Inter-Area MPLS TE with IS-IS

« Inter-Area MPLS TE with OSPF (/workbook/view/service-provider-v4/task/inter-area-mpls-te-with-ospf-Mjg4Nw%3D%3D) | Inter-AS MPLS TE (/workbook/view/service-provider-v4/task/inter-as-mpls-te-Mjg4OQ%3D%3D) »

Last updated: April 22, 2016

Note:

Initial Configuration & Diagrams: Load the initial configuration files for the section named **Base IPv4**, which can be found in CCIE SPv4 Topology Diagrams & Initial Configurations (http://labs.ine.com/workbook/view/service-provider-v4/task/ccie-spv4-topology-diagrams-initial-configs). Refer to the **Base IPv4 Diagram** in order to complete this task.

Task

- Configure IS-IS routing in the network as follows:
  - R1, R2, R3, and R4 should use NET address 00.0000.0000.000Y.00, where Y is the router number.
  - R5, R6, XR1, and XR2 should use NET address 01.0000.0000.000Y.00, where Y is the router number; for XR1 use 19, and for XR2 use 20.
  - Level-2 consists of links interconnecting R3 & R4, R3 & R6, R4 & R6, R4 & R5, R5 & R6, and all their Loopback0 interfaces.
  - Level-1 consists of all other links and Loopbacks.
- Configure the network to support MPLS TE tunnels as follows:
  - Enable MPLS TE support for IS-IS Level-1 and Level-2.
  - Set the IS-IS MPLS TE Router-ID to be the Loopback0 interfaces.
  - Enable support for RSVP and MPLS TE on all transit interfaces.
- Configure an MPLS TE tunnel from R1 to XR2 as follows:
  - Unnumber the tunnel to R1's Loopback0 interface.
  - Set the tunnel destination as XR2's Loopback0 interface.
  - Configure the tunnel's explicit path option to use loose next-hops as follows:
    - R1 should use R3 as the L1/L2 router.
    - R3 should use R6 as the next L1/L2 router.
  - Configure Autoroute Destination so that R1 uses the tunnel to route toward XR2's Loopback0.
- Configure an MPLS TE tunnel from XR2 to R1 as follows:
  - Unnumber the tunnel to XR2's Loopback0 interface.
  - Set the tunnel destination as R1's Loopback0 interface.
  - Configure the tunnel's explicit path option to use loose next-hops as follows:
    - XR2 should use R5 as the L1/L2 router.
    - R5 should use R4 as the next L1/L2 router.
  - Configure static routing so that XR2 uses the tunnel to route toward R1's Loopback0.

Configuration **Click to *collapse***

```
R1:
mpls traffic-eng tunnels
!
ip explicit-path name INTER_AREA_TE enable
 next-address loose 3.3.3.3
 next-address loose 6.6.6.6
!
interface Tunnel0
 ip unnumbered Loopback0
 tunnel mode mpls traffic-eng
 tunnel destination 20.20.20.20
 tunnel mpls traffic-eng autoroute destination
 tunnel mpls traffic-eng path-option 10 explicit name INTER_AREA_TE
!
interface Loopback0
 ip router isis 1
!
interface GigabitEthernet1.12
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
!
router isis 1
 net 00.0000.0000.0001.00
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
 is-type level-1


R2:
mpls traffic-eng tunnels
!
interface Loopback0
 ip router isis 1
!
interface GigabitEthernet1.12
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
!
interface GigabitEthernet1.23
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
!
interface GigabitEthernet1.24
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
!
router isis 1
 net 00.0000.0000.0002.00
 metric-style wide
```

```
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
 is-type level-1

R3:
mpls traffic-eng tunnels
!
interface Loopback0
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.23
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-1
!
interface GigabitEthernet1.34
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.36
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
!
router isis 1
 net 00.0000.0000.0003.00
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
 mpls traffic-eng level-1

R4:
mpls traffic-eng tunnels
!
interface Loopback0
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.24
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-1
!
interface GigabitEthernet1.34
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
```

```
!
interface GigabitEthernet1.45
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.46
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
!
router isis 1
 net 00.0000.0000.0004.00
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
 mpls traffic-eng level-1
```

R5:

```
mpls traffic-eng tunnels
!
interface Loopback0
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.45
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.56
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.519
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-1
!
router isis 1
 net 01.0000.0000.0005.00
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
 mpls traffic-eng level-1
```

