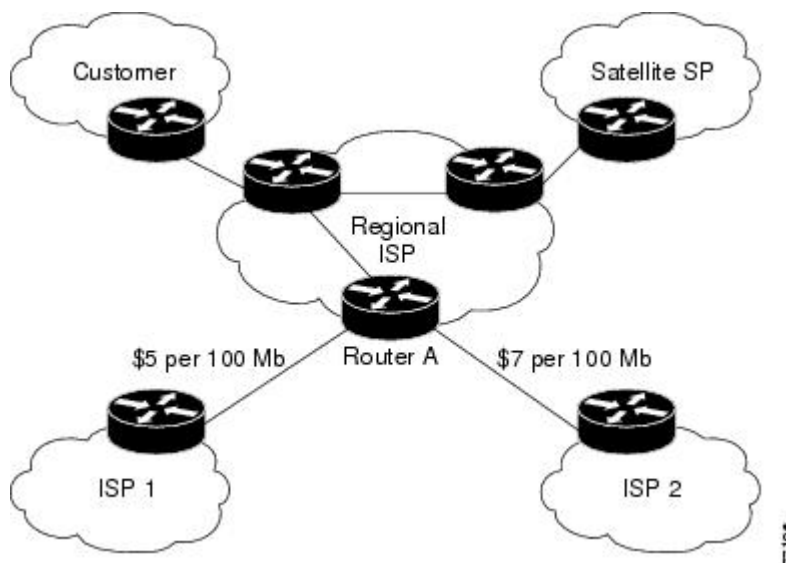
There are two types of route policies. The first type (regular BGP route policies) is used to filter the BGP routes advertised into or out from the BGP links. This type of route policy is applied to the specific BGP neighbor. The second type (specific route policy) is used to set up a traffic index for the BGP prefixes. This route policy is applied to the global BGP IPv4 address family to set up the traffic index when the BGP routes are inserted into the RIB table. BGP policy accounting uses the second type of route policy.

Using BGP policy accounting, you can account for traffic according to the route it traverses. Service providers can identify and account for all traffic by customer and bill accordingly. In [Figure 1: Sample Topology for BGP Policy Accounting, on page 4](#), BGP policy accounting can be implemented in Router A to measure packet and byte volumes in autonomous system buckets. Customers are billed appropriately for traffic that is routed from a domestic, international, or satellite source.

**Note**

BGP policy accounting measures and classifies IP traffic for BGP prefixes only.

Figure 1: Sample Topology for BGP Policy Accounting



Based on the specified routing policy, BGP policy accounting assigns each prefix a traffic index (bucket) associated with an interface. BGP prefixes are downloaded from the RIB to the FIB along with the traffic index.

There are a total of 63 (1 to 63) traffic indexes (bucket numbers) that can be assigned for BGP prefixes. Internally, there is an accounting table associated with the traffic indexes to be created for each input (ingress) and output (egress) interface. The traffic indexes allow you to account for the IP traffic, where the source IP address, the destination IP address, or both are BGP prefixes.

**Note**

Traffic index 0 contains the packet count using Interior Gateway Protocol (IGP) routes.

Reverse Path Forwarding (Strict and Loose)

Unicast IPv4 and IPv6 Reverse Path Forwarding (uRPF), both strict and loose modes, help mitigate problems caused by the introduction of malformed or spoofed IP source addresses into a network by discarding IP packets that lack a verifiable IP source address. Unicast RPF does this by doing a reverse lookup in the CEF table. Therefore, Unicast Reverse Path Forwarding is possible only if CEF is enabled on the router.

IPv6 uRPF is supported with ASR 9000-SIP-700 LC, ASR 9000 Ethernet LC and ASR 9000 Enhanced Ethernet LC.

**Note**

Unicast RPF allows packets with 0.0.0.0 source addresses and 255.255.255.255 destination addresses to pass so that Bootstrap Protocol and Dynamic Host Configuration Protocol (DHCP) will function properly.

When strict uRPF is enabled, the source address of the packet is checked in the FIB. If the packet is received on the same interface that would be used to forward the traffic to the source of the packet, the packet passes the check and is further processed; otherwise, it is dropped. Strict uRPF should only be applied where there is natural or configured symmetry. Because internal interfaces are likely to have routing asymmetry, that is, multiple routes to the source of a packet, strict uRPF should not be implemented on interfaces that are internal to the network.

**Note**

The behavior of strict RPF varies slightly by platform, number of recursion levels, and number of paths in Equal-Cost Multipath (ECMP) scenarios. A platform may switch to loose RPF check for some or all prefixes, even though strict RPF is configured.

When loose uRPF is enabled, the source address of the packet is checked in the FIB. If it exists and matches a valid forwarding entry, the packet passes the check and is further processed; otherwise, it is dropped.

Strict mode uRPF requires maintenance of uRPF interfaces list for the prefixes. The list contains only strict mode uRPF configured interfaces pointed by the prefix path. uRPF interface list is shared among the prefixes wherever possible. Size of this list is 12 for ASR 9000 Ethernet Line Cards and 64 for integrated 20G SIP cards. Strict to loose mode uRPF fallback happens when the list goes beyond the maximum supported value.

Loose and strict uRPF supports two options: **allow self-ping** and **allow default**. The **self-ping** option allows the source of the packet to ping itself. The **allow default** option allows the lookup result to match a default routing entry. When the **allow default** option is enabled with the strict mode of the uRPF, the packet is processed further only if it arrived through the default interface.

Per-Flow Load Balancing

Load balancing describes the functionality in a router that distributes packets across multiple links based on Layer 3 (network layer) and Layer 4 (transport layer) routing information. If the router discovers multiple paths to a destination, the routing table is updated with multiple entries for that destination.

Per-flow load balancing performs these functions:

- Incoming data traffic is evenly distributed over multiple equal-cost connections within a bundle interface.
- Layer 2 bundle and Layer 3 (network layer) load balancing decisions are taken on IPv4, IPv6, and MPLS flows which are supported for the 5-tuple hash algorithm.
- A 5-tuple hash algorithm provides more granular load balancing than the 3-tuple hash algorithm.
- The same hash algorithm (3-tuple or 5-tuple) is used for load balancing over multiple equal-cost Layer 3 (network layer) paths. The Layer 3 (network layer) path is on a physical interface or on a bundle interface. In addition, load balancing over member links can occur within a Layer 2 bundle interface.
- The **cef load-balancing fields L3 global** command allows you to select the 3-tuple hash algorithm.
- By default, 5-tuple hash algorithm is used for load balancing. If you use the **cef load-balancing fields L3 global** command, 3-tuple hash algorithm is enabled.

