Network Configuration Example

Configuring LDP Over RSVP

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Introduction

This document describes the LDP-over-RSVP feature and the benefits of using it. It also includes a step-by-step procedure for configuring an LDP-over-RSVP topology.

Benefits of Configuring the LDP-Over-RSVP Feature

MPLS is a significant technology in the service provider environment and is becoming more relevant to enterprise networks. MPLS enables:

- Virtualization
- Traffic engineering
- Consolidation of different traffic types such as IPv4, IPv6, unicast, and multicast across Layer 2 and Layer 3 VPNs
- Quality of service
- Link and node redundancy
- Compliance with service-level agreements

This shift to MPLS is primarily due to the opportunity to increase revenue and improve management of current network resources.

The Juniper Networks Junos® operating system (Junos OS) provides a standards-based MPLS solution based on BGP, LDP, and RSVP.

Deploying MPLS in a service provider network enables support for IPTV, financial applications, collaboration-based applications, and virtual private LAN service (VPLS).

Deploying MPLS functionality in the aggregation and core layers can provide the flexibility needed for the enterprise to achieve its segmentation and traffic engineering needs.

One MPLS feature that can be deployed in multiple scenarios is LDP over RSVP. LDP over RSVP combines the simplicity and scalability benefits of LDP with RSVP's traffic engineering and traffic protection capabilities.

Technically, LDP does not run over RSVP-TE, but rather an LDP signaled label-switched path (LSP) runs through a TE tunnel that was set up using RSVP-TE. In this case, LDP can be turned on at the edge, RSVP-TE can be used across the core, and the RSVP-TE LSP acts as the link connecting two LDP peers.

One example of how the LDP-over-RSVP feature is used is in service provider networks where they are interconnecting diverse customer networks across multiple providers.

The benefits to service providers are:

- LDP over RSVP provides convergence of different traffic types such as IPv4, IPv6, unicast, and multicast across Layer 2 and Layer 3 VPNs.
- It enables flexible access connectivity options that can accommodate multiple topologies, different protocols, and multiple administrative boundaries.

- It enables secure interworking among multiple providers.
- RSVP tunnels in the core network provide differentiated services on a per customer basis. RSVP-TE supports traffic engineering, bandwidth guarantees, and link and node redundancy capabilities.
- Using RSVP reduces the number of LSPs required in the core, which reduces the resource requirements of the protocols and routers as well as reducing convergence time.
- LDP over RSVP provides cost-efficient rollouts with minimal network disruption because the LSPs are built using point-to-point TE tunnels to directly attached neighbors. These TE tunnels only go to the next hop, not end to end. Then when LDP is run over those tunnels, the sessions are built to the directly connected neighbor. When there is a change in the network, such as adding a new node, the directly connected neighbors of the new node have RSVP and LDP sessions. Thus, the RSVP LSPs are only to the next hop, and LDP takes care of advertising labels for the new addresses.

Another example is an enterprise network connected to a provider edge (PE) router that supports both LDP and RSVP LSPs. The LDP-over-RSVP feature enables you to establish a full mesh of RSVP LSPs between PE devices and simultaneously deploy LDP for simplicity. RSVP LSPs can be deployed in the MPLS core of a campus network to reap the benefits of traffic engineering. In this case, the PE routers and P routers tunnel LDP LSPs through RSVP LSPs.

The benefits of this approach are:

- It is easier to configure LDP than to configure RSVP.
- LDP uses reliable TCP as the transport protocol for all but the discovery messages.
- RSVP-TE supports traffic engineering.
- RSVP-TE supports quality-of-service capabilities.
- RSVP-TE supports link and node redundancy capabilities.
- Using RSVP can reduce the number of LSPs required in the core, which reduces the resource requirements of the protocols and routers.
- If a PE router does not support RSVP-TE, it can still take advantage of the benefits provided by traffic engineering in the core by using LDP over RSVP.

Related Documentation

- Example: Configuring an LDP-Over-RSVP VPN Topology on page 2

Example: Configuring an LDP-Over-RSVP VPN Topology

This example shows how to set up a VPN topology in which LDP packets are tunneled over an RSVP label-switched path (LSP).

Requirements

This example can be configured using the following hardware and software components:

- Junos OS Release 9.1 or later
- MX Series 3D Universal Edge Routers or M Series Multiservice Edge Routers for the Provider Edge (PE) Routers PE1, PE2
- T Series Core Routers for the Core Routers P1, P2, and P3
- EX Series Ethernet Switches for Devices CE1 and CE2

NOTE: The PE routers could also be T Series Core Routers but that is not typical. Depending on your scaling requirements, the core routers could also be MX Series 3D Universal Edge Routers or M Series Multiservice Edge Routers. The Customer Edge (CE) devices could be other routers or switches from Juniper Networks or another vendor.

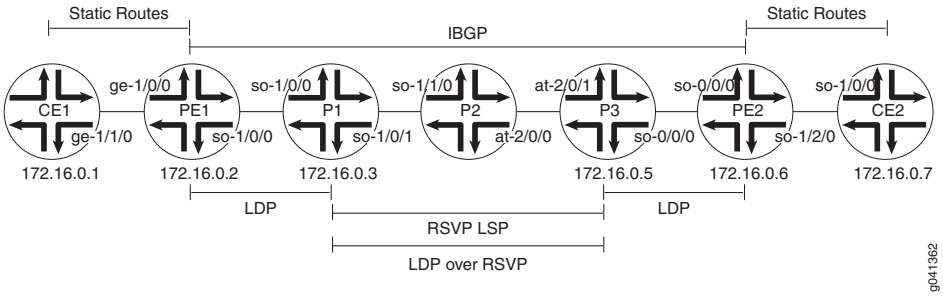
No special configuration beyond device initialization is required before configuring this example.

Overview

This configuration consists of the following components (see Figure 1 on page 3):

- One VPN (VPN-A)
- Two PE routers
- LDP as the signaling protocol between the PE routers and their adjacent P routers
- An RSVP LSP between two of the P routers over which LDP is tunneled

Figure 1: Example of an LDP-Over-RSVP VPN Topology



"CLI Quick Configuration" on page 6 shows the configuration for all of the devices in Figure 1 on page 3. The section "Step-by-Step Procedure" on page 8 describes the steps on Device CE1, Device PE1, Device P1, and Device P2.

The following steps describe how this topology is established and how packets are sent from Device CE2 to Device CE1:

1. Device P1 and Device P3 establish RSVP LSPs between each other and install their loopback addresses in their inet.3 routing tables.
2. Device PE1 establishes an LDP session with Device P1 over interface so-1/0/0.0.
3. Device P1 establishes an LDP session with Device P3's loopback address, which is reachable using the RSVP LSP.
4. Device P1 sends its label bindings, which include a label to reach Device PE1, to Device P3. These label bindings allow Device P3 to direct LDP packets to Device PE1.
5. Device P3 establishes an LDP session with Device PE2 over interface so-0/0/0.0 and establishes an LDP session with Device P1's loopback address.
6. Device P3 sends its label bindings, which include a label to reach Device PE2, to Device P1. These label bindings allow Device P1 to direct LDP packets to Device PE2's loopback address.
7. Devices PE1 and PE2 establish IBGP sessions with each other.
8. When Device PE1 announces to Device PE2 routes that it learned from Device CE1, it includes its VPN label. (The PE router creates the VPN label and binds it to the interface between the PE and CE devices.) Similarly, when Device PE2 announces routes that it learned from Device CE2, it sends its VPN label to Device PE1.

