Module 12a – MPLS Traffic Engineering Configuration Lab

Objective: All the routers are pre-configured with basic interface, OSPF, BGP, MPLS Label Distribution Protocol (LDP) configuration according to the following topology diagram. Required LSPs are already built among the loopback interfaces of all the infrastructure routers. Need to configure and test MPLS Traffic Engineering (TE) feature from one side of the TE tunnel to the other side.
Main strategy will be to verify the TE tunnel operation is by checking the LSP for an FEC (i.e destination prefix) before the tunnel is setup and how the LSP has been changed (I.e. LDP Labels) after the tunnel has been setup.

Prerequisites: Knowledge of IGP, EGP, MPLS, LDP and Cisco IOS CLI.

The following will be the common topology and IP address plan used for the labs.

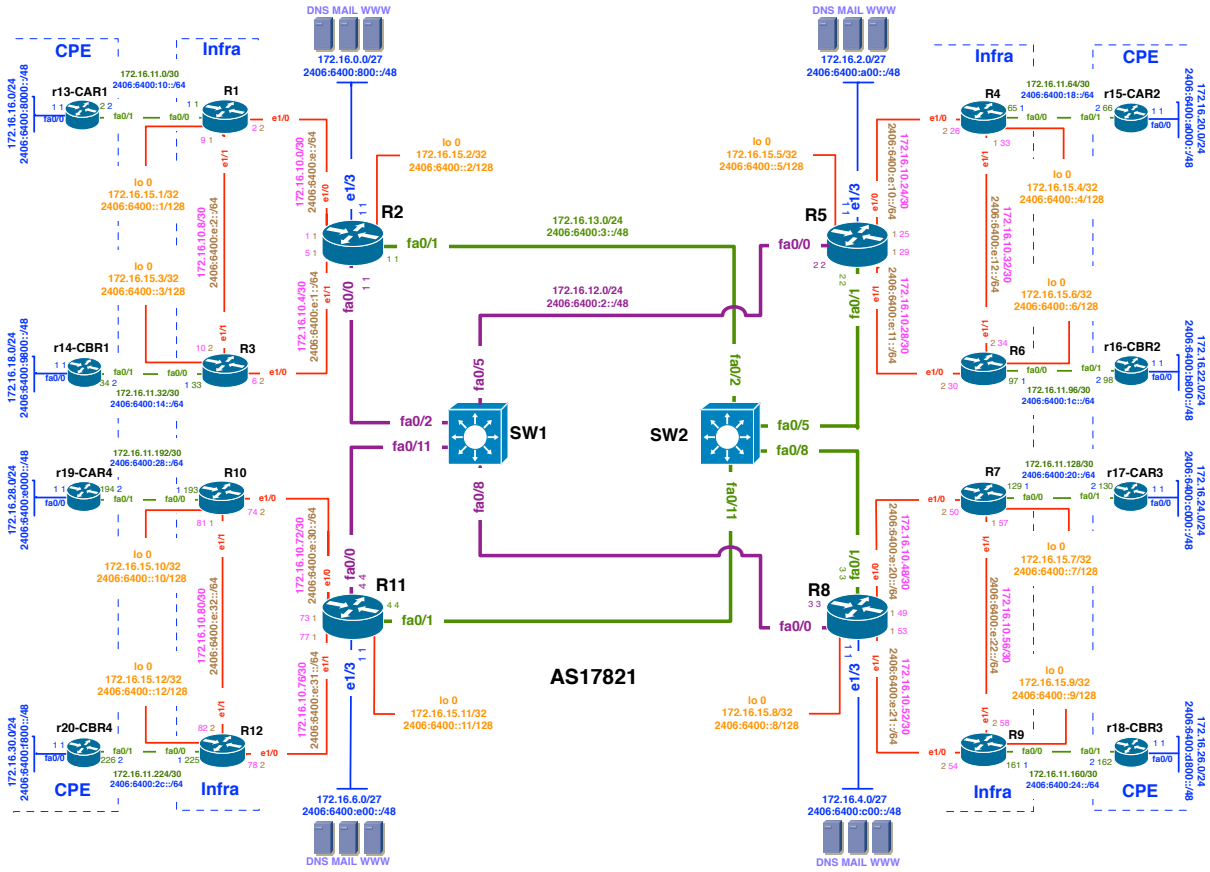

Figure 1 – ISP Lab Basic Configuration

Lab Notes

On this module participants need to configure basic traffic engineering tunnel to verify their understanding on how RSVP protocol is exchanging routing related information through a supported IGP protocol i.e. OSPF and influencing IGP path selection process.

Lab Exercise : TE Tunnels

MPLS TE tunnel will be created according to following scenarios:

1. r1 (Head-end) ⇔ r4 (End-point)
   - Mid-point: r2 & r5
   - Verify normal IGP path from r1 to r4 and check the existing LSP. Write down all the labels and next hop IP for that path.
   - Now look at the diagram and find other possible path from r1 to r4.
   - Add constrain (lower RSVP BW) to the current path i.e r5 e1/0 RSVP BW 90.
   - This information will be propagated to other routers via OSPF and OSPF will trigger to change the IGP path. MPLS LDP will change the label. So route to r4 will be change via r6.

