



Implementing Cisco Express Forwarding

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Implementing Cisco Express Forwarding

Cisco Express Forwarding (CEF) is an 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. CEF is an inherent feature and the users need not perform any configuration to enable it. If required, the users can change the default route purge delay and static routes.

Components

Cisco IOS XR software CEF always operates in CEF mode with two distinct components:

- Forwarding Information Base (FIB) database: The protocol-dependent FIB process maintains the forwarding tables for IPv4 and IPv6 unicast in the route processor . The FIB on each node processes Routing Information Base (RIB) updates, performing route resolution and maintaining FIB tables independently in the route processor . FIB tables on each node can be slightly different.
- Adjacency table—a protocol-independent adjacency information base (AIB)

Adjacency FIB entries are maintained only on a local node, and adjacency entries linked to FIB entries could be different.

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 features are supported for CEF on Cisco IOS XR software:

- Bundle 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

CEF 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.

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

- IPv4 CEF database—Stores IPv4 Unicast routes for forwarding IPv4 unicast packets
- IPv6 CEF database—Stores IPv6 Unicast routes for forwarding IPv6 unicast packets
- MPLS LFD database—Stores MPLS Label table for forwarding MPLS packets

Verifying CEF

To view the details of the IPv4 or IPv6 CEF tables, use the following commands:

- `show cef {ipv4 address| ipv6 address} hardware egress`

Displays the IPv4 or IPv6 CEF table. The next hop and forwarding interface are displayed for each prefix. The output of the **show cef** command varies by location.

```
Router# show cef 37.37.37.37/32 hardware egress
37.37.37.37/32, version 46, internal 0x1000001 0x0 (ptr 0x8b0477f8) [1], 0x0 (0x0), 0x0
(0x0)
local adjacency 1.0.0.2
Prefix Len 32, traffic index 0, precedence n/a, priority 3
  via 1.0.0.2/32, TenGigE0/0/0/0, 5 dependencies, weight 0, class 0 [flags 0x0]
  path-idx 0 NHID 0x0 [0x8b43bb30 0x0]
  next hop 1.0.0.2/32
  local adjacency
Show-data Print at RPLC
LEAF - HAL pd context :
sub-type : IPV4, ecd_marked:0, has_collapsed_ldi:0
collapse_bwalk_required:0, ecdv2_marked:0
Leaf H/W Result:
VRF          Net Address          Mask          Status
  0           37.37.37.37          255.255.255.255  Programmed

TX H/W Result for NP:0 (index: 0x18739 (BE)):
```

```

Next Hop Data
Next Hop Valid:          YES
Next Hop Index:         100153
--More-- RP/0/RP0/CPU0:Aug  6 16:38:59.302 : vic_1[180]: %PLATFORM-VIC-4-SIGNAL : Interface
HundredGigE0/0/1/3, Detected Signal failure
RP/0/RP0/CPU0:Aug  6 16:38:59.312 : ifmgr[172]: %PKT_INFRA-LINK-3-UPDOWN : Interface
HundredGigE0/0/1/3, changed state to Up
Egress Next Hop IF:     100045
Hw Next Hop Intf:       6
HW Port:                1
Next Hop Flags:        COMPLETE-->This indicates that the router can forward traffic.
Next Hop MAC:           4055.395f.46b7

```

```

NHINDEX H/W Result for NP:0 (index: 0 (BE)):
NhIndex is NOT required on this platform

```

```

NHINDEX STATS: pkts 0, bytes 0 (all NPs combined, no stats)

```

```

RX H/W Result on NP:0 [Adj ptr:0x40 (BE)]:
Rx-Adj is NOT required on this platform

```

- `show cef {ipv4| ipv6} summary`

Displays a summary of the IPv4 or IPv6 CEF table.

```

Router#show cef ipv4 summary
Router ID is 0.0.0.0
IP CEF with switching (Table Version 0) for node0_RP0_CPU0
  Load balancing: L4
  Tableid 0xe0000000 (0x8a2d7380), Vrfid 0x60000000, Vrid 0x20000000, Flags 0x1019
  Vrfname default, Refcount 88
  39 routes, 0 protected, 0 reresolve, 0 unresolved (0 old, 0 new), 9048 bytes
  11 rib, 0 lsd, 17:0 aib, 0 internal, 8 interface, 4 special, 1 default routes
  39 load sharing elements, 32176 bytes, 2 references
  2 shared load sharing elements, 1600 bytes
  37 exclusive load sharing elements, 30576 bytes
  0 route delete cache elements
  24 local route bufs received, 0 remote route bufs received,  0 mix bufs received
  11 local routes, 0 remote routes
  26 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, 2 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
  20 next hops
  0 incomplete next hops
  0 PD backwalks on LDIs with backup path

```

- `show cef { ipv4 address| ipv6 address } detail`

Displays the details of the IPv4 or IPv6 CEF table.

```

Router#show cef 1.0.0.2 detail
1.0.0.2/32, version 0, internal 0x1020001 0x0 (ptr 0x8a35d1a8) [1], 0x0 (0x0), 0x0 (0x0)
Updated Aug  3 11:00:37.829
local adjacency 1.0.0.2
Prefix Len 32, traffic index 0, Adjacency-prefix, precedence n/a, priority 15

