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.

Note For complete descriptions of the CEF commands listed in this module, you can refer to the Related Documents, on page 35 section of this module.

Feature History for Implementing CEF

Release	Modification
Release 2.0	This feature was introduced.
Release 3.3.0	Loose and Strict support for uRPF was added. The CEF Nonrecursive Accounting feature was removed.
Release 3.6.0	Per-flow load balancing feature was added.
Release 3.7.0	The OSPFv2 SPF Prefix Prioritization feature was added. The **show cef bgp-attribute** command was added.

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 softwareCEF 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 processor (RP) and each MSC.

The FIB on each node processes Routing Information Base (RIB) updates, performing route resolution and maintaining FIB tables independently in the RP 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

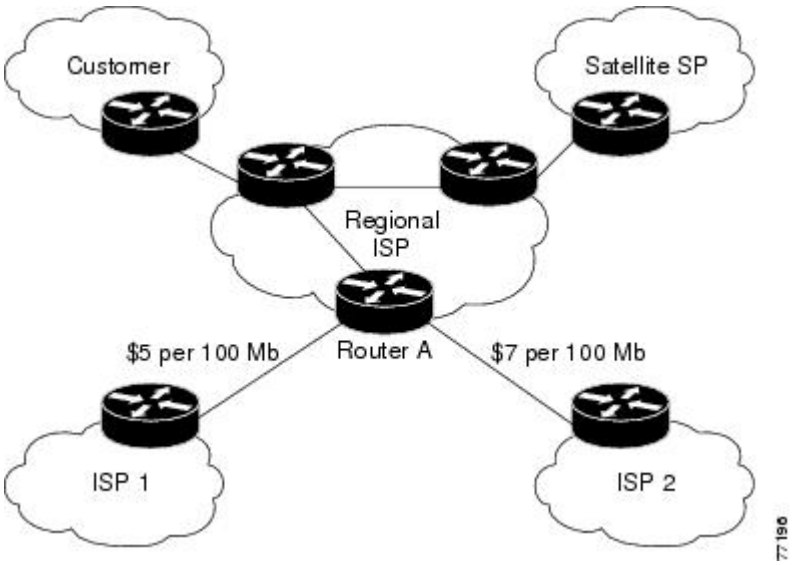
Border Gateway Protocol (BGP) policy accounting measures and classifies IP traffic that is sent to, or received from, different peers. Policy accounting is enabled on an individual input or output interface basis, and counters based on parameters such as community list, autonomous system number, or autonomous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

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.

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.

Route Processor Management Ethernet Forwarding

Forwarding from the MSC interface to the RP Management Ethernet is disabled by default. The **rp mgmtethernet forwarding** command is used to enable forwarding from the MSC interface to RP Management Ethernet.

Forwarding from the RP Management Ethernet to the MSC interface, and from the RP Management Ethernet to RP Management Ethernet, is enabled by default.

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 7-tuple hash algorithm.
- A 7-tuple hash algorithm provides more granular load balancing than the existing 3-tuple hash algorithm.
- The same hash algorithm (3-tuple or 7-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** command allows you to select either the 3-tuple hash algorithm (default) or the 7-tuple hash algorithm.

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

The 7-tuple load-balance hash calculation contains 3-tuple inputs and these additional following Layer 4 (Transport Layer) inputs:

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
- Protocol
- Ingress interface handle

Note For MPLS packets with non-IPv4/non-IPv6 payload, when CRS is used as a core router, these fields are considered for load balancing:

- 3 tuple hashing - MPLS Label, Router ID
- 7 tuple hashing - MPLS Label, Router ID, Ingress interface handle

For more information about configuring the hashing algorithm (**cef load-balancing fields l4** command) that is used for load balancing during forwarding, see the *IP Addresses and Services Command Reference for Cisco CRS Routers*.

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.

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.