Layer 3 (Network Layer) Routing Information

The 3-tuple load-balance hash calculation contains these Layer 3 (Network Layer) inputs:

- Source IP address
- Destination IP address
- Router ID

Layer 4 (Transport Layer) Routing Information

The 5-tuple load-balance hash calculation contains 3-tuple inputs and these additional following Layer 4 (Transport Layer) inputs:

- Source port
- Destination port

**Note**

In load-balancing scenarios, a line card may not use all output paths downloaded from routing protocols. This behavior varies with platform, number of recursion levels, and the fact whether MPLS is involved, or not.

Limitations for 3-Tuple Load Balance Hash Algorithm

- Load balancing is not symmetrical if the load balanced paths involve different speeds such as, 10 Gigabit Ethernet, 40 Gigabit Ethernet, or 100 Gigabit Ethernet ports.
- Because the 3-tuple hash algorithm excludes Layer 4 information and becomes dependent on Layer 3 information, load balancing is not symmetrical if the distribution of source and destination IP addresses is not varied enough, even if all ports operate at the same speed.
- You can configure 3-tuple hash algorithm only on Cisco ASR 9000 Enhanced Ethernet Line Cards.

BGP Attributes Download

The BGP Attributes Download feature enables you to display the installed BGP attributes in CEF. Configure the **show cef bgp-attribute** command to display the installed BGP attributes in CEF. You can use the **show cef bgp-attribute attribute-id** command and the **show cef bgp-attribute local-attribute-id** command to look at specific BGP attributes by attribute ID and local attribute ID.

How to Implement CEF

This section contains instructions for the following tasks:

Verifying CEF

This task allows you to verify CEF.

SUMMARY STEPS

1. **show cef {ipv4 | ipv6}**
2. **show cef {ipv4 | ipv6} summary**
3. **show cef {ipv4 | ipv6} detail**
4. **show adjacency detail**

DETAILED STEPS

	Command or Action	Purpose
Step 1	show cef {ipv4 ipv6} Example: RP/0/RSP0/CPU0:router# show cef ipv4	Displays the IPv4 or IPv6 CEF table. The next hop and forwarding interface are displayed for each prefix. Note The output of the show cef command varies by location.
Step 2	show cef {ipv4 ipv6} summary Example: RP/0/RSP0/CPU0:router# show cef ipv4 summary	Displays a summary of the IPv4 or IPv6 CEF table.
Step 3	show cef {ipv4 ipv6} detail Example: RP/0/RSP0/CPU0:router# show cef ipv4 detail	Displays detailed IPv4 or IPv6 CEF table information.
Step 4	show adjacency detail Example: RP/0/RSP0/CPU0:router# show adjacency detail	Displays detailed adjacency information, including Layer 2 information for each interface. Note The output of the show adjacency command varies by location.

Configuring BGP Policy Accounting

This task allows you to configure BGP policy accounting.



Note

There are two types of route policies. BGP policy accounting uses the type that is used to set up a traffic index for the BGP prefixes. The route policy is applied to the global BGP IPv4 address family to set up the traffic index when the BGP routes are inserted into the RIB table.

BGP policy accounting enables per interface accounting for ingress and egress IP traffic based on the traffic index assigned to the source IP address (BGP prefix) and destination IP address (BGP prefix). The traffic

index of BGP prefixes can be assigned according to the following parameters using Routing Policy Language (RPL):

- prefix-set
- AS-path-set
- community-set

**Note**

BGP policy accounting is supported on IPv4 prefixes only.

Two configuration tasks provide the ability to classify BGP prefixes that are in the RIB according to the prefix-set, AS-path-set, or the community-set parameters:

- 1 Use the **route-policy** command to define the policy for traffic index setup based on the prefix-set, AS-path-set, or community-set.
- 2 Use the BGP **table-policy** command to apply the defined route policy to the global BGP IPv4 unicast address family.

See the *Cisco ASR 9000 Series Aggregation Services Router Routing Command Reference* for information on the **route-policy** and **table-policy** commands.

BGP policy accounting can be enabled on each interface with the following options:

- Use the `ipv4 bgp policy accounting` command with one of the following keyword options:
 - input source-accounting
 - input destination-accounting
 - input source-accounting destination-accounting
- Use the `ipv4 bgp policy accounting` command with one of the following keyword options:
 - output source-accounting
 - output destination-accounting
 - output source-accounting destination-accounting
- Use any combination of the keywords provided for the **ipv4 bgp policy accounting** command.

Before You Begin

Before using the BGP policy accounting feature, you must enable BGP on the router (CEF is enabled by default). See the *Cisco ASR 9000 Series Aggregation Services Router Routing Configuration Guide* for information on enabling BGP.

SUMMARY STEPS

1. configure
2. as-path-set
3. exit
4. **prefix-set** *name*
5. exit
6. **route-policy** *policy-name*
7. end
8. configure
9. **router bgp** *autonomous-system-number*
10. **address-family ipv4** {unicast | multicast }
11. **table policy** *policy-name*
12. end
13. configure
14. **interface** *type interface-path-id*
15. **ipv4 bgp policy accounting** {input | output {destination-accounting [source-accounting] | source-accounting [destination-accounting]}}
16. Do one of the following:
 - end
 - commit

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure	Enters global configuration mode.
	Example: RP/0/RSP0/CPU0:router# configure	
Step 2	as-path-set	Enters policy configuration mode.
	Example: RP/0/RSP0/CPU0:router(config)# as-path-set as107 RP/0/RSP0/CPU0:router(config-as)# ios-regex '107\$' RP/0/RSP0/CPU0:router(config-as)# end-set RP/0/RSP0/CPU0:router(config)# as-path-set as108 RP/0/RSP0/CPU0:router(config-as)# ios-regex '108\$' RP/0/RSP0/CPU0:router(config-as)# end-set	

	Command or Action	Purpose
Step 3	exit Example: RP/0/RSP0/CPU0:router(config-as)# exit	Returns to global configuration mode.
Step 4	prefix-set <i>name</i> Example: RP/0/RSP0/CPU0:router(config)# prefix-set RT-65	Defines the prefix list.
Step 5	exit Example: RP/0/RSP0/CPU0:router(config-pfx)# exit	Returns to global configuration mode.
Step 6	route-policy <i>policy-name</i> Example: RP/0/RSP0/CPU0:router(config)# route-policy rp501b	Specifies the route-policy name.
Step 7	end Example: RP/0/RSP0/CPU0:router(config-rpl)# end	Saves configuration changes. <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: <pre>Uncommitted changes found, commit them before exiting(yes/no/cancel)?[cancel]:</pre> <ul style="list-style-type: none"> ◦ Entering yes saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. ◦ Entering no exits the configuration session and returns the router to EXEC mode without committing the configuration changes. ◦ Entering cancel leaves the router in the current configuration session without exiting or committing the configuration changes.
Step 8	configure Example: RP/0/RSP0/CPU0:router# configure	Enters global configuration mode.

