Configuring Multiprotocol Label Switching (MPLS)

Multiprotocol Label Switching

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

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Restrictions for Multiprotocol Label Switching

- Multiprotocol Label Switching (MPLS) fragmentation is not supported.

- MPLS maximum transmission unit (MTU) is not supported.

Information about Multiprotocol Label Switching

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.

Label Switching Functions

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.

Once 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 Multiprotocol Label Switching (MPLS) Virtual Private Network (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, Label Distribution Protocol (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 classify and mark network traffic by modifying the Multiprotocol Label Switching (MPLS) experimental bits (EXP) field in IP packets.

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

Following is the list of 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.

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

MPLS switching on Cisco switches requires that Cisco Express Forwarding be enabled.

✎

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

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef distributed**
4. **mpls label range** *minimum-value maximum-value*
5. **mpls label protocol ldp**

DETAILED STEPS

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

	Command or Action	Purpose
Step 5	**mpls label protocol ldp** **Example:** Device(config)# mpls label protocol ldp	Specifies the label distribution protocol for the platform.

Configuring a Switch for MPLS Forwarding

MPLS forwarding on Cisco switches requires that forwarding of IPv4 packets be enabled.

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

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot*/*subslot* /*port*
4. **mpls ip**
5. **mpls label protocol ldp**
6. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** Device> **enable**	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** Device# configure terminal	Enters global configuration mode.
Step 3	**interface** *type slot*/*subslot* /*port* **Example:** 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 Device(config)# interface vlan 1000
Step 4	**mpls ip** **Example:** Device(config-if)# mpls ip	Enables MPLS forwarding of IPv4 packets along routed physical interfaces (Gigabit Ethernet), Switch Virtual Interface (SVI), or port channels.

	Command or Action	Purpose
Step 5	**mpls label protocol ldp** **Example:** `Device(config-if)# mpls label protocol ldp`	Specifies the label distribution protocol for an interface. **Note** MPLS LDP cannot be enabled on a Virtual Routing and Forwarding (VRF) interface.
Step 6	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Verifying Multiprotocol Label Switching Configuration

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

Verifying Configuration of MPLS Switching

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

SUMMARY STEPS

1. **show ip cef summary**

DETAILED STEPS

show ip cef summary

Example:

```
Switch# 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)
Switch#
```

Verifying Configuration of MPLS Forwarding

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

<img> (Note pencil icon)

| **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. |

SUMMARY STEPS

1. **show mpls interfaces detail**
2. **show running-config interface**
3. **show mpls forwarding**

DETAILED STEPS

Step 1 **show mpls interfaces detail**

Example:

```
For physical (Gigabit Ethernet) interface:
Switch# 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):
Switch# 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:
Switch# 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):
                    Switch# 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:
Switch#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
Switch#
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)*

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for Multiprotocol Label Switching

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

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Table 1: Feature Information for Multiprotocol Label Switching

Release	Modification
Cisco IOS XE Everest 16.5.1a	This feature was introduced.