LDP over RSVP Using OSPF as IGP

In This Chapter

This section provides information about Label Distribution protocol (LDP) over Resource Reservation Protocol for Traffic Engineering (RSVP-TE), also called LDPoRSVP, that uses RSVP Label Switched Paths (LSPs) as a transport vehicle to carry the packets using LDP LSPs.

Topics in this section include:

Applicability

This section is applicable to all of the 7750, 7450 and 7710 SR series. Tested on release 7.0.R.5. No pre-requisites are required. The 7750 SR-c4 is supported from 8.0.R.4 and higher.

Overview

Introduction

Only user packets are tunneled over the RSVP LSPs, targeted LDP (T-LDP) control messages are still sent unlabeled using the IGP shortest path. Since LDP does not have traffic engineering (TE) and fast reroute (FRR) convergence below 50 ms, it can now benefit from these two RSVP-TE features.

The main advantage of LDPoRSVP is seen in large networks. A full mesh of intra-area RSVP LSPs between PE nodes (which in some cases is not scalable) is not needed anymore. While an LER may not have that many tunnels, any transit node will potentially have thousands of LSPs, and if each transit node also has to deal with detours tunnels or bypass tunnels, this number can make the LSR overly burdened.

LDPoRSVP feature can be configured in an intra-area domain and an inter-area domain. Any router in a given area can be a stitching point for LDP over RSVP. LDPoRSVP introduces a new tunnel type, tunnel-in-tunnel (in addition to the existing LDP tunnel type and RSVP tunnel type). If multiple tunnel types match the destination PE Forwarding Equivalence Class (FEC) lookup, LDP will prefer an LDP tunnel over an LDPoRSVP tunnel by default.

First, it is important to understand how LDP FEC resolution is working (with LDPoRSVP enabled). A more detailed explanation can be found later on in this section. The ingress LER receives an LDP label message including a FEC with prefix **P** and label **L** from peer **A** by a T-LDP session. LDP tries to resolve prefix **P** by performing a lookup in the Routing Table Manager (RTM). The result of this is a next-hop (NH) to the destination PE, either an intra-area PE (intra-area context) or an ABR (inter-area context). When the NH matches the targeted LDP peer, LDP performs a second lookup for that NH in the Tunnel Table Manager (TTM) which returns a user configured RSVP LSP with the best metric. If there are more than one configured RSVP LSP with the best metric, LDP selects the first available RSVP LSP. If all user configured RSVP LSPs are down, no more action is taken. If the user did not configure any RSVP LSPs under the T-LDP context, the lookup in TTM will return the first available RSVP LSP which terminates on the ABR (inter-area) or intra-area PE with the lowest metric.

If the lookup in TTM results in no RSVP LSP, the system can fall back to link-level LDP (iLDP), In that way, it is possible that the NH is reachable using iLDP. Accordingly, the egress label will be installed on the ingress LER.

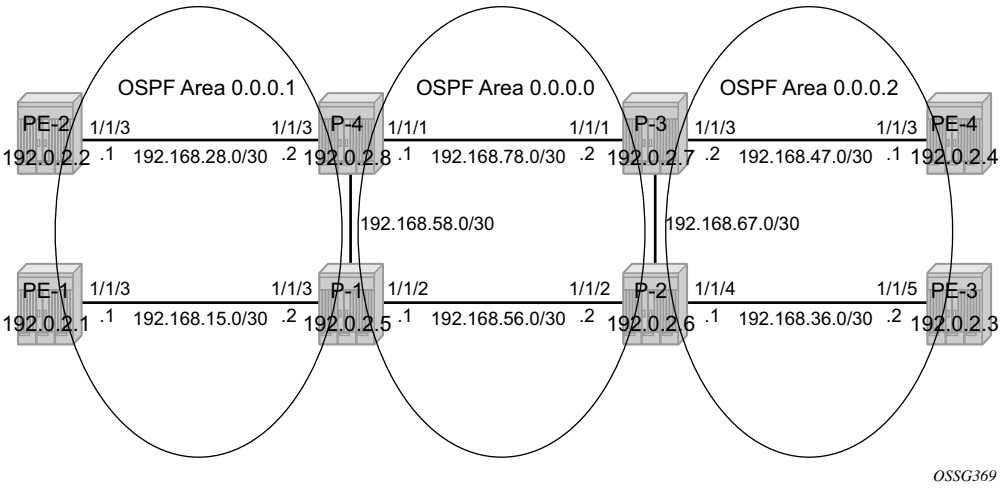

Figure 153: Initial Topology

OSPF area 0.0.0.1 and OSPF area 0.0.0.2 should be seen as two metro areas, connected to each other via a core area, represented by OSPF backbone area (area 0.0.0.0). Therefore, P-1/P-2/P-3 and P-4 are all acting as area border routers (ABRs). LDPoRSVP principles will be shown for intra-area PE communication (PE-1 <=> PE-2) and inter-area communication (PE-1 <=> PE-3).

Configuration

Step 1. Configuring the IP/MPLS network.

The system addresses and IP interface addresses are configured according to Figure 153 on page 1068. An interior gateway protocol (IGP) is needed to distribute routing information on all PEs. In this case, the IGP is OSPF using the backbone area (area 0.0.0.0) in the core and normal areas (area 0.0.0.1 and area 0.0.0.2) in the two metro regions, connected towards the backbone area via ABRs. A configuration example is shown below for PE-1 and P-1. A similar configuration can be derived for the other P and PE nodes.

```
A:PE-1# configure router ospf
            traffic-engineering
            area 0.0.0.1
                interface "system"
                exit
                interface "int-PE-1-P-1"
                    interface-type point-to-point
                exit
            exit

A:P-1# configure router ospf
            traffic-engineering
            area 0.0.0.0
                interface "int-P-1-P-2"
                    interface-type point-to-point
                exit
                interface "int-P-1-P-4"
                    interface-type point-to-point
                exit
            exit
            area 0.0.0.1
                interface "int-P-1-PE-1"
                    interface-type point-to-point
                exit
            exit
```

Since fast reroute will be enabled on the RSVP LSPs in the core area, traffic engineering is needed on the IGP. By doing this, OSPF will generate opaque LSAs which are collected in a traffic engineering database (TED), separate from the traditional OSPF topology database. OSPF interfaces are setup as type point-to-point to improve convergence, no DR/BDR election process is performed.[1]

On all nodes originating/terminating a T-LDP session, an explicit **ldp-over-rsvp** parameter must be configured to enable this OSPF instance for LDPoRSVP. In the example, this becomes.

```
A:PE-[1..4]# configure router ospf ldp-over-rsvp
A:P-[1..4]# configure router ospf ldp-over-rsvp
```

1.Convergence is out of the scope of this document.