2. r10 (Head-end) ⇔ r7 (End-point)
   - Mid-point: r11 & r8
   - Verify normal IGP path from r10 to r7 and check the existing LSP. Write down all the labels and next hop IP for that path.
   - Now look at the diagram and find other possible path from r10 to r7.
   - Add constrain (lower RSVP BW) to the current path i.e r8 e1/0 RSVP BW 90.
   - This information will be propagated to other routers via OSPF and OSPF will trigger to change the IGP path. MPLS LDP will change the label. So route to r7 will be change via r9.

Scenario 1 will involve configuration of router r1, r2, r3, r4, r5, r6. Here are the steps.

- Step 1: All 6 router need to prepare their routers to support MPLS TE features
- Step 2: Only head end router “r1” need to configure the tunnel configuration. End point is r4
- Step 3: Since the IP network traffic is two way so participant need to create two unidirectional tunnel to verify the MPLS TE functionality. Reverse traffic tunnel head-end is r4 and end point r1

Scenario 2 will involve configuration of router r7, r8, r9, r10, r11, r12. Here are the steps.

- Step 1: All 6 router need to prepare their routers to support MPLS TE features
- Step 2: Only head end router “r10” need to configure the tunnel configuration. End point is r7
- Step 3: Since the IP network traffic is two way so participant need to create two unidirectional tunnel to verify the MPLS TE functionality. Reverse traffic tunnel head-end r7 and end point r10.

Lab Exercise

Scenario 1 sample configuration:

1. Prepare all routers involving into MPLS TE tunnel:

Here is an example configuration for router R1:

```
config t
mpls traffic-eng tunnels
```

Enable MPLS TE support on the router

```
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
```

Enable MPLS TE support on the interface and reserve RSVP bandwidth in kbps. This command can take two parameter, first one is total reservable bandwidth on the interface, second one is per-flow maximum which is irrelevant for MPLS TE and ignore it.

```
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
```

Similar configuration for other interfaces participating in TE tunnel configuration.

```
exit
```

2. Enable OSPF to support MPLS TE tunnel:

Here is an example configuration for router R1:

```
router ospf 17821
mpls traffic-eng router-id loopback 0
```

Setting up loopback interface 0 to be used as router ID for MPLS TE tunnel path calculation. It is highly recommended to use same loopback interface for OSPF, BGP, MPLS LDP and TE router ID.

```
mpls traffic-eng area 0
```

This exercise use single area (Intra-Area) TE tunnel exercise. OSPF can do multi area (Inter-area) traffic engineering which will be done in another module exercise.

```
end
```

3. Tunnel head-end configuration for MPLS TE tunnel:

Here is an example configuration for router R1:

```
config t
interface tunnel 10
```

Will create an interface tunnel 10 on the router

```
ip unnumbered Loopback 0
```
Share the same IP address configured on the loopback interface 0. Since TE tunnels are unidirectional and don't have don't have the concept of link neighbor with which to communicate so no need configure an unique IP address. But IOS need an address to configure.

```
mpls ip
```
MPLS is enable on the tunnel interface

```
tunnel mode mpls traffic-eng
```
Tunnel encapsulation type is mpls traffic-eng like other tunnel GRE, IPSec etc.

```
tunnel destination 172.16.15.4
```
Tunnel destination will be the MPLS traffic engineering RID (loopback address) of the end point of the tunnel.

```
tunnel mpls traffic-eng path-option 10 dynamic
```
This command will defines a path-option for this tunnel. Preference is a number from 1 to 1000. Different path-option values are tried in preference order from lowest to highest. Tells the router that it is supposed to calculate the best path that fits the configured tunnel constraints, such as band-width and affinity bits.

```
tunnel mpls traffic-eng bandwidth 100
```
This command is very important that can modify the behavior of the tunnel. Using this command the tunnel interface is claiming to reserve 100kbps bandwidth for the entire path. Supported OSPF will check and determine the path which support the required bandwidth.

```
tunnel mpls traffic-eng autoroute announce
```
This command specifies that the IGP should use the tunnel (if the tunnel is up) in its enhanced SPF calculation

```
tunnel mpls traffic-eng priority 0 0
```
MPLS TE tunnels can have priority of its own i.e. VoIP and data tunnels are competing for the same resource. First priority field can be set anywhere from 0 7. 0 is the highest and 7 is the lowest importance tunnel. Second field is the preemption parameter. 0 mean you can not preempt.

```
end
```

4. Verification command for MPLS TE tunnel:

To verify MPLS TE support on this router:

```
Router1#sh mpls traffic-eng tunnels summary
```

```
Router1#sh mpls traffic-eng tunnels summary
Signalling  Summary:
    LSP Tunnels Process:            running
    Passive LSP Listener:           running
    RSVP Process:                   running
    Forwarding:                     enabled
```