When Device PE2 wants to forward a packet to Device CE1, it pushes two labels onto the packet's label stack: first the VPN label that is bound to the interface between Device PE1 and Device CE1, then the LDP label used to reach Device PE1. Then it forwards the packets to Device P3 over interface so-0/0/1.0.

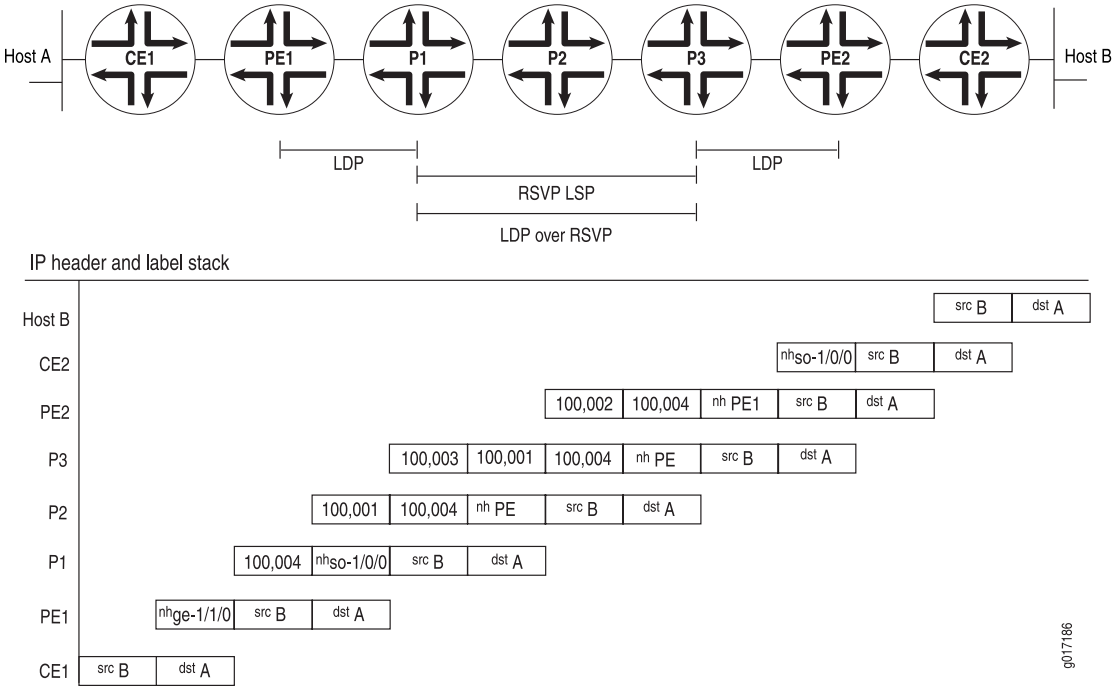
1. When Device P3 receives the packets from Device PE2, it swaps the LDP label that is on top of the stack (according to its LDP database) and also pushes an RSVP label onto the top of the stack so that the packet can now be switched by the RSVP LSP. At this point, there are three labels on the stack: the inner (bottom) label is the VPN label, the middle is the LDP label, and the outer (top) is the RSVP label.
2. Device P2 receives the packet and switches it to Device P1 by swapping the RSVP label. In this topology, because Device P2 is the penultimate-hop router in the LSP, it pops the RSVP label and forwards the packet over interface so-1/1/0.0 to Device P1. At this point, there are two labels on the stack: The inner label is the VPN label, and the outer one is the LDP label.
3. When Device P1 receives the packet, it pops the outer label (the LDP label) and forwards the packet to Device PE1 using interface so-1/0/0.0. In this topology, Device PE1 is the egress LDP router, so Device P1 pops the LDP label instead of swapping it with another label. At this point, there is only one label on the stack, the VPN label.
4. When Device PE1 receives the packet, it pops the VPN label and forwards the packet as an IPv4 packet to Device CE1 over interface ge-1/1/0.0.

A similar set of operations occurs for packets sent from Device CE1 that are destined for Device CE2.

The following list explains how, for packets being sent from Device CE2 to Device CE1, the LDP, RSVP, and VPN labels are announced by the various routers. These items include examples of label values (illustrated in Figure 2 on page 5).

- LDP labels
  - Device PE1 announces LDP label 3 for itself to Device P1.
  - Device P1 announces LDP label 100,001 for Device PE1 to Device P3.
  - Device P3 announces LDP label 100,002 for Device PE1 to Device PE2.
- RSVP labels
  - Device P1 announces RSVP label 3 to Device P2.
  - Device P2 announces RSVP label 100,003 to Device P3.
- VPN label
  - Device PE1 announces VPN label 100,004 to Device PE2 for the route from Device CE1 to Device CE2.

Figure 2: Label Pushing and Popping



For a packet sent from Host B in Figure 2 on page 5 to Host A, the packet headers and labels change as the packet travels to its destination.

1. The packet that originates from Host B has a source address of B and a destination address of A in its header.
2. Device CE2 adds to the packet a next hop of interface so-1/0/0.
3. Device PE2 swaps out the next hop of interface so-1/0/0 and replaces it with a next hop of PE1. It also adds two labels for reaching Device PE1, first the VPN label (100,004), then the LDP label (100,002). The VPN label is thus the inner (bottom) label on the stack, and the LDP label is the outer label.
4. Device P3 swaps out the LDP label added by Device PE2 (100,002) and replaces it with its LDP label for reaching Device PE1 (100,001). It also adds the RSVP label for reaching Device P2 (100,003).
5. Device P2 removes the RSVP label (100,003) because it is the penultimate hop in the MPLS LSP.
6. Device P1 removes the LDP label (100,001) because it is the penultimate LDP router. It also swaps out the next hop of PE1 and replaces it with the next-hop interface, so-1/0/0.
7. Device PE1 removes the VPN label (100,004). It also swaps out the next-hop interface of so-1/0/0 and replaces it with its next-hop interface, ge-1/1/0.
8. Device CE1 removes the next-hop interface of ge-1/1/0, and the packet header now contains just a source address of B and a destination address of A.

Configuration

CLI Quick Configuration

To quickly configure this example, copy the following commands, paste them into a text file, remove any line breaks, change any details necessary to match your network configuration, and then copy and paste the commands into the CLI at the **[edit]** hierarchy level.