To verify that OSPF neighbors are up (state null, **show router ospf neighbor**) is performed. To check if IP interface addresses/subnets are known on all PEs, **show router route-table** or **show router fib** *IOM-card-slot* will display the content of the forwarding information base (FIB).

```
A:PE-1# show router ospf neighbor
===============================================================================
OSPF Neighbors
===============================================================================
Interface-Name                   Rtr Id          State      Pri  RetxQ   TTL
-------------------------------------------------------------------------------
int-PE-1-P-1                     192.0.2.5       Full       1    0       36
-------------------------------------------------------------------------------
No. of Neighbors: 1
===============================================================================
A:PE-1#


A:PE-1# show router route-table
===============================================================================
Route Table (Router: Base)
===============================================================================
Dest Prefix                                    Type    Proto    Age         Pref
       Next Hop[Interface Name]                                      Metric
-------------------------------------------------------------------------------
192.0.2.1/32                                   Local   Local    02h42m42s   0
       system                                                        0
192.0.2.2/32                                   Remote  OSPF     02h42m26s   10
       192.168.15.2                                                  3000
192.0.2.3/32                                   Remote  OSPF     02h42m26s   10
       192.168.15.2                                                  3000
192.0.2.4/32                                   Remote  OSPF     02h41m55s   10
       192.168.15.2                                                  4000
192.0.2.5/32                                   Remote  OSPF     02h42m27s   10
       192.168.15.2                                                  1000
192.0.2.6/32                                   Remote  OSPF     02h42m26s   10
       192.168.15.2                                                  2000
192.0.2.7/32                                   Remote  OSPF     02h42m10s   10
       192.168.15.2                                                  3000
192.0.2.8/32                                   Remote  OSPF     02h42m25s   10
       192.168.15.2                                                  2000
192.168.15.0/30                                Local   Local    02h42m32s   0
       int-PE-1-P-1                                                  0
192.168.28.0/30                                Remote  OSPF     02h42m10s   10
       192.168.15.2                                                  3000
192.168.36.0/30                                Remote  OSPF     02h42m26s   10
       192.168.15.2                                                  3000
192.168.47.0/30                                Remote  OSPF     02h42m10s   10
       192.168.15.2                                                  4000
192.168.56.0/30                                Remote  OSPF     02h42m27s   10
       192.168.15.2                                                  2000
192.168.58.0/30                                Remote  OSPF     02h42m27s   10
       192.168.15.2                                                  2000
192.168.67.0/30                                Remote  OSPF     02h42m26s   10
       192.168.15.2                                                  3000
192.168.78.0/30                                Remote  OSPF     02h42m10s   10
       192.168.15.2                                                  3000
-------------------------------------------------------------------------------
No. of Routes: 16
```

```
===============================================================================
A:PE-1#

A:PE-1# show router fib 1
===============================================================================
FIB Display
===============================================================================
Prefix                                                          Protocol
    NextHop
-------------------------------------------------------------------------------
192.0.2.1/32                                                    LOCAL
    192.0.2.1 (system)
192.0.2.2/32                                                    OSPF
    192.168.15.2 (int-PE-1-P-1)
192.0.2.3/32                                                    OSPF
    192.168.15.2 (int-PE-1-P-1)
192.0.2.4/32                                                    OSPF
    192.168.15.2 (int-PE-1-P-1)
192.0.2.5/32                                                    OSPF
    192.168.15.2 (int-PE-1-P-1)
192.0.2.6/32                                                    OSPF
    192.168.15.2 (int-PE-1-P-1)
192.0.2.7/32                                                    OSPF
    192.168.15.2 (int-PE-1-P-1)
192.0.2.8/32                                                    OSPF
    192.168.15.2 (int-PE-1-P-1)
192.168.15.0/30                                                 LOCAL
    192.168.15.0 (int-PE-1-P-1)
192.168.28.0/30                                                 OSPF
    192.168.15.2 (int-PE-1-P-1)
192.168.36.0/30                                                 OSPF
    192.168.15.2 (int-PE-1-P-1)
192.168.47.0/30                                                 OSPF
    192.168.15.2 (int-PE-1-P-1)
192.168.56.0/30                                                 OSPF
    192.168.15.2 (int-PE-1-P-1)
192.168.58.0/30                                                 OSPF
    192.168.15.2 (int-PE-1-P-1)
192.168.67.0/30                                                 OSPF
    192.168.15.2 (int-PE-1-P-1)
192.168.78.0/30                                                 OSPF
    192.168.15.2 (int-PE-1-P-1)
-------------------------------------------------------------------------------
Total Entries : 16
-------------------------------------------------------------------------------
===============================================================================
A:PE-1#
```

The next step in the process of setting up the IP/MPLS network, is enabling the IP interfaces in the MPLS and RSVP context on all involved nodes (PE and P nodes). By default, the system interface is put automatically within the MPLS/RSVP context. When an interface is put in the MPLS context, the system also copies it into the RSVP context. Explicit enabling of MPLS and RSVP context is done by the **no shutdown** command. The following output displays the MPLS/RSVP configuration for PE-1.

```
A:PE-1# configure router mpls no shutdown

A:PE-1# configure router rsvp no shutdown

A:PE-1# configure router mpls
            interface "system"
            exit
            interface "int-PE-1-P-1"
            exit
            no shutdown

A:PE-1# configure router rsvp
            interface "system"
            exit
            interface "int-PE-1-P-1"
            exit
            no shutdown
```