R6:

```
mpls traffic-eng tunnels
```

```
!
interface Loopback0
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.36
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.46
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.56
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-2
!
interface GigabitEthernet1.619
 mpls traffic-eng tunnels
 ip rsvp bandwidth
 ip router isis 1
 isis circuit-type level-1
!
router isis 1
 net 01.0000.0000.0006.00
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-2
 mpls traffic-eng level-1


XR1:
router isis 1
 net 01.0000.0000.0019.00
 is-type level-1
 address-family ipv4 unicast
  metric-style wide
  mpls traffic-eng level-1
 !
 interface Loopback0
  address-family ipv4 unicast
  !
 !
 interface GigabitEthernet0/0/0/0.519
  address-family ipv4 unicast
  !
 !
 interface GigabitEthernet0/0/0/0.619
  address-family ipv4 unicast
```

```
  !
 !
 interface GigabitEthernet0/0/0/0.1920
  address-family ipv4 unicast
  !
 !
!
rsvp
 interface GigabitEthernet0/0/0/0.1920
 !
 interface GigabitEthernet0/0/0/0.519
 !
 interface GigabitEthernet0/0/0/0.619
 !
!
mpls traffic-eng
 interface GigabitEthernet0/0/0/0.1920
 !
 interface GigabitEthernet0/0/0/0.519
 !
 interface GigabitEthernet0/0/0/0.619
 !
!
mpls ldp


XR2:
explicit-path name INTER_AREA_TE
 index 1 next-address loose ipv4 unicast 5.5.5.5
 index 2 next-address loose ipv4 unicast 4.4.4.4
!
interface tunnel-te0
 ipv4 unnumbered Loopback0
 destination 1.1.1.1
 path-option 10 explicit name INTER_AREA_TE
!
router static
 address-family ipv4 unicast
  1.1.1.1/32 tunnel-te0
 !
!
router isis 1
 net 01.0000.0000.0020.00
 is-type level-1
 address-family ipv4 unicast
  metric-style wide
  mpls traffic-eng level-1
 !
 interface Loopback0
  address-family ipv4 unicast
  !
 !
 interface GigabitEthernet0/0/0/0.1920
  address-family ipv4 unicast
  !
```

```
 !
!
rsvp
 interface GigabitEthernet0/0/0/0.1920
!
mpls traffic-eng
!
mpls traffic-eng
 interface GigabitEthernet0/0/0/0.1920
!
mpls ldp
```

Verification

This section is very similar to the previous Inter-Area MPLS TE example, except that the IGP used is IS-IS instead of OSPF. As with OSPF, IS-IS MPLS TE normally requires that the Head End and Tail End of the TE tunnel be in the same flooding domain (same IS-IS level); otherwise a full cSPF run cannot be completed and the cSPT cannot be formed. The workaround is to specify the L1/L2 routers (like the OSPF ABRs) as loose hops in an explicit path. When the signaling is sent to the L1/L2 routers, they will calculate a dynamic path to the next L1/L2 router and expand the path into a full explicit path to be used for the purposes of TE.