Verification

```
Router# show cef bgp-attribute
Wed Aug 21 14:05:51.772 UTC

VRF: default

_____________
Table ID: 0xe0000000. Total number of entries: 1
OOR state: GREEN. Number of OOR attributes: 0

BGP Attribute ID: 0x6, Local Attribute ID: 0x1
    Aspath      :    2
    Community   :
```

```
Origin AS   :    2
Next Hop AS :    2
```

GTP Tunnel Load Balancing

GPRS Tunneling Protocol (GTP) is used mainly to deliver mobile data on wireless networks via Cisco CRS Router as core router. When two routers carrying GTP traffic are connected with link bundling, the traffic is required to be distributed evenly between all bundle members. You can use the **bundle-hash** command in EXEC mode to verify that the interface selected within the bundle for load balancing matches with the output from the **bundle-hash** command.

When two routers carrying GTP traffic are connected with equal-cost multi-path (ECMP) between them, you can use the **sh cef exact-route** command in EXEC mode to verify the interface selected for load balancing.

To achieve load balancing, Cisco CRS router uses 7-tuple load balancing mechanism which takes account of source IP, destination IP, router-id, ingress interface, protocol, L4 source and destination port (if traffic is TCP or UDP) fields from the packet. But for GTP traffic, limited number of unique values for these fields restrict the equal distribution of traffic load on tunnel.

In order to avoid the polarization for GTP traffic in load balancing, a tunnel endpoint identifier (TEID) in GTP header is used instead of UDP port number. Since TEID is unique per tunnel, traffic can be evenly load balanced across multiple links in the bundle.

GTP tunnel load balancing feature adds support for:

- GTP with IPv4/IPv6 transport header on physical interface
- GTP traffic over TE tunnel
- GTPv1-U with UDP port 2152

The **cef load-balancing fields L4** command enables the GTP tunnel load balancing.

To know the egress interface for GTP traffic after load balancing, use **show cef {ipv4 | ipv6} exact-route** command with TEID in place of L4 protocol source and destination port number. Use 16MSBist of TEID in source port and 16LSBits of TEID in destination port.

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/RP0/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/RP0/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/RP0/CPU0:router# show cef ipv4 detail`	Displays detailed IPv4 or IPv6 CEF table information.
Step 4	show adjacency detail **Example:** `RP/0/RP0/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 *Routing Command Reference for Cisco CRS Routers* 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 *Routing Configuration Guide for Cisco CRS Routers* for information on enabling BGP.

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 8.

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/RP0/CPU0:router# show route bgp`	Displays all BGP routes with traffic indexes.
Step 2	**show bgp summary** **Example:** `RP/0/RP0/CPU0:router# show bgp summary`	Displays the status of all BGP neighbors.
Step 3	**show bgp** *ip-address* **Example:** `RP/0/RP0/CPU0:router# show bgp 40.1.1.1`	Displays BGP prefixes with BGP attributes.
Step 4	**show route ipv4** *ip-address* **Example:** `RP/0/RP0/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** *prefix* **Example:** `RP/0/RP0/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** *prefix* **detail** **Example:** `RP/0/RP0/CPU0:router# show cef ipv4 40.1.1.1 detail`	Displays the specific BGP prefix with detailed information in the RP FIB.
Step 7	**show cef ipv4 interface** *type interface-path-id* **bgp-policy-statistics** **Example:** `RP/0/RP0/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** *seconds* **Example:** `RP/0/RP0/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** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface GigabitEthernet 0/1/0/0`	Enters interface configuration mode.

	Command or Action	Purpose
Step 3	{**ipv4** | **ipv6**} **verify unicast source reachable-via** {**any** | **rx**} [**allow-default**] [**allow-self-ping**] **Example:** `RP/0/RP0/CPU0:router(config-if)# ipv4 verify unicast source reachable-via rx`	Enables IPv4 or IPv6 uRPF checking. • 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. **Note** IPv6 uRPF checking is not supported on ASR 9000 Ethernet line cards.
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/RP0/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 a 7-Tuple Hash Algorithm

This task allows you to configure per-flow load balancing for a 7-tuple hash algorithm.