Device CE1

```
set interfaces ge-1/1/0 unit 0 family inet address 10.0.0.1/30
set interfaces ge-1/1/0 unit 0 description to_PE1
set interfaces lo0 unit 0 family inet address 172.16.0.1/32
set routing-options static route 0.0.0.0/0 next-hop 10.0.0.2
```

Device CE2

```
set interfaces so-1/0/0 unit 0 family inet address 10.0.0.22/30
set interfaces so-1/0/0 unit 0 description to_PE2
set interfaces lo0 unit 0 family inet address 172.16.0.7/32
set routing-options static route 0.0.0.0/0 next-hop 10.0.0.21
```

Device PE1

```
set interfaces ge-1/0/0 unit 0 family inet address 10.0.0.2/30
set interfaces ge-1/0/0 unit 0 description to_CE1
set interfaces so-1/0/0 unit 0 family inet address 10.0.0.5/30
set interfaces so-1/0/0 unit 0 description to_P1
set interfaces so-1/0/0 unit 0 family mpls
set interfaces lo0 unit 0 family inet address 172.16.0.2/32
set protocols mpls interface so-1/0/0.0
set protocols bgp group isp-a type internal
set protocols bgp group isp-a local-address 172.16.0.2
set protocols bgp group isp-a family inet-vpn unicast
set protocols bgp group isp-a neighbor 172.16.0.6
set protocols ospf traffic-engineering
```

```
set protocols ospf area 0.0.0.0 interface so-1/0/0.0
set protocols ospf area 0.0.0.0 interface lo0.0 passive
set protocols ldp interface so-1/0/0.0
set protocols ldp interface lo0.0
set routing-instances VPN-A instance-type vrf
set routing-instances VPN-A interface ge-1/0/0.0
set routing-instances VPN-A route-distinguisher 64510:0
set routing-instances VPN-A vrf-target target:64510:3
set routing-instances VPN-A routing-options static route 172.16.0.1/32 next-hop 10.0.0.1
set routing-options autonomous-system 64510
```

Device PE2

```
set interfaces so-0/0/0 unit 0 family inet address 10.0.0.18/30
set interfaces so-0/0/0 unit 0 description to_P3
set interfaces so-0/0/0 unit 0 family mpls
set interfaces so-1/2/0 unit 0 family inet address 10.0.0.21/30
set interfaces so-1/2/0 unit 0 description to_CE2
set interfaces lo0 unit 0 family inet address 172.16.0.6/32
set protocols mpls interface so-0/0/0.0
set protocols bgp group isp-a type internal
set protocols bgp group isp-a local-address 172.16.0.6
set protocols bgp group isp-a family inet-vpn unicast
set protocols bgp group isp-a neighbor 172.16.0.2
set protocols ospf traffic-engineering
set protocols ospf area 0.0.0.0 interface so-0/0/0.0
set protocols ospf area 0.0.0.0 interface lo0.0 passive
set protocols ldp interface so-0/0/0.0
set protocols ldp interface lo0.0
set routing-instances VPN-A instance-type vrf
set routing-instances VPN-A interface so-1/2/0.0
set routing-instances VPN-A route-distinguisher 64510:1
set routing-instances VPN-A vrf-target target:64510:3
set routing-instances VPN-A routing-options static route 172.16.0.7/32 next-hop 10.0.0.22
set routing-options autonomous-system 64510
```

Device P1

```
set interfaces so-1/0/0 unit 0 family inet address 10.0.0.6/30
set interfaces so-1/0/0 unit 0 description to_PE1
set interfaces so-1/0/0 unit 0 family mpls
set interfaces so-1/0/1 unit 0 family inet address 10.0.0.9/30
set interfaces so-1/0/1 unit 0 description to_P2
set interfaces so-1/0/1 unit 0 family mpls
set interfaces lo0 unit 0 family inet address 172.16.0.3/32
set protocols rsvp interface so-1/0/1.0
set protocols rsvp interface lo0.0
set protocols rsvp interface so-1/0/0.0
set protocols mpls label-switched-path P1-to-P3 to 172.16.0.5
set protocols mpls label-switched-path P1-to-P3 ldp-tunneling
set protocols mpls interface so-1/0/0.0
set protocols mpls interface so-1/0/1.0
set protocols ospf traffic-engineering
set protocols ospf area 0.0.0.0 interface so-1/0/0.0
set protocols ospf area 0.0.0.0 interface so-1/0/1.0
set protocols ospf area 0.0.0.0 interface lo0.0 passive
set protocols ldp interface so-1/0/0.0
set protocols ldp interface lo0.0
```

Device P3

```
set interfaces at-2/0/1 unit 0 family inet address 10.0.0.14/30
set interfaces at-2/0/1 unit 0 description to_P2
set interfaces at-2/0/1 unit 0 family mpls
set interfaces so-0/0/0 unit 0 family inet address 10.0.0.17/30
set interfaces so-0/0/0 unit 0 description to_PE2
set interfaces so-0/0/0 unit 0 family mpls
set interfaces lo0 unit 0 family inet address 172.16.0.5/32
set protocols rsvp interface at-2/0/1.0
set protocols rsvp interface lo0.0
set protocols rsvp interface so-0/0/0.0
set protocols mpls label-switched-path P3-to-P1 to 172.16.0.3
set protocols mpls label-switched-path P3-to-P1 ldp-tunneling
set protocols mpls interface so-0/0/0.0
set protocols mpls interface at-2/0/1.0
set protocols ospf traffic-engineering
set protocols ospf area 0.0.0.0 interface at-2/0/1.0
set protocols ospf area 0.0.0.0 interface so-0/0/0.0
set protocols ospf area 0.0.0.0 interface lo0.0 passive
set protocols ldp interface so-0/0/0.0
set protocols ldp interface lo0.0
```

Device P2

```
set interfaces so-1/1/0 unit 0 family inet address 10.0.0.10/30
set interfaces so-1/1/0 unit 0 description to_P1
set interfaces so-1/1/0 unit 0 family mpls
set interfaces at-2/0/0 unit 0 family inet address 10.0.0.13/30
set interfaces at-2/0/0 unit 0 description to_P3
set interfaces at-2/0/0 unit 0 family mpls
set interfaces lo0 unit 0 family inet address 172.16.0.4/32
set protocols rsvp interface so-1/1/0.0
set protocols rsvp interface at-2/0/0.0
set protocols rsvp interface lo0.0
set protocols mpls interface so-1/1/0.0
set protocols mpls interface at-2/0/0.0
set protocols ospf traffic-engineering
set protocols ospf area 0.0.0.0 interface so-1/1/0.0
set protocols ospf area 0.0.0.0 interface at-2/0/0.0
set protocols ospf area 0.0.0.0 interface lo0.0 passive
```

Step-by-Step Procedure

The following example requires you to navigate various levels in the configuration hierarchy. For information about navigating the CLI, see Using the CLI Editor in Configuration Mode in the CLI User Guide.

To configure Device CE1:

1. Configure the interfaces.

   ```
   [edit interfaces]
   user@CE1# set ge-1/1/0 unit 0 family inet address 10.0.0.1/30
   user@CE1# set lo0 unit 0 family inet address 172.16.0.1/32
   ```

2. Configure a static default route to Device PE1.

   Alternatively, you can configure a routing protocol between Device CE1 and Device PE1.

   ```
   [edit routing-options]
   ```

```
user@CE1# set static route 0.0.0.0/0 next-hop 10.0.0.2
```

Similarly, configure Device CE2.

Step-by-Step Procedure

The following example requires you to navigate various levels in the configuration hierarchy. For information about navigating the CLI, see Using the CLI Editor in Configuration Mode in the CLI User Guide.

To configure Device PE1:

1. Configure the interfaces.

   Enable the MPLS address family on the interface that faces the provider core.

   ```
   [edit interfaces]
   user@PE1# set ge-1/0/0 unit 0 family inet address 10.0.0.2/30
   user@PE1# set ge-1/0/0 unit 0 description to_CE1

   user@PE1# set so-1/0/0 unit 0 family inet address 10.0.0.5/30
   user@PE1# set so-1/0/0 unit 0 description to_P1
   user@PE1# set so-1/0/0 unit 0 family mpls

   user@PE1# set lo0 unit 0 family inet address 172.16.0.2/32
   ```

2. Add the core-facing interface to the MPLS protocol.

   ```
   [edit protocols mpls]
   user@PE1# set interface so-1/0/0.0
   ```

3. Configure an internal BGP connection to Device PE2.

   To enable the VPN, include the **family inet-vpn** statement.