```

```

gateway array (0x8a08af70) reference count 1, flags 0x4000, source aib-hi (3), 0 backups
    [1 type 3 flags 0x48401 (0x8ald9e18) ext 0x0 (0x0)]
LW-LDI[type=0, refc=0, ptr=0x0, sh-ldi=0x0]
gateway array update type-time 1 Aug 3 11:00:37.829
LDI Update time Aug 3 11:00:37.829
  via 1.0.0.2/32, TenGigE0/0/0/0, 3 dependencies, weight 0, class 0 [flags 0x0]
  path-idx 0 NHID 0x0 [0x8b7df0a0 0x0]
  next hop 1.0.0.2/32
  local adjacency
  Load distribution: 0 (refcount 1)
  Hash OK Interface Address
  0 Y TenGigE0/0/0/0 1.0.0.2

```

- show adjacency detail

Displays detailed adjacency information, including Layer 2 information for each interface. The output of the show adjacency command varies by location.

```

Router#show adjacency detail
-----
0/RP0/CPU0
-----
Interface                Address                Version  Refcount Protocol
Te0/0/0/29                (interface)            30      1( 0)
                        (interface entry)
                        mtu: 1500, flags 1 4
                        0 packets, 0 bytes
Te0/0/0/77                (interface)            78      1( 0)
                        (interface entry)
                        mtu: 1500, flags 1 4
                        0 packets, 0 bytes
Te0/0/0/20                (interface)            21      1( 0)
                        (interface entry)
                        mtu: 1500, flags 1 4
                        0 packets, 0 bytes
Te0/0/0/33                (interface)            34      1( 0)
                        (interface entry)
                        mtu: 1500, flags 1 4
                        0 packets, 0 bytes
Hu0/0/1/3                 (interface)            84      1( 0)
                        (interface entry)
                        mtu: 1500, flags 1 4
                        88 packets, 3696 bytes
Te0/0/0/24                (interface)            25      1( 0)

```

Per-Flow Load Balancing

The system inherently supports the 5-tuple hash algorithm. 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.
- Incoming data Data traffic is evenly distributed over multiple equal-cost connections member links 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 and 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 5-tuple load-balance hash calculation contains:
 - Source IP address
 - Destination IP address
 - Router ID
 - Source port
 - Destination port

Configuring Static Route

Routers forward packets using either route information from route table entries that you manually configure or the route information that is calculated using dynamic routing algorithms. Static routes, which define explicit paths between two routers, cannot be automatically updated; you must manually reconfigure static routes when network changes occur. Static routes use less bandwidth than dynamic routes. Use static routes where network traffic is predictable and where the network design is simple. You should not use static routes in large, constantly changing networks because static routes cannot react to network changes. Most networks use dynamic routes to communicate between routers but might have one or two static routes configured for special cases. Static routes are also useful for specifying a gateway of last resort (a default router to which all unroutable packets are sent).

Configuration Example

Create a static route between Router A and B over a TenGigE interface. The destination IP address is 37.37.37.37/32 and the next hop address is 1.0.0.2.



```
Router(config)# router static address-family ipv4 unicast
Router(config-static-afi)# 37.37.37.37/32 tengigE 0/0/0/0 1.0.0.2
Router(config-static-afi)# commit
```

Running Configuration

```
Router#show running-config router static address-family ipv4 unicast
router static
  address-family ipv4 unicast
    37.37.37.37/32 tengigE 0/0/0/0 1.0.0.2
  !
!
```

Verification

Verify that the Next Hop Flags fields indicate COMPLETE for accurate functioning of the configuration.

```

Router#show cef 37.37.37.37/32 hardware egress
37.37.37.37/32, version 46, internal 0x1000001 0x0 (ptr 0x8b0477f8) [1], 0x0 (0x0), 0x0
(0x0)
local adjacency 1.0.0.2
  Prefix Len 32, traffic index 0, precedence n/a, priority 3
  via 1.0.0.2/32, TenGigE0/0/0/0, 5 dependencies, weight 0, class 0 [flags 0x0]
  path-idx 0 NHID 0x0 [0x8b43bb30 0x0]
  next hop 1.0.0.2/32
  local adjacency
  Show-data Print at RPLC
  LEAF - HAL pd context :
  sub-type : IPV4, ecd_marked:0, has_collapsed_ldi:0
  collapse_bwalk_required:0, ecdv2_marked:0
Leaf H/W Result:
  VRF          Net Address          Mask          Status
  0            37.37.37.37          255.255.255.255  Programmed

TX H/W Result for NP:0 (index: 0x18739 (BE)):
  Next Hop Data
  Next Hop Valid:          YES
  Next Hop Index:         100153
  --More-- vic_1[180]: %PLATFORM-VIC-4-SIGNAL : Interface HundredGigE0/0/1/3, Detected
  Signal failure
  : ifmgr[172]: %PKT_INFRA-LINK-3-UPDOWN : Interface HundredGigE0/0/1/3, changed state to Up

  Egress Next Hop IF:     100045
  Hw Next Hop Intf:       6
  HW Port:                 1
  Next Hop Flags: COMPLETE--->This indicates that the router can forward traffic.
  Next Hop MAC:           4055.395f.46b7

NHINDEX H/W Result for NP:0 (index: 0 (BE)):
  NhIndex is NOT required on this platform

NHINDEX STATS: pkts 0, bytes 0 (all NPs combined, no stats)

RX H/W Result on NP:0 [Adj ptr:0x40 (BE)]:
  Rx-Adj is NOT required on this platform

```

Associated Commands

- `show cef`