Step 2. Configure the RSVP LSPs. In both metro areas RSVP LSPs are setup from all PEs towards the ABRs, no intra-area PE-PE RSVP LSPs are needed. In the core/backbone, a full RSVP LSP mesh is required. To simplify the RSVP LSP configuration, no fast reroute is enabled on the RSVP LSPs in the metro areas, only in the backbone area. All RSVP paths are set up as **strict**. As an example, the configuration commands for PE-1 and P-1 node will look like the following output.

```
A:PE-1# configure router mpls
            ...
            path "p-pe1-p1"
                hop 1 192.168.15.2 strict
                no shutdown
            exit
            path "p-pe1-p1-p4"
                hop 1 192.168.15.2 strict
                hop 2 192.168.58.2 strict
                no shutdown
            exit
            lsp "LSP-PE-1-P-1"
                to 192.0.2.5
                primary "p-pe1-p1"
                exit
                no shutdown
            exit
            lsp "LSP-PE-1-P-4"
                to 192.0.2.8
                primary "p-pe1-p1-p4"
                exit
                no shutdown
            exit
            no shutdown

A:P-1# configure router mpls
            ...
            path "p-p1-p2"
                hop 1 192.168.56.2 strict
                no shutdown
            exit
            path "p-p1-p4"
                hop 1 192.168.58.2 strict
                no shutdown
            exit
            path "p-p1-p2-p3"
                hop 1 192.168.56.2 strict
                hop 2 192.168.67.2 strict
                no shutdown
            exit
            path "p-p1-pe1"
                hop 1 192.168.15.1 strict
                no shutdown
            exit
            path "p-p1-p4-pe2"
                hop 1 192.168.58.2 strict
                hop 2 192.168.28.1 strict
                no shutdown
            exit
            lsp "LSP-P-1-PE-1"
                to 192.0.2.1
                primary "p-p1-pe1"
```

```
        exit
        no shutdown
    exit
    lsp "LSP-P-1-PE-2"
        to 192.0.2.2
        primary "p-p1-p4-pe2"
        exit
        no shutdown
    exit
    lsp "LSP-P-1-P-2"
        to 192.0.2.6
        cspf
        fast-reroute facility
        exit
        primary "p-p1-p2"
        exit
        no shutdown
    exit
    lsp "LSP-P-1-P-3"
        to 192.0.2.7
        cspf
        fast-reroute facility
        exit
        primary "p-p1-p2-p3"
        exit
        no shutdown
    exit
    lsp "LSP-P-1-P-4"
        to 192.0.2.8
        cspf
        fast-reroute facility
        exit
        primary "p-p1-p4"
        exit
        no shutdown
    exit
    no shutdown
```

To display the state of RSVP LSPs, several show commands can be used. A command to show the TTM is **show router tunnel-table** with parameter **rsvp** to reference to RSVP LSP signaling protocol. By default, an RSVP LSP has preference **7**.

```
A:PE-1# show router mpls lsp
===============================================================================
MPLS LSPs (Originating)
===============================================================================
LSP Name                            To                  Fastfail     Adm   Opr
                                                        Config
-------------------------------------------------------------------------------
LSP-PE-1-P-1                        192.0.2.5           No           Up    Up
LSP-PE-1-P-4                        192.0.2.8           No           Up    Up
-------------------------------------------------------------------------------
LSPs : 2
===============================================================================
A:PE-1#
A:PE-1# show router tunnel-table
===============================================================================
Tunnel Table (Router: Base)
===============================================================================
Destination        Owner Encap TunnelId  Pref     Nexthop        Metric
-------------------------------------------------------------------------------
192.0.2.5/32       rsvp  MPLS  1         7        192.168.15.2   65535
192.0.2.8/32       rsvp  MPLS  131       7        192.168.15.2   65535
===============================================================================
A:PE-1#
```

```
A:P-1# show router mpls lsp
===============================================================================
MPLS LSPs (Originating)
===============================================================================
LSP Name                            To                  Fastfail     Adm   Opr
                                                        Config
-------------------------------------------------------------------------------
LSP-P-1-PE-1                        192.0.2.1           No           Up    Up
LSP-P-1-P-2                         192.0.2.6           Yes          Up    Up
LSP-P-1-P-3                         192.0.2.7           Yes          Up    Up
LSP-P-1-P-4                         192.0.2.8           Yes          Up    Up
LSP-P-1-PE-2                        192.0.2.2           No           Up    Up
-------------------------------------------------------------------------------
LSPs : 5
===============================================================================
A:PE-1#
```

```
A:P-1# show router tunnel-table
===============================================================================
Tunnel Table (Router: Base)
===============================================================================
Destination        Owner Encap TunnelId  Pref     Nexthop        Metric
-------------------------------------------------------------------------------
192.0.2.1/32       rsvp  MPLS  1         7        192.168.15.1   65535
192.0.2.2/32       rsvp  MPLS  269       7        192.168.58.2   65535
192.0.2.6/32       rsvp  MPLS  7         7        192.168.56.2   1000
192.0.2.7/32       rsvp  MPLS  11        7        192.168.56.2   2000
```

```
192.0.2.8/32       rsvp  MPLS  13        7        192.168.58.2   1000
===============================================================================
A:PE-1#
```

By default, the metric for strict LSPs configured without constrained shortest path first (CSPF) (RSVP LSPs in metro areas) is infinite (value = 65535). The LSP metric for CSPF LSPs (RSVP LSPs in the core are a) follows the IGP cost. LSP metrics can be explicitly set on the LSP level, see also in the additional topics section.

```
A:P[E]-[1..4]# configure router mpls lsp <lsp-name> metric [0..65535]
```

Note that whenever an RSVP LSP comes up, it is, by default, eligible for LDPoRSVP, meaning that RSVP will signal to the relevant IGP (OSPF in this case) that the LSP should be included in the IGP/SPF run. The destination of the LSP (192.0.2.5) will be considered as a potential endpoint in the FEC resolution. With the **info detail** command, all default settings of a context are shown.

```
A:PE-1# configure router mpls lsp "LSP-PE-1-P-1"
A:PE-1>config>router>mpls>lsp# info detail
                to 192.0.2.5
                ...
                ldp-over-rsvp include
                ...

A:PE-1# show router mpls lsp LSP-PE-1-P-1 detail
===============================================================================
MPLS LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : LSP-PE-1-P-1                    LSP Tunnel ID  : 1
From        : 192.0.2.1                       To             : 192.0.2.5
Adm State   : Up                              Oper State     : Up
...
LdpOverRsvp : Enabled                         VprnAutoBind   : Enabled
...
===============================================================================
A:PE-1#
```

To make an RSVP LSP ineligible for LDPoRSVP, use the **exclude** command.

```
A:PE-1# configure router mpls lsp <LSP-name> ldp-over-rsvp exclude
```

Step 3. Create T-LDP sessions according to RSVP LSPs. It is a must that when configuring an RSVP LSP eligible for LDPoRSVP, also a T-LDP session is initiated. This must be done on all PE and P nodes.

```
A:PE-1# configure router ldp
===============================================================================
            targeted-session
                peer 192.0.2.5
                exit
                peer 192.0.2.8
                exit
            exit
===============================================================================
A:PE-1#


A:PE-1# show router ldp session
===============================================================================
LDP Sessions
===============================================================================
Peer LDP Id        Adj Type   State         Msg Sent  Msg Recv  Up Time
-------------------------------------------------------------------------------
192.0.2.5:0        Targeted   Established   3216      3217      0d 04:53:52
192.0.2.8:0        Targeted   Established   3220      3222      0d 04:53:54
-------------------------------------------------------------------------------
No. of Sessions: 2
===============================================================================
A:PE-1#
```

Step 4. Enable LDPoRSVP. This is done using the **tunneling** keyword inside the T-LDP session context. Configuration is needed on all PE and ABR nodes.

```
A:PE-1# configure router ldp
===============================================================================
            targeted-session
                peer 192.0.2.5
                    tunneling
                    exit
                exit
                peer 192.0.2.8
                    tunneling
                    exit
                exit
            exit
===============================================================================
A:PE-1#
```

As a result of the **tunneling** command, LDPoRSVP process (FEC resolving) is initiated. As already stated in the introduction, FEC resolution is a three-step process. First run an SPF calculation to the destination, then select an endpoint(s) as close to that destination followed by a tunnel(s) to that endpoint. The next two steps go more into detail on this FEC resolution process. Step 5 will handle inter-area FEC resolving and Step 6 will handle intra-area FEC resolving.

