IP Unicast Layer 3 Switching

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**Note**

- For complete syntax and usage information for the commands used in this chapter, see these publications:
  

- Cisco IOS Release 15.1SY supports only Ethernet interfaces. Cisco IOS Release 15.1SY does not support any WAN features or commands.

- For information about IP multicast Layer 3 switching, see Chapter 14, “IPv4 Multicast Layer 3 Features.”

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**Tip**

For additional information about Cisco Catalyst 6500 Series Switches (including configuration examples and troubleshooting information), see the documents listed on this page:


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**Prerequisites for Hardware Layer 3 Switching**

None.

**Restrictions for Hardware Layer 3 Switching**

- IPX traffic is fast switched on the route processor (RP)
Information About Layer 3 Switching

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Hardware Layer 3 Switching

Hardware Layer 3 switching allows the PFC and DFCs, instead of the RP, to forward IP unicast traffic between subnets. Hardware Layer 3 switching provides wire-speed forwarding on the PFC and DFCs, instead of in software on the RP. Hardware Layer 3 switching requires minimal support from the RP. The RP routes any traffic that cannot be hardware Layer 3 switched.

Hardware Layer 3 switching supports the routing protocols configured on the RP. Hardware Layer 3 switching does not replace the routing protocols configured on the RP.

Hardware Layer 3 switching runs equally on the PF3 and DFCs to provide IP unicast Layer 3 switching locally on each module. Hardware Layer 3 switching provides the following functions:

- Hardware access control list (ACL) switching for policy-based routing (PBR)
- Hardware flow-based switching for TCP intercept and reflexive ACL forwarding decisions
- Hardware Cisco Express Forwarding (CEF) switching for all other IP unicast traffic

Hardware Layer 3 switching on the PFC supports modules that do not have a DFC. The RP forwards traffic that cannot be Layer 3 switched.

Traffic is hardware Layer 3 switched after being processed by access lists and quality of service (QoS).

Hardware Layer 3 switching makes a forwarding decision locally on the ingress-port module for each packet and sends the rewrite information for each packet to the egress port, where the rewrite occurs when the packet is transmitted from the switch.

Hardware Layer 3 switching generates flow statistics for Layer 3-switched traffic. Hardware Layer 3 flow statistics can be used for NetFlow. (See Chapter 23, “NetFlow Hardware Support”.)

Layer 3-Switched Packet Rewrite

When a packet is Layer 3 switched from a source in one subnet to a destination in another subnet, the switch performs a packet rewrite at the egress port based on information learned from the RP so that the packets appear to have been routed by the RP.

Packet rewrite alters five fields:

- Layer 2 (MAC) destination address
- Layer 2 (MAC) source address
- Layer 3 IP Time to Live (TTL)
Information About Layer 3 Switching

- Layer 3 checksum
- Layer 2 (MAC) checksum (also called the frame checksum or FCS)

**Note**

Packets are rewritten with the encapsulation appropriate for the next-hop subnet.

If Source A and Destination B are in different subnets and Source A sends a packet to the RP to be routed to Destination B, the switch recognizes that the packet was sent to the Layer 2 (MAC) address of the RP. To perform Layer 3 switching, the switch rewrites the Layer 2 frame header, changing the Layer 2 destination address to the Layer 2 address of Destination B and the Layer 2 source address to the Layer 2 address of the RP. The Layer 3 addresses remain the same.

In IP unicast and IP multicast traffic, the switch decrements the Layer 3 TTL value by 1 and recomputes the Layer 3 packet checksum. The switch recomputes the Layer 2 frame checksum and forwards (or, for multicast packets, replicates as necessary) the rewritten packet to Destination B’s subnet.

A received IP unicast packet is formatted (conceptually) as follows:

<table>
<thead>
<tr>
<th>Layer 2 Frame Header</th>
<th>Layer 3 IP Header</th>
<th>Data</th>
<th>FCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td>Source</td>
<td>Destination</td>
<td>Source</td>
</tr>
<tr>
<td><strong>RP MAC</strong></td>
<td><strong>Source A MAC</strong></td>
<td><strong>Destination B IP</strong></td>
<td><strong>Source A IP</strong></td>
</tr>
</tbody>
</table>

After the switch rewrites an IP unicast packet, it is formatted (conceptually) as follows:

<table>
<thead>
<tr>
<th>Layer 2 Frame Header</th>
<th>Layer 3 IP Header</th>
<th>Data</th>
<th>FCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td>Source</td>
<td>Destination</td>
<td>Source</td>
</tr>
<tr>
<td><strong>Destination B MAC</strong></td>
<td><strong>RP MAC</strong></td>
<td><strong>Destination B IP</strong></td>
<td><strong>Source A IP</strong></td>
</tr>
</tbody>
</table>

**Hardware Layer 3 Switching Examples**

*Figure 3-1 on page 3-4* shows a simple network topology. In this example, Host A is on the Sales VLAN (IP subnet 171.59.1.0), Host B is on the Marketing VLAN (IP subnet 171.59.3.0), and Host C is on the Engineering VLAN (IP subnet 171.59.2.0).