	Command or Action	Purpose
Step 9	router bgp <i>autonomous-system-number</i> Example: RP/0/RSP0/CPU0:router(config)# router bgp 1	Allows you to configure the BGP routing process.
Step 10	address-family ipv4 {unicast multicast } Example: RP/0/RSP0/CPU0:router(config-bgp)# address-family ipv4 unicast	Allows you to enter the address family configuration mode while configuring a BGP routing session.
Step 11	table policy <i>policy-name</i> Example: RP/0/RSP0/CPU0:router(config-bgp-af)# table-policy set-traffic-index	Applies a routing policy to routes being installed into the routing table.
Step 12	end Example: RP/0/RSP0/CPU0:router(config-bgp-af)# end	Saves configuration changes. <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: <pre>Uncommitted changes found, commit them before exiting(yes/no/cancel)?[cancel]:</pre> <ul style="list-style-type: none"> ◦ Entering yes saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. ◦ Entering no exits the configuration session and returns the router to EXEC mode without committing the configuration changes. ◦ Entering cancel leaves the router in the current configuration session without exiting or committing the configuration changes.
Step 13	configure Example: RP/0/RSP0/CPU0:router# configure	Enters global configuration mode.
Step 14	interface <i>type interface-path-id</i> Example: RP/0/RSP0/CPU0:router(config)# interface TenGigE0/1/0/2	Enters interface configuration mode.

	Command or Action	Purpose
Step 15	ipv4 bgp policy accounting {input output {destination-accounting [source-accounting] source-accounting [destination-accounting]}} Example: RP/0/RSP0/CPU0:router(config-if)# ipv4 bgp policy accounting output destination-accounting	Enables BGP policy accounting.
Step 16	Do one of the following: <ul style="list-style-type: none"> • end • commit Example: RP/0/RSP0/CPU0:router(config-if)# end or RP/0/RSP0/CPU0:router(config-if)# commit	Saves configuration changes. <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: <pre>Uncommitted changes found, commit them before exiting(yes/no/cancel)?[cancel]:</pre> <ul style="list-style-type: none"> ◦ Entering yes saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. ◦ Entering no exits the configuration session and returns the router to EXEC mode without committing the configuration changes. ◦ Entering cancel leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the commit command to save the configuration changes to the running configuration file and remain within the configuration session.

Verifying BGP Policy Accounting

This task allows you to verify BGP policy accounting.



Note

BGP policy accounting is supported on IPv4 prefixes.

Before You Begin

BGP policy accounting must be configured. See the [Configuring BGP Policy Accounting](#), on page 7.

SUMMARY STEPS

1. **show route bgp**
2. **show bgp summary**
3. **show bgp *ip-address***
4. **show route ipv4 *ip-address***
5. **show cef ipv4 *prefix***
6. **show cef ipv4 *prefix* detail**
7. **show cef ipv4 interface *type interface-path-id* bgp-policy-statistics**

DETAILED STEPS

	Command or Action	Purpose
Step 1	show route bgp Example: RP/0/RSP0/CPU0:router# show route bgp	Displays all BGP routes with traffic indexes.
Step 2	show bgp summary Example: RP/0/RSP0/CPU0:router# show bgp summary	Displays the status of all BGP neighbors.
Step 3	show bgp <i>ip-address</i> Example: RP/0/RSP0/CPU0:router# show bgp 40.1.1.1	Displays BGP prefixes with BGP attributes.
Step 4	show route ipv4 <i>ip-address</i> Example: RP/0/RSP0/CPU0:router# show route ipv4 40.1.1.1	Displays the specific BGP route with the traffic index in the RIB.
Step 5	show cef ipv4 <i>prefix</i> Example: RP/0/RSP0/CPU0:router# show cef ipv4 40.1.1.1	Displays the specific BGP prefix with the traffic index in the RP FIB.
Step 6	show cef ipv4 <i>prefix</i> detail Example: RP/0/RSP0/CPU0:router# show cef ipv4 40.1.1.1 detail	Displays the specific BGP prefix with detailed information in the RP FIB.

	Command or Action	Purpose
Step 7	show cef ipv4 interface <i>type interface-path-id</i> bgp-policy-statistics Example: RP/0/RSP0/CPU0:router# show cef ipv4 interface TenGigE 0/2/0/4 bgp-policy-statistics	Displays the BGP Policy Accounting statistics for the specific interface.

Configuring a Route Purge Delay

This task allows you to configure a route purge delay. A purge delay purges routes when the RIB or other related process experiences a failure.

SUMMARY STEPS

1. **configure**
2. **cef purge-delay *seconds***
3. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure	
Step 2	cef purge-delay <i>seconds</i> Example: RP/0/RSP0/CPU0:router(config)# cef purge-delay 180	Configures a delay in purging routes when the Routing Information Base (RIB) or other related processes experience a failure.
Step 3	commit	

Configuring Unicast RPF Checking

This task allows you to configure unicast Reverse Path Forwarding (uRPF) checking. Unicast RPF checking allows you to mitigate problems caused by malformed or forged (spoofed) IP source addresses that pass through a router. Malformed or forged source addresses can indicate denial-of-service (DoS) attacks based on source IP address spoofing.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id*
3. **{ipv4 | ipv6} verify unicast source reachable-via {any | rx} [allow-default] [allow-self-ping]**
4. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure	
Step 2	interface <i>type interface-path-id</i> Example: RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet 0/1/0/0	Enters interface configuration mode.
Step 3	{ipv4 ipv6} verify unicast source reachable-via {any rx} [allow-default] [allow-self-ping] Example: RP/0/RSP0/CPU0:router(config-if)# ipv4 verify unicast source reachable-via rx	Enables IPv4 or IPv6 uRPF checking. <ul style="list-style-type: none"> • The rx keyword enables strict unicast RPF checking. If strict unicast RPF is enabled, a packet is not forwarded unless its source prefix exists in the routing table and the output interface matches the interface on which the packet was received. • The allow-default keyword enables the matching of default routes. This option applies to both loose and strict RPF. • The allow-self-ping keyword enables the router to ping out an interface. This option applies to both loose and strict RPF. <p>Note IPv6 uRPF checking is not supported on ASR 9000 Ethernet line cards.</p>
Step 4	commit	

Configuring Modular Services Card-to-Route Processor Management Ethernet Interface Switching

This task allows you to enable MSC-to-RP management Ethernet interface switching.

SUMMARY STEPS

1. **configure**
2. **rp mgmtethernet forwarding**
3. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure	
Step 2	rp mgmtethernet forwarding Example: RP/0/RSP0/CPU0:router(config)# rp mgmtethernet forwarding	Enables switching from the MSC to the route processor Management Ethernet interfaces.
Step 3	commit	

Configuring Per-Flow Load Balancing

This section describes the following tasks to configure per-flow load balancing:

Configuring 3-Tuple Hash Algorithm

This task allows you to configure per-flow load balancing for a 3-tuple hash algorithm.