As in the previous example, the best verification for this is the output of `debug mpls traffic- eng path lookup` and `debug mpls traffic-eng tunnel signalling` , as seen below.

```
R1#debug mpls traffic-eng tunnels signalling
MPLS traffic-eng tunnels signalling debugging is on
R1#debug mpls traffic-eng path lookup
MPLS traffic-eng path lookup events debugging is on
R1#config t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int tun0
R1(config-if)#no shut
R1(config-if)#


TE-SIG-HE:  Tunnel0 [0]: Attempting to activate
TE-PCALC-API: 1.1.1.1_36->20.20.20.20_0 {7}:  P2P LSP Path Lookup called
TE-PCALC: 1.1.1.1_36->20.20.20.20_0 {7}:  Path Request Info
  Flags:  IP_EXPLICIT_PATH  METRIC_TE
   IP explicit-path: Supplied
     3.3.3.3 Loose
     6.6.6.6 Loose
  bw 0, min_bw 0, metric: 0
  setup_pri 7, hold_pri 7
  affinity_bits 0x0, affinity_mask 0xFFFF
TE-PCALC-PATH: 1.1.1.1_36->20.20.20.20_0 {7}:  Area (isis  level-1) Path Lookup begin
TE-PCALC-PATH: Area (isis  level-1):  Dest ip addr 20.20.20.20 not found
TE-PCALC-PATH: lsr_exists: first Loose Hop is to addr 3.3.3.3
TE-PCALC-PATH: Path from 0000.0000.0001.00 -> 0000.0000.0003.00:
   20.2.3.3->0.0.0.0 (admin_weight=20):
  20.2.3.2->0.0.0.0 (admin_weight=20):
  10.1.2.2->0.0.0.0 (admin_weight=10):
  10.1.2.1->0.0.0.0 (admin_weight=10):
  num_hops 5, accumulated_aw 20, min_bw 750000
TE-PCALC-PATH: 1.1.1.1_36->20.20.20.20_0 {7}: Freeing rrr_path_setup_t
TE-PCALC-PATH: 1.1.1.1_36->20.20.20.20_0 {7}: Free all paths in path tree
TE-PCALC: Verify Path Lookup: 1.1.1.1_36->20.20.20.20_0 {7}: (protocol nil  area nil)
  Flags:  METRIC_TE
   Last Strict Router: 3.3.3.3
  sub-lsp weight:0 (Total LSP weight:20)
   Hop List:
     10.1.2.1
     10.1.2.2
     20.2.3.2
     20.2.3.3
     3.3.3.3
     6.6.6.6 Loose
TE-PCALC-VERIFY: VERIFY to 3.3.3.3 BEGIN:
TE-PCALC-VERIFY: Verify:
TE-PCALC-VERIFY:  0000.0000.0001.00, 10.1.2.1 points to
TE-PCALC-VERIFY:  0000.0000.0002.00, 10.1.2.2
TE-PCALC-VERIFY: Verify:
TE-PCALC-VERIFY:  0000.0000.0002.00, 20.2.3.2 points to
TE-PCALC-VERIFY:  0000.0000.0003.00, 20.2.3.3
TE-PCALC-VERIFY:  VERIFY to 3.3.3.3 PASSED
TE-PCALC-PATH: 1.1.1.1_36->20.20.20.20_0 {7}: Area (isis  level-1) Path Lookup end: path found
TE-PCALC-API: 1.1.1.1_36->20.20.20.20_0 {7}: P2P LSP Path Lookup result: success
TE-SIG-HE: Tunnel0 [36]->20.20.20.20: RSVP head-end open
```

```
TE-SIG-HE:  Tunnel0 [36]: Activation succeeded
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}: received ADD RESV request
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}:  path next hop is 10.1.2.2 (GigabitEthernet1.12)
TE-SIG: Installed up_tag 4294967294
TE-SIG:  Installed down_tag 18
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}: sending ADD RESV reply
TE-SIG-HE: Tunnel0 [36]->20.20.20.20: received RESV CREATE
TE-SIG-HE: Tunnel0 [36]->20.20.20.20: notified of new label information
        GigabitEthernet1.12, nhop 10.1.2.2, frame, 18
TE-SIG-HE: Tunnel0 [36]->20.20.20.20: label information Changed
TE-SIG-HE: Tunnel0: route change: GigabitEthernet1.12:17->GigabitEthernet1.12:18
%LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, changed state to up
```

R1 initializes its tunnel and calculates a dynamic path to the first loose hop, 3.3.3.3 (R3). The expansion of this path is from R1 to R2 to R3. R1 then asks R3 to further expand the path to the next loose hop, 6.6.6.6 (R6).

```
R3#
TE-PCALC-API:  1.1.1.1_36->6.6.6.6_0 {7}: LSP Path Expand called
TE-PCALC: 1.1.1.1_36->6.6.6.6_0 {7}:  Path Request Info
  Flags:  END_SWCAP_UNKNOWN
  IP explicit-path: None (dynamic)
  bw 0, min_bw 0, metric: 0
  setup_pri 7, hold_pri 7
  affinity_bits 0x0, affinity_mask 0x0
TE-PCALC-PATH: 1.1.1.1_36->6.6.6.6_0 {7}: rrr_pcalc_lsr_expand:  Exclude node: 2.2.2.2 (intf: 20.2.3.2)
TE-PCALC-PATH: 1.1.1.1_36->6.6.6.6_0 {7}: rrr_pcalc_lsr_expand:  Exclude node: 1.1.1.1 (intf: 10.1.2.1)
TE-PCALC-PATH: 1.1.1.1_36->6.6.6.6_0 {7}:  Area (isis  level-2) Path Lookup begin
TE-PCALC-PATH: exclude_path: system_id 0-0-0-0-0-0-0 not known!
TE-PCALC-PATH: exclude_path: system_id 0-0-0-0-0-0-0 not known!
TE-PCALC-PATH:Path from 0000.0000.0003.00 -> 0000.0000.0006.00:
   20.3.6.6->0.0.0.0 (admin_weight=10):
  20.3.6.3->0.0.0.0 (admin_weight=10):
  num_hops 3, accumulated_aw 10, min_bw 750000
TE-PCALC-PATH: 3.3.3.3_36->6.6.6.6_0 {7}:  Area (isis  level-2) Path Lookup end: path found
 6.6.6.6 expands to:
20.3.6.3
20.3.6.6
6.6.6.6
TE-PCALC-API: 3.3.3.3_36->6.6.6.6_0 {7}:  LSP Path Expand result: success
TE-PCALC-PATH: 3.3.3.3_36->6.6.6.6_0 {7}: Freeing rrr_path_setup_t
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}: received ADD RESV request
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}:  path previous hop is 20.2.3.2 (GigabitEthernet1.23)
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}:  path next hop is 20.3.6.6 (GigabitEthernet1.36)
TE-SIG:  Installed up_tag 16
TE-SIG:  Installed down_tag 22
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}: sending ADD RESV reply
```