SUMMARY STEPS

1. **configure**
2. **cef load-balancing fields** {**L3** | **L4**}
3. **commit**
4. **show cef** {**ipv4** | **ipv6**} **summary** [**location** *node-id*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**cef load-balancing fields** {**L3** | **L4**} **Example:** `RP/0/RP0/CPU0:router(config)# cef load-balancing fields L4`	Configures the hashing algorithm that is used for load balancing during forwarding. The example shows that the L4 field is selected. • Use the **L3** keyword to specify the Layer 3 load-balancing for the hash algorithm Since L3 is configured as the default value, you do not need to use the **cef load-balancing fields** command unless you want to configure Layer 4. • Use the **L4** keyword to specify the Layer 3 and Layer 4 load-balancing for the hash algorithm. For a list of the inputs for Layer 3 and Layer 4, see Per-Flow Load Balancing, on page 5.
Step 3	**commit**	
Step 4	**show cef** {**ipv4** | **ipv6**} **summary** [**location** *node-id*] **Example:** `RP/0/RP0/CPU0:router# show cef ipv4 summary`	Displays the load balancing field for the IPv4 or IPv6 CEF table. • (Optional) Use the **location** keyword display a summary of the IPv4 CEF table for the designated node. The *node-id* argument is entered in the *rack/slot/module* notation

Verifying the CEF Exact Route with 7-Tuple Parameters

The following 7-tuple parameters are specified to obtain the CEF exact route for both IPv4 and IPv6:

- Source address
- Destination address
- Source port and range of destination ports
- Protocol

- Ingress interface
- Router ID

To display the path an MPLS flow would take, use the **show mpls forwarding exact-route** command. The MPLS flow comprises a source address and a destination address.

To display the path a bundle flow would take, use the **bundle-hash** command. The bundle flow comprises a source and a destination address. For more information, see *Interface and Hardware Component Command Reference for Cisco CRS Routers* .

To verify the IPv4 7-tuple parameters, perform the following steps:

SUMMARY STEPS

1. Configure parallel interfaces between back-to-back routers.
2. Create route traffic streams so that there is a stream placed onto each configured interface.
3. Use the **show cef ipv4 exact-route** command in EXEC mode to verify that the interface selected for load balancing matches with the output from this command. The following example shows the exact route for the Layer 4 information:
4. Configure Equal Cost Multipath Protocol (ECMP) interfaces, for example, between back-to-back routers.
5. Create route traffic streams so that there is a stream placed onto each configured interface.
6. Use the **show cef ipv6 exact-route** command in EXEC mode to verify that the interface selected for load balancing matches with the output from this command. The following example shows the exact route for the Layer 4 information:

DETAILED STEPS

Step 1 Configure parallel interfaces between back-to-back routers.

Step 2 Create route traffic streams so that there is a stream placed onto each configured interface.

Step 3 Use the **show cef ipv4 exact-route** command in EXEC mode to verify that the interface selected for load balancing matches with the output from this command. The following example shows the exact route for the Layer 4 information:

Example:

```
RP/0/RP0/CPU0:router# show cef ipv4 exact-route 20 .6.1.9 22.6.1.9 protocol udp source-port 1
destination-port 1 ingress-interface GigabitEthernet 0/1/0/4


22.6.1.9/32 version 0, internal 0x40040001 (0x78439fd0) [3], 0x0 (0x78aaf928), 0x4400 (0x78ed62d0)
 remote adjacency to GigabitEthernet0/1/4/4  Prefix Len 32, traffic index 0, precedence routine (0)
   via GigabitEthernet0/1/4/4
```

To verify the IPv6 7-tuple parameters, perform the following steps:

Step 4 Configure Equal Cost Multipath Protocol (ECMP) interfaces, for example, between back-to-back routers.