To verify MPLS TE are configured on router interface:

```
Router1#sh mpls interfaces
```

```
Router1#sh mpls interfaces
Interface              IP           Tunnel   BGP Static Operational
Ethernet1/0            Yes (ldp)    Yes      No  No     Yes
Ethernet1/1            Yes (ldp)    Yes      No  No     Yes
```

To check RSVP bandwidth status for a router interface:

```
Router1#sh ip rsvp interface
interface    rsvp       allocated  i/f max  flow max sub max  VRF
Et1/0        ena        100K       256K     256K     0
Et1/1        ena        0          256K     256K     0
```

To check new LDP binding to reflect the path change:

```
Router5#sh mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
500        Pop Label  172.16.15.6/32   0             Et1/1      172.16.10.30
501        Pop Label  172.16.15.4/32   456           Et1/0      172.16.10.26
502        Pop Label  172.16.10.32/30  0             Et1/0      172.16.10.26
           Pop Label  172.16.10.32/30  0             Et1/1      172.16.10.30
503        1100       172.16.15.12/32  0             Fa0/0      172.16.12.4
```

```
Router1#sh ip int brief
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/0        172.16.11.1     YES NVRAM  up                    up
FastEthernet0/1        unassigned      YES NVRAM  administratively down down
Ethernet1/0            172.16.10.2     YES NVRAM  up                    up
Ethernet1/1            172.16.10.9     YES NVRAM  up                    up
Ethernet1/2            unassigned      YES NVRAM  administratively down down
Ethernet1/3            unassigned      YES NVRAM  administratively down down
Loopback0              172.16.15.1     YES NVRAM  up                    up
Tunnel10               172.16.15.1     YES TFTP   up                    up
```

```
Router1#sh ip route
O        172.16.15.2/32 [110/11] via 172.16.10.1, 1d00h, Ethernet1/0
O        172.16.15.3/32 [110/21] via 172.16.10.1, 1d00h, Ethernet1/0
O        172.16.15.4/32 [110/22] via 172.16.15.4, 23:36:44, Tunnel10
O        172.16.15.5/32 [110/12] via 172.16.10.1, 1d00h, Ethernet1/0
```

5. Lower RSVP bandwidth on the preferred path for MPLS TE tunnel and verify the outcome as explained above.

Workshop templates for reference purpose only:

R1:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```

Head-end

```
config t
interface tunnel 10
ip unnumbered Loopback 0
mpls ip
tunnel mode mpls traffic-eng
tunnel destination 172.16.15.4
tunnel mpls traffic-eng path-option 10 dynamic
tunnel mpls traffic-eng bandwidth 100
tunnel mpls traffic-eng autoroute announce
tunnel mpls traffic-eng priority 0 0
end
```

R2:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface fa 0/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface fa 0/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
```

```
mpls traffic-eng area 0
end
```

R3:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```

R4:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 90
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```

Head-end

```
config t
interface tunnel 10
ip unnumbered Loopback 0
mpls ip
tunnel mode mpls traffic-eng
tunnel destination 172.16.15.1
tunnel mpls traffic-eng path-option 10 dynamic
tunnel mpls traffic-eng bandwidth 100
tunnel mpls traffic-eng autoroute announce
tunnel mpls traffic-eng priority 0 0
end
```

R5:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 90
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface fa 0/0
mpls traffic-eng tunnels
ip rsvp bandwidth 9
interface fa 0/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```

R6:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```

R7:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 90
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
```

```
mpls traffic-eng area 0
end
```

Head-end

```
config t
interface tunnel 10
ip unnumbered Loopback 0
mpls ip
tunnel mode mpls traffic-eng
tunnel destination 172.16.15.10
tunnel mpls traffic-eng path-option 10 dynamic
tunnel mpls traffic-eng bandwidth 100
tunnel mpls traffic-eng autoroute announce
tunnel mpls traffic-eng priority 0 0
end
```

R8:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 90
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface fa 0/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface fa 0/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```

R9:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
```

```
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```

R10:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```

Head-end

```
config t
interface tunnel 10
ip unnumbered Loopback 0
mpls ip
tunnel mode mpls traffic-eng
tunnel destination 172.16.15.7
tunnel mpls traffic-eng path-option 10 dynamic
tunnel mpls traffic-eng bandwidth 100
tunnel mpls traffic-eng autoroute announce
tunnel mpls traffic-eng priority 0 0
end
```

R11:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface fa 0/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface fa 0/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
```

```
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```

R12:

```
config t
mpls traffic-eng tunnels
interface ethernet 1/0
mpls traffic-eng tunnels
ip rsvp bandwidth 256
interface ethernet 1/1
mpls traffic-eng tunnels
ip rsvp bandwidth 256
exit
router ospf 17821
mpls traffic-eng router-id loopback 0
mpls traffic-eng area 0
end
```