Step 5. Inter-area FEC resolving (ingress LER is PE-1, egress LER is PE-3)

Step 5.1 Verification endpoint nodes and associated RSVP tunnels.

The first thing to do in the inter-area FEC resolving process is PE-1 performs an SPF calculation towards PE-3 with the purpose to search for an eligible endpoint, as close as possible to PE-3. An endpoint is eligible when a T-LDP session exists between PE-1 and the endpoint node, tunneling is configured on the endpoint node, PE-1 received a label for the destination FEC from the endpoint and an RSVP LSP exists between PE-1 and endpoint node that can be used for LDPoRSVP.

Endpoint node in OSPF area 1 can be either P-1 or P-4 (only those nodes have a T-LDP session towards PE-1). With **show router ldp bindings prefix 192.0.2.3/32 active**, it can be concluded that P-1 will be the endpoint node.

```
A:PE-1# show router ldp bindings prefix 192.0.2.3/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                 Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.3/32           Push   --      131060    LspId 1        192.0.2.5
192.0.2.3/32           Swap 131063    131060    LspId 1        192.0.2.5
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#


A:PE-1# show router mpls lsp detail
===============================================================================
MPLS LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : LSP-PE-1-P-1                    LSP Tunnel ID  : 1
...
===============================================================================
A:PE-1#


A:PE-1# show router tunnel-table
===============================================================================
Tunnel Table (Router: Base)
===============================================================================
Destination        Owner Encap TunnelId  Pref     Nexthop        Metric
-------------------------------------------------------------------------------
...
192.0.2.5/32       rsvp  MPLS  1         7        192.168.15.2   65535
...
===============================================================================
A:PE-1#
```

Endpoint node in OSPF area 0 can be either P-2,P-3 or P-4 (only those nodes have a T-LDP session towards P-1). With **show router ldp bindings prefix 192.0.2.3/32 active**, it can be concluded that P-2 will be the endpoint node.

```
A:P-1# show router ldp bindings prefix 192.0.2.3/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.3/32          Push   --      131070    LspId 7        192.0.2.6
192.0.2.3/32          Swap 131060    131070    LspId 7        192.0.2.6
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:P-1#


A:P-1# show router mpls lsp detail
===============================================================================
MPLS LSPs (Originating) (Detail)
===============================================================================
...
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : LSP-P-1-P-2                     LSP Tunnel ID  : 7
...
===============================================================================
A:P-1#


A:P-1# show router tunnel-table
===============================================================================
Tunnel Table (Router: Base)
===============================================================================
Destination        Owner Encap TunnelId  Pref     Nexthop        Metric
-------------------------------------------------------------------------------
...
192.0.2.6/32       rsvp  MPLS  7         7        192.168.56.2   1000
...
===============================================================================
A:P-1#
```

On P-2 node, the same commands can be repeated for the final destination node (PE-3). Also there, an RSVP LSP towards PE-3 will be used as transport tunnel for user packets.

```
A:P-2# show router ldp bindings prefix 192.0.2.3/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
```

```
Prefix                  Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.3/32            Push   --      131071    LspId 5        192.0.2.3
192.0.2.3/32            Swap 131070    131071    LspId 5        192.0.2.3
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:P-2#


A:P-2# show router mpls lsp detail
...
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : LSP-P-2-PE-3                     LSP Tunnel ID  : 5
...

A:P-2# show router tunnel-table
===============================================================================
Tunnel Table (Router: Base)
===============================================================================
Destination        Owner Encap TunnelId  Pref     Nexthop        Metric
-------------------------------------------------------------------------------
...
192.0.2.3/32       rsvp  MPLS  5         7        192.168.36.2   65535
...
===============================================================================
A:P-2#
```

P-1 node and P-2 node act as stitching nodes to stitch RSVP LSPs. P-1 will stitch LSP-PE-1-P-1and LSP-P-1-P2 together while P-2 node will stitch LSP-P-1-P-2 and LSP-P-2-PE-3 together.

When the endpoints are defined, one corresponding RSVP LSP to those endpoints will be chosen (when ECMP=1). Selection criteria are as follows. When RSVP LSPs are configured under the T-LDP **tunneling** command (maximum 4), the one with the lowest LSP metric will be selected. When no RSVP LSPs are configured under the T-LDP **tunneling** command, LDP checks TTM for all available RSVP LSPs. The RSVP LSP with the least metric and operational state up will be selected.

Step 5.2 Traffic verification using a VPRN service.