Step 5 Create route traffic streams so that there is a stream placed onto each configured interface.

Step 6 Use the **show cef ipv6 exact-route** command in EXEC mode to verify that the interface selected for load balancing matches with the output from this command. The following example shows the exact route for the Layer 4 information:

Example:

```
RP/0/RP0/CPU0:router# show cef ipv6 exact-route 20:6:1::9 22:6:1::9 protocol udp source-port 1
```

```
destination-port 1 ingress-interface GigabitEthernet 0/1/0/4


22:6:1::/64, version 0, internal 0x40000001 (0x7846c048) [3], 0x0 (0x78aea3d0), 0x0 (0x0)  remote
adjacency to GigabitEthernet0/1/4/4  Prefix Len 64, traffic index 0, precedence routine (0)
   via GigabitEthernet0/1/4/4
```

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** {*attribute-id* | *local-attribute-id* } **Example:** `RP/0/RP0/CPU0:router(config)# cef bgp attribute {attribute-id| local-attribute-id}`	Configures a CEF BGP attribute.
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
190.1.1.1 255.255.255.255
```

Configure interfaces with the BGP policy accounting options:

```
interface TenGigE0/2/0/2
 mtu 1514
 ipv4 address
17.1.0.1 255.255.255.0
 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
17.1.1.1 255.255.255.0
 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
18.1.0.1 255.255.255.0
 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
18.1.
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 GigabitEthernet 0/0/0/4
 mtu 4474
 ipv4 address
4.1.0.
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
 encapsulation ppp
 GigabitEthernet
  crc 32
 !
 keepalive disable
!
interface GigabitEthernet 0/0/0/8
 mtu 4474
 ipv4 address
8.
1.0.1 255.255.0.0
 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  (
27.1.1.0/24) then
    set traffic-index 1
  elseif destination in  (
27.1.2.0/24) then
    set traffic-index 2
  elseif destination in  (
27.1.3.0/24) then
    set traffic-index 3
  elseif destination in  (
27.1.4.0/24) then
    set traffic-index 4
  elseif destination in  (
27.1.5.0/24) then
    set traffic-index 5
  endif

  if destination in  (
28.1.1.0/24) then
    set traffic-index 6
  elseif destination in  (
28.1.2.0/24) then
    set traffic-index 7
  elseif destination in  (
```