R3 can successfully expand the path toward R6, because both are in the same flooding domain (IS-IS Level-2). R3 expands the path as R3 to R6, and then asks R6 to expand the path to the final destination, 20.20.20.20 (XR2).

```
R6#
TE-PCALC-API:  1.1.1.1_36->20.20.20.20_0 {7}: LSP Path Expand called
TE-PCALC: 1.1.1.1_36->20.20.20.20_0 {7}:  Path Request Info
  Flags:  END_SWCAP_UNKNOWN
  IP explicit-path: None (dynamic)
  bw 0, min_bw 0, metric: 0
  setup_pri 7, hold_pri 7
  affinity_bits 0x0, affinity_mask 0x0
TE-PCALC-PATH: 1.1.1.1_36->20.20.20.20_0 {7}: rrr_pcalc_lsr_expand:  Exclude node: 3.3.3.3 (intf: 20.3.6.3)
TE-PCALC-PATH: 1.1.1.1_36->20.20.20.20_0 {7}: rrr_pcalc_lsr_expand:  Can't get router ID addr for 20.2.3.2
TE-PCALC-PATH: 1.1.1.1_36->20.20.20.20_0 {7}: rrr_pcalc_lsr_expand:  Can't get router ID addr for 10.1.2.1
TE-PCALC-PATH: 1.1.1.1_36->20.20.20.20_0 {7}: Area (isis  level-1) Path Lookup begin
TE-PCALC-PATH: exclude_path: system_id 0-0-0-0-0-0 not known!
TE-PCALC-PATH: exclude_path: system_id 0-0-0-0-0-0 not known!
TE-PCALC-PATH: exclude_path: system_id 0-0-0-0-0-0 not known!
TE-PCALC-PATH:Path from 0000.0000.0006.00 -> 0000.0000.0020.00:
   10.19.20.20->10.19.20.19 (admin_weight=20):
  10.19.20.19->10.19.20.19 (admin_weight=20):
  20.6.19.19->20.6.19.6 (admin_weight=10):
  20.6.19.6->0.0.0.0 (admin_weight=10):
  num_hops 5, accumulated_aw 20, min_bw 0
TE-PCALC-PATH: 6.6.6.6_36->20.20.20.20_0 {7}:  Area (isis  level-1) Path Lookup end: path found
 20.20.20.20 expands to:
20.6.19.6
20.6.19.19
10.19.20.19
10.19.20.20
20.20.20.20
TE-PCALC-API: 6.6.6.6_36->20.20.20.20_0 {7}:  LSP Path Expand result: success
TE-PCALC-PATH: 6.6.6.6_36->20.20.20.20_0 {7}: Freeing rrr_path_setup_t
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}: received ADD RESV request
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}: path previous hop is 20.3.6.3 (GigabitEthernet1.36)
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}: path next hop is 20.6.19.19 (GigabitEthernet1.619)
TE-SIG:  Installed up_tag 22
TE-SIG:  Installed down_tag 16020
TE-SIG-LM: 1.1.1.1_36->20.20.20.20_0 {7}: sending ADD RESV reply
```

R6 receives the expansion request from R3 and is able to fulfill it, because R6 and XR2 are in the same flooding domain (IS-IS Level-1). R6 then expands the path as R6 to XR1 to XR2, and sends the RSVP messages to request the reservation of XR2. The final result is that the tunnel is signaled end to end, and traffic flows from R1 to XR2 via R3 and via R6.

```
R1#traceroute 20.20.20.20
Type escape sequence to abort.
Tracing the route to 20.20.20.20
VRF info: (vrf in name/id, vrf out name/id)
  1 10.1.2.2 [MPLS: Label 18 Exp 0] 23 msec 19 msec 16 msec
  2 20.2.3.3 [MPLS: Label 16 Exp 0] 20 msec 16 msec 16 msec
  3 20.3.6.6 [MPLS: Label 22 Exp 0] 20 msec 20 msec 20 msec
  4 20.6.19.19 [MPLS: Label 16020 Exp 0] 16 msec 20 msec 16 msec
  5 10.19.20.20 16 msec *  73 msec
```

Just like in the previous example with OSPF, a separate TED is maintained for each level on the L1/L2 routers.

Although most features work accross Inter-Area TE tunnels, there are a few that dont as they rely on the tunnel head and tail being in the same area/level/flooding domain. Out of the features that we have covered, Auto-Route Announce and Forwarding Adjacency will not work over Inter-Area tunnels. Additionally, it is not possible to compute a dynamic path to the tunnel destination with the "tunnel mpls traffic-eng path-option dynamic" command, since we need to manually help out the process by providing the ABRs/L1-L2 routers along the way.

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