



MPLS Label Distribution Protocol (LDP)

First Published: January 1, 1999

Last Updated: May 4, 2009

MPLS Label Distribution Protocol (LDP) enables peer label switch routers (LSRs) in an Multiprotocol Label Switching (MPLS) network to exchange label binding information for supporting hop-by-hop forwarding in an MPLS network. This module explains the concepts related to MPLS LDP and describes how to configure MPLS LDP in a network.

Finding Feature Information

For the latest feature information and caveats, see 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 for MPLS Label Distribution Protocol”](#) section on page 25.

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

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Prerequisites for MPLS Label Distribution Protocol

Label switching on a router requires that Cisco Express Forwarding (CEF) be enabled on that router.

Information About MPLS Label Distribution Protocol

To configure MPLS LDP, you should understand the following concepts:

- [Introduction to MPLS Label Distribution Protocol, page 2](#)
- [MPLS Label Distribution Protocol Functional Overview, page 2](#)
- [Introduction to LDP Sessions, page 2](#)
- [Introduction to LDP Label Bindings, Label Spaces, and LDP Identifiers, page 4](#)

Introduction to MPLS Label Distribution Protocol

MPLS LDP provides the means for LSRs to request, distribute, and release label prefix binding information to peer routers in a network. LDP enables LSRs to discover potential peers and to establish LDP sessions with those peers for the purpose of exchanging label binding information.

MPLS LDP enables one LSR to inform another LSR of the label bindings it has made. Once a pair of routers communicate the LDP parameters, they establish a label switched path (LSP). MPLS LDP enables LSRs to distribute labels along normally routed paths to support MPLS forwarding. This method of label distribution is also called hop-by-hop forwarding. With IP forwarding, when a packet arrives at a router the router looks at the destination address in the IP header, performs a route lookup, and forwards the packet to the next hop. With MPLS forwarding, when a packet arrives at a router the router looks at the incoming label, looks up the label in a table, and then forwards the packet to the next hop. MPLS LDP is useful for applications that require hop-by-hop forwarding, such as MPLS VPNs.

MPLS Label Distribution Protocol Functional Overview

Cisco MPLS LDP provides the building blocks for MPLS-enabled applications, such as MPLS Virtual Private Networks (VPNs).

LDP provides a standard methodology for hop-by-hop, or dynamic label, distribution in an MPLS network by assigning labels to routes that have been chosen by the underlying Interior Gateway Protocol (IGP) routing protocols. The resulting labeled paths, called label switch paths (LSPs), forward label traffic across an MPLS backbone to particular destinations. These capabilities enable service providers to implement MPLS-based IP VPNs and IP+ATM services across multivendor MPLS networks.

Introduction to LDP Sessions

When you enable MPLS LDP, the LSRs send out messages to try to find other LSRs with which they can create LDP sessions. The following sections explain the differences between directly connected LDP sessions and nondirectly connected LDP sessions.

Directly Connected MPLS LDP Sessions

If an LSR is one hop from its neighbor, it is directly connected to its neighbor. The LSR sends out LDP link Hello messages as User Datagram Protocol (UDP) packets to all the routers on the subnet (multicast). A neighboring LSR may respond to the link Hello message, allowing the two routers to establish an LDP session. This is called basic discovery.

To initiate an LDP session between routers, the routers determine which router will take the active role and which router will take the passive role. The router that takes the active role establishes the LDP TCP connection session and initiates the negotiation of the LDP session parameters. To determine the roles, the two routers compare their transport addresses. The router with the higher IP address takes the active role and establishes the session.

After the LDP TCP connection session is established, the LSRs negotiate the session parameters, including the method of label distribution to be used. Two methods are available:

- Downstream Unsolicited: An LSR advertises label mappings to peers without being asked to.
- Downstream on Demand: An LSR advertises label mappings to a peer only when the peer asks for them.

For information about creating LDP sessions, see the [“Enabling Directly Connected LDP Sessions” section on page 5](#).

Nondirectly Connected MPLS LDP Sessions

If the LSR is more than one hop from its neighbor, it is nondirectly connected to its neighbor. For these nondirectly connected neighbors, the LSR sends out a targeted Hello message as a UDP packet, but as a unicast message specifically addressed to that LSR. The nondirectly connected LSR responds to the Hello message and the two routers begin to establish an LDP session. This is called extended discovery.

An MPLS LDP targeted session is a label distribution session between routers that are not directly connected. When you create an MPLS traffic engineering tunnel interface, you need to establish a label distribution session between the tunnel headend and the tailend routers. You establish nondirectly connected MPLS LDP sessions by enabling the transmission of targeted Hello messages.

You can use the **mpls ldp neighbor targeted** command to set up a targeted session when other means of establishing targeted sessions do not apply, such as configuring **mpls ip** on a traffic engineering (TE) tunnel or configuring Any Transport over MPLS (AToM) virtual circuits (VCs). For example, you can use this command to create a targeted session between directly connected MPLS label switch routers (LSRs) when MPLS label forwarding convergence time is an issue.

The **mpls ldp neighbor targeted** command can improve label convergence time for directly connected neighbor LSRs when the links directly connecting them are down. When the links between the neighbor LSRs are up, both the link and targeted Hellos maintain the LDP session. If the links between the neighbor LSRs go down, and there is an alternate route between neighbors, the targeted Hellos would maintain the session, allowing the LSRs to retain labels learned from each other. When a link directly connecting the LSRs comes back up, the LSRs can immediately reinstall labels for forwarding use without having to reestablish their LDP session and exchange labels.