```
28.1.3.0/24) then
    set traffic-index 8
  elseif destination in  (
28.1.4.0/24) then
    set traffic-index 9
  elseif destination in  (
28.1.5.0/24) 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
```

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
4.
1.0.2
  remote-as 107
  use neighbor-group ebgp-peer-using-int-addr
 !
 neighbor
8.
1.0.2
  remote-as 108
  use neighbor-group ebgp-peer-using-int-addr
 !
 neighbor
17.
1.0.2
  use neighbor-group ebgp-peer-using-int-addr-121
 !
 neighbor
17.1.
1.2
  use neighbor-group ebgp-peer-using-int-addr-121
 !
neighbor
18.
1.0.2
  remote-as 122
  use neighbor-group ebgp-peer-using-int-addr
 !
 neighbor
18.
1.1.2
  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 0/0/08 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
   27.1.1.0/24 [20/0] via
17.
1.1.2, 00:07:09
      Traffic Index 1

B    27.1.2.0/24 [20/0] via
17.
1.1.2, 00:07:09
      Traffic Index 2
B
27.1.3.0/24 [20/0] via
17.
1.1.2, 00:07:09
      Traffic Index 3
B
27.1.4.0/24 [20/0] via
17.
1.1.2, 00:07:09
      Traffic Index 4
B
27.1.5.0/24 [20/0] via
17.
1.1.2, 00:07:09
      Traffic Index 5
B
28.
1.1.0/24 [20/0] via
18.
1.1.2, 00:07:09
      Traffic Index 6
B
28.
1.2.0/24 [20/0] via
18.
1.1.2, 00:07:09
      Traffic Index 7
B
28.
1.3.0/24 [20/0] via
18.
1.1.2, 00:07:09
      Traffic Index 8
B
28.
```

```
1.4.0/24 [20/0] via
18.
1.1.2, 00:07:09
      Traffic Index 9
B
28.
1.5.0/24 [20/0] via
18.
1.1.2, 00:07:09
      Traffic Index 10
B
65.
0.1.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 15
B
65.
0.2.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 15
B
65.
0.3.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 15
B
65.
0.
4.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 15
B
65.
0.5.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 15
B
65.
0.6.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 15
B
65.
0.7.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 15
B
65.
0.8.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 15
B
65.
0.9.0/24 [20/0] via
4.
1.0.2, 00:07:09
```

```
      Traffic Index 15
B
65.
0.10.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 15
B
66.
0.1.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 16
B
66.
0.2.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 16
B
66.
0.3.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 16
B
66.
0.4.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 16
B
66.
0.5.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 16
B
66.
0.6.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 16
B
66.
0.7.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 16
B
66.
0.8.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 16
B
66.
0.9.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 16
B
66.
0.10.0/24 [20/0] via
```

```
8.
1.0.2, 00:07:09
      Traffic Index 16
B
67.
0.1.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
67.
0.2.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
67.
0.3.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
67.
0.4.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
67.
0.5.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
   67.
0.6.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
   67.
0.7.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
   67.
0.8.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
   67.
0.9.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
   67.
0.10.0/24 [20/0] via
4.
1.0.2, 00:07:09
      Traffic Index 7
B
```

```
68.
0.1.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8
B
   68.
0.2.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8
B
   68.
0.3.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8
B
   68.
0.4.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8
B
   68.
0.5.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8
B
   68.
0.6.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8
B
   68.
0.7.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8
B
   68.
0.8.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8
B
   68.
0.9.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8
B
   68.
0.10.0/24 [20/0] via
8.
1.0.2, 00:07:09
      Traffic Index 8

show bgp summary

BGP router identifier
190.
```

```
1.
1.
1, 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         RecvTblVer    bRIB/RIB  SendTblVer
Speaker               151         151         151

Neighbor        Spk    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  St/PfxRcd

4.
1.0.2           0   107      54      53      151    0    0 00:25:26       20

8.1.0.2           0   108      54      53      151    0    0 00:25:28       20

17.1.0.2          0   121      53      54      151    0    0 00:25:42        0

17.1.1.2          0   121      53      53      151    0    0 00:25:06        5

17.1.2.2          0   121      52      54      151    0    0 00:25:04        0

17.1.3.2          0   121      52      53      151    0    0 00:25:26        0

17.1.4.2          0   121      53      54      151    0    0 00:25:41        0

17.1.5.2          0   121      53      54      151    0    0 00:25:43        0

17.1.6.2          0   121      51      53      151    0    0 00:24:59        0

17.1.7.2          0   121      51      52      151    0    0 00:24:44        0

17.1.8.2          0   121      51      52      151    0    0 00:24:49        0

18.
1.0.2          0   122      52      54      151    0    0 00:25:21        0

18.
1.1.2          0  1221      54      54      151    0    0 00:25:43        5

18.
1.2.2          0  1222      53      54      151    0    0 00:25:38        0

18.
1.3.2          0  1223      52      53      151    0    0 00:25:17        0

18.
1.4.2          0  1224      51      52      151    0    0 00:24:57        0

18.
1.5.2          0  1225      52      53      151    0    0 00:25:14        0

18.
1.6.2          0  1226      52      54      151    0    0 00:25:04        0

18.
1.7.2          0  1227      52      54      151    0    0 00:25:13        0

18.
1.8.2          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

17.1.1.2 from
17.1.1.2 (
17.1.1.2)
      Origin incomplete, localpref 100, valid, external, best
      Community: 27:1 121:1

show bgp
28.1.1.1

BGP routing table entry for
28.1.1.0/24
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker               107         107
Paths: (1 available, best #1)
  Not advertised to any peer
  Received by speaker 0
  1221

    18.
1.1.2 from
18.
1.1.2 (18.1.1.2)
      Origin incomplete, localpref 100, valid, external, best
      Community: 28:1 1221:1

show bgp
65.0.1.1

BGP routing table entry for
65.0.1.0/24
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker               112         112
Paths: (1 available, best #1)
  Not advertised to any peer
  Received by speaker 0
  107

4.1.0.2 from
4.1.0.2 (
4.1.0.2)
      Origin incomplete, localpref 100, valid, external, best
      Community: 107:65

show bgp
66.
0.1.1

BGP routing table entry for
66.
0.1.0/24
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, GigabitEthernet0/2/0/4.1 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, GigabitEthernet0/0/0/4 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, GigabitEthernet0/0/0/8 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 and Layer 4 load-balancing for the hash algorithm from the **cef load-balancing fields** 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
 end
 !
show cef summary
Router ID is 10.6.6.6

IP CEF with switching (Table Version 0) for node0_0_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

  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 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 Layer 4 load-balancing