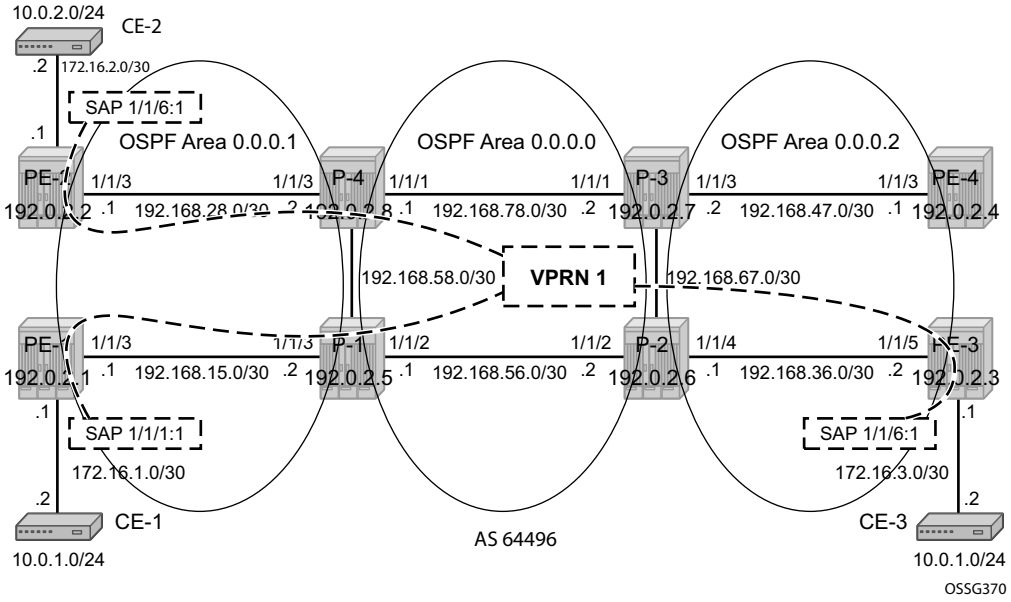

Figure 154: VPRN 1 with LDPoRSVP and No Intra-Area PE Connectivity

VPRN service 1 is setup between three PE nodes (PE-1/PE-2 and PE-3) using the **auto-bind ldp** command. See also Figure 154 for the exact addressing scheme.

```
A:PE-1# configure service vprn 1
            autonomous-system 64496
            route-distinguisher 64496:1
            auto-bind ldp
            vrf-target target:64496:1
            interface "towards-CE-1" create
                address 172.16.1.1/30
                sap 1/1/1:1 create
                exit
            exit
            static-route 10.0.1.0/24 next-hop 172.16.1.2
            no shutdown
```

In order to distribute VPRN information (vpn-ipv4 routes and VPRN service labels) across the service provider network, multi-protocol BGP (MP-BGP) is needed. MP-BGP is configured on PE-1/PE-2 and PE-3 with P-1 (192.0.2.5) acting as route reflector (RR). In this way no full BGP mesh between the three PE-nodes is needed, only a BGP peering towards RR.

```
A:PE-1# configure router bgp
            group "internal"
                family ipv4 vpn-ipv4
                type internal
                neighbor 192.0.2.5
                exit
            exit
            no shutdown

A:P-1# configure router bgp
            group "internal"
                family ipv4 vpn-ipv4
                type internal
                cluster 1.1.1.1
                neighbor 192.0.2.1
                exit
                neighbor 192.0.2.2
                exit
                neighbor 192.0.2.3
                exit
            exit
```

If user traffic is monitored between PE-1 (ingress LER) and PE-3 (egress LER) three labels should be seen. The outer label is the transport label (distributed using RSVP protocol), the inner label is the service label (distributed using MP-BGP). LDPoRSVP will add an extra MPLS label between transport and service label (distributed using LDP). This middle label is used to tell the endpoint nodes (P-1 and P-2 acting as ABR) what to do.

Translated into show commands for traffic ingresssing port 1/1/3 on P-1 node (PE-1<=>P-1 link):

Transport label 131064is added as the top RSVP label on each user packet

```
A:PE-1# show router rsvp session lsp-name LSP-PE-1-P-1::p-pe1-p1 detail
===============================================================================
RSVP Sessions (Detailed)
===============================================================================
-------------------------------------------------------------------------------
LSP : LSP-PE-1-P-1::p-pe1-p1
-------------------------------------------------------------------------------
From           : 192.0.2.1              To             : 192.0.2.5
Tunnel ID      : 1                      LSP ID         : 1536
Style          : SE                     State          : Up
Session Type   : Originate
In Interface   : n/a                    Out Interface  : 1/1/3
In Label       : n/a                    Out Label      : 131064
Previous Hop   : n/a                    Next Hop       : 192.168.15.2
...
===============================================================================
A:PE-1#
```

LDPoRSVP label 131060 is added as the middle LDP label on each user packet

```
A:PE-1# show router ldp bindings prefix 192.0.2.3/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                 Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.3/32           Push   --      131060    LspId 1        192.0.2.5
192.0.2.3/32           Swap 131063    131060    LspId 1        192.0.2.5
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#
```

Service label 131070[2] is added as the inner MP-BGP label on each user packet

```
A:PE-1# show router bgp neighbor 192.0.2.5 received-routes vpn-ipv4
===============================================================================
 BGP Router ID:192.0.2.1        AS:64496       Local AS:64496
===============================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best
===============================================================================
BGP VPN-IPv4 Routes
===============================================================================
Flag  Network                                          LocalPref   MED
      Nexthop                                                      VPNLabel
      As-Path
-------------------------------------------------------------------------------
...
u*>i  64496:1:172.16.3.0/30                            100         None
      192.0.2.3                                                    131070
      No As-Path
===============================================================================
A:PE-1#
```

2.This label will not change at endpoint nodes (P-1 and P-2). Ingress LER (PE-1) will push the service label to the user packet while the egress LER (PE-3) will pop the service label.

Translated into show commands for traffic ingresssing port 1/1/2 on P-2 node (P-1<=>P-2 link):

Transport label 131062 is added as the top RSVP label on each user packet.

```
A:P-1# show router rsvp session lsp-name LSP-P-1-P-2::p-p1-p2 detail
===============================================================================
RSVP Sessions (Detailed)
===============================================================================
-------------------------------------------------------------------------------
LSP : LSP-P-1-P-2::p-p1-p2
-------------------------------------------------------------------------------
From           : 192.0.2.5              To             : 192.0.2.6
Tunnel ID      : 7                      LSP ID         : 48128
Style          : SE                     State          : Up
Session Type   : Originate
In Interface   : n/a                    Out Interface  : 1/1/2
In Label       : n/a                    Out Label      : 131062
Previous Hop   : n/a                    Next Hop       : 192.168.56.2
...
===============================================================================
A:PE-1#
```

LDPoRSVP label 131070 is added as the middle LDP label on each user packet.

```
A:P-1# show router ldp bindings prefix 192.0.2.3/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                 Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.3/32           Push   --      131070    LspId 7        192.0.2.6
192.0.2.3/32           Swap 131060    131070    LspId 7        192.0.2.6
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:P-1#
```

Service label 131070 is added as the inner MP-BGP label on each user packet.

Translated into show commands for traffic ingresssing port 1/1/5 on PE-3 node (P-2<=>PE-3 link).