The exchange of targeted Hello messages between two nondirectly connected neighbors can occur in several ways, including the following:

- Router 1 sends targeted Hello messages carrying a response request to Router 2. Router 2 sends targeted Hello messages in response if its configuration permits. In this situation, Router 1 is considered to be *active* and Router 2 is considered to be *passive*.
- Router 1 and Router 2 both send targeted Hello messages to each other. Both routers are considered to be *active*. Both, one, or neither router can also be *passive*, if they have been configured to respond to requests for targeted Hello messages from each other.

The default behavior of an LSR is to ignore requests from other LSRs that send targeted Hello messages. You can configure an LSR to respond to requests for targeted Hello messages by issuing the **mpls ldp discovery targeted-hello accept** command.

The active LSR mandates the protocol that is used for a targeted session. The passive LSR uses the protocol of the received targeted Hello messages.

For information about creating MPLS LDP targeted sessions, see the [“Establishing Nondirectly Connected MPLS LDP Sessions” section on page 8](#).

Introduction to LDP Label Bindings, Label Spaces, and LDP Identifiers

An LDP label binding is an association between a destination prefix and a label. The label used in a label binding is allocated from a set of possible labels called a label space.

LDP supports two types of label spaces:

- **Interface-specific**—An interface-specific label space uses interface resources for labels. For example, label-controlled ATM (LC-ATM) interfaces use virtual path identifiers/virtual circuit identifiers (VPIs/VCI) for labels. Depending on its configuration, an LDP platform may support zero, one, or more interface-specific label spaces.
- **Platform-wide**—An LDP platform supports a single platform-wide label space for use by interfaces that can share the same labels. For Cisco platforms, all interface types, except LC-ATM, use the platform-wide label space.

LDP uses a 6-byte quantity called an LDP Identifier (or LDP ID) to name label spaces. The LDP ID is made up of the following components:

- The first four bytes, called the LDP router ID, identify the LSR that owns the label space.
- The last two bytes, called the local label space ID, identify the label space within the LSR. For the platform-wide label space, the last two bytes of the LDP ID are always both 0.

The LDP ID takes the following form:

<LDP router ID> : <local label space ID>

The following are examples of LDP IDs:

- 172.16.0.0:0
- 192.168.0.0:3

The router determines the LDP router ID as follows, if the **mpls ldp router-id** command is not executed,

1. The router examines the IP addresses of all operational interfaces.
2. If these IP addresses include loopback interface addresses, the router selects the largest loopback address as the LDP router ID.

3. Otherwise, the router selects the largest IP address pertaining to an operational interface as the LDP router ID.

The normal (default) method for determining the LDP router ID may result in a router ID that is not usable in certain situations. For example, the router might select an IP address as the LDP router ID that the routing protocol cannot advertise to a neighboring router. The **mpls ldp router-id** command allows you to specify the IP address of an interface as the LDP router ID. Make sure the specified interface is operational so that its IP address can be used as the LDP router ID.

When you issue the **mpls ldp router-id** command without the **force** keyword, the router selects the IP address of the specified interface (provided that the interface is operational) the next time it is necessary to select an LDP router ID, which is typically the next time the interface is shut down or the address is configured.

When you issue the **mpls ldp router-id** command with the **force** keyword, the effect of the **mpls ldp router-id** command depends on the current state of the specified interface:

- If the interface is up (operational) and if its IP address is not currently the LDP router ID, the LDP router ID changes to the IP address of the interface. This forced change in the LDP router ID tears down any existing LDP sessions, releases label bindings learned via the LDP sessions, and interrupts MPLS forwarding activity associated with the bindings.
- If the interface is down (not operational) when the **mpls ldp router-id force** command is issued, when the interface transitions to up, the LDP router ID changes to the IP address of the interface. This forced change in the LDP router ID tears down any existing LDP sessions, releases label bindings learned via the LDP sessions, and interrupts MPLS forwarding activity associated with the bindings.

How to Configure MPLS Label Distribution Protocol

This section contains the following procedures:

- [Enabling Directly Connected LDP Sessions, page 5](#) (required)
- [Establishing Nondirectly Connected MPLS LDP Sessions, page 8](#) (optional)
- [Specifying the LDP Router ID, page 10](#) (optional)
- [Preserving QoS Settings with MPLS LDP Explicit Null, page 12](#) (optional)
- [Protecting Data Between LDP Peers with MD5 Authentication, page 16](#) (optional)

Enabling Directly Connected LDP Sessions

This procedure explains how to configure MPLS LDP sessions between two directly connected routers.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls ip**
4. **mpls label protocol ldp**
5. **interface** *type slot/subslot/port[.subinterface-number]*
6. **mpls ip**

7. **exit**
8. **exit**
9. **show mpls interfaces** [*interface*] [**detail**]
10. **show mpls ldp discovery** [**all** | **vrf** *vpn-name*] [**detail**]
11. **show mpls ldp neighbor** [[**vrf** *vpn-name*] [*address* | *interface*] [**detail**] | **all**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	mpls ip Example: Router(config)# mpls ip	Configures MPLS hop-by-hop forwarding globally. <ul style="list-style-type: none"> The mpls ip command is enabled by default; you do not have to specify this command. Globally enabling MPLS forwarding does not enable it on the router interfaces. You must enable MPLS forwarding on the interfaces as well as for the router.
Step 4	mpls label protocol ldp Example: Router(config)# mpls label protocol ldp	Configures the use of LDP on all interfaces.
Step 5	Router(config)# interface <i>type</i> <i>slot/subslot/port</i> [. <i>subinterface-number</i>] Example: Router(config)# interface fastethernet03/0	Specifies the interface to be configured and enters interface configuration mode.
Step 6	mpls ip Example: Router(config-if)# mpls ip	Configures MPLS hop-by-hop forwarding on the interface. <ul style="list-style-type: none"> You must enable MPLS forwarding on the interfaces as well as for the router.
Step 7	exit Example: Router(config-if)# exit	Exits interface configuration mode and enters global configuration mode.
Step 8	exit Example: Router(config)# exit	Exits global configuration mode and enters privileged EXEC mode.