   Include the **local-address** statement, specifying the local PE router's loopback interface address. The IBGP session for VPNs runs through the loopback address.

   Include the **neighbor** statement, specifying the IP address of the neighboring PE router, which is Device PE2's loopback interface (lo0) address.

   ```
   [edit protocols bgp group isp-a]
   user@PE1# set type internal
   user@PE1# set local-address 172.16.0.2
   user@PE1# set family inet-vpn unicast
   user@PE1# set neighbor 172.16.0.6
   ```

4. Configure OSPF on the interface that faces the provider core and on the loopback interface.

   Enable OSPF traffic engineering support.

   ```
   [edit protocols ospf]
   user@PE1# set traffic-engineering

   [edit protocols ospf area 0.0.0.0]
   user@PE1# set interface so-1/0/0.0
   user@PE1# set interface lo0.0 passive
   ```

5. Enable LDP on the interface that faces the provider core and on the loopback interface.

   ```
   [edit protocols ldp]
   user@PE1# set interface so-1/0/0.0
   user@PE1# set interface lo0.0
   ```

6. Configure the routing instance.

   ```
   [edit routing-instances VPN-A]
   user@PE1# set instance-type vrf
   user@PE1# set interface ge-1/0/0.0
   user@PE1# set route-distinguisher 64510:0
   user@PE1# set vrf-target target:64510:3
   ```

7. In the routing instance, configure a static route to Device CE1.

   ```
   [edit routing-instances VPN-A routing-options]
   user@PE1# set static route 172.16.0.1/32 next-hop 10.0.0.1
   ```

8. Configure the autonomous system number.

   ```
   [edit routing-options]
   user@PE1# set autonomous-system 64510
   ```

9. Repeat this configuration on Device PE2, changing the interface names and addresses as needed.

Step-by-Step Procedure

The following example requires you to navigate various levels in the configuration hierarchy. For information about navigating the CLI, see Using the CLI Editor in Configuration Mode in the CLI User Guide.

To configure Device P1:

1. Configure the interfaces.

   Enable the MPLS address family on the transit interfaces.

   ```
   [edit interfaces]
   user@P1# set so-1/0/0 unit 0 family inet address 10.0.0.6/30
   user@P1# set so-1/0/0 unit 0 description to_PE1
   user@P1# set so-1/0/0 unit 0 family mpls

   user@P1# set so-1/0/1 unit 0 family inet address 10.0.0.9/30
   user@P1# set so-1/0/1 unit 0 description to_P2
   user@P1# set so-1/0/1 unit 0 family mpls

   user@P1# set lo0 unit 0 family inet address 172.16.0.3/32
   ```

2. Enable RSVP on the transit interfaces and on the loopback interface.

   ```
   [edit protocols rsvp]
   user@P1# set interface so-1/0/1.0
   user@P1# set interface so-1/0/0.0
   user@P1# set interface lo0.0
   ```

3. Add transit interfaces to the MPLS protocol.

Configure a label-switched path (LSP) from Device P1 to Device P3, and enable the LSP to be used for LDP tunneling.

```
[edit protocols mpls]
user@P1# set interface so-1/0/0.0
user@P1# set interface so-1/0/1.0
user@P1# set label-switched-path P1-to-P3 to 172.16.0.5
user@P1# set label-switched-path P1-to-P3 ldp-tunneling
```

4. Configure OSPF on the transit interfaces and on the loopback interface.

   Enable OSPF traffic engineering support.

   ```
   [edit protocols ospf]
   user@P1# set traffic-engineering


   [edit protocols ospf area 0.0.0.0]
   user@P1# set interface so-1/0/0.0
   user@P1# set interface so-1/0/1.0
   user@P1# set interface lo0.0 passive
   ```

5. Enable LDP on the interface that faces Device PE1 and on the loopback interface.

   ```
   [edit protocols ldp]
   user@P1# set interface so-1/0/0.0
   user@P1# set interface lo0.0
   ```

6. Repeat this configuration On Device P3, changing the interface names and addresses as needed.

Step-by-Step Procedure

The following example requires you to navigate various levels in the configuration hierarchy. For information about navigating the CLI, see Using the CLI Editor in Configuration Mode in the CLI User Guide.

To configure Device P2:

1. Configure the interfaces.

   Enable the MPLS address family on the transit interfaces.

   ```
   [edit interfaces]
   user@P2# set so-1/1/0 unit 0 family inet address 10.0.0.10/30
   user@P2# set so-1/1/0 unit 0 description to_P1
   user@P2# set so-1/1/0 unit 0 family mpls


   user@P2# set at-2/0/0 unit 0 family inet address 10.0.0.13/30
   user@P2# set at-2/0/0 unit 0 description to_P3
   user@P2# set at-2/0/0 unit 0 family mpls


   user@P2# set lo0 unit 0 family inet address 172.16.0.4/32
   ```

2. Enable RSVP on the transit interfaces and on the loopback interface.

   ```
   [edit protocols rsvp]
   user@P2# set interface so-1/1/0.0
   user@P2# set interface at-2/0/0.0
   user@P2# set interface lo0.0
   ```

3. Add transit interfaces to the MPLS protocol.

```
[edit protocols mpls]
user@P2# set interface so-1/1/0.0
user@P2# set interface at-2/0/0.0
```

4. Configure OSPF on the transit interfaces and on the loopback interface.

   Enable OSPF traffic engineering support.

```
[edit protocols ospf]
user@P2# set traffic-engineering


[edit protocols ospf area 0.0.0.0]
user@P2# set interface so-1/1/0.0
user@P2# set interface at-2/0/0.0
user@P2# set interface lo0.0 passive
```

Results From configuration mode, confirm your configuration by entering the **show interfaces**, **show protocols**, **show routing-instances**, and **show routing-options** commands. If the output does not display the intended configuration, repeat the instructions in this example to correct the configuration.

Device CE1

```
user@CE1# show interfaces
ge-1/1/0 {
   unit 0{
      description to_PE1;
      family inet {
         address 10.0.0.1/30;
      }
   }
}
lo0 {
   unit 0{
      family inet {
         address 172.16.0.1/32;
      }
   }
}

user@CE1# show routing-options
static {
   route 0.0.0.0/0 next-hop 10.0.0.2;
}
```

Device PE1

```
user@PE1# show interfaces
ge-1/0/0 {
   unit 0 {
      description to_CE1;
      family inet {
         address 10.0.0.2/30;
      }
   }
}
so-1/0/0 {
   unit 0 {
```



```
      description to_P1;
      family inet {
        address 10.0.0.5/30;
      }
      family mpls;
    }
  }
  lo0 {
    unit 0 {
      family inet {
        address 172.16.0.2/32;
      }
    }
  }

  user@PE1# show protocols
  mpls {
    interface so-1/0/0.0;
  }
  bgp {
    group isp-a {
      type internal;
      local-address 172.16.0.2;
      family inet-vpn {
        unicast;
      }
      neighbor 172.16.0.6;
    }
  }
  ospf {
    traffic-engineering;
    area 0.0.0.0 {
      interface so-1/0/0.0;
      interface lo0.0 {
        passive;
      }
    }
  }
  ldp {
    interface so-1/0/0.0;
    interface lo0.0;
  }

  user@PE1# show routing-instances
  VPN-A {
    instance-type vrf;
    interface ge-1/0/0.0;
    route-distinguisher 64510:0;
    vrf-target target:64510:3;
    routing-options {
      static {
        route 172.16.0.1/32 next-hop 10.0.0.1;
      }
    }
  }
```

```
user@PE1# show routing-options
autonomous-system 64510;
```