SUMMARY STEPS

1. **configure**
2. **cef load-balancing fields L3 global**
3. **commit**
4. **show running-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure	
Step 2	cef load-balancing fields L3 global Example: RP/0/RSP0/CPU0:router(config)# cef load-balancing fields L3 global	Configures the 3-tuple hashing algorithm for load balancing during forwarding. The cef load-balancing fields l3 global command configures the hash tuple with the following fields: <ul style="list-style-type: none"> • Source IP address. • Destination IP address. • Router ID. The following Layer 4 fields are ignored:

	Command or Action	Purpose
		<ul style="list-style-type: none"> Source port. Destination port. <p>The cef load-balancing fields l3 global command is supported only on Cisco ASR 9000 Enhanced Ethernet Line Cards. This command is ignored on the other line cards.</p>
Step 3	commit	
Step 4	show running-config Example: RP/0/RSP0/CPU0:router# show running config	Displays the running configuration which contains the load balancing information.

Configuring BGP Attributes Download

This task allows you to configure the BGP Attributes Download feature.

Configuring BGP Attributes Download

SUMMARY STEPS

1. **configure**
2. **cef bgp attribute** *{attribute-id | local-attribute-id }*
3. **commit**

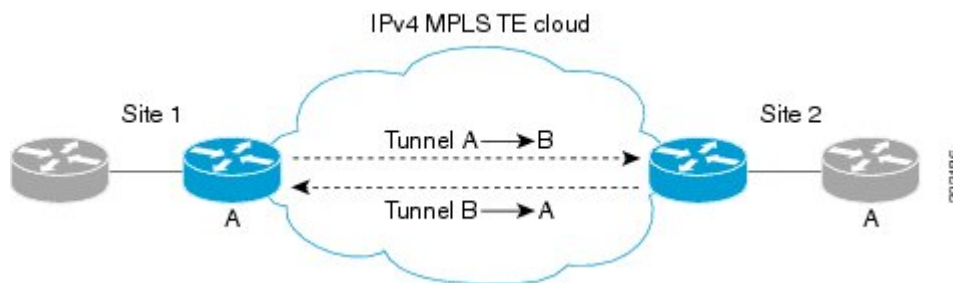
DETAILED STEPS

	Command or Action	Purpose
Step 1	configure	
Step 2	cef bgp attribute <i>{attribute-id local-attribute-id }</i> Example: RP/0/RSP0/CPU0:router(config)# cef bgp attribute 508	Configures a CEF BGP attribute.
Step 3	commit	

IPv6 Routing over IPv4 MPLS TE Tunnels

IPv6 routing over IPv4 Multiprotocol Label Switching with Traffic Engineering (MPLS TE) tunnels in the core is achieved by configuring the TE tunnels into the IPv6 Interior Gateway Protocol (IGP) topology as IPv6 forwarding adjacencies.

Figure 2: IPv6 Routing over IPv4 MPLS TE



This figure shows two IPv4/IPv6-aware sites connected over a TE core, where TE is not IPv6-aware. Two tunnels are set up across the core, and are announced as forwarding adjacencies into the IPv6 topologies at Site 1 and Site 2. Routers at Site 1 and Site 2 can use these tunnels to compute the best IPv6 route to the other site within their IS-IS SPF.

Restrictions for Implementing IPv6 routing over IPv4 MPLS TE tunnels

The following restrictions apply to implementing IPv6 routing over IPv4 MPLS TE tunnels:

- It is supported for IS-IS only.
- IS-ISv4 and v6 must exist in a single topology.
- IS-ISv4 and v6 must be configured under the same IS-IS instance at the endpoints.

Configuring tunnel as IPV6 Forwarding-Adjacency

Perform this task to configure a tunnel as an IPv6 forwarding adjacency.

SUMMARY STEPS

1. `configure`
2. `interface tunnel-te n forwarding-adjacency include-ipv6`
3. `commit`

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure	
Step 2	interface tunnel-te <i>n</i> forwarding-adjacency include-ipv6 Example: RP/0/RSP0/CPU0:router(config)# interface tunnel-te 1 forwarding-adjacency include-ipv6	Configures tunnel as an IPV6 Forwarding-Adjacency.
Step 3	commit	

Configuring tunnel as IPV6 interface

Perform this task to configure a tunnel as an IPV6 interface.

SUMMARY STEPS

1. **configure**
2. **interface tunnel-te *n* ipv6 enable**
3. **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure	
Step 2	interface tunnel-te <i>n</i> ipv6 enable Example: RP/0/RSP0/CPU0:router(config)# interface tunnel-te 1 ipv6 enable	Configures tunnel as an IPV6 interface.
Step 3	commit	

Configuration Examples for Implementing CEF on Routers Software

This section provides the following configuration examples:

Configuring BGP Policy Accounting: Example

The following example shows how to configure BGP policy accounting.

Configure loopback interfaces for BGP router-id:

```
interface Loopback1
ipv4 address 10
.1.1.1 255.255.255.255
```

Configure interfaces with the BGP policy accounting options:

```
interface TenGigE0/2/0/2
mtu 1514
ipv4 address 10
.1.0.1 255.255.255.0
proxy-arp
ipv4 directed-broadcast
ipv4 bgp policy accounting input source-accounting destination-accounting
ipv4 bgp policy accounting output source-accounting destination-accounting
!
interface TenGigE0/2/0/2.1
ipv4 address 10
.1.1.1 255.255.255.0
ipv4 bgp policy accounting input source-accounting destination-accounting
ipv4 bgp policy accounting output source-accounting destination-accounting
encapsulation dot1q 1
!
interface TenGigE0/2/0/4
mtu 1514
ipv4 address 10
.1.0.1 255.255.255.0
proxy-arp
ipv4 directed-broadcast
ipv4 bgp policy accounting input source-accounting destination-accounting
ipv4 bgp policy accounting output source-accounting destination-accounting
!
interface TenGigE0/2/0/4.1
ipv4 address 10
.1.2
.1 255.255.255.0
ipv4 bgp policy accounting input source-accounting destination-accounting
ipv4 bgp policy accounting output source-accounting destination-accounting
encapsulation dot1q 1
!
interface GigabitEthernet 0/0/0/4
mtu 4474
ipv4 address 10
.1.0.40
255.255.0.0
ipv4 directed-broadcast
ipv4 bgp policy accounting input source-accounting destination-accounting
ipv4 bgp policy accounting output source-accounting destination-accounting
encapsulation ppp
GigabitEthernet
crc 32
!
keepalive disable
!
interface GigabitEthernet 0/0/0/8
mtu 4474
ipv4 address 18
.8
.0.1 255.255.0.0
ipv4 directed-broadcast
ipv4 bgp policy accounting input source-accounting destination-accounting
ipv4 bgp policy accounting output source-accounting destination-accounting
GigabitEthernet
crc 32
```

```
!  
keepalive disable  
!
```