	Command or Action	Purpose
Step 9	<code>show mpls interfaces [interface] [detail]</code> Example: Router# show mpls interfaces	Verifies that the interfaces have been configured to use LDP.
Step 10	<code>show mpls ldp discovery [all vrf vpn-name] [detail]</code> Example: Router# show mpls ldp discovery	Verifies that the interface is up and is sending Discovery Hello messages.
Step 11	<code>show mpls ldp neighbor [[vrf vpn-name] [address interface] [detail] all]</code> Example: Router# show mpls ldp neighbor	Displays the status of LDP sessions.

Examples

The following **show mpls interfaces** command verifies that interfaces FastEthernet 0/3/0 and 0/3/1 have been configured to use LDP:

```
Router# show mpls interfaces
```

```
Interface                IP           Tunnel  BGP Static Operational
FastEthernet0/3/0        Yes (ldp)   No      No  No      Yes
FastEthernet0/3/1        Yes         No      No  No      Yes
```

The following **show mpls ldp discovery** command verifies that the interface is up and is sending LDP Discovery Hello messages (as opposed to TDP Hello messages):

```
Router# show mpls ldp discovery
```

```
Local LDP Identifier:
 172.16.12.1:0
Discovery Sources:
Interfaces:
  FastEthernet0/3/0 (ldp): xmit
```

The following example shows that the LDP session between routers was successfully established:

```
Router# show mpls ldp neighbor
```

```
Peer LDP Ident: 10.1.1.2:0; Local LDP Ident 10.1.1.1:0
TCP connection: 10.1.1.2.18 - 10.1.1.1.66
State: Oper; Msgs sent/rcvd: 12/11; Downstream
Up time: 00:00:10
LDP discovery sources:
FastEthernet0/1/0, Src IP addr: 10.20.10.2
Addresses bound to peer LDP Ident:
10.1.1.2 10.20.20.1 10.20.10.2
```

For examples on configuring directly connected LDP sessions, see the [“Configuring Directly Connected MPLS LDP Sessions: Example”](#) section on page 19.

Establishing Nondirectly Connected MPLS LDP Sessions

This section explains how to configure nondirectly connected MPLS LDP sessions, which enable you to establish an LDP session between routers that are not directly connected.

Prerequisites

- MPLS requires Cisco Express Forwarding.
- You must configure the routers at both ends of the tunnel to be active or enable one router to be passive with the **mpls ldp discovery targeted-hello accept** command.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls ip**
4. **mpls label protocol ldp**
5. **interface tunnel *number***
6. **tunnel destination *ip-address***
7. **mpls ip**
8. **exit**
9. **exit**
10. **show mpls ldp discovery [all | vrf *vpn-name*] [detail]**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	mpls ip Example: Router(config)# mpls ip	Configures MPLS hop-by-hop forwarding globally. <ul style="list-style-type: none"> • The mpls ip command is enabled by default; you do not have to specify this command. • Globally enabling MPLS forwarding does not enable it on the router interfaces. You must enable MPLS forwarding on the interfaces as well as for the router.

	Command or Action	Purpose
Step 4	mpls label protocol ldp Example: Router(config)# mpls label protocol ldp	Configures the use of LDP on all interfaces.
Step 5	interface tunnel number Example: Router(config)# interface tunnell	Configures a tunnel interface and enters interface configuration mode.
Step 6	tunnel destination ip-address Example: Router(config-if)# tunnel destination 172.16.1.1	Assigns an IP address to the tunnel interface.
Step 7	mpls ip Example: Router(config-if)# mpls ip	Configures MPLS hop-by-hop forwarding on the interface. <ul style="list-style-type: none"> You must enable MPLS forwarding on the interfaces as well as for the router.
Step 8	exit Example: Router(config-if)# exit	Exits interface configuration mode and enters global configuration mode.
Step 9	exit Example: Router(config)# exit	Exits global configuration mode and enters privileged EXEC mode.
Step 10	show mpls ldp discovery [all vrf vpn-name] [detail] Example: Router# show mpls ldp discovery	Verifies that the interface is up and is sending Discovery Hello messages.

Examples

The following example shows the output of the **show mpls ldp discovery** command for a nondirectly connected LDP session:

```
Router# show mpls ldp discovery

Local LDP Identifier:
    172.16.0.0:0
Discovery Sources:
Interfaces:
    POS1/2/0 (ldp): xmit/recv
        LDP Id: 172.31.255.255:0
    Tunnell (ldp): Targeted -> 192.168.255.255
Targeted Hellos:
    172.16.0.0 -> 192.168.255.255 (ldp): active, xmit/recv
        LDP Id: 192.168.255.255:0
    172.16.0.0 -> 192.168.0.0 (ldp): passive, xmit/recv
        LDP Id: 192.168.0.0:0
```

This command output indicates that:

- The local LSR (172.16.0.0) sent LDP link Hello messages on interface POS1/2/0 and discovered neighbor 172.31.255.255.
- The local LSR sent LDP targeted Hello messages associated with interface Tunnel1 to target 192.168.255.255. The LSR was configured to use LDP.
- The local LSR is active for targeted discovery activity with 192.168.255.255; this means that the targeted Hello messages it sends to 192.168.255.255 carry a response request. The local LSR was configured to have an LDP session with the nondirectly connected LSR 192.168.255.255.
- The local LSR is not passive from the discovery activity with 192.168.255.255 for one of the following reasons:
 - The targeted Hello messages it receives from 192.168.255.255 do not carry a response request.
 - The local LSR has not been configured to respond to such requests.
- The local LSR sent TDP directed Hello messages to the target LSR 192.168.0.0. This LSR uses TDP because the Hello messages received from the target LSR 192.168.0.0 were TDP directed Hello messages.
- The local LSR is passive in discovery activity with LSR 192.168.0.0. This means that the directed Hello messages it receives from LSR 192.168.0.0 carry a response request and that the local LSR has been configured with the **mpls ldp discovery targeted-hello accept** command to respond to such requests from LSR 192.168.0.0.
- The local LSR is not active in discovery activity with LSR 192.168.0.0, because no application that requires an LDP session with LSR 192.168.0.0 has been configured on the local LSR.