Device P1

```
user@P1# show interfaces
so-1/0/0 {
  unit 0{
    description to_PE1;
    family inet {
      address 10.0.0.6/30;
    }
    family mpls;
  }
}
so-1/0/1 {
  unit 0 {
    description to_P2;
    family inet {
      address 10.0.0.9/30;
    }
    family mpls;
  }
}
lo0 {
  unit 0 {
    family inet {
      address 172.16.0.3/32;
    }
  }
}

user@P1# show protocols
rsvp {
  interface so-1/0/1.0;
  interface lo0.0;
  interface so-1/0/0.0;
}
mpls {
  label-switched-path P1-to-P3 {
    to 172.16.0.5;
    ldp-tunneling;
  }
  interface so-1/0/0.0;
  interface so-1/0/1.0;
}
ospf {
  traffic-engineering;
  area 0.0.0.0 {
    interface so-1/0/0.0;
    interface so-1/0/1.0;
    interface lo0.0 {
      passive;
    }
  }
}
ldp {
  interface so-1/0/0.0;
```

```
    interface lo0.0;
}
```

Device P2

```
user@P2# show interfaces
so-1/1/0 {
    unit 0 {
        description to_P1;
        family inet {
            address 10.0.0.10/30;
        }
        family mpls;
    }
}
at-2/0/0 {
    unit 0 {
        description to_P3;
        family inet {
            address 10.0.0.13/30;
        }
        family mpls;
    }
}
lo0 {
    unit 0 {
        family inet {
            address 172.16.0.4/32;
        }
    }
}

user@P2# show protocols
rsvp {
    interface so-1/1/0.0;
    interface at-2/0/0.0;
    interface lo0.0;
}
mpls {
    interface so-1/1/0.0;
    interface at-2/0/0.0;
}
ospf {
    traffic-engineering;
    area 0.0.0.0 {
        interface so-1/1/0.0;
        interface at-2/0/0.0;
        interface lo0.0 {
            passive;
        }
    }
}
```

If you are done configuring the devices, enter **commit** from configuration mode.

Verification

Confirm that the configuration is working properly.

Checking the LDP Session States

Purpose Verify that the LDP-over-RSVP session is working.

Action From operational mode, enter the **show ldp session extensive** command.

```
user@PE1> show ldp session extensive
Address: 172.16.0.2, State: Operational, Connection: Open, Hold time: 23
  Session ID: 172.16.0.3:0--172.16.0.2:0
  Next keepalive in 3 seconds
  Active, Maximum PDU: 4096, Hold time: 30, Neighbor count: 1
  Neighbor types: discovered
  Keepalive interval: 10, Connect retry interval: 1
  Local address: 172.16.0.3, Remote address: 172.16.0.2
  Up for 03:17:32
  Last down 03:17:33 ago; Reason: connection error
  Capabilities advertised: none
  Capabilities received: none
  Protection: disabled
  Session flags: none
  Local - Restart: disabled, Helper mode: enabled
  Remote - Restart: disabled, Helper mode: enabled
  Local maximum neighbor reconnect time: 120000 msec
  Local maximum neighbor recovery time: 240000 msec
  Local Label Advertisement mode: Downstream unsolicited
  Remote Label Advertisement mode: Downstream unsolicited
  Negotiated Label Advertisement mode: Downstream unsolicited
  Nonstop routing state: Not in sync
  Next-hop addresses received:
    10.0.0.5
    172.16.0.2
  Queue depth: 0
Message type              Total                 Last 5 seconds
                        Sent      Received          Sent      Received
Initialization             1             1             0             0
Keepalive               1185          1185             1             1
Notification               0             0             0             0
Address                    1             1             0             0
Address withdraw           0             0             0             0
Label mapping              4             4             0             0
Label request              0             0             0             0
Label withdraw             0             0             0             0
Label release              0             0             0             0
Label abort                0             0             0             0
```

```
Address: 172.16.0.5, State: Operational, Connection: Open, Hold time: 25
  Session ID: 172.16.0.3:0--172.16.0.5:0
  Next keepalive in 3 seconds
  Passive, Maximum PDU: 4096, Hold time: 30, Neighbor count: 1
  Neighbor types: configured-tunneled
  Keepalive interval: 10, Connect retry interval: 1
  Local address: 172.16.0.3, Remote address: 172.16.0.5
  Up for 03:17:29
  Capabilities advertised: none
  Capabilities received: none
  Protection: disabled
  Session flags: none
  Local - Restart: disabled, Helper mode: enabled
  Remote - Restart: disabled, Helper mode: enabled
  Local maximum neighbor reconnect time: 120000 msec
  Local maximum neighbor recovery time: 240000 msec
  Local Label Advertisement mode: Downstream unsolicited
  Remote Label Advertisement mode: Downstream unsolicited
  Negotiated Label Advertisement mode: Downstream unsolicited
  Nonstop routing state: Not in sync
  Next-hop addresses received:
    10.0.0.17
    172.16.0.5
  Queue depth: 0
Message type              Total                 Last 5 seconds
                        Sent      Received          Sent      Received
Initialization             1             1             0             0
Keepalive               1185          1185             0             1
Notification               0             0             0             0
Address                    1             1             0             0
Address withdraw           0             0             0             0
Label mapping              4             4             0             0
Label request              0             0             0             0
Label withdraw             0             0             0             0
Label release              0             0             0             0
Label abort                0             0             0             0
```

Meaning On the LDP neighborship with Device PE1, the Neighbor Type is **discovered**. This means that the routers are directly connected.

The LDP session between Device P1 and Device P3 is not direct. On Device P1, the LDP neighborship is formed with Device P3 over the RSVP tunnel. This is identified by verifying that the Neighbor Type state is **configured-tunneled**. The Local and Remote addresses indicate that the peering is between the two neighboring routers. In this case, they are Device P1 and Device P3, which are connected through Device P2.

Checking the LDP Neighbor State

Purpose Identify the difference between the tunneled LDP and the directly connected LDP neighbors.

Action

```
user@P1> show ldp neighbor extensive
Address            Interface          Label space ID         Hold time
10.0.0.5           so-1/0/0.0         172.16.0.2:0             13
  Transport address: 172.16.0.2, Configuration sequence: 3
  Up for 03:41:18
  Reference count: 1
  Hold time: 15, Proposed local/peer: 15/15
  Hello flags: none
  Neighbor types: discovered
172.16.0.5         lo0.0              172.16.0.5:0             44
  Transport address: 172.16.0.5, Configuration sequence: 2
  Up for 03:40:26
  Reference count: 2
  Hold time: 45, Proposed local/peer: 45/45
  Hello interval: 15
  Hello flags: targeted, request send targeted
  Neighbor types: configured-tunneled
Address            Interface          Label space ID         Hold time
```

Meaning On the LDP neighborship with Device PE1, the Neighbor Type is **discovered**. The connection is made over Device P1's directly connected interface, so-1/0/0.0.