Transport label 131066 is added as the top RSVP label on each user packet.

```
A:P-2# show router rsvp session lsp-name LSP-P-2-PE-3::p-p2-pe3 detail
===============================================================================
RSVP Sessions (Detailed)
===============================================================================
LSP : LSP-P-2-PE-3::p-p2-pe3
-------------------------------------------------------------------------------
From           : 192.0.2.6              To             : 192.0.2.3
```

```
Tunnel ID      : 5                      LSP ID         : 54272
Style          : SE                     State          : Up
Session Type   : Originate
In Interface   : n/a                    Out Interface  : 1/1/4
In Label       : n/a                    Out Label      : 131066
...
===============================================================================
A:P-2#
```

LDPoRSVP label 131068 is added as the middle LDP label on each user packet.

```
A:P-2# show router ldp bindings prefix 192.0.2.3/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                 Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.3/32           Push   --      131071    LspId 5        192.0.2.3
192.0.2.3/32           Swap 131070    131071    LspId 5        192.0.2.3
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:P-2#
```

Service label 131070 is added as the inner MP-BGP label on each user packet.

Step 6. Intra-area FEC resolving (ingress LER is PE-1, egress LER is PE-2).

Step 6.1 Verification endpoint node and associated RSVP tunnel.

The first thing to do in the intra-area FEC resolving process is PE-1 performs an SPF calculation towards PE-2 with the purpose to search for an eligible endpoint, as close as possible to PE-2. An endpoint is eligible when a T-LDP session exists between PE-1 and the endpoint node, tunneling is configured on the endpoint node, PE-1 received a label for the destination FEC from the endpoint and an RSVP LSP exists between PE-1 and endpoint node that can be used for LDPoRSVP.

First endpoint node in OSPF area 1 can be either P-1 or P-4 (only those nodes have a T-LDP session towards PE-1). With **show router ldp bindings prefix 192.0.2.2/32 active** it can be concluded that P-1 will be the endpoint node.

```
A:PE-1# show router ldp bindings prefix 192.0.2.2/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.2/32          Push   --      131066    LspId 1        192.0.2.5
192.0.2.2/32          Swap 131064    131066    LspId 1        192.0.2.5
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#


A:PE-1# show router mpls lsp detail
===============================================================================
MPLS LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : LSP-PE-1-P-1                    LSP Tunnel ID  : 1
...
===============================================================================
A:PE-1#

A:PE-1# show router tunnel-table
===============================================================================
Tunnel Table (Router: Base)
===============================================================================
Destination        Owner Encap TunnelId  Pref     Nexthop        Metric
-------------------------------------------------------------------------------
...
192.0.2.5/32       rsvp  MPLS  1         7        192.168.15.2   65535
...
===============================================================================
A:PE-1#
```

On P-1 node, the same commands can be repeated for the final destination node (PE-2). Also there, an RSVP LSP towards PE-2 will be used as transport tunnel for user packets can be seen.

```
A:P-1# show router ldp bindings prefix 192.0.2.2/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.2/32          Push   --      131071    LspId 269      192.0.2.2
192.0.2.2/32          Swap 131066    131071    LspId 269      192.0.2.2
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#


A:PE-1# show router mpls lsp detail
===============================================================================
MPLS LSPs (Originating) (Detail)
===============================================================================
...
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : LSP-P-1-PE-2                    LSP Tunnel ID  : 269
...
===============================================================================
A:PE-1#


A:P-1# show router tunnel-table
===============================================================================
Tunnel Table (Router: Base)
===============================================================================
Destination        Owner Encap TunnelId  Pref     Nexthop        Metric
-------------------------------------------------------------------------------
...
192.0.2.2/32       rsvp  MPLS  269       7        192.168.58.2   65535
...
===============================================================================
A:PE-1#
```

P-1 node act as a stitching node to stitch RSVP LSPs. P-1 will stitch LSP-PE-1-P-1 and LSP-P-1-PE2 together.

When the endpoint node (P-1) is defined, the corresponding RSVP LSP to this endpoint will be chosen. Selection criteria are as follows (when ECMP=1). When RSVP LSPs are configured under the T-LDP **tunneling** command (maximum 4), the one with the lowest LSP metric will be selected. When no RSVP LSPs are configured under the T-LDP **tunneling** command, LDP checks TTM for all available RSVP LSPs. The RSVP LSP with the least metric and operational state **up** will be selected.

Step 6.2 Traffic verification using a VPRN service (see Figure 154 on page 1082).

If user traffic between PE-1 (ingress LER) and PE-2 (egress LER) is monitored, three labels are seen. The outer one is the transport label (distributed using RSVP protocol), the inner one is the service label (distributed using MP-BGP). LDPoRSVP will add an extra MPLS label between transport and service label (distributed using LDP). This middle label is used to tell the endpoint node (P-1) what to do.

Translated into show commands for traffic ingresssing port 1/1/3 on P-1 node (PE-1<=>P-1 link):

Transport label 131064 is added as the top RSVP label on each user packet.

```
A:PE-1# show router rsvp session lsp-name LSP-PE-1-P-1::p-pe1-p1 detail
===============================================================================
RSVP Sessions (Detailed)
===============================================================================
LSP : LSP-PE-1-P-1::p-pe1-p1
-------------------------------------------------------------------------------
From           : 192.0.2.1              To             : 192.0.2.5
Tunnel ID      : 1                      LSP ID         : 1536
Style          : SE                     State          : Up
Session Type   : Originate
In Interface   : n/a                    Out Interface  : 1/1/3
In Label       : n/a                    Out Label      : 131064
Previous Hop   : n/a                    Next Hop       : 192.168.15.2
...
===============================================================================
A:PE-1#
```

LDPoRSVP label 131066 is added as the middle LDP label on each user packet.

```
A:PE-1# show router ldp bindings prefix 192.0.2.2/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.2/32          Push   --      131066    LspId 1        192.0.2.5
192.0.2.2/32          Swap 131064    131066    LspId 1        192.0.2.5
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#
```

Service label 131070 is added as the inner MP-BGP label on each user packet[3].

```
A:PE-1# show router bgp neighbor 192.0.2.5 received-routes vpn-ipv4
===============================================================================
 BGP Router ID:192.0.2.1        AS:64496       Local AS:64496
===============================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best
===============================================================================
BGP VPN-IPv4 Routes
===============================================================================
Flag  Network                                                LocalPref   MED
      Nexthop                                                           VPNLabel
      As-Path
-------------------------------------------------------------------------------
u*>i  64496:1:10.0.2.0/24                                    100         None
      192.0.2.2                                                         131070
      No As-Path
□
      No As-Path
u*>i  64496:1:172.16.2.0/30                                  100         None
      192.0.2.2                                                         131070
      No As-Path
...
-------------------------------------------------------------------------------
Routes : 4
===============================================================================
A:PE-1#
```

Translated into show commands for traffic ingresssing port 1/1/3 on PE-2 node (PE-2<=>P-4 link):

Transport label 131064 is added as the top RSVP label on each user packet.

```
A:P-1# show router mpls lsp LSP-P-1-PE-2 path detail[4]
===============================================================================
MPLS LSP LSP-P-1-PE-2 Path  (Detail)
===============================================================================
Legend :
    @ - Detour Available              # - Detour In Use
    b - Bandwidth Protected           n - Node Protected
    s - Soft Preemption
===============================================================================
-------------------------------------------------------------------------------
LSP LSP-P-1-PE-2 Path p-p1-p4-pe2
-------------------------------------------------------------------------------
LSP Name    : LSP-P-1-PE-2                       Path LSP ID : 6144
```

3. This label will not change at endpoint node (P-1). Ingress LER (PE-1) will push the service label to the user packet while the egress LER (PE-2) will pop the service label.

