# Configuring Multiprotocol Label Switching (MPLS)


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## Multiprotocol Label Switching

This module describes Multiprotocol Label Switching (MPLS) and how to configure it on Cisco switches.

## Restrictions for Multiprotocol Label Switching

- MPLS fragmentation is not supported.
- MPLS maximum transmission unit (MTU) is not supported.
- Cisco Catalyst 9500X Series Switches only supports the per-VRF MPLS label allocation mode for local label allocation. This is also the default mode. However, Cisco Catalyst 9500X Series Switches can interoperate with remote peers operating in the per-prefix mode.

## Information about Multiprotocol Label Switching

MPLS combines the performance and capabilities of Layer 2 (data link layer) switching with the proven scalability of Layer 3 (network layer) routing. MPLS enables you to meet the challenges of explosive growth in network utilization while providing the opportunity to differentiate services without sacrificing the existing network infrastructure. The MPLS architecture is flexible and can be employed in any combination of Layer 2 technologies. MPLS support is offered for all Layer 3 protocols, and scaling is possible well beyond that typically offered in today's networks.

# Functional Description of Multiprotocol Label Switching

Label switching is a high-performance packet forwarding technology that integrates the performance and traffic management capabilities of data link layer (Layer 2) switching with the scalability, flexibility, and performance of network layer (Layer 3) routing.

# Functions of Label Switching

In conventional Layer 3 forwarding mechanisms, as a packet traverses the network, each switch extracts all the information relevant to forwarding the packet from the Layer 3 header. This information is then used as an index for a routing table lookup to determine the next hop for the packet.

In the most common case, the only relevant field in the header is the destination address field, but in some cases, other header fields might also be relevant. As a result, the header analysis must be done independently at each switch through which the packet passes. In addition, a complicated table lookup must also be done at each switch.

In label switching, the analysis of the Layer 3 header is done only once. The Layer 3 header is then mapped into a fixed length, unstructured value called a *label* .

Many different headers can map to the same label, as long as those headers always result in the same choice of next hop. In effect, a label represents a *forwarding equivalence class* --that is, a set of packets which, however different they may be, are indistinguishable by the forwarding function.

The initial choice of a label need not be based exclusively on the contents of the Layer 3 packet header; for example, forwarding decisions at subsequent hops can also be based on routing policy.

After a label is assigned, a short label header is added at the front of the Layer 3 packet. This header is carried across the network as part of the packet. At subsequent hops through each MPLS switch in the network, labels are swapped and forwarding decisions are made by means of MPLS forwarding table lookup for the label carried in the packet header. Hence, the packet header does not need to be reevaluated during packet transit through the network. Because the label is of fixed length and unstructured, the MPLS forwarding table lookup process is both straightforward and fast.

# Distribution of Label Bindings

Each label switching router (LSR) in the network makes an independent, local decision as to which label value to use to represent a forwarding equivalence class. This association is known as a label binding. Each LSR informs its neighbors of the label bindings it has made. This awareness of label bindings by neighboring switches is facilitated by the following protocols:

- Label Distribution Protocol (LDP)--enables peer LSRs in an MPLS network to exchange label binding information for supporting hop-by-hop forwarding in an MPLS network
- Border Gateway Protocol (BGP)--Used to support MPLS virtual private networks (VPNs)

When a labeled packet is being sent from LSR A to the neighboring LSR B, the label value carried by the IP packet is the label value that LSR B assigned to represent the forwarding equivalence class of the packet. Thus, the label value changes as the IP packet traverses the network.

For more information about LDP configuration, see the see MPLS: LDP Configuration Guide at http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mpls/config_library/xe-3s/mp-xe-3s-library.html

**Note** As the scale of label entries is limited in, especially with ECMP, it is recommended to enable LDP label filtering. LDP labels shall be allocated only for well known prefixes like loopback interfaces of routers and any prefix that needs to be reachable in the global routing table.

# MPLS Layer 3 VPN

A MPLS VPN consists of a set of sites that are interconnected by means of an MPLS provider core network. At each customer site, one or more customer edge (CE) routers attach to one or more provider edge (PE) routers.

Before configuring MPLS Layer 3 VPNs, you should have MPLS, LDP, and Cisco Express Forwarding (CEF) installed in your network. All routers in the core, including the PE routers, must be able to support CEF and MPLS forwarding.