When Host A initiates an HTTP file transfer to Host C, Hardware Layer 3 switching uses the information in the local forwarding information base (FIB) and adjacency table to forward packets from Host A to Host C.
Default Settings for Hardware Layer 3 Switching

<table>
<thead>
<tr>
<th>Feature</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware Layer 3 switching enable state</td>
<td>Enabled (cannot be disabled)</td>
</tr>
<tr>
<td>Cisco IOS CEF enable state on RP</td>
<td>Enabled (cannot be disabled)</td>
</tr>
<tr>
<td>Cisco IOS dCEF enable state on RP</td>
<td>Enabled (cannot be disabled)</td>
</tr>
</tbody>
</table>

How to Configure Hardware Layer 3 Switching

For information on configuring unicast routing on the RP, see Chapter 5, “Layer 3 Interfaces.”

Hardware Layer 3 switching is permanently enabled. No configuration is required.

To display information about Layer 3-switched traffic, perform this task:

```
Router# show interface {(type slot/port) | (port-channel number)} | begin L3
```

Displays a summary of Layer 3-switched traffic.
This example shows how to display information about hardware Layer 3-switched traffic on Gigabit Ethernet port 3/3:

```
Router# show interface gigabitethernet 3/3 | begin L3
L3 in Switched: ucast: 0 pkt, 0 bytes - mcast: 12 pkt, 778 bytes  mcast
L3 out Switched: ucast: 0 pkt, 0 bytes - mcast: 0 pkt, 0 bytes
4046399 packets input, 349370039 bytes, 0 no buffer
Received 3795255 broadcasts, 2 runts, 0 giants, 0 throttles
<...output truncated...>
```

```
Router#
```

**Note**
The Layer 3 switching packet count is updated approximately every five seconds.

Cisco IOS CEF and dCEF are permanently enabled. No configuration is required to support hardware Layer 3 switching.

With a PFC (and DFCs, if present), hardware Layer 3 switching uses per-flow load balancing based on IP source and destination addresses. Per-flow load balancing avoids the packet reordering that can be necessary with per-packet load balancing. For any given flow, all PFC- and DFC-equipped switches make exactly the same load-balancing decision, which can result in nonrandom load balancing.

The Cisco IOS CEF `ip load-sharing per-packet`, `ip cef accounting per-prefix`, and `ip cef accounting non-recursive` commands on the RP apply only to traffic that is CEF-switched in software on the RP. The commands do not affect traffic that is hardware Layer 3 switched on the PFC or on DFC-equipped switching modules.

### Displaying Hardware Layer 3 Switching Statistics

Hardware Layer 3 switching statistics are obtained on a per-VLAN basis.

To display hardware Layer 3 switching statistics, perform this task:

```
Command
Router# show interfaces {{type slot/port} | (port-channel number)}
```

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Router# show interfaces {{type slot/port}</td>
<td>(port-channel number)}</td>
</tr>
</tbody>
</table>

This example shows how to display hardware Layer 3 switching statistics:

```
Router# show interfaces gigabitethernet 9/5 | include Switched
L2 Switched: ucast: 8199 pkt, 1362060 bytes - mcast: 6980 pkt, 371952 bytes
L3 in Switched: ucast: 0 pkt, 0 bytes - mcast: 0 pkt, 0 bytes mcast
L3 out Switched: ucast: 0 pkt, 0 bytes - mcast: 0 pkt, 0 bytes mcast
```

To display adjacency table information, perform this task:

```
Command
Router# show adjacency {{{type slot/port} | (port-channel number)} | detail | internal | summary}
```

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Router# show adjacency {{type slot/port}</td>
<td>(port-channel number)}</td>
</tr>
</tbody>
</table>
This example shows how to display adjacency statistics, which are updated approximately every 60 seconds:

```
Router# show adjacency gigabitethernet 9/5 detail
Protocol Interface                 Address
IP       GigabitEthernet9/5        172.20.53.206(11)
         504 packets, 6110 bytes
         00605C865B82
         000164F83FA50800
         ARP 03:49:31
```

Tips

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