For examples of configuring LDP targeted sessions, see the [“Establishing Nondirectly Connected MPLS LDP Sessions: Example”](#) section on page 20.

Specifying the LDP Router ID

The **mpls ldp router-id** command allows you to establish the IP address of an interface as the LDP router ID.

The following steps describe the normal process for determining the LDP router ID:

1. The router considers all the IP addresses of all operational interfaces.
2. If these addresses include loopback interface addresses, the router selects the largest loopback address. Configuring a loopback address helps ensure a stable LDP ID for the router, because the state of loopback addresses does not change. However, configuring a loopback interface and IP address on each router is not required.

The loopback IP address does not become the router ID of the local LDP ID under the following circumstances:

- If the loopback interface has been explicitly shut down.
- If the **mpls ldp router-id** command specifies that a different interface should be used as the LDP router ID.

If you use a loopback interface, make sure that the IP address for the loopback interface is configured with a /32 network mask. In addition, make sure that the routing protocol in use is configured to advertise the corresponding /32 network.

3. Otherwise, the router selects the largest interface address.

The router might select a router ID that is not usable in certain situations. For example, the router might select an IP address that the routing protocol cannot advertise to a neighboring router.

The router implements the router ID the next time it is necessary to select an LDP router ID. The effect of the command is delayed until the next time it is necessary to select an LDP router ID, which is typically the next time the interface is shut down or the address is deconfigured.

If you use the **force** keyword with the **mpls ldp router-id** command, the router ID takes effect more quickly. However, implementing the router ID depends on the current state of the specified interface:

- If the interface is up (operational) and its IP address is not currently the LDP router ID, the LDP router ID is forcibly changed to the IP address of the interface. This forced change in the LDP router ID tears down any existing LDP sessions, releases label bindings learned via the LDP sessions, and interrupts MPLS forwarding activity associated with the bindings.
- If the interface is down, the LDP router ID is forcibly changed to the IP address of the interface when the interface transitions to up. This forced change in the LDP router ID tears down any existing LDP sessions, releases label bindings learned via the LDP sessions, and interrupts MPLS forwarding activity associated with the bindings.

Prerequisites

Make sure the specified interface is operational before assigning it as the LDP router ID.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls ip**
4. **mpls label protocol {ldp | tdp | both}**
5. **mpls ldp router-id *interface* [force]**
6. **exit**
7. **show mpls ldp discovery [all | detail | vrf *vpn-name*]**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
Step 3	mpls ip Example: Router(config)# mpls ip	Configures MPLS hop-by-hop forwarding globally. <ul style="list-style-type: none"> The mpls ip command is enabled by default; you do not have to specify this command. Globally enabling MPLS forwarding does not enable it on the router interfaces. You must enable MPLS forwarding on the interfaces as well as for the router.
Step 4	mpls label protocol ldp Example: Router(config)# mpls label protocol ldp	Configures the use of LDP on all interfaces. configuration mode.
Step 5	mpls ldp router-id interface [force] Example: Router(config)# mpls ldp router-id pos2/0/0	Specifies the preferred interface for determining the LDP router ID.
Step 6	exit Example: Router(config)# exit	Exits global configuration mode and enters privileged EXEC mode.
Step 7	show mpls ldp discovery [all detail vrf vpn-name] Example: Router# show mpls ldp discovery	Displays the LDP identifier for the local router.

Example

The following example assigns interface pos2/0/0 as the LDP router ID:

```
Router> enable
Router# configure terminal
Router(config)# mpls ip
Router(config)# mpls label protocol ldp
Router(config)# mpls ldp router-id pos2/0/0 force
```

The following example displays the LDP router ID (10.15.15.15):

```
Router# show mpls ldp discovery

Local LDP Identifier:
 10.15.15.15:0
Discovery Sources:
 Interfaces:
   FastEthernet0/3/0 (ldp): xmit/recv
     LDP Id: 10.14.14.14:0
```

Preserving QoS Settings with MPLS LDP Explicit Null

Normally, LDP advertises an Implicit Null label for directly connected routes. The Implicit Null label causes the second last (penultimate) label switched router (LSR) to remove the MPLS header from the packet. In this case, the penultimate LSR and the last LSR do not have access to the quality of service

(QoS) values that the packet carried before the MPLS header was removed. To preserve the QoS values, you can configure the LSR to advertise an explicit NULL label (a label value of zero). The LSR at the penultimate hop forwards MPLS packets with a NULL label instead of forwarding IP packets.

**Note**

An explicit NULL label is not needed when the penultimate hop receives MPLS packets with a label stack that contains at least two labels and penultimate hop popping is performed. In that case, the inner label can still carry the QoS value needed by the penultimate and edge LSR to implement their QoS policy.

When you issue the **mpls ldp explicit-null** command, Explicit Null is advertised in place of Implicit Null for directly connected prefixes.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls ip**
4. **mpls label protocol ldp**
5. **interface** *type slot/subslot/port[.subinterface-number]*
6. **mpls ip**
7. **exit**
8. **mpls ldp explicit-null** [**for** *prefix-acl* | **to** *peer-acl* | **for** *prefix-acl to peer-acl*]
9. **exit**
10. **show mpls forwarding-table** [*network {mask | length}* | **labels** *label* [- *label*] | **interface** *interface* | *next-hop address* | **lsp-tunnel** [*tunnel-id*]] [**vrf** *vpn-name*] [**detail**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	mpls ip Example: Router(config)# mpls ip	Configures MPLS hop-by-hop forwarding globally. <ul style="list-style-type: none"> • The mpls ip command is enabled by default; you do not have to specify this command. • Globally enabling MPLS forwarding does not enable it on the router interfaces. You must enable MPLS forwarding on the interfaces as well as for the router.