```
configure
```

```
 cef load-balancing fields L4
 end
 !
show cef summary

Router ID is
10
1.1.1.101

IP CEF with switching (Table Version 0) for node0_RP0_CPU0

  Load balancing: L4
  Tableid 0xe0000000, Vrfid 0x60000000, Vrid 0x20000000, Flags 0x301
  Vrfname default, Refcount 286242
  286122 routes, 0 reresolve, 0 unresolved (0 old, 0 new), 20600784 bytes
  11124 load sharing elements, 3014696 bytes, 297064 references
  8 shared load sharing elements, 3008 bytes
  11116 exclusive load sharing elements, 3011688 bytes
  0 CEF route update drops, 3900571 revisions of existing leaves
  Resolution Timer: 15s
  0 prefixes modified in place
  0 deleted stale prefixes
  0 prefixes with label imposition, 11032 prefixes with label information Adjacency Table
has 15 adjacencies
  1 incomplete adjacency
```

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}
```

Configuring GTP Tunnel Load Balancing: Example

The following example shows how to enable GTP tunnel load balancing by configuring Layer 4 load-balancing for the 7-tuple hash algorithm:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# cef load-balancing fields L4
RP/0/RP0/CPU0:router(config)# commit
```

The following example shows how to verify summary information for the IPv4 or IPv6 CEF table:

```
RP/0/RP0/CPU0:router# show cef ipv4 summary

Router ID is 10.2.2.2

IP CEF with switching (Table Version 0) for node0_RP0_CPU0

  Load balancing: L4
  Tableid 0xe0000000 (0x9cdbc1dc), Vrfid 0x60000000, Vrid 0x20000000, Flags 0x21
  Vrfname default, Refcount 527
  293 routes, 0 protected, 0 reresolve, 0 unresolved (0 old, 0 new), 23440 bytes
  222 load sharing elements, 64376 bytes, 85 references
  14 shared load sharing elements, 4064 bytes
  208 exclusive load sharing elements, 60312 bytes
```

```
  0 route delete cache elements
  2036 local route bufs received, 1264 remote route bufs received,  0 mix bufs d
  117 local routes, 0 remote routes
  8762 total local route updates processed
  0 total remote route updates processed
  0 pkts pre-routed to cust card
  0 pkts pre-routed to rp card
  0 pkts received from core card
  0 CEF route update drops, 2151 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
  0 prefixes with label imposition, 0 prefixes with label information
  0 LISP EID prefixes, 0 merged, via 0 rlocs
 159 next hops
  0 incomplete next hops