On the LDP neighborship with Device P3, the Neighbor Type is **configured-tunneled**. The connection is made over the Device P1's loopback interface, lo0.0. Device P3's loopback interface address is 172.16.0.5. This address is listed as the LDP neighbor address and as the transport address.

Checking the LDP Database

Purpose On Router PE1, verify that the label is being advertised for the remote PE router (Device PE2) loopback interface address.

Action

```
user@PE1> show ldp database

Input label database, 172.16.0.2:0--172.16.0.3:0
  Label     Prefix
 299776      172.16.0.2/32
      3      172.16.0.3/32
 299792      172.16.0.5/32
 299808      172.16.0.6/32

Output label database, 172.16.0.2:0--172.16.0.3:0
  Label     Prefix
      3      172.16.0.2/32
 299776      172.16.0.3/32
 299792      172.16.0.5/32
 299808      172.16.0.6/32
```

Meaning The output shows that Device PE2's loopback interface address is in the input label database and the output label database.

Checking the Path Between the PE Devices

Purpose Run traceroute from Device PE1 to Device PE2 to verify that LDP traffic is being tunneled over RSVP.

Action

```
user@PE1> traceroute mpls ldp 172.16.0.6

  Probe options: ttl 64, retries 3, wait 10, paths 16, exp 7, fanout 16

  ttl    Label  Protocol    Address          Previous Hop     Probe Status
    1   299808  LDP         10.0.0.6         (null)           Success

    2   299792  RSVP-TE     10.0.0.10        10.0.0.6         Non-compliant

    3                       172.16.0.5       10.0.0.10        Success

    4        3  LDP         10.0.0.18        172.16.0.5       Egress


  Path 1 via so-1/0/0.0 destination 127.0.0.64
```

Meaning The **RSVP-TE** hop identifies that LDP traffic is being tunneled over RSVP.

Verifying Connectivity

Purpose Ping between the CE devices to verify that the VPN is functioning.

Action

```
user@CE1> ping 172.16.0.7
PING 172.16.0.7 (172.16.0.7): 56 data bytes
64 bytes from 172.16.0.7: icmp_seq=0 ttl=59 time=1.391 ms
64 bytes from 172.16.0.7: icmp_seq=1 ttl=59 time=1.321 ms
^C
--- 172.16.0.7 ping statistics ---
2 packets transmitted, 2 packets received, 0% packet loss
round-trip min/avg/max/stddev = 1.321/1.356/1.391/0.035 ms

user@CE2> ping 172.16.0.1
PING 172.16.0.1 (172.16.0.1): 56 data bytes
64 bytes from 172.16.0.1: icmp_seq=0 ttl=59 time=10.866 ms
64 bytes from 172.16.0.1: icmp_seq=1 ttl=59 time=1.361 ms
^C
--- 172.16.0.1 ping statistics ---
2 packets transmitted, 2 packets received, 0% packet loss
round-trip min/avg/max/stddev = 1.361/6.114/10.866/4.752 ms
```

Checking the Routing Tables

Purpose Run the **show route** command on each device to check the routes and the label information.