	Command or Action	Purpose
Step 4	mpls label protocol ldp Example: Router(config)# mpls label protocol ldp	Configures the use of LDP on all interfaces.
Step 5	interface type <i>slot/subslot/port[.subinterface-number]</i> Example: Router(config)# interface atm2/2/0	Specifies the interface to be configured and enters interface configuration mode.
Step 6	mpls ip Example: Router(config-if)# mpls ip	Configures MPLS hop-by-hop forwarding on the interface. <ul style="list-style-type: none"> You must enable MPLS forwarding on the interfaces as well as for the router.
Step 7	exit Example: Router(config-if)# exit	Exits interface configuration mode and enters global configuration mode.
Step 8	mpls ldp explicit-null [<i>for prefix-acl</i> to peer-acl <i>for prefix-acl to peer-acl</i>] Example: Router(config)# mpls ldp explicit-null	Advertises an Explicit Null label in situations where it would normally advertise an Implicit Null label.
Step 9	exit Example: Router(config)# exit	Exits global configuration mode and enter privileged EXEC mode.
Step 10	show mpls forwarding-table [<i>network {mask length}</i>] labels label [- <i>label</i>] interface interface <i>next-hop address</i> lsp-tunnel [<i>tunnel-id</i>] [vrf vpn-name] [detail] Example: Router# show mpls forwarding-table	Verifies that MPLS packets are forwarded with an explicit-null label (value of 0).

Examples

Enabling explicit-null on an egress LSR causes that LSR to advertise the explicit-null label to all adjacent MPLS routers.

```
Router# configure terminal
Router(config)# mpls ldp explicit-null
```

If you issue the **show mpls forwarding-table** command on an adjacent router, the output shows that MPLS packets are forwarded with an explicit-null label (value of 0). In the following example, the second column shows that entries have outgoing labels of 0, where once they were marked “Pop label”.

```
Router# show mpls forwarding-table
```

```
Local   Outgoing   Prefix           Bytes label  Outgoing   Next Hop
label  label or VC or Tunnel Id   switched      interface
```

```

19   Pop tag      10.12.12.12/32  0           Fa2/1/0      172.16.0.1
22   0            10.14.14.14/32  0           Fa2/0/0      192.168.0.2
23   0            172.24.24.24/32 0           Fa2/0/0      192.168.0.2
24   0            192.168.0.0/8   0           Fa2/0/0      192.168.0.2
25   0            10.15.15.15/32  0           Fa2/0/0      192.168.0.2
26   0            172.16.0.0/8    0           Fa2/0/0      192.168.0.2
27   25           10.16.16.16/32  0           Fa2/0/0      192.168.0.22
28   0            10.34.34.34/32  0           Fa2/0/0      192.168.0.2

```

Enabling explicit-null and specifying the **for** keyword with a standard access control list (ACL) changes all adjacent MPLS routers' tables to swap an explicit-null label for only those entries specified in the access-list. In the following example, an access-list is created that contains the 10.24.24.24/32 entry. Explicit null is configured and the access list is specified.

```

Router# configure terminal
Router(config)# mpls label protocol ldp
Router(config)# access-list 24 permit host 10.24.24.24
Router(config)# mpls ldp explicit-null for 24

```

If you issue the **show mpls forwarding-table** command on an adjacent router, the output shows that the only the outgoing labels for the addresses specified (172.24.24.24/32) change from Pop label to 0. All other Pop label outgoing labels remain the same.

```

Router# show mpls forwarding-table

```

Local label	Outgoing label or VC	Prefix or Tunnel Id	Bytes switched	label	Outgoing interface	Next Hop
19	Pop tag	10.12.12.12/32	0		Fa2/1/0	172.16.0.1
22	0	10.14.14.14/32	0		Fa2/0/0	192.168.0.2
23	0	172.24.24.24/32	0		Fa2/0/0	192.168.0.2
24	0	192.168.0.0/8	0		Fa2/0/0	192.168.0.2
25	0	10.15.15.15/32	0		Fa2/0/0	192.168.0.2
26	0	172.16.0.0/8	0		Fa2/0/0	192.168.0.2
27	25	10.16.16.16/32	0		Fa2/0/0	192.168.0.22
28	0	10.34.34.34/32	0		Fa2/0/0	192.168.0.2

Enabling explicit null and adding the **to** keyword and an access list enables you to advertise explicit-null labels to only those adjacent routers specified in the access-list. To advertise explicit-null to a particular router, you must specify the router's LDP ID in the access-list.

In the following example, an access-list contains the 10.15.15.15/32 entry, which is the LDP ID of an adjacent MPLS router. The router that is configured with explicit null advertises explicit-null labels only to that adjacent router.

```

Router# show mpls ldp discovery

Local LDP Identifier:
  10.15.15.15:0
Discovery Sources:
  Interfaces:
    FastEthernet2/0/0(ldp): xmit/recv
      TDP Id: 10.14.14.14:0

```

```

Router# configure terminal
Router(config)# mpls label protocol ldp
Router(config)# access-list 15 permit host 10.15.15.15
Router(config)# mpls ldp explicit-null to 15

```

If you issue the **show mpls forwarding-table** command, the output shows that explicit null labels are going only to the router specified in the access list.

```

Router# show mpls forwarding-table