 0 PD backwalks on LDIs with backup path

RP/0/RP0/CPU0:router# show cef ipv6 summary

Router ID is 10.2.2.2

IP CEF with switching (Table Version 0) for node0_RP0_CPU0

  Load balancing: L4
  Tableid 0xe0800000 (0x9cdee368), Vrfid 0x60000000, Vrid 0x20000000, Flags 0x21
  Vrfname default, Refcount 39
  17 routes, 0 protected, 0 reresolve, 0 unresolved (0 old, 0 new), 1360 bytes
  17 load sharing elements, 4876 bytes, 4 references
  4 shared load sharing elements, 1072 bytes
  13 exclusive load sharing elements, 3804 bytes
  0 route delete cache elements
  199321 local route bufs received, 49838 remote route bufs received,  0 mix bud
  9 local routes, 0 remote routes
  1046420 total local route updates processed
  0 total remote route updates processed
  0 pkts pre-routed to cust card
  0 pkts pre-routed to rp card
  0 pkts received from core card
  0 CEF route update drops, 1 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
  0 prefixes with label imposition, 0 prefixes with label information
  0 LISP EID prefixes, 0 merged, via 0 rlocs
 3 next hops
  0 incomplete next hops

 0 PD backwalks on LDIs with backup path
```

Use the **show cef {ipv4 | ipv6} exact-route** command in EXEC mode to verify that the interface selected for load balancing matches with the output from this command. The following examples show the exact route for the Layer 4 information:

Note Use 16MSBist of TEID in source port and 16LSBits of TEID in destination port in place of L4 protocol source and destination port number.

For example:

If TEID=241210E1 (in hexadecimal), then source-port=9234 (Decimal equivalent of 16MSBits of TEID 2412) and destination-port=4321 (Decimal equivalent of 16LSBits of TEID 10E1)

If TEID=0069012F (in hexadecimal), then source-port= 105 (Decimal equivalent of 16MSBits of TEID 0069) and destination-port= 303 (Decimal equivalent of 16LSBits of TEID 012F)

```
RP/0/RP0/CPU0:router# show cef ipv4 exact-route 20.0.0.2 60.0.0.2 protocol udp source-port
 9234 destination-port 4321 ingress-interface GigabitEthernet 0/6/5/0

0.0.0.0/0, version 12, proxy default, internal 0x4000021 (ptr 0x9d760060) [1], )
 Updated Jul 17 03:12:35.566
 local adjacency 172.29.52.1
 Prefix Len 0, traffic index 0, precedence routine (0), priority 3
   via MgmtEth0/RP0/CPU0/0
   via 172.29.52.1, 5 dependencies, recursive [flags 0x0]
    path-idx 0 [0x9d760648 0x0]
    next hop 172.29.52.1 via 172.29.52.1/32

RP/0/RP0/CPU0:router# show cef ipv6 exact-route 20:6:1::9 22:6:1::9 protocol udp source-port
 105 destination-port 303 ingress-interface GigabitEthernet 0/6/5/4

::/0, version 8, proxy default, internal 0x4000021 (ptr 0x9d6ac06c) [1], 0x0 (0)
 Updated Jul 17 03:14:49.695
 remote adjacency to GigabitEthernet0/6/5/0.22
 Prefix Len 0, traffic index 0, precedence routine (0), priority 3
   via GigabitEthernet0/6/5/0.22
   via 5001:db8::1, GigabitEthernet0/6/5/0.22, 4 dependencies, weight 0, class ]
    path-idx 0 [0x9dd7e0c4 0x0]
    next hop 5001:db8::1
    remote adjacency
```

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	*Cisco Express Forwarding Commands* module in *IP Addresses and Services Command Reference for Cisco CRS Routers*
BGP commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	*BGP Commands* module in the *Routing Command Reference for Cisco CRS Routers*

Related Topic	Document Title
Link Bundling Commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	*Link Bundling Commands* module in the *Interface and Hardware Component Command Reference for Cisco CRS Routers*

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: https://mibs.cloudapps.cisco.com/ITDIT/MIBS/servlet/index

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