# Classifying and Marking MPLS QoS EXP

The QoS EXP Matching feature allows you to organize network traffic by setting values for the MPLS EXP field in MPLS packets. By choosing different values for the MPLS EXP field, you can mark packets so that packets have the priority that they require during periods of congestion. Setting the MPLS EXP value allows you to:

- **Classify traffic:** The classification process selects the traffic to be marked. Classification accomplishes this by partitioning traffic into multiple priority levels, or classes of service. Traffic classification is the primary component of class-based QoS provisioning.
- **Police and mark traffic**: Policing causes traffic that exceeds the configured rate to be discarded or marked to a different drop level. Marking traffic is a way to identify packet flows to differentiate them. Packet marking allows you to partition your network into multiple priority levels or classes of service.

### Restrictions for classifying and marking MPLS QoS EXP

- Only Uniform mode and Pipe mode are supported; Short-pipe mode is not supported.
- Support range of QoS-group values range between 0 and 30. (Total 31 QoS-groups).
- EXP marking using QoS policy is supported only on the outer label; inner EXP marking is not supported.

# LAN MACsec over MPLS

From the Cisco IOS XE Dublin 17.11.1 release, MPLS packets can be encrypted with a MACsec tag. Media Access Control security (MACsec) protocol is a IEEE 802.1AE standard for authenticating and encrypting packets between two MACsec-capable devices. To use MPLS with MACsec both MPLS and MACsec need to be configured on both the devices. When an MPLS packet is forwarded by one device, the MPLS packet is treated as the inner payload and is encrypted with a MACsec tag. This encrypted packet is then securely forwarded to the other device. MACsec encryption safeguards the network against a range of attacks including denial of service, intrusion, man-in-the-middle and eavesdropping. The other device receives the MACsec tagged MPLS packet. It decrypts the MACsec tag and forwards the MPLS packet.

# How to Configure Multiprotocol Label Switching

This section explains how to perform the basic configuration required to prepare a switch for MPLS switching and forwarding.

## Configuring a Switch for MPLS Switching

Before you configure MPLS switching on Cisco switches, ensure that the Cisco Express Forwarding (CEF) is enabled.

**Note** The command **ip unnumbered** is not supported in MPLS configuration.

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Device> enable` | Enables privileged EXEC mode.<br>Enter your password, if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Device# configure terminal` | Enters global configuration mode. |
| **Step 3** | **ip cef distributed**<br>**Example:**<br>`Device(config)# ip cef distributed` | Enables Cisco Express Forwarding on the switch. |
| **Step 4** | **mpls label range** *minimum-value maximum-value*<br>**Example:**<br>`Device(config)# mpls label range 16 4096` | Configure the range of local labels available for use with MPLS applications on packet interfaces. |
| **Step 5** | **mpls label protocol ldp**<br>**Example:**<br>`Device(config)# mpls label protocol ldp` | Specifies the label distribution protocol for the platform. |

# Configuring a Switch for MPLS Forwarding

Before you configure MPLS forwarding on Cisco switches, ensure that the forwarding of IPv4 packets is enabled.

**Note** The command **ip unnumbered** is not supported in MPLS configuration.

### Procedure

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br>**Example:**<br>`Device> enable` | Enables privileged EXEC mode.<br>Enter your password, if prompted. |
| **Step 2** | **configure terminal**<br>**Example:**<br>`Device# configure terminal` | Enters global configuration mode. |
| **Step 3** | **interface** *type slot/subslot /port*<br>**Example:**<br>`Device(config)# interface gigabitethernet 1/0/0` | Specifies the Gigabit Ethernet interface and enters interface configuration mode. For Switch Virtual Interface (SVI), the example is<br>`Device(config)# interface vlan 1000` |
| **Step 4** | **mpls ip**<br>**Example:**<br>`Device(config-if)# mpls ip` | Enables MPLS forwarding of IPv4 packets along routed physical interfaces (Gigabit Ethernet), Switch Virtual Interface (SVI), or port channels. |
| **Step 5** | **mpls label protocol ldp**<br>**Example:**<br>`Device(config-if)# mpls label protocol ldp` | Specifies the label distribution protocol for an interface.<br>**Note**<br>MPLS LDP cannot be enabled on a Virtual Routing and Forwarding (VRF) interface. |
| **Step 6** | **end**<br>**Example:**<br>`Device(config-if)# end` | Exits interface configuration mode and returns to privileged EXEC mode. |

# How to Verify Multiprotocol Label Switching Configuration

This section explains how to verify successful configuration of MPLS switching and forwarding.

## Verifying Configuration of MPLS Switching

To verify whether Cisco Express Forwarding has been configured properly, enter the **show ip cef summary** command, which generates output similar to that shown below:

### Procedure

**show ip cef summary**

**Example:**

```
Device# show ip cef summary

IPv4 CEF is enabled for distributed and running
VRF Default
 150 prefixes (149/1 fwd/non-fwd)
 Table id 0x0
 Database epoch:        4 (150 entries at this epoch)
Device#
```

## Verifying Configuration of MPLS Forwarding

To verify whether MPLS forwarding has been configured properly, enter the **show mpls interfaces detail** command, which generates output similar to that shown below:

**Note** The MPLS MTU value is equivalent to the IP MTU value of the port or switch by default. MTU configuration for MPLS is not supported.