Action

```
user@CE1> show route
inet.0: 4 destinations, 4 routes (4 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0.0.0.0/0          *[Static/5] 00:06:44
                    > to 10.0.0.2 via ge-1/1/0.0
10.0.0.0/30        *[Direct/0] 00:06:44
                    > via ge-1/1/0.0
10.0.0.1/32        *[Local/0] 00:06:47
                      Local via ge-1/1/0.0
172.16.0.1/32      *[Direct/0] 00:06:47
                    > via lo0.0

user@CE2> show route
inet.0: 4 destinations, 4 routes (4 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0.0.0.0/0          *[Static/5] 00:07:13
                    > to 10.0.0.21 via so-1/0/0.0
10.0.0.20/30       *[Direct/0] 00:07:13
                    > via so-1/0/0.0
10.0.0.22/32       *[Local/0] 00:07:16
                      Local via so-1/0/0.0
172.16.0.7/32      *[Direct/0] 00:07:16
                    > via lo0.0

user@PE1> show route
inet.0: 11 destinations, 11 routes (11 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.0.0.4/30        *[Direct/0] 00:07:46
                    > via so-1/0/0.0
10.0.0.5/32        *[Local/0] 00:07:48
                      Local via so-1/0/0.0
10.0.0.8/30        *[OSPF/10] 00:06:43, metric 2
                    > to 10.0.0.6 via so-1/0/0.0
10.0.0.12/30       *[OSPF/10] 00:06:43, metric 3
                    > to 10.0.0.6 via so-1/0/0.0
10.0.0.16/30       *[OSPF/10] 00:06:43, metric 4
                    > to 10.0.0.6 via so-1/0/0.0
172.16.0.2/32      *[Direct/0] 00:07:48
                    > via lo0.0
172.16.0.3/32      *[OSPF/10] 00:06:56, metric 1
                    > to 10.0.0.6 via so-1/0/0.0
172.16.0.4/32      *[OSPF/10] 00:06:43, metric 2
                    > to 10.0.0.6 via so-1/0/0.0
172.16.0.5/32      *[OSPF/10] 00:06:43, metric 3
                    > to 10.0.0.6 via so-1/0/0.0
172.16.0.6/32      *[OSPF/10] 00:06:43, metric 4
                    > to 10.0.0.6 via so-1/0/0.0
224.0.0.5/32       *[OSPF/10] 00:07:54, metric 1
                      MultiRecv

inet.3: 3 destinations, 3 routes (3 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

172.16.0.3/32      *[LDP/9] 00:06:56, metric 1
                    > to 10.0.0.6 via so-1/0/0.0
172.16.0.5/32      *[LDP/9] 00:06:23, metric 1
                    > to 10.0.0.6 via so-1/0/0.0, Push 299792
172.16.0.6/32      *[LDP/9] 00:06:23, metric 1
                    > to 10.0.0.6 via so-1/0/0.0, Push 299808
```

```
VPN-A.inet.0: 5 destinations, 5 routes (5 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.0.0.0/30        *[Direct/0] 00:07:47
                    > via ge-1/0/0.0
10.0.0.2/32        *[Local/0] 00:07:47
                      Local via ge-1/0/0.0
10.0.0.20/30       *[BGP/170] 00:06:23, localpref 100, from 172.16.0.6
                      AS path: I, validation-state: unverified
                    > to 10.0.0.6 via so-1/0/0.0, Push 299792, Push 299808(top)
172.16.0.1/32      *[Static/5] 00:07:47
                    > to 10.0.0.1 via ge-1/0/0.0
172.16.0.7/32      *[BGP/170] 00:06:23, localpref 100, from 172.16.0.6
                      AS path: I, validation-state: unverified
                    > to 10.0.0.6 via so-1/0/0.0, Push 299792, Push 299808(top)

mpls.0: 9 destinations, 9 routes (9 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0                  *[MPLS/0] 00:07:54, metric 1
                      Receive
1                  *[MPLS/0] 00:07:54, metric 1
                      Receive
2                  *[MPLS/0] 00:07:54, metric 1
                      Receive
13                 *[MPLS/0] 00:07:54, metric 1
                      Receive
299776             *[LDP/9] 00:06:56, metric 1
                    > to 10.0.0.6 via so-1/0/0.0, Pop
299776(S=0)        *[LDP/9] 00:06:56, metric 1
                    > to 10.0.0.6 via so-1/0/0.0, Pop
299792             *[VPN/170] 00:06:40
                    > to 10.0.0.1 via ge-1/0/0.0, Pop
299808             *[LDP/9] 00:06:23, metric 1
                    > to 10.0.0.6 via so-1/0/0.0, Swap 299792
299824             *[LDP/9] 00:06:23, metric 1
                    > to 10.0.0.6 via so-1/0/0.0, Swap 299808

bgp.l3vpn.0: 2 destinations, 2 routes (2 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

64510:1:10.0.0.20/30
                   *[BGP/170] 00:06:40, localpref 100, from 172.16.0.6
                      AS path: I, validation-state: unverified
                    > to 10.0.0.6 via so-1/0/0.0, Push 299792, Push 299808(top)
64510:1:172.16.0.7/32
                   *[BGP/170] 00:06:40, localpref 100, from 172.16.0.6
                      AS path: I, validation-state: unverified
                    > to 10.0.0.6 via so-1/0/0.0, Push 299792, Push 299808(top)
```

```
user@PE2> show route
inet.0: 11 destinations, 11 routes (11 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.0.0.4/30        *[OSPF/10] 00:07:12, metric 4
                    > to 10.0.0.17 via so-0/0/0.0
10.0.0.8/30        *[OSPF/10] 00:07:23, metric 3
                    > to 10.0.0.17 via so-0/0/0.0
10.0.0.12/30       *[OSPF/10] 00:07:28, metric 2
                    > to 10.0.0.17 via so-0/0/0.0
10.0.0.16/30       *[Direct/0] 00:08:19
```

```
                    > via so-0/0/0.0
10.0.0.18/32       *[Local/0] 00:08:19
                      Local via so-0/0/0.0
172.16.0.2/32      *[OSPF/10] 00:07:12, metric 4
                    > to 10.0.0.17 via so-0/0/0.0
172.16.0.3/32      *[OSPF/10] 00:07:12, metric 3
                    > to 10.0.0.17 via so-0/0/0.0
172.16.0.4/32      *[OSPF/10] 00:07:23, metric 2
                    > to 10.0.0.17 via so-0/0/0.0
172.16.0.5/32      *[OSPF/10] 00:07:28, metric 1
                    > to 10.0.0.17 via so-0/0/0.0
172.16.0.6/32      *[Direct/0] 00:08:20
                    > via lo0.0
224.0.0.5/32       *[OSPF/10] 00:08:26, metric 1
                      MultiRecv

inet.3: 3 destinations, 3 routes (3 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

172.16.0.2/32      *[LDP/9] 00:06:52, metric 1
                    > to 10.0.0.17 via so-0/0/0.0, Push 299808
172.16.0.3/32      *[LDP/9] 00:06:52, metric 1
                    > to 10.0.0.17 via so-0/0/0.0, Push 299792
172.16.0.5/32      *[LDP/9] 00:07:28, metric 1
                    > to 10.0.0.17 via so-0/0/0.0

VPN-A.inet.0: 5 destinations, 5 routes (5 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.0.0.0/30        *[BGP/170] 00:06:52, localpref 100, from 172.16.0.2
                      AS path: I, validation-state: unverified
                    > to 10.0.0.17 via so-0/0/0.0, Push 299792, Push 299808(top)
10.0.0.20/30       *[Direct/0] 00:08:18
                    > via so-0/2/0.0
10.0.0.21/32       *[Local/0] 00:08:18
                      Local via so-0/2/0.0
172.16.0.1/32      *[BGP/170] 00:06:52, localpref 100, from 172.16.0.2
                      AS path: I, validation-state: unverified
                    > to 10.0.0.17 via so-0/0/0.0, Push 299792, Push 299808(top)
172.16.0.7/32      *[Static/5] 00:08:18
                    > to 10.0.0.22 via so-0/2/0.0

mpls.0: 9 destinations, 9 routes (9 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0                  *[MPLS/0] 00:08:25, metric 1
                      Receive
1                  *[MPLS/0] 00:08:25, metric 1
                      Receive
2                  *[MPLS/0] 00:08:25, metric 1
                      Receive
13                 *[MPLS/0] 00:08:25, metric 1
                      Receive
299776             *[LDP/9] 00:07:28, metric 1
                    > to 10.0.0.17 via so-0/0/0.0, Pop
299776(S=0)        *[LDP/9] 00:07:28, metric 1
                    > to 10.0.0.17 via so-0/0/0.0, Pop
299792             *[VPN/170] 00:07:11
                    > to 10.0.0.22 via so-0/2/0.0, Pop
299808             *[LDP/9] 00:06:52, metric 1
                    > to 10.0.0.17 via so-0/0/0.0, Swap 299792
```

```
299824             *[LDP/9] 00:06:52, metric 1
                    > to 10.0.0.17 via so-0/0/0.0, Swap 299808

bgp.l3vpn.0: 2 destinations, 2 routes (2 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

