



Implementing MPLS Forwarding

All Multiprotocol Label Switching (MPLS) features require a core set of MPLS label management and forwarding services; the MPLS Forwarding Infrastructure (MFI) supplies these services.

Feature History for Implementing MPLS-TE

Release	Modification
Release 2.0	This feature was introduced.
Release 3.0	No modification.
Release 3.2	No modification.
Release 3.3.0	No modification.
Release 3.4.0	No modification.
Release 3.5.0	No modification.
Release 3.6.0	No modification.
Release 3.7.0	No modification.
Release 3.8.0	No modification.
Release 3.9.0	The MPLS IP Time-to-Live Propagation feature was added.

- [Prerequisites for Implementing Cisco MPLS Forwarding, page 2](#)
- [Restrictions for Implementing Cisco MPLS Forwarding, page 2](#)
- [Information About Implementing MPLS Forwarding, page 2](#)
- [How to Implement MPLS Forwarding on Cisco IOS XR Software, page 5](#)
- [Additional References, page 7](#)

Prerequisites for Implementing Cisco MPLS Forwarding

These prerequisites are required to implement MPLS 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.
- Router that runs Cisco IOS XR software.
- Installed composite mini-image and the MPLS package, or a full composite image.

Restrictions for Implementing Cisco MPLS Forwarding

- Label switching on a Cisco router requires that Cisco Express Forwarding (CEF) be enabled.
- CEF is mandatory for Cisco IOS XR software and it does not need to be enabled explicitly.

Information About Implementing MPLS Forwarding

To implement MPLS Forwarding, you should understand these concepts:

- [MPLS Forwarding Overview](#), page 2
- [Label Switching Functions](#), page 3
- [Distribution of Label Bindings](#), page 3
- [MFI Control-Plane Services](#), page 4
- [MFI Data-Plane Services](#), page 4
- [Time-to-Live Propagation in Hierarchical MPLS](#), page 4
- [MPLS Maximum Transmission Unit](#), page 4

MPLS Forwarding Overview

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 service providers to meet the challenges of 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.

Based on routing information that is stored in the VRF IP routing table and VRF CEF table, packets are forwarded to their destination using MPLS.

A PE router binds a label to each customer prefix learned from a CE router and includes the label in the network reachability information for the prefix that it advertises to other PE routers. When a PE router forwards a packet received from a CE router across the provider network, it labels the packet with the label learned

from the destination PE router. When the destination PE router receives the labeled packet it pops the label and uses it to direct the packet to the correct CE router. Label forwarding across the provider backbone, is based on either dynamic label switching or traffic engineered paths. A customer data packet carries two levels of labels when traversing the backbone:

- Top label directs the packet to the correct PE router
- Second label indicates how that PE router should forward the packet to the CE router

Related Topics

- [Configuring the Size of the Local Label, page 6](#)

Label Switching Functions

In conventional Layer 3 forwarding mechanisms, as a packet traverses the network, each router 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 router through which the packet passes. In addition, a complicated table lookup must also be done at each router.

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 router 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.



Note

The distribution of label bindings cannot be done statically for the Layer 2 VPN pseudowire.

Each LSR informs its neighbors of the label bindings it has made. This awareness of label bindings by neighboring routers is facilitated by these protocols:

Label Distribution Protocol (LDP) Supports MPLS forwarding along normally routed paths.

Resource Reservation Protocol (RSVP)	Supports MPLS traffic engineering.
Border Gateway Protocol (BGP)	Supports MPLS virtual private networks (VPNs).

When a labeled packet is 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.

MFI Control-Plane Services

The MFI control-plane provides services to MPLS applications, such as Label Distribution Protocol (LDP) and Traffic Engineering (TE), that include enabling and disabling MPLS on an interface, local label allocation, MPLS rewrite setup (including backup links), management of MPLS label tables, and the interaction with other forwarding paths (IP Version 4 [IPv4] for example) to set up imposition and disposition.

MFI Data-Plane Services

The MFI data-plane provides a software implementation of MPLS forwarding in all of these forms:

- Imposition
- Disposition
- Label swapping

Time-to-Live Propagation in Hierarchical MPLS

Cisco IOS XR software provides the flexibility to enable or disable the time-to-live (TTL) propagation for locally generated packets that are independent of packets forwarded from a customer edge (CE) device.

The IP header contains a field of 8 bits that signifies the time that a packet still has before its life ends and is dropped. When an IP packet is sent, its TTL is usually 255 and is then decremented by 1 at each hop. When the TTL field is decremented down to zero, the datagram is discarded. In such a case, the router that dropped the IP packet for which the TTL reached 0 sends an Internet Control Message Protocol (ICMP) message type 11 and code 0 (time exceeded) to the originator of the IP packet.