```

Local label	Outgoing label or VC	Prefix or Tunnel Id	Bytes switched	label	Outgoing interface	Next Hop
19	Pop tag	10.12.12.12/32	0		Fa2/1/0	172.16.0.1
22	0	10.14.14.14/32	0		Fa2/0/0	192.168.0.2
23	0	172.24.24.24/32	0		Fa2/0/0	192.168.0.2
24	0	192.168.0.0/8	0		Fa2/0/0	192.168.0.2
25	0	10.15.15.15/32	0		Fa2/0/0	192.168.0.2
26	0	172.16.0.0/8	0		Fa2/0/0	192.168.0.2
27	25	10.16.16.16/32	0		Fa2/0/0	192.168.0.22
28	0	10.34.34.34/32	0		Fa2/0/0	192.168.0.2

Enabling explicit-null with both the **for** and **to** keywords enables you to specify which routes to advertise with explicit-null labels and to which adjacent routers to advertise these explicit-null labels.

```
Router# show access 15
```

```
Standard IP access list 15
  permit 10.15.15.15 (7 matches)
```

```
Router# show access 24
```

```
Standard IP access list 24
  permit 10.24.24.24 (11 matches)
```

```
Router# configure terminal
```

```
Router(config)# mpls label protocol ldp
Router(config)# mpls ldp explicit-null for 24 to 15
```

If you issue the **show mpls forwarding-table** command, the output shows that it receives explicit null labels for 10.24.24.24/32.

```
Router# show mpls forwarding-table
```

Local label	Outgoing label or VC	Prefix or Tunnel Id	Bytes switched	label	Outgoing interface	Next Hop
17	0 <---	10.24.24.24/32	0		Fe2/0/0	172.16.0.1
20	Pop tag	172.16.0.0/8	0		Fe2/0/0	172.16.0.1
21	20	10.12.12.12/32	0		Fe2/0/0	172.16.0.1
22	16	10.0.0.0/8	0		Fe2/0/0	172.16.0.1
23	21	10.13.13.13/32	0		Fe2/0/0	172.16.0.1
25	Pop tag	10.14.14.14/32	0		Fe2/0/0	172.16.0.1
27	Pop tag	192.168.0.0/8	0		Fe2/0/0	172.16.0.1
28	25	10.16.16.16/32	0		Fe2/0/0	172.16.0.1
29	Pop tag	192.168.34.34/32	0		Fe2/0/0	172.16.0.1

Protecting Data Between LDP Peers with MD5 Authentication

You can enable authentication between two LDP peers, which verifies each segment sent on the TCP connection between the peers. You must configure authentication on both LDP peers using the same password; otherwise, the peer session is not established.

Authentication uses the Message Digest 5 (MD5) algorithm to verify the integrity of the communication and authenticate the origin of the message.

To enable authentication, issue the **mpls ldp neighbor** command with the **password** keyword. This causes the router to generate an MD5 digest for every segment sent on the TCP connection and check the MD5 digest for every segment received from the TCP connection.

When you configure a password for an LDP neighbor, the router tears down existing LDP sessions and establishes new sessions with the neighbor.

If a router has a password configured for a neighbor, but the neighboring router does not have a password configured, a message such as the following appears on the console who has a password configured while the two routers attempt to establish an LDP session. The LDP session is not established.

```
%TCP-6-BADAUTH: No MD5 digest from [peer's IP address] (11003) to [local router's IP address] (646)
```

Similarly, if the two routers have different passwords configured, a message such as the following appears on the console. The LDP session is not established.

```
%TCP-6-BADAUTH: Invalid MD5 digest from [peer's IP address] (11004) to [local router's IP address] (646)
```

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls ip**
4. **mpls label protocol ldp**
5. **mpls ldp neighbor [vrf vpn-name] ip-address [password [0-7] password-string]**
6. **show mpls ldp neighbor [[vrf vpn-name] [address | interface] [detail] | all]**

DETAILED STEPS

	Command or Action	Purpose
Step 1	enable Example: Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> • Enter your password if prompted.
Step 2	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 3	mpls ip Example: Router(config)# mpls ip	Configures MPLS hop-by-hop forwarding globally. <ul style="list-style-type: none"> • The mpls ip command is enabled by default; you do not have to specify this command. • Globally enabling MPLS forwarding does not enable it on the router interfaces. You must enable MPLS forwarding on the interfaces as well as for the router.
Step 4	mpls label protocol ldp Example: Router(config)# mpls label protocol ldp	Configures the use of LDP on all interfaces.

	Command or Action	Purpose
Step 5	<pre>mpls ldp neighbor [vrf vpn-name] ip-address [password [0-7] password-string]</pre> <p>Example: Router(config)# mpls ldp neighbor 172.27.0.15 password onethirty9</p>	Specifies authentication between two LDP peers.
Step 6	<pre>exit</pre> <p>Example: Router(config)# exit</p>	Exits global configuration mode and enters privileged EXEC mode.
Step 7	<pre>show mpls ldp neighbor [[vrf vpn-name] [address interface] [detail] all]</pre> <p>Example: Router# show mpls ldp neighbor detail</p>	<p>Displays the status of LDP sessions.</p> <p>If the passwords have been set on both LDP peers and the passwords match, the show mpls ldp neighbor command displays that the LDP session was successfully established.</p>

Examples

The following example configures a router with the password cisco:

```
Router> enable
Router# configure terminal
Router(config)# mpls ip
Router(config)# mpls label protocol ldp
Router(config)# mpls ldp neighbor 10.1.1.1 password cisco
Router(config)# exit
```

The following example shows that the LDP session between routers was successfully established:

```
Router# show mpls ldp neighbor

Peer LDP Ident: 10.1.1.2:0; Local LDP Ident 10.1.1.1:0
TCP connection: 10.1.1.2.11118 - 10.1.1.1.646
State: Oper; Msgs sent/rcvd: 12/11; Downstream
Up time: 00:00:10
LDP discovery sources:
FastEthernet1/0/0, Src IP addr: 10.20.10.2
Addresses bound to peer LDP Ident:
10.1.1.2 10.20.20.1 10.20.10.2
```