Configure controller:

```
controller GigabitEthernet 0/0/0/4  
  ais-shut  
  path  
  ais-shut  
  !  
  threshold sf-ber 5  
!  
controller SONET0/0/0/8  
  ais-shut  
  path  
  ais-shut  
  !  
  threshold sf-ber 5  
!
```

Configure AS-path-set and prefix-set:

```
as-path-set as107  
  ios-regex '107$'  
end-set  
  
as-path-set as108  
  ios-regex '108$'  
end-set  
  
prefix-set RT-65.0  
  65.0.0.0/16 ge 16 le 32  
end-set  
  
prefix-set RT-66.0  
  66.0.0.0/16 ge 16 le 32  
end-set
```

Configure the route-policy (table-policy) to set up the traffic indexes based on each prefix, AS-path-set, and prefix-set:

```
route-policy bpa1  
  
  if destination in (10  
  .1.1.0/24) then  
    set traffic-index 1  
  elseif destination in (10  
  .1.2.0/24) then  
    set traffic-index 2  
  elseif destination in (10  
  .1.3.0/24) then  
    set traffic-index 3  
  elseif destination in (10  
  .1.4.0/24) then  
    set traffic-index 4  
  elseif destination in (10  
  .1.5.0/24) then  
    set traffic-index 5  
  endif  
  
  if destination in (10  
  .1.1.0/24) then  
    set traffic-index 6  
  elseif destination in (10  
  .1.2.0/24) then  
    set traffic-index 7  
  elseif destination in (10  
  .1.3.0/24) then  
    set traffic-index 8  
  elseif destination in (10  
  .1.4.0/24) then
```

```

        set traffic-index 9
    elseif destination in (10
.1.5.0/24) then
        set traffic-index 10
    endif

    if as-path in as107 then
        set traffic-index 7
    elseif as-path in as108 then
        set traffic-index 8
    endif

    if destination in RT-65.0 then
        set traffic-index 15
    elseif destination in RT-66.0 then
        set traffic-index 16
    endif
end-policy

```

end-policy

Configure the regular BGP route-policy to pass or drop all the BGP routes:

```

route-policy drop-all
    drop
end-policy
!
route-policy pass-all
    pass
end-policy
!

```

Configure the BGP router and apply the table-policy to the global ipv4 address family:

```

router bgp 100
    bgp router-id Loopback1
    bgp graceful-restart
    bgp as-path-loopcheck
    address-family ipv4 unicast
        table-policy bpa1
        maximum-paths 8
    bgp dampening
!

```

Configure the BGP neighbor-group:

```

neighbor-group ebgp-peer-using-int-addr
    address-family ipv4 unicast
        policy pass-all in
        policy drop-all out
    !
!
neighbor-group ebgp-peer-using-int-addr-121
    remote-as 121
    address-family ipv4 unicast
        policy pass-all in
        policy drop-all out
    !
!
neighbor-group ebgp-peer-using-int-addr-pass-out
    address-family ipv4 unicast
        policy pass-all in
        policy pass-all out
    !
!

```

Configure BGP neighbors:

```

neighbor 10
.4
.0.2
    remote-as 107
    use neighbor-group ebgp-peer-using-int-addr
!

```

```

neighbor 10
.8
.0.2
  remote-as 108
  use neighbor-group ebgp-peer-using-int-addr
!
neighbor 10
.7
.0.2
  use neighbor-group ebgp-peer-using-int-addr-121
!
neighbor 10
.1.7
.2
  use neighbor-group ebgp-peer-using-int-addr-121
!
neighbor 10
.18
.0.2
  remote-as 122
  use neighbor-group ebgp-peer-using-int-addr
!
neighbor 10
.18
.1.2
  remote-as 1221
  use neighbor-group ebgp-peer-using-int-addr
!
end

```

Verifying BGP Policy Statistics: Example

The following example shows how to verify the traffic index setup for each BGP prefix and BGP Policy Accounting statistics on ingress and egress interfaces. The following traffic stream is configured for this example:

- Traffic comes in from GigabitEthernet 0/2/0/4 and goes out to 5 VLAN subinterfaces under GigabitEthernet 0/2/0/2
- Traffic comes in from GigabitEthernet 0/0/0/8 and goes out to GigabitEthernet 0/0/0/4

```
show cef ipv4 interface GigabitEthernet 0/0/0/8 bgp-policy-statistics
```

```

GigabitEthernet0/0/0/8 is up
Input BGP policy accounting on dst IP address enabled
  buckets      packets      bytes
  7             5001160    500116000
  15            10002320   1000232000
Input BGP policy accounting on src IP address enabled
  buckets      packets      bytes
  8             5001160    500116000
  16            10002320   1000232000
Output BGP policy accounting on dst IP address enabled
  buckets      packets      bytes
  0             15         790
Output BGP policy accounting on src IP address enabled
  buckets      packets      bytes
  0             15         790

```

```
show cef ipv4 interface GigabitEthernet 0/0/0/4 bgp-policy-statistics
```

```

GigabitEthernet0/0/0/4 is up
Input BGP policy accounting on dst IP address enabled
  buckets      packets      bytes
Input BGP policy accounting on src IP address enabled
  buckets      packets      bytes
Output BGP policy accounting on dst IP address enabled

```

```

    buckets      packets      bytes
    0             13           653
    7             5001160      500116000
    15            10002320     1000232000
Output BGP policy accounting on src IP address enabled
    buckets      packets      bytes
    0             13           653
    8             5001160      500116000
    16            10002320     1000232000

show cef ipv4 interface GigabitEthernet 0/2/0/4 bgp-policy-statistics

GigabitEthernet0/2/0/4 is up
Input BGP policy accounting on dst IP address enabled
    buckets      packets      bytes
    1            3297102      329710200
    2            3297102      329710200
    3            3297102      329710200
    4            3297101      329710100
    5            3297101      329710100
Input BGP policy accounting on src IP address enabled
    buckets      packets      bytes
    6            3297102      329710200
    7            3297102      329710200
    8            3297102      329710200
    9            3297101      329710100
    10           3297101      329710100
Output BGP policy accounting on dst IP address enabled
    buckets      packets      bytes
    0             15           733
Output BGP policy accounting on src IP address enabled
    buckets      packets      bytes
    0             15           733

show cef ipv4 interface GigabitEthernet 0/2/0/2.1 bgp-policy-statistics

GigabitEthernet 0/2/0/2.1 is up
Input BGP policy accounting on dst IP address enabled
    buckets      packets      bytes
Input BGP policy accounting on src IP address enabled
    buckets      packets      bytes
Output BGP policy accounting on dst IP address enabled
    buckets      packets      bytes
    0             15           752
    1            3297102      329710200
    2            3297102      329710200
    3            3297102      329710200
    4            3297101      329710100
    5            3297101      329710100
Output BGP policy accounting on src IP address enabled
    buckets      packets      bytes
    0             15           752
    6            3297102      329710200
    7            3297102      329710200
    8            3297102      329710200
    9            3297101      329710100
    10           3297101      329710100