4. **show router rsvp session lsp-name LSP-P-1-PE-2::p-p1-p4-pe2 detail** cannot be used since it only shows the outgoing RSVP label towards P-4 node. On P-4 node, RSVP transport label 131057 will be swapped into RSVP transport label 131064 for the link P-4 <=> PE-2.

```
From        : 192.0.2.5                             To          : 192.0.2.2
Adm State   : Up                                    Oper State  : Up
Path Name   : p-p1-p4-pe2                           Path Type   : Primary
Path Admin  : Up                                    Path Oper   : Up
OutInterface: 1/1/4                                 Out Label   : 131057

ExplicitHops:
    192.168.58.2    -> 192.168.28.1
Actual Hops :
    192.168.58.1(192.0.2.5)                         Record Label    : N/A
 -> 192.168.58.2(192.0.2.8)                         Record Label    : 131057
 -> 192.168.28.1                                    Record Label    : 131064
...
===============================================================================
A:PE-1#
```

LDPoRSVP label 131071 is added as the middle LDP label on each user packet.

```
A:P-1# show router ldp bindings prefix 192.0.2.2/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.2/32          Push   --      131071    LspId 269      192.0.2.2
192.0.2.2/32          Swap 131066    131071    LspId 269      192.0.2.2
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#
```

Service label 131070 is added as the inner MP-BGP label on each user packet.

Additional Topics

Command: **prefer-tunnel-in-tunnel**

If the next-hop router advertised the same FEC over link-level LDP (iLDP), LDP will prefer the iLDP tunnel by default unless the user explicitly changed the default preference using the **prefer-tunnel-in-tunnel** command. In this case an LDPoRSVP tunnel will have precedence.

Until now in this example, no RSVP LSPs are configured inside the **ldp targeted-session peer tunneling** context. Therefore, two additional strict non-cspf RSVP LSPs are added between ingress LER PE-1 node and egress LER P-1 node. Both LSPs will have an explicit metric setting and will be applied inside the **ldp tunneling** context. On the Layer 3 interface between PE-1 and P-1 node, iLDP is enabled.

```
A:PE-1# configure router ldp
            interface-parameters
                interface "int-PE-1-P-1"
                exit
            exit

A:P-1# configure router ldp
            interface-parameters
                interface "int-P-1-PE-1"
                exit
            exit

A:PE-1# configure router mpls
            ...
            path "p-pe1-p1"
                hop 1 192.168.15.2 strict
                no shutdown
            exit
            ...
            lsp "LSP-PE-1-P-1-metric100"
                to 192.0.2.5
                metric 100
                primary "p-pe1-p1"
                exit
            exit
            lsp "LSP-PE-1-P-1-metric200"
                to 192.0.2.5
                metric 200
                primary "p-pe1-p1"
                exit
            exit
            no shutdown

A:PE-1# configure router ldp
            ...
            targeted-session
                peer 192.0.2.5
                    tunneling
                        lsp "LSP-PE-1-P-1-metric100"
```

```
                    lsp "LSP-PE-1-P-1-metric200"
                exit
            exit
            ...
        exit
```

TTM on PE-1 node will look like this:

```
A:PE-1# show router tunnel-table
===============================================================================
Tunnel Table (Router: Base)
===============================================================================
Destination        Owner Encap TunnelId  Pref     Nexthop        Metric
-------------------------------------------------------------------------------

192.0.2.5/32       rsvp  MPLS  1         7        192.168.15.2   65535
192.0.2.5/32       rsvp  MPLS  2         7        192.168.15.2   100
192.0.2.5/32       rsvp  MPLS  3         7        192.168.15.2   200
192.0.2.5/32       ldp   MPLS  -         9        192.168.15.2   1000
...
===============================================================================
A:PE-1#
```

Four LSPs are setup towards P-1 node, three RSVP LSPs and one LDP LSP. Tunnel ID 1 is a reference to LSP-PE-1-P-1. Tunnel ID 2 is a reference to LSP-PE-1-P-1-metric100. Tunnel ID 3 is a reference to LSP-PE-1-P-1-metric200 and owner LDP is a reference to iLDP.

Taken into account the FEC resolution rules, iLDP will win (no LDPoRSVP tunnel will be used).

```
A:PE-1# show router ldp bindings prefix 192.0.2.5/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                 Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.5/32           Push   --      131071    1/1/3          192.168.15.2
192.0.2.5/32           Swap 131067    131071    1/1/3          192.168.15.2
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#
```

This behavior can be changed by setting the **prefer-tunnel-in-tunnel** command in the LDP context. Now, the LDPoRSVP tunnel with the best (= lowest) metric is taken.

```
A:PE-1# configure router ldp prefer-tunnel-in-tunnel
A:PE-1# show router ldp bindings prefix 192.0.2.5/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
```

```
Prefix                  Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.5/32            Push   --      131071    LspId 2        192.0.2.5
192.0.2.5/32            Swap 131067    131071    LspId 2        192.0.2.5
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#


A:PE-1# show router mpls lsp detail
===============================================================================
MPLS LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : LSP-PE-1-P-1-metric100           LSP Tunnel ID  : 2
...
===============================================================================
A:PE-1#
```

If LSP-PE-1-P-1-metric 100 is shutdown, LSP-PE-1-P-1-metric 200 will becomes active.

```
A:PE-1# configure router mpls lsp LSP-PE-1-P-1-metric100 shutdown

A:PE-1# show router ldp bindings prefix 192.0.2.5/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                  Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.5/32            Push   --      131071    LspId 3        192.0.2.5
192.0.2.5/32            Swap 131067    131071    LspId 3        192.0.2.5
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#


A:PE-1# show router mpls lsp detail
===============================================================================
MPLS LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : LSP-PE-1-P-1-metric200           LSP Tunnel ID  : 3
...
===============================================================================
A:PE-1#
```

If LSP-PE-1-P-1-metric 200 is shutdown, iLDP resumes.

```
A:PE-1# configure router mpls lsp LSP-PE-1-P-1-metric200 shutdown

A:PE-1# show router ldp bindings prefix 192.0.2.5/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                  Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.5/32            Push   --      131071    1/1/3          192.168.15.2
192.0.2.5/32            Swap 131067    131071    1/1/3          192.168.15.2
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#
```

Intra-PE connectivity will change LDPoRSVP behavior.