The following **show mpls ldp neighbor detail** command shows that MD5 (shown in bold) is used for the LDP session.

```
Router# show mpls ldp neighbor 10.0.0.21 detail

Peer LDP Ident: 10.0.0.21:0; Local LDP Ident 10.0.0.22:0
TCP connection: 10.0.0.21.646 - 10.0.0.22.14709; MD5 on
State: Oper; Msgs sent/rcvd: 1020/1019; Downstream; Last TIB rev sent 2034
Up time: 00:00:39; UID: 3; Peer Id 1;
LDP discovery sources:
FastEthernet1/1/0; Src IP addr: 172.16.1.1
holdtime: 15000 ms, hello interval: 5000 ms
Addresses bound to peer LDP Ident:
10.0.0.21 10.0.38.28 10.88.88.2 172.16.0.1
172.16.1.1
Peer holdtime: 180000 ms; KA interval: 60000 ms; Peer state: estab
```

Configuration Examples for MPLS Label Distribution Protocol

This section includes the following configuration examples:

- [Configuring Directly Connected MPLS LDP Sessions: Example, page 19](#)
- [Establishing Nondirectly Connected MPLS LDP Sessions: Example, page 20](#)

Configuring Directly Connected MPLS LDP Sessions: Example

[Figure 1](#) shows a sample network for configuring directly connected LDP sessions.

This example configures the following:

- MPLS hop-by-hop forwarding for the POS links between Router 1 and Router 2 and between Router 1 and Router 3.
- LDP for label distribution between Router 1 and Router 2.
- TDP for label distribution between Router 1 and Router 3.
- A loopback interface and IP address for each LSR that can be used as the LDP router ID.

Figure 1 Configuration of MPLS LDP



Note

The configuration examples below show only the commands related to configuring LDP for Router 1, Router 2, and Router 3 in the sample network shown in [Figure 1](#).

Router 1 Configuration

```
ip cef distributed                !Assumes R1 supports distributed CEF
interface Loopback0              !Loopback interface for LDP ID.
ip address 172.16.0.11 255.255.255.255
!
interface POS0/3/0
ip address 10.0.0.44 255.0.0.0
mpls ip                          !Enable hop-by-hop MPLS forwarding
```

```

mpls label protocol ldp
!
interface POS1/3/0
ip address 192.168.0.44 255.0.0.0
mpls ip                               !Enable hop-by-hop MPLS forwarding
mpls label protocol ldp

```

Router 2 Configuration

```

ip cef distributed                       !Assumes R2 supports distributed CEF
!
interface Loopback0                     !Loopback interface for LDP ID.
ip address 172.16.0.22 255.255.255.255
!
interface POS2/0/0
ip address 10.0.0.33 255.0.0.0
mpls ip                                 !Enable hop-by-hop MPLS forwarding
mpls label protocol ldp

```

Router 3 Configuration

```

ip cef                                  !Assumes R3 does not support dCEF
!
interface Loopback0                     !Loopback interface for LDP ID.
ip address 172.16.0.33 255.255.255.255
!
interface POS1/0/0
ip address 192.168.0.55 255.0.0.0
mpls ip                                 !Enable hop-by-hop MPLS forwarding
mpls label protocol ldp

```

The LDP configuration for Router 1 uses the **mpls label protocol ldp** command in interface configuration mode. To specify LDP for all interfaces, use the **mpls label protocol ldp** command in global configuration mode without any interface **mpls label protocol** commands.

The configuration of Router 2 also uses the **mpls label protocol ldp** command in interface configuration mode. To specify LDP for all interfaces, use the **mpls label protocol ldp** command in global configuration mode without any interface **mpls label protocol** commands.

Configuring the **mpls ip** command on an interface triggers the transmission of discovery Hello messages for the interface.

Establishing Nondirectly Connected MPLS LDP Sessions: Example

The following examples illustrate the configuration of platforms for MPLS LDP nondirectly connected sessions using the sample network shown in [Figure 2](#). Note that Routers 1, 4, 5, and 6 in this sample network are not directly connected to each other.

Figure 2 **Sample Network for Configuring LDP for Targeted Sessions**

The configuration example shows the following:

- Targeted sessions between Routers 1 and 4 use LDP. Routers 1 and 4 are both active.
- Targeted sessions between Routers 1 and 6 use LDP. Router 1 is active and Router 6 is passive.
- Targeted sessions between Routers 1 and 5 use LDP. Router 5 is active.

These examples assume that the active ends of the nondirectly connected sessions are associated with tunnel interfaces, such as MPLS traffic engineering tunnels. They show only the commands related to configuring LDP targeted sessions. The examples do not show configuration of the applications that initiate the targeted sessions.

Router 1 Configuration

Tunnel interfaces Tunnel14 and Tunnel16 specify LDP for targeted sessions associated with these interfaces. The targeted session for Router 5 requires TDP. The **mpls label protocol ldp** command in global configuration mode makes it unnecessary to explicitly specify LDP as part of the configuration from the Tunnel14 and Tunnel16.

```
ip cef distributed                !Router1 supports distributed CEF

mpls label protocol ldp         !Use LDP for all interfaces

interface Loopback0             !Loopback interface for LDP ID.
ip address 10.25.0.11 255.255.255.255

interface Tunnel14              !Tunnel to Router 4 requiring label distribution
tunnel destination 10.11.0.4    !Tunnel endpoint is Router 4
mpls ip                         !Enable hop-by-hop forwarding on the interface

interface Tunnel15              !Tunnel to Router 5 requiring label distribution
tunnel destination 10.11.0.5    !Tunnel endpoint is Router 5
mpls label protocol ldp        !Use LDP for session with Router 5
mpls ip                         !Enable hop-by-hop forwarding on the interface

interface Tunnel16              !Tunnel to Router 6 requiring label distribution
tunnel destination 10.11.0.6    !Tunnel endpoint is Router 6
mpls ip                         !Enable hop-by-hop forwarding on the interface
```