Related Topics

- [Configuring the Time-to-Live Propagation in Hierarchical MPLS, page 5](#)

MPLS Maximum Transmission Unit

MPLS maximum transmission unit (MTU) indicates that the maximum size of the IP packet can still be sent on a data link, without fragmenting the packet. In addition, data links in MPLS networks have a specific MTU, but for labeled packets. All IPv4 packets have one or more labels. This does imply that the labeled packets are slightly bigger than the IP packets, because for every label, four bytes are added to the packet. So, if n is the number of labels, $n * 4$ bytes are added to the size of the packet when the packet is labeled. The MPLS MTU parameter pertains to labeled packets.

How to Implement MPLS Forwarding on Cisco IOS XR Software

These topics explain how to configure a router for MPLS forwarding.

- [Configuring the Time-to-Live Propagation in Hierarchical MPLS](#), page 5
- [Configuring the Size of the Local Label](#), page 6

Configuring the Time-to-Live Propagation in Hierarchical MPLS

Perform this task to enable or disable the time-to-live (TTL) propagation for locally generated packets that are independent of packets forwarded from a customer edge (CE) device.

SUMMARY STEPS

1. **configure**
2. **mpls ip-ttl-propagate disable [forwarded | local]**
3. Use one of the following commands:
 - **end**
 - **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	configure Example: RP/0/RP0/CPU0:router# configure	Enters global configuration mode.
Step 2	mpls ip-ttl-propagate disable [forwarded local] Example: RP/0/RP0/CPU0:router(config)# mpls ip-ttl-propagate disable forwarded	Stops the propagation of IP TTL to and from the MPLS header. The example shows how to disable IP TTL propagation for forwarded MPLS packets. forwarded Prevents the traceroute command from showing the hops for the forwarded packets. local Prevents the traceroute command from showing the hops only for local packets.
Step 3	Use one of the following commands: <ul style="list-style-type: none"> • end • commit 	Saves configuration changes. <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:

	Command or Action	Purpose
	<p>Example: RP/0/RP0/CPU0:router(config)# end or RP/0/RP0/CPU0:router(config)# commit</p>	<ul style="list-style-type: none"> ◦ Entering yes saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. ◦ Entering no exits the configuration session and returns the router to EXEC mode without committing the configuration changes. ◦ Entering cancel leaves the router in the current configuration session without exiting or committing the configuration changes. <ul style="list-style-type: none"> • Use the commit command to save the configuration changes to the running configuration file and remain within the configuration session.

Related Topics

- [Time-to-Live Propagation in Hierarchical MPLS, page 4](#)

Configuring the Size of the Local Label

Perform this task to configure the dynamic range of local labels that are available on packet interfaces.

SUMMARY STEPS

1. **configure**
2. **mpls label range table** *table-id* {*minimum maximum*}
3. Use one of the following commands:
 - **end**
 - **commit**
4. **show mpls label range**

DETAILED STEPS

	Command or Action	Purpose
Step 1	<p>configure</p> <p>Example: RP/0/RP0/CPU0:router#configure</p>	<p>Enters global configuration mode.</p>

	Command or Action	Purpose
Step 2	<p>mpls label range table <i>table-id</i> {<i>minimum</i> <i>maximum</i>}</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config)#mpls label range 16200 120000</pre>	Configures the size of the local label space. The example shows how to configure the size of the local label space using a minimum of 16200 and a maximum of 120000.
Step 3	<p>Use one of the following commands:</p> <ul style="list-style-type: none"> • end • commit <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config)# end OR RP/0/RP0/CPU0:router(config)# commit</pre>	<p>Saves configuration changes.</p> <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: <pre>Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:</pre> <ul style="list-style-type: none"> ◦ Entering yes saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. ◦ Entering no exits the configuration session and returns the router to EXEC mode without committing the configuration changes. ◦ Entering cancel leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the commit command to save the configuration changes to the running configuration file and remain within the configuration session.
Step 4	<p>show mpls label range</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router# show mpls label range</pre>	Displays the range of local labels available for use on packet interfaces.

Related Topics

- [MPLS Forwarding Overview, page 2](#)

Additional References

For additional information related to implementing MPLS Forwarding, refer to the following references:

Related Documents

Related Topic	Document Title
MPLS Forwarding commands	<i>MPLS Forwarding Commands on Cisco IOS XR Software</i> module in <i>Cisco IOS XR MPLS Command Reference for the Cisco CRS-1 Router</i>

Related Topic	Document Title
Getting started material	<i>Cisco IOS XR Getting Started Guide for the Cisco CRS-1 Router</i>
Information about user groups and task IDs	<i>Configuring AAA Services on Cisco IOS XR Software module of Cisco IOS XR System Security Configuration Guide for the Cisco CRS-1 Router</i>

Standards

Standards	Title
Technical Assistance Center (TAC) home page, containing 30,000 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.	—

MIBs

MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at the following URL and choose a platform under the Cisco Access Products menu: http://cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml

RFCs

RFCs	Title
RFC 3031	<i>Multiprotocol Label Switching Architecture</i>
RFC 3443	<i>Time to Live (TTL) Processing in Multi-Protocol Label Switching (MPLS) Networks</i>
RFC 4105	<i>Requirements for Inter-Area MPLS Traffic Engineering</i>