```

The following example show how to verify BGP routes and traffic indexes:

```

show route bgp

B      10
.1.1.0/24 [20/0] via 10
.17
.1.2, 00:07:09
      Traffic Index 1
B      10
.1.2.0/24 [20/0] via 10
.17
.1.2, 00:07:09
      Traffic Index 2
B      10

```



```
.1.3.0/24 [20/0] via 10
.17
.1.2, 00:07:09
    Traffic Index 3
B    10
.1.4.0/24 [20/0] via 10
.17
.1.2, 00:07:09
    Traffic Index 4
B    10
.1.5.0/24 [20/0] via 10
.17
.1.2, 00:07:09
    Traffic Index 5
B    10
.18
.1.0/24 [20/0] via 10
.18
.1.2, 00:07:09
    Traffic Index 6
B    10
.18
.2.0/24 [20/0] via 10
.18
.1.2, 00:07:09
    Traffic Index 7
B    10
.18
.3.0/24 [20/0] via 10
.18
.1.2, 00:07:09
    Traffic Index 8
B    10
.28
.4.0/24 [20/0] via 10
.18
.1.2, 00:07:09
    Traffic Index 9
B    10
.28
.5.0/24 [20/0] via 10
.18
.1.2, 00:07:09
    Traffic Index 10
B    10
.65
.1.0/24 [20/0] via 10
.45
.0.2, 00:07:09
    Traffic Index 15
B    10
.65
.2.0/24 [20/0] via 10
.45
.0.2, 00:07:09
    Traffic Index 15
B    10
.65
.3.0/24 [20/0] via 10
.45
.0.2, 00:07:09
    Traffic Index 15
B    10
.65
.0/24 [20/0] via 10
.45
.0.2, 00:07:09
    Traffic Index 15
B    10
.65
.5.0/24 [20/0] via 10
.45
```

```

.0.2, 00:07:09
    Traffic Index 15
B    10
.65
.6.0/24 [20/0] via 10
.45
.0.2, 00:07:09
    Traffic Index 15
B    10
.65
.7.0/24 [20/0] via 10
.45
.0.2, 00:07:09
    Traffic Index 15
B    10
.65
.8.0/24 [20/0] via 10
.45
.0.2, 00:07:09
    Traffic Index 15
B    10
.65
.9.0/24 [20/0] via 10
.45
.0.2, 00:07:09
    Traffic Index 15
B    10
.65
.10.0/24 [20/0] via 10
.45
.0.2, 00:07:09
    Traffic Index 15
B    10
.66
.1.0/24 [20/0] via 10
.32
.0.2, 00:07:09
    Traffic Index 16
B    10
.66
.2.0/24 [20/0] via 10
.32
.0.2, 00:07:09
    Traffic Index 16
B    10
.66
.3.0/24 [20/0] via 10
.32
.0.2, 00:07:09
    Traffic Index 16
B    10
.66
.4.0/24 [20/0] via 10
.32
.0.2, 00:07:09
    Traffic Index 16
B    10
.66
.5.0/24 [20/0] via 10
.32
.0.2, 00:07:09
    Traffic Index 16
B    10
.66
.6.0/24 [20/0] via 10
.32
.0.2, 00:07:09
    Traffic Index 16
B    10
.66
.7.0/24 [20/0] via 10
.32
.0.2, 00:07:09

```

```

        Traffic Index 16
B      10
.66
.8.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 16
B      10
.66
.9.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 16
B      10
.66
.10.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 16
B      10
.67
.1.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 7
B      10
.67
.2.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 7
B      10
.67
.3.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 7
B      10
.67
.4.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 7
B      10
.67
.5.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 7
B      10
.67
.6.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 7
B      10
.67
.7.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 7
B      10
.67
.8.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 7
B      10
.67
.9.0/24 [20/0] via 10
.32
.0.2, 00:07:09
        Traffic Index 7
```

```

B      10
.67
.10.0/24 [20/0] via 10
.32
.0.2, 00:07:09
      Traffic Index 7
B      10
.68
.1.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8
B      10
.68
.2.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8
B      10
.68
.3.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8
B      10
.68
.4.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8
B      10
.68
.5.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8
B      10
.68
.6.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8
B      10
.68
.7.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8
B      10
.68
.8.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8
B      10
.68
.9.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8
B      10
.68
.10.0/24 [20/0] via 10
.8
.0.2, 00:07:09
      Traffic Index 8

show bgp summary

BGP router identifier 192
.0
.2
.0

```

```
, local AS number 100
BGP generic scan interval 60 secs
BGP main routing table version 151
Dampening enabled
BGP scan interval 60 secs
BGP is operating in STANDALONE mode.
```