Refer to Figure 155. In the two metro areas, both of the intra PEs are physically connected with each other. Compared with the previous figures, PE-1 node is directly connected to PE-2 and PE-3 node is directly connected to PE-4 (up to the OSPF level).

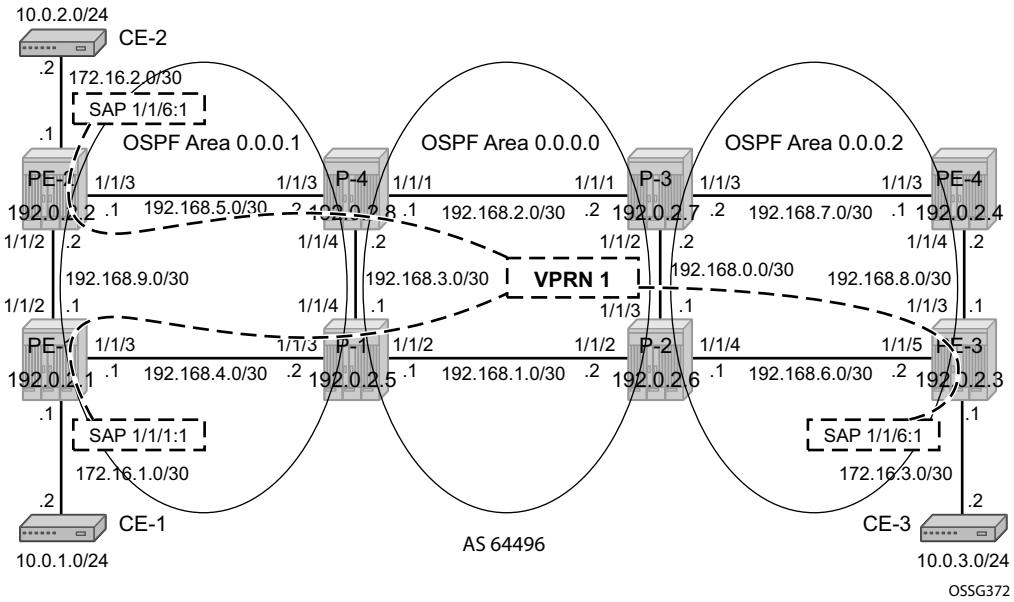

Figure 155: VPRN 1 with LDPoRSVP and Intra-Area PE Connectivity

The SPF path calculation on PE-1 towards destination (PE-2) will not point anymore to P-1 node (as was seen before) but will point directly to PE-2 (shortest, least IGP metric). As a conclusion it can be said that when possible intra-area endpoint node(s) are not part of the calculated SPF path, LDPoRSVP will be not be preferred anymore. For this situation it is advisable to configure iLDP on the intra-PE interfaces to have a fall back mechanism.

Translated into configuration commands on PE-1/PE-2 node, this becomes:

```
A:PE-1# configure router interface int-PE-1-PE-2
            address 192.168.12.1/30
            port 1/1/2

A:PE-2# configure router interface int-PE-1-PE-2
            address 192.168.12.2/30
            port 1/1/2

A:PE-1# configure router ospf
            ...
            area 0.0.0.1
```

```
                ...
                interface "int-PE-1-PE-2"
                    interface-type point-to-point
                exit
            exit

A:PE-2# configure router ospf
            ...
            area 0.0.0.1
                ...
                interface "int-PE-2-PE-1"
                    interface-type point-to-point
                exit
            exit
```

From the moment iLDP is configured, an LDP LSP is setup. Intra-area PE traffic will flow over this LDP LSP.

```
A:PE-1# configure router ldp
            interface-parameters
                interface "int-PE-1-PE-2"
                exit
            exit

A:PE-2# configure router ldp
            interface-parameters
                interface "int-PE-2-PE-1"
                exit
            exit

A:PE-1# show router tunnel-table 192.0.2.2/32
===============================================================================
Tunnel Table (Router: Base)
===============================================================================
Destination        Owner Encap TunnelId  Pref     Nexthop        Metric
-------------------------------------------------------------------------------
192.0.2.2/32       ldp   MPLS   -        9        192.168.12.2   1000
===============================================================================
A:PE-1#
```

If user traffic is monitored, between PE-1 (ingress LER) and PE-2 (egress LER) only two labels are seen. The outer one is the transport label (distributed using LDP protocol), the inner one is the service label (distributed using MP-BGP). No LDPoRSVP label is present anymore. Translated into show commands for traffic ingresssing port 1/1/2 on PE-2 node (PE-1<=>PE-2 link):

Transport label 131071 is added as the top LDP label on each user packet.

```
A:PE-1#  show router ldp bindings prefix 192.0.2.2/32 active
===============================================================================
Legend:  (S) - Static
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix                  Op   IngLbl    EgrLbl    EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
192.0.2.2/32            Push   --      131071    1/1/2          192.168.12.2
192.0.2.2/32            Swap 131063    131071    1/1/2          192.168.12.2
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
A:PE-1#
```

Service label 131070 is added as the inner MP-BGP label on each user packet.

```
A:PE-1# show router bgp neighbor 192.0.2.5 received-routes vpn-ipv4
===============================================================================
 BGP Router ID:192.0.2.1        AS:64496       Local AS:64496
===============================================================================
 Legend -
 Status codes  : u - used, s - suppressed, h - history, d - decayed, * - valid
 Origin codes  : i - IGP, e - EGP, ? - incomplete, > - best
===============================================================================
BGP VPN-IPv4 Routes
===============================================================================
Flag  Network                                              LocalPref   MED
      Nexthop                                                         VPNLabel
      As-Path
-------------------------------------------------------------------------------
u*>i  64496:1:10.0.2.0/24                                  100         None
      192.0.2.2                                                       131070
      No As-Path
...
u*>i  64496:1:172.16.2.0/30                                100         None
      192.0.2.2                                                       131070
      No As-Path
===============================================================================
A:PE-1#
```

Conclusion

LDPoRSVP allows tunneling of user packets towards an LDP far-end destination inside an RSVP LSP (with the benefits of RSVP LSPs, fast-reroute (FRR) and traffic engineering (TE)). The main application of this feature is for deployment of MPLS based services, for example, VPRN, VLL and VPLS services, in large networks where a full mesh of LSPs reaches the limits of scalability.