### Procedure

**Step 1** **show mpls interfaces detail**

**Example:**

```
For physical (Gigabit Ethernet) interface:
Device# show mpls interfaces detail interface GigabitEthernet 1/0/0

        Type Unknown
        IP labeling enabled
        LSP Tunnel labeling not enabled
```

```
        IP FRR labeling not enabled
        BGP labeling not enabled
        MPLS not operational
        MTU = 1500

For Switch Virtual Interface (SVI):
Device# show mpls interfaces detail interface Vlan1000

        Type Unknown
        IP labeling enabled (ldp) :
          Interface config
        LSP Tunnel labeling not enabled
        IP FRR labeling not enabled
        BGP labeling not enabled
        MPLS operational
        MTU = 1500
```

**Step 2** **show running-config interface**

**Example:**

```
For physical (Gigabit Ethernet) interface:
Device# show running-config interface interface GigabitEthernet 1/0/0

Building configuration...


Current configuration : 307 bytes
!
interface TenGigabitEthernet1/0/0
no switchport
ip address xx.xx.x.x xxx.xxx.xxx.x
mpls ip
mpls label protocol ldp
end

For Switch Virtual Interface (SVI):
Device# show running-config interface interface Vlan1000

Building configuration...


Current configuration : 187 bytes
!
interface Vlan1000
ip address xx.xx.x.x xxx.xxx.xxx.x
mpls ip
mpls label protocol ldp
end
```

**Step 3** **show mpls forwarding**

**Example:**

```
For physical (Gigabit Ethernet) interface:
Device# show mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
500        No Label   l2ckt(3)         0             Gi3/0/22   point2point
501        No Label   l2ckt(1)         12310411816789 none       point2point
502        No Label   l2ckt(2)         0             none       point2point
503        566        15.15.15.15/32   0             Po5        192.1.1.2
504        530        7.7.7.7/32       538728528     Po5        192.1.1.2
```

```
505        573        6.6.6.10/32      0             Po5        192.1.1.2
506        606        6.6.6.6/32       0             Po5        192.1.1.2
507        explicit-n 1.1.1.1/32       0             Po5        192.1.1.2
556        543        19.10.1.0/24     0             Po5        192.1.1.2
567        568        20.1.1.0/24      0             Po5        192.1.1.2
568        574        21.1.1.0/24      0             Po5        192.1.1.2
574        No Label   213.1.1.0/24[V]  0             aggregate/vpn113
575        No Label   213.1.2.0/24[V]  0             aggregate/vpn114
576        No Label   213.1.3.0/24[V]  0             aggregate/vpn115
577        No Label   213:1:1::/64     0             aggregate
594        502        103.1.1.0/24     0             Po5        192.1.1.2
595        509        31.1.1.0/24      0             Po5        192.1.1.2
596        539        15.15.1.0/24     0             Po5        192.1.1.2
597        550        14.14.1.0/24     0             Po5        192.1.1.2
633        614        2.2.2.0/24       0             Po5        192.1.1.2
634        577        90.90.90.90/32   873684        Po5        192.1.1.2
635        608        154.1.1.0/24     0             Po5        192.1.1.2
636        609        153.1.1.0/24     0             Po5        192.1.1.2
Device# end
```

# Additional References for Multiprotocol Label Switching

**Related Documents**

| Related Topic | Document Title |
|---|---|
| For complete syntax and usage information for the commands used in this chapter. | See the Multiprotocol Label Switching (MPLS) Commands section of the *Command Reference (Catalyst 9500 Series Switches)* |

# Feature History for Multiprotocol Label Switching

This table provides release and related information for features explained in this module.

These features are available on all releases subsequent to the one they were introduced in, unless noted otherwise.

| Release | Feature | Feature Information |
|---|---|---|
| Cisco IOS XE Everest 16.5.1a | Multiprotocol Label Switching | Multiprotocol Label Switching combines the performance and capabilities of Layer 2 (data link layer) switching with the proven scalability of Layer 3 (network layer) routing. |
| Cisco IOS XE Cupertino 17.7.1 | Multiprotocol Label Switching | This feature was implemented on the C9500X-28C8D model. |
| Cisco IOS XE Dublin 17.10.1b | Multiprotocol Label Switching | This feature was implemented on the C9500X-60L4D model. |

Use Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/.