Process Speaker	RecvTblVer 151	bRIB/RIB 151	SendTblVer 151							
Neighbor	Spk	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	St/PfxRcd	
10										
.4										
.0.2		0	107	54	53		151	0	0 00:25:26	20
10										
.1.0.2		0	108	54	53		151	0	0 00:25:28	20
10										
.1.0.2	0	121	53	54	151	0	0	00:25:42		0
10										
.1.1.2	0	121	53	53	151	0	0	00:25:06		5
10										
.1.2.2	0	121	52	54	151	0	0	00:25:04		0
10										
.1.3.2	0	121	52	53	151	0	0	00:25:26		0
10										
.1.4.2	0	121	53	54	151	0	0	00:25:41		0
10										
.1.5.2	0	121	53	54	151	0	0	00:25:43		0
10										
.1.6.2	0	121	51	53	151	0	0	00:24:59		0
10										
.1.7.2	0	121	51	52	151	0	0	00:24:44		0
10										
.1.8.2	0	121	51	52	151	0	0	00:24:49		0
10										
.2										
.0.2	0	122	52	54	151	0	0	00:25:21		0
10										
.2										
.1.2	0	1221	54	54	151	0	0	00:25:43		5
10										
.2										
.2.2	0	1222	53	54	151	0	0	00:25:38		0
10										
.2										
.3.2	0	1223	52	53	151	0	0	00:25:17		0
10										
.2										
.4.2	0	1224	51	52	151	0	0	00:24:57		0
10										
.2										
.5.2	0	1225	52	53	151	0	0	00:25:14		0
10										
.2										
.6.2	0	1226	52	54	151	0	0	00:25:04		0
10										
.2										
.7.2	0	1227	52	54	151	0	0	00:25:13		0
10										
.2										
.8.2	0	1228	53	54	151	0	0	00:25:36		0

```
show bgp 27.1.1.1
```

```
BGP routing table entry for 27.1.1.0/24
Versions:
  Process          bRIB/RIB  SendTblVer
  Speaker          102      102
Paths: (1 available, best #1)
  Not advertised to any peer
  Received by speaker 0
  121
  10
```

```

.1.1.2 from 10
.1.1.2 (10
.1.1.2)
    Origin incomplete, localpref 100, valid, external, best
    Community: 27:1 121:1

show bgp 10
.1.1.1

BGP routing table entry for 10
.1.1.0/24
Versions:
  Process          bRIB/RIB  SendTblVer
  Speaker          107      107
Paths: (1 available, best #1)
  Not advertised to any peer
  Received by speaker 0
  1221
    10
.2
.1.2 from 10
.2
.1.2 (18.1.1.2)
    Origin incomplete, localpref 100, valid, external, best
    Community: 28:1 1221:1

show bgp 10
.0.1.1

BGP routing table entry for 10
.0.1.0/24
Versions:
  Process          bRIB/RIB  SendTblVer
  Speaker          112      112
Paths: (1 available, best #1)
  Not advertised to any peer
  Received by speaker 0
  107
    10
.1.0.2 from 10
.1.0.2 (10
.1.0.2)
    Origin incomplete, localpref 100, valid, external, best
    Community: 107:65

show bgp 10
.2
.1.1

BGP routing table entry for 10
.2
.1.0/24
Versions:
  Process          bRIB/RIB  SendTblVer
  Speaker          122      122
Paths: (1 available, best #1)
  Not advertised to any peer
  Received by speaker 0
  108
    8.1.0.2 from 8.1.0.2 (8.1.0.2)
    Origin incomplete, localpref 100, valid, external, best
    Community: 108:66

show bgp 67.0.1.1

BGP routing table entry for 67.0.1.0/24
Versions:
  Process          bRIB/RIB  SendTblVer
  Speaker          132      132
Paths: (1 available, best #1)
  Not advertised to any peer
  Received by speaker 0
  107

```

```
4.1.0.2 from 4.1.0.2 (4.1.0.2)
  Origin incomplete, localpref 100, valid, external, best
  Community: 107:67

show bgp 68.0.1.1

BGP routing table entry for 68.0.1.0/24
Versions:
  Process          bRIB/RIB   SendTblVer
  Speaker          142        142
Paths: (1 available, best #1)
  Not advertised to any peer
  Received by speaker 0
  108
    8.1.0.2 from 8.1.0.2 (8.1.0.2)
      Origin incomplete, localpref 100, valid, external, best
      Community: 108:68

show route ipv4 27.1.1.1

Routing entry for 27.1.1.0/24
  Known via "bgp 100", distance 20, metric 0
  Tag 121, type external, Traffic Index 1
  Installed Nov 11 21:14:05.462
  Routing Descriptor Blocks
    17.1.1.2, from 17.1.1.2
      Route metric is 0
  No advertising protos.

show route ipv4 28.1.1.1

Routing entry for 28.1.1.0/24
  Known via "bgp 100", distance 20, metric 0
  Tag 1221, type external, Traffic Index 6
  Installed Nov 11 21:14:05.462
  Routing Descriptor Blocks
    18.1.1.2, from 18.1.1.2
      Route metric is 0
  No advertising protos.

show route ipv4 65.0.1.1

Routing entry for 65.0.1.0/24
  Known via "bgp 100", distance 20, metric 0
  Tag 107, type external, Traffic Index 15
  Installed Nov 11 21:14:05.462
  Routing Descriptor Blocks
    4.1.0.2, from 4.1.0.2
      Route metric is 0
  No advertising protos.

show route ipv4 66.0.1.1

Routing entry for 66.0.1.0/24
  Known via "bgp 100", distance 20, metric 0
  Tag 108, type external, Traffic Index 16
  Installed Nov 11 21:14:05.462
  Routing Descriptor Blocks
    8.1.0.2, from 8.1.0.2
      Route metric is 0
  No advertising protos.

show route ipv4 67.0.1.1

Routing entry for 67.0.1.0/24
  Known via "bgp 100", distance 20, metric 0
  Tag 107, type external, Traffic Index 7
  Installed Nov 11 21:14:05.462
  Routing Descriptor Blocks
    4.1.0.2, from 4.1.0.2
      Route metric is 0
  No advertising protos.
```

```

show route ipv4 68.0.1.1

Routing entry for 68.0.1.0/24
  Known via "bgp 100", distance 20, metric 0
  Tag 108, type external, Traffic Index 8
  Installed Nov 11 21:14:05.462
  Routing Descriptor Blocks
    8.1.0.2, from 8.1.0.2
      Route metric is 0
  No advertising protos.

show cef ipv4 27.1.1.1

27.1.1.0/24, version 263, source-destination sharing
Prefix Len 24, Traffic Index 1, precedence routine (0)
  via 17.1.1.2, 0 dependencies, recursive
    next hop 17.1.1.2/24, GigabitEthernet 0/2/0/2.1 via 17.1.1.0/24
    valid remote adjacency
  Recursive load sharing using 17.1.1.0/24

show cef ipv4 28.1.1.1

28.1.1.0/24, version 218, source-destination sharing
Prefix Len 24, Traffic Index 6, precedence routine (0)
  via 18.1.1.2, 0 dependencies, recursive
    next hop 18.1.1.2/24, GigabitEthernet 0/2/0/4.1 via 18.1.1.0/24
    valid remote adjacency
  Recursive load sharing using 18.1.1.0/24

show cef ipv4 65.0.1.1

65.0.1.0/24, version 253, source-destination sharing
Prefix Len 24, Traffic Index 15, precedence routine (0)
  via 4.1.0.2, 0 dependencies, recursive
    next hop 4.1.0.2/16, GigabitEthernet 0/0/0/4 via 4.1.0.0/16
    valid remote adjacency
  Recursive load sharing using 4.1.0.0/16

show cef ipv4 66.0.1.1

66.0.1.0/24, version 233, source-destination sharing
Prefix Len 24, Traffic Index 16, precedence routine (0)
  via 8.1.0.2, 0 dependencies, recursive
    next hop 8.1.0.2/16, GigabitEthernet 0/0/0/8 via 8.1.0.0/16
    valid remote adjacency
  Recursive load sharing using 8.1.0.0/16

show cef ipv4 67.0.1.1

67.0.1.0/24, version 243, source-destination sharing
Prefix Len 24, Traffic Index 7, precedence routine (0)
  via 4.1.0.2, 0 dependencies, recursive
    next hop 4.1.0.2/16, GigabitEthernet 0/0/0/4 via 4.1.0.0/16
    valid remote adjacency
  Recursive load sharing using 4.1.0.0/16

show cef ipv4 68.0.1.1

68.0.1.0/24, version 223, source-destination sharing
Prefix Len 24, Traffic Index 8, precedence routine (0)
  via 8.1.0.2, 0 dependencies, recursive
    next hop 8.1.0.2/16, GigabitEthernet 0/0/0/8 via 8.1.0.0/16
    valid remote adjacency
  Recursive load sharing using 8.1.0.0/16

show cef ipv4 27.1.1.1 detail

27.1.1.0/24, version 263, source-destination sharing
Prefix Len 24, Traffic Index 1, precedence routine (0)
  via 17.1.1.2, 0 dependencies, recursive
    next hop 17.1.1.2/24, GigabitEthernet 0/2/0/2.1 via 17.1.1.0/24
    valid remote adjacency