64510:0:10.0.0.0/30
                   *[BGP/170] 00:07:11, localpref 100, from 172.16.0.2
                      AS path: I, validation-state: unverified
                    > to 10.0.0.17 via so-0/0/0.0, Push 299792, Push 299808(top)
64510:0:172.16.0.1/32
                   *[BGP/170] 00:07:11, localpref 100, from 172.16.0.2
                      AS path: I, validation-state: unverified
                    > to 10.0.0.17 via so-0/0/0.0, Push 299792, Push 299808(top)

user@P1> show route
inet.0: 12 destinations, 12 routes (12 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.0.0.4/30        *[Direct/0] 00:08:49
                    > via so-1/0/0.0
10.0.0.6/32        *[Local/0] 00:08:49
                      Local via so-1/0/0.0
10.0.0.8/30        *[Direct/0] 00:08:48
                    > via so-1/0/1.0
10.0.0.9/32        *[Local/0] 00:08:49
                      Local via so-1/0/1.0
10.0.0.12/30       *[OSPF/10] 00:07:48, metric 2
                    > to 10.0.0.10 via so-1/0/1.0
10.0.0.16/30       *[OSPF/10] 00:07:48, metric 3
                    > to 10.0.0.10 via so-1/0/1.0
172.16.0.2/32      *[OSPF/10] 00:07:59, metric 1
                    > to 10.0.0.5 via so-1/0/0.0
172.16.0.3/32      *[Direct/0] 00:08:49
                    > via lo0.0
172.16.0.4/32      *[OSPF/10] 00:07:48, metric 1
                    > to 10.0.0.10 via so-1/0/1.0
172.16.0.5/32      *[OSPF/10] 00:07:48, metric 2
                    > to 10.0.0.10 via so-1/0/1.0
172.16.0.6/32      *[OSPF/10] 00:07:48, metric 3
                    > to 10.0.0.10 via so-1/0/1.0
224.0.0.5/32       *[OSPF/10] 00:08:57, metric 1
                      MultiRecv

inet.3: 4 destinations, 7 routes (3 active, 0 holddown, 3 hidden)
+ = Active Route, - = Last Active, * = Both

172.16.0.2/32      *[LDP/9] 00:07:59, metric 1
                    > to 10.0.0.5 via so-1/0/0.0
172.16.0.5/32      *[RSVP/7/1] 00:07:26, metric 2
                    > to 10.0.0.10 via so-1/0/1.0, label-switched-path P1-to-P3
                    [LDP/9] 00:07:26, metric 1
                    > to 10.0.0.10 via so-1/0/1.0, label-switched-path P1-to-P3
172.16.0.6/32      *[LDP/9] 00:07:26, metric 1
                    > to 10.0.0.10 via so-1/0/1.0, label-switched-path P1-to-P3

mpls.0: 8 destinations, 8 routes (8 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0                  *[MPLS/0] 00:08:56, metric 1
                      Receive
1                  *[MPLS/0] 00:08:56, metric 1
```

```
                   Receive
2                  *[MPLS/0] 00:08:56, metric 1
                   Receive
13                 *[MPLS/0] 00:08:56, metric 1
                   Receive
299776             *[LDP/9] 00:07:59, metric 1
                    > to 10.0.0.5 via so-1/0/0.0, Pop
299776(S=0)        *[LDP/9] 00:07:59, metric 1
                    > to 10.0.0.5 via so-1/0/0.0, Pop
299792             *[LDP/9] 00:07:26, metric 1
                    > to 10.0.0.10 via so-1/0/1.0, label-switched-path P1-to-P3
299808             *[LDP/9] 00:07:26, metric 1
                    > to 10.0.0.10 via so-1/0/1.0, label-switched-path P1-to-P3

user@P2> show route
inet.0: 12 destinations, 12 routes (12 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.0.0.4/30        *[OSPF/10] 00:08:38, metric 2
                    > to 10.0.0.9 via so-1/1/0.0
10.0.0.8/30        *[Direct/0] 00:09:37
                    > via so-1/1/0.0
10.0.0.10/32       *[Local/0] 00:09:37
                   Local via so-1/1/0.0
10.0.0.12/30       *[Direct/0] 00:09:33
                    > via at-2/0/0.0
10.0.0.13/32       *[Local/0] 00:09:33
                   Local via at-2/0/0.0
10.0.0.16/30       *[OSPF/10] 00:08:38, metric 2
                    > to 10.0.0.14 via at-2/0/0.0
172.16.0.2/32      *[OSPF/10] 00:08:38, metric 2
                    > to 10.0.0.9 via so-1/1/0.0
172.16.0.3/32      *[OSPF/10] 00:08:38, metric 1
                    > to 10.0.0.9 via so-1/1/0.0
172.16.0.4/32      *[Direct/0] 00:09:37
                    > via lo0.0
172.16.0.5/32      *[OSPF/10] 00:08:38, metric 1
                    > to 10.0.0.14 via at-2/0/0.0
172.16.0.6/32      *[OSPF/10] 00:08:38, metric 2
                    > to 10.0.0.14 via at-2/0/0.0
224.0.0.5/32       *[OSPF/10] 00:09:46, metric 1
                   MultiRecv

mpls.0: 8 destinations, 8 routes (8 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0                  *[MPLS/0] 00:09:45, metric 1
                   Receive
1                  *[MPLS/0] 00:09:45, metric 1
                   Receive
2                  *[MPLS/0] 00:09:45, metric 1
                   Receive
13                 *[MPLS/0] 00:09:45, metric 1
                   Receive
299776             *[RSVP/7/1] 00:08:15, metric 1
                    > to 10.0.0.14 via at-2/0/0.0, label-switched-path P1-to-P3
299776(S=0)        *[RSVP/7/1] 00:08:15, metric 1
                    > to 10.0.0.14 via at-2/0/0.0, label-switched-path P1-to-P3
299792             *[RSVP/7/1] 00:08:13, metric 1
                    > to 10.0.0.9 via so-1/1/0.0, label-switched-path P3-to-P1
299792(S=0)        *[RSVP/7/1] 00:08:13, metric 1
                    > to 10.0.0.9 via so-1/1/0.0, label-switched-path P3-to-P1
```

```
user@P3> show route
inet.0: 12 destinations, 12 routes (12 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

10.0.0.4/30        *[OSPF/10] 00:08:09, metric 3
                    > to 10.0.0.13 via at-2/0/1.0
10.0.0.8/30        *[OSPF/10] 00:08:19, metric 2
                    > to 10.0.0.13 via at-2/0/1.0
10.0.0.12/30       *[Direct/0] 00:09:08
                    > via at-2/0/1.0
10.0.0.14/32       *[Local/0] 00:09:15
                      Local via at-2/0/1.0
10.0.0.16/30       *[Direct/0] 00:09:14
                    > via so-0/0/0.0
10.0.0.17/32       *[Local/0] 00:09:14
                      Local via so-0/0/0.0
172.16.0.2/32      *[OSPF/10] 00:08:09, metric 3
                    > to 10.0.0.13 via at-2/0/1.0
172.16.0.3/32      *[OSPF/10] 00:08:09, metric 2
                    > to 10.0.0.13 via at-2/0/1.0
172.16.0.4/32      *[OSPF/10] 00:08:19, metric 1
                    > to 10.0.0.13 via at-2/0/1.0
172.16.0.5/32      *[Direct/0] 00:09:15
                    > via lo0.0
172.16.0.6/32      *[OSPF/10] 00:08:24, metric 1
                    > to 10.0.0.18 via so-0/0/0.0
224.0.0.5/32       *[OSPF/10] 00:09:21, metric 1
                      MultiRecv

inet.3: 4 destinations, 7 routes (3 active, 0 holddown, 3 hidden)
+ = Active Route, - = Last Active, * = Both

172.16.0.2/32      *[LDP/9] 00:07:48, metric 1
                    > to 10.0.0.13 via at-2/0/1.0, label-switched-path P3-to-P1
172.16.0.3/32      *[RSVP/7/1] 00:07:48, metric 2
                    > to 10.0.0.13 via at-2/0/1.0, label-switched-path P3-to-P1
                    [LDP/9] 00:07:48, metric 1
                    > to 10.0.0.13 via at-2/0/1.0, label-switched-path P3-to-P1
172.16.0.6/32      *[LDP/9] 00:08:24, metric 1
                    > to 10.0.0.18 via so-0/0/0.0

mpls.0: 8 destinations, 8 routes (8 active, 0 holddown, 0 hidden)
+ = Active Route, - = Last Active, * = Both

0                  *[MPLS/0] 00:09:21, metric 1
                      Receive
1                  *[MPLS/0] 00:09:21, metric 1
                      Receive
2                  *[MPLS/0] 00:09:21, metric 1
                      Receive
13                 *[MPLS/0] 00:09:21, metric 1
                      Receive
299776             *[LDP/9] 00:08:24, metric 1
                    > to 10.0.0.18 via so-0/0/0.0, Pop
299776(S=0)        *[LDP/9] 00:08:24, metric 1
                    > to 10.0.0.18 via so-0/0/0.0, Pop
299792             *[LDP/9] 00:07:48, metric 1
                    > to 10.0.0.13 via at-2/0/1.0, label-switched-path P3-to-P1
299808             *[LDP/9] 00:07:48, metric 1
                    > to 10.0.0.13 via at-2/0/1.0, label-switched-path P3-to-P1
```

Related Documentation

- Configuring a Signaling Protocol and LSPs for VPNs
- Benefits of Configuring the LDP-Over-RSVP Feature on page 1