Router 4 Configuration

The **mpls label protocol ldp** command in global configuration mode makes it unnecessary to explicitly specify LDP as part of the configuration for the Tunnel41 targeted session with Router 1.

```
ip cef distributed          !Router 4 supports distributed CEF

mpls label protocol ldp    !Use LDP for all interfaces

interface Loopback0        !Loopback interface for LDP ID.
ip address 10.25.0.44 255.255.255.255

interface Tunnel41         !Tunnel to Router 1 requiring label distribution
tunnel destination 10.11.0.1 !Tunnel endpoint is Router 1
mpls ip                    !Enable hop-by-hop forwarding on the interface
```

Router 5 Configuration

Router 5 uses LDP for all targeted sessions. Therefore, its configuration includes the **mpls label protocol ldp** command.

```
ip cef                    !Router 5 supports CEF

mpls label protocol ldp    !Use LDP for all interfaces

interface Loopback0        !Loopback interface for LDP ID.
ip address 10.25.0.55 255.255.255.255

interface Tunnel151        !Tunnel to Router 1 requiring label distribution
tunnel destination 10.11.0.1 !Tunnel endpoint is Router 1
mpls ip                    !Enable hop-by-hop forwarding on the interface
```

Router 6 Configuration

By default, a router cannot be a passive neighbor in targeted sessions. Therefore, Router 1, Router 4, and Router 5 are active neighbors in any targeted sessions. The **mpls ldp discovery targeted-hello accept** command permits Router 6 to be a passive target in targeted sessions with Router 1. Router 6 can also be an active neighbor in targeted sessions, although the example does not include such a configuration.

```
ip cef distributed          !Router 6 supports distributed CEF

interface Loopback0        !Loopback interface for LDP ID.
ip address 10.25.0.66 255.255.255.255

mpls ldp discovery targeted-hellos accept from LDP_SOURCES
                                !Respond to requests for targeted hellos
                                !from sources permitted by acl LDP_SOURCES

ip access-list standard LDP_SOURCES !Define acl for targeted hello sources.
permit 10.11.0.1              !Accept targeted hello request from Router 1.
deny any                     !Deny requests from other sources.
```

Additional References

The following sections provide references related to the MPLS Label Distribution Protocol feature.

Related Documents

Related Topic	Document Title
Configures LDP on every interface associated with a specified IGP instance.	<i>MPLS LDP Autoconfiguration</i>
Ensures that LDP is fully established before the IGP path is used for switching.	<i>MPLS LDP-IGP Synchronization</i>
Allows ACLs to control the label bindings that an LSR accepts from its peer LSRs.	<i>MPLS LDP Inbound Label Binding Filtering</i>
Enables standard, SNMP-based network management of the label switching features in Cisco IOS XE release software.	<i>MPLS Label Distribution Protocol MIB Version 8 Upgrade</i>
MPLS LDP commands	<i>Cisco IOS Multiprotocol Label Switching Command Reference</i>

Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIB	MIBs Link
<ul style="list-style-type: none"> MPLS Label Distribution Protocol MIB (draft-ietf-mpls-ldp-mib-08.txt) SNMP-VACM-MIB The View-based Access Control Model (ACM) MIB for SNMP 	To locate and download MIBs for selected platforms, Cisco IOS XE software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mib

RFCs

RFC	Title
RFC 3036	<i>LDP Specification</i>

Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<p>http://www.cisco.com/techsupport</p>

Feature Information for MPLS Label Distribution Protocol

Table 1 lists the features in this module and provides links to specific configuration information.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS XE software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to <http://www.cisco.com/go/cfn>. An account on Cisco.com is not required.



Note

Table 1 lists only the Cisco IOS XE software release that introduced support for a given feature in a given Cisco IOS XE software release train. Unless noted otherwise, subsequent releases of that Cisco IOS XE software release train also support that feature.

Table 1 Feature Information for MPLS Label Distribution Protocol

Feature Name	Releases	Feature Information
MPLS Label Distribution Protocol (LDP)	Cisco IOS XE Release 2.1	<p>MPLS Label Distribution Protocol (LDP) enables peer label switch routers (LSRs) in an Multiprotocol Label Switching (MPLS) network to exchange label binding information for supporting hop-by-hop forwarding in an MPLS network. This module explains the concepts related to MPLS LDP and describes how to configure MPLS LDP in a network.</p> <p>In Cisco IOS XE Release 2.1, this feature was implemented on the Cisco ASR 1000 Series Aggregation Services Router.</p> <p>The following sections provide information about this feature:</p> <ul style="list-style-type: none"> • Introduction to MPLS Label Distribution Protocol, page 2 • MPLS Label Distribution Protocol Functional Overview, page 2 • Introduction to LDP Sessions, page 2 • Introduction to LDP Label Bindings, Label Spaces, and LDP Identifiers, page 4 • Enabling Directly Connected LDP Sessions, page 5 • Establishing Nondirectly Connected MPLS LDP Sessions, page 8 • Specifying the LDP Router ID, page 10 • Preserving QoS Settings with MPLS LDP Explicit Null, page 12 • Protecting Data Between LDP Peers with MD5 Authentication, page 16 <p>The following commands were introduced or modified: debug mpls atm-ldp failure, mpls label protocol (global configuration), mpls ldp advertise-labels, mpls ldp discovery, mpls ldp neighbor implicit-withdraw, mpls ldp neighbor targeted-session, mpls ldp router-id.</p>

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