```



```

Recursive load sharing using 17.1.1.0/24
Load distribution: 0 (refcount 6)

Hash OK Interface Address Packets
1 Y GigabitEthernet 0/2/0/2.1 (remote) 0

show cef ipv4 28.1.1.1 detail

28.1.1.0/24, version 218, source-destination sharing
Prefix Len 24, Traffic Index 6, precedence routine (0)
  via 18.1.1.2, 0 dependencies, recursive
    next hop 18.1.1.2/24, GigabitEthernet 0/2/0/4.1 via 18.1.1.0/24
    valid remote adjacency

Recursive load sharing using 18.1.1.0/24
Load distribution: 0 (refcount 6)

Hash OK Interface Address Packets
1 Y GigabitEthernet 0/2/0/4.1 (remote) 0

show cef ipv4 65.0.1.1 detail

65.0.1.0/24, version 253, source-destination sharing
Prefix Len 24, Traffic Index 15, precedence routine (0)
  via 4.1.0.2, 0 dependencies, recursive
    next hop 4.1.0.2/16, GigabitEthernet0/0/0/4 via 4.1.0.0/16
    valid remote adjacency

Recursive load sharing using 4.1.0.0/16
Load distribution: 0 (refcount 21)

Hash OK Interface Address Packets
1 Y GigabitEthernet0/0/0/4 (remote) 0

show cef ipv4 66.0.1.1 detail

66.0.1.0/24, version 233, source-destination sharing
Prefix Len 24, Traffic Index 16, precedence routine (0)
  via 8.1.0.2, 0 dependencies, recursive
    next hop 8.1.0.2/16, GigabitEthernet0/0/0/8 via 8.1.0.0/16
    valid remote adjacency

Recursive load sharing using 8.1.0.0/16
Load distribution: 0 (refcount 21)

Hash OK Interface Address Packets
1 Y GigabitEthernet 0/0/0/8 (remote) 0

show cef ipv4 67.0.1.1 detail

67.0.1.0/24, version 243, source-destination sharing
Prefix Len 24, Traffic Index 7, precedence routine (0)
  via 4.1.0.2, 0 dependencies, recursive
    next hop 4.1.0.2/16, GigabitEthernet 0/0/0/4 via 4.1.0.0/16
    valid remote adjacency

Recursive load sharing using 4.1.0.0/16
Load distribution: 0 (refcount 21)

Hash OK Interface Address Packets
1 Y GigabitEthernet 0/0/0/4 (remote) 0

show cef ipv4 68.0.1.1 detail

68.0.1.0/24, version 223, source-destination sharing
Prefix Len 24, Traffic Index 8, precedence routine (0)
  via 8.1.0.2, 0 dependencies, recursive
    next hop 8.1.0.2/16, GigabitEthernet 0/0/0/8 via 8.1.0.0/16
    valid remote adjacency

Recursive load sharing using 8.1.0.0/16
Load distribution: 0 (refcount 21)

```

Hash	OK	Interface	Address	Packets
1	Y	GigabitEthernet 0/0/0/8		(remote) 0

Configuring Unicast RPF Checking: Example

The following example shows how to configure unicast RPF checking:

```
configure
interface GigabitEthernet 0/0/0/1
ipv4 verify unicast source reachable-via rx
end
```

Configuring the Switching of Modular Services Card to Management Ethernet Interfaces on the Route Processor: Example

The following example shows how to configure the switching of the MSC to Management Ethernet interfaces on the route processor:

```
configure
rp mgmtethernet forwarding
end
```

Configuring Per-Flow Load Balancing: Example

The following examples show how to configure Layer 3 load-balancing for the hash algorithm from the **cef load-balancing fields L3 global** command, and how to verify summary information for the CEF table from the **show cef summary** command:

Configuring Layer 3 load-balancing

```
configure
 cef load-balancing fields L3 global
end
!
show cef summary
Router ID is 10.6.6.6
```

IP CEF with switching (Table Version 0) for node0_RSP0_CPU0

```
Load balancing: L3
Tableid 0xe0000000 (0x9cbb51b0), Vrfid 0x60000000, Vrid 0x20000000, Flags 0x2031
Vrfname default, Refcount 577
300 routes, 0 protected, 0 reresolve, 0 unresolved (0 old, 0 new), 21600 bytes
212 load sharing elements, 62576 bytes, 324 references
19 shared load sharing elements, 5388 bytes
193 exclusive load sharing elements, 57188 bytes
0 route delete cache elements
622 local route bufs received, 1 remote route bufs received, 0 mix bufs received
176 local routes, 0 remote routes
4096 total local route updates processed
0 total remote route updates processed
0 pkts pre-routed to cust card
0 pkts pre-routed to cust card
0 pkts received from core card
0 CEF route update drops, 96 revisions of existing leaves
0 CEF route update drops due to version mis-match
Resolution Timer: 15s
0 prefixes modified in place
0 deleted stale prefixes
```

```
82 prefixes with label imposition, 107 prefixes with label information
95 next hops
0 incomplete next hops

0 PD backwalks on LDIs with backup path
```

Configuring BGP Attributes Download: Example

The following example shows how to configure the BGP Attributes Download feature:

```
router configure
show cef bgp attribute {attribute-id| local-attribute-id}
```

Additional References

The following sections provide references related to implementing CEF.

Related Documents

Related Topic	Document Title
CEF commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	<i>Cisco Express Forwarding Commands</i> module in <i>Cisco ASR 9000 Series Aggregation Services Router IP Addresses and Services Command Reference</i>
BGP commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	<i>BGP Commands</i> module in the <i>Cisco ASR 9000 Series Aggregation Services Router Routing Command Reference</i>
Link Bundling Commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	<i>Link Bundling Commands</i> module in the <i>Cisco ASR 9000 Series Aggregation Services Router Interface and Hardware Component Command Reference</i>

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.	—

MIBs

MIBs	MIBs Link
—	To locate and download MIBs, use the Cisco MIB Locator found at the following URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport