Flex LSP Overview

Flex LSP also known as Associated Bidirectional LSPs is the combination of static bidirectional MPLS-TP and dynamic MPLS-TE. Flex LSP provides bidirectional label switched paths (LSPs) set up dynamically through Resource Reservation Protocol–Traffic Engineering (RSVP-TE). It does not support non-co routed LSPs.

Flex Label Switched Paths are LSP instances where the forward and the reverse direction paths are setup, monitored and protected independently and associated together during signaling. You use a RSVP Association object to bind the two forward and reverse LSPs together to form either a co-routed or non co-routed associated bidirectional TE tunnel.

You can associate a protecting MPLS-TE tunnel with either a working MPLS-TE LSP, protecting MPLS-TE LSP, or both. The working LSP is the primary LSP backed up by the protecting LSP. When a working LSP goes down, the protecting LSP is automatically activated. You can configure a MPLS-TE tunnel to operate without protection as well.

Effective Cisco IOS XE Release 3.18.1SP, Flex LSP supports inter-area tunnels with non co-routed mode.

Signaling Methods and Object Association for Flex LSPs

This section provides an overview of the association signaling methods for the bidirectional LSPs. Two unidirectional LSPs can be bound to form an associated bidirectional LSP in the following scenarios:

- No unidirectional LSP exists, and both must be established.
- Both unidirectional LSPs exist, but the association must be established.
- One unidirectional LSP exists, but the reverse associated LSP must be established.

Associated Bidirectional Non Co-routed and Co-routed LSPs

This section provides an overview of associated bidirectional non co-routed and co-routed LSPs. Establishment of MPLS TE-LSP involves computation of a path between a head-end node to a tail-end node, signaling along the path, and modification of intermediate nodes along the path. The signaling process ensures bandwidth reservation (if signaled bandwidth is lesser than 0 and programming of forwarding entries).

Path computation is performed by the head-end nodes of both the participating LSPs using Constrained Shortest Path First (CSPF). CSPF is the 'shortest path (measured in terms of cost) that satisfies all relevant LSP TE constraints or attributes, such as required bandwidth, priority and so on.

Associated Bidirectional Non Co-routed LSPs: A non co-routed bidirectional TE LSP follows two different paths, that is, the forward direction LSP path is different than the reverse direction LSP path. Here is an illustration.
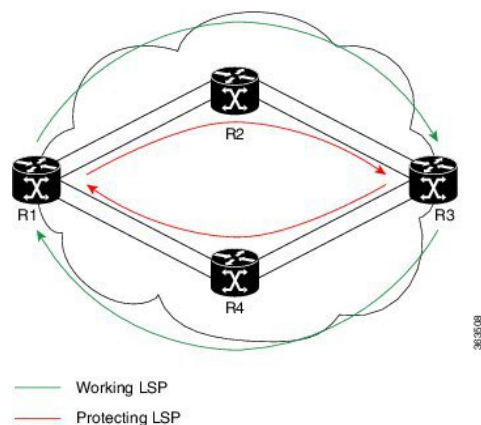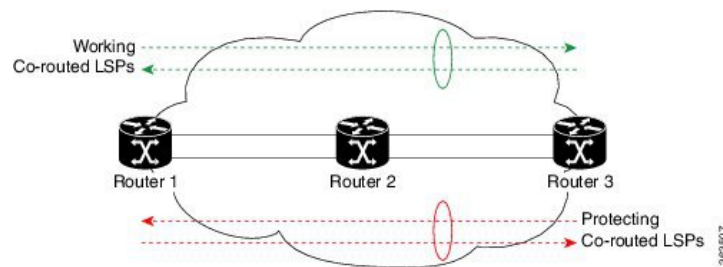

In the above topology:

- The outer paths (in green) are working LSP pairs.
- The inner paths (in red) are protecting LSP pairs.
- Router 1 sets up working LSP to Router 3 and protecting LSP to Router 3 independently.
- Router 3 sets up working LSP to Router 1 and protecting LSP to Router 1 independently.

Non co-routed bidirectional TE LSP is available by default, and no configuration is required.

Note In case of non co-routed LSPs, the head-end nodes relax the constraint on having identical forward and reverse paths. Hence, depending on network state you can have identical forward and reverse paths, though the bidirectional LSP is co-routed.

Associated Bidirectional Co-routed LSPs: A co-routed bidirectional TE LSP denotes a bidirectional tunnel where the forward direction LSP and reverse direction LSP must follow the same path, for example, the same nodes and paths. Here is an illustration.

In the above topology:

- Paths at the top of the figure (in green) indicate working co-routed LSP pairs.
- Paths at the bottom of the figure (in red) indicate protecting co-routed LSP pairs.
- Router 1 sets up working LSP to Router 3 (in red) after performing bidirectional CSPF and sends reverse explicit route object (ERO) to Router 3. Node Router 3 uses the received reverse ERO to set up reverse red working LSP to Router 1.
- Router 3 sets up protecting LSP to Router 1 (in green) after performing bidirectional CSPF and sends reverse ERO to Router 1. Node Router 1 uses the received reverse ERO to set up reverse green protecting LSP to Router 3.

Restrictions for Flex LSP

- Exp-null over Flex-LSP is not supported.

- Flex-LSP does not support tunnel statistics.

- VC (layer 2 VPN ckts) statistics are not supported.

- It is recommended to configure for the following timers for Flex-LSP deployments:

  mpls traffic-eng reoptimize timers frequency 120

  mpls traffic-eng reoptimize timers delay installation 30

  mpls traffic-eng reoptimize timers delay cleanup 90

- The **no mpls ip propagate-tcl** command is not recommended with Flex-LSP. The PREC value of BFD control packet is set to "0". Therefore, packet prioritization cannot be done at mid-points and BFD flap can occur with traffic congestions.

- It is recommended to configure BFD timers as 10x3 during cable pull testing or in Flex LSP feature deployments.

- 50 msec convergence is not guaranteed for local shut on Cisco ASR 920 routers without BFD.

- 50 msec convergence is not guaranteed without WRAP protection. WRAP protection is mandatory to achieve 50 msec convergence for remote failures.

- With scale and multiple other feature mix-up, it is possible to see higher convergence.

- TE NSR and IGP NSR are mandatory for RSP switchover.

- Flex LSP is supported with the IPv4 template.

- The **ip rsvp signalling hello** command is not mandatory and it can cause a large punt during the cutover and can lead to unexpected results like BFD flapping.

- VPLS over Flex-LSP is not supported.

- Both IGP and FRR must be configured as clients for single-hop BFD when the WRAP protection is enabled; only FRR cannot be the only client configured at midpoint.

- Layer 3 VPN over Flex-LSP is not supported.

- It is recommended to configure 10x3 BFD timers for cable failures, to achieve 50 msec of convergence.

Restrictions for Non Co-routed Inter-Area Flex LSP Tunnels

- The dynamic path option feature for TE tunnels (**tunnel mpls traffic-eng path-option number dynamic**) is not supported for inter-area tunnels. An explicit path identifying the area border routers (ABRs) is required.

- The MPLS TE AutoRoute feature (**tunnel mpls traffic-eng autoroute announce**) is not supported for inter-area tunnels.

- Tunnel affinity (**tunnel mpls traffic-eng affinity**) is not supported for inter-area tunnels.

- Tunnel metric (**tunnel mpls traffic-eng path-selection metric**) is not supported for inter-area tunnels.

- The re-optimization of tunnel paths is not supported for inter-area tunnels.

How to Configure Co-routed Flex LSPs

A co-routed bidirectional packet LSP is a combination of two LSPs (one in the forward direction and the other in reverse direction) sharing the same path between a pair of ingress and egress nodes. It is established using the extensions to RSVP-TE. This type of LSP can be used to carry any of the standard types of MPLS-based traffic, including Layer 2 VPNs and Layer 2 circuits. You can configure a single BFD session for the bidirectional LSP (that is, you do not need to configure a BFD session for each LSP in each direction). You can also configure a single standby bidirectional LSP to provide a backup for the primary bidirectional LSP.

The configuration includes the following steps:

1. Enable basic MPLS Traffic Engineering on hostname PE1.

2. Map L2VPN pseudowire to a specific FLEX LSP tunnel.

3. Configure Flex LSP.

4. Enable BFD.

5. Enable Wrap and Fault OAM.

6. Enable BDIs on a core-facing interface.

Configuring Co-routed Flex LSPs

Before you begin

- You must have symmetric source and destination TE router IDs in order for bidirectional LSPs to be associated.

- Tunnels attributes must be configured identically on both sides of co-routed bidirectional LSP.

Note Up to 250 Flex LSP tunnels are supported.

Procedure

1. Enable basic MPLS Traffic Engineering on hostname PE1:

```
mpls traffic-eng tunnels
mpls traffic-eng fault-oam
mpls traffic-eng nsr
router ospf 100
 router-id 1.1.1.1
 nsr
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

2. Map L2VPN pseudowire to a specific Flex LSP tunnel:

```
template type pseudowire mpls-te1 (mpls-te1 can be any name)
encapsulation mpls
preferred-path interface Tunnel1 disable-fallback
bandwidth 100

template type pseudowire mpls-te4
encapsulation mpls
preferred-path interface Tunnel4 disable-fallback
bandwidth 100
```

3. Configure Flex LSP:

```
interface Tunnel1
bandwidth 1000
ip unnumbered Loopback0
tunnel mode mpls traffic-eng
tunnel destination 22.22.22.22
tunnel mpls traffic-eng autoroute announce
tunnel mpls traffic-eng priority 7 7
tunnel mpls traffic-eng bandwidth 1000
tunnel mpls traffic-eng path-option 1 explicit name BDI1 bandwidth 1000
tunnel mpls traffic-eng path-option protect 1 explicit name BACKUP1 bandwidth 1000
tunnel mpls traffic-eng bidirectional association id 1 source-address 11.11.11.11 global-id
1
```

NOTE: To bring up the bi-directional tunnels, association ID, source address and global ID must match on both sides of the tunnel.

```
tunnel mpls traffic-eng bidirectional association type co-routed
ip explicit-path name BDI1 enable
next-address 1.11.1.1
next-address 10.1.2.2
next-address 2.22.1.22
```

```
ip explicit-path name BACKUP1 enable
next-address 10.3.11.1.10
next-address 10.4.22.22
```

4. Enable BFD

```
bfd-template single-hop BFD_FLEX
interval min-tx 50 min-rx 50 multiplier 3
interface Tunnel1
tunnel mpls traffic-eng bfd encap-mode gal BFD_FLEX
```

5. Enable Wrap and Fault OAM

```
interface Tunnel1
tunnel mpls traffic-eng bidirectional association type co-routed fault-oam wrap-protection
```

6. Enable BDIs on core-facing interface:
NOTE: Since VLANs are not supported, to represent a VLAN interface, BDI must be used towards
 core-facing interface.

```
interface BDI1
ip address 1.11.1.11 255.255.255.0
ip ospf 1 area 0
mpls traffic-eng tunnels


interface BDI4
ip address 1.11.4.11 255.255.255.0
ip ospf 1 area 0
mpls traffic-eng tunnels

interface GigabitEthernet0/3/1
ip address 10.3.11.11 255.255.255.0
ip ospf 1 area 0
mpls traffic-eng tunnels

interface GigabitEthernet0/3/0
service instance 1 ethernet
encapsulation dot1q 1
rewrite ingress tag pop 1 symmetric
bridge-domain 1
service instance 4 ethernet
encapsulation dot1q 4
rewrite ingress tag pop 1 symmetric
bridge-domain 4
End
```

Verifying the Co-routed Flex LSP Configuration

To verify the FLEX LSP tunnel summary, use the **show mpls traffic-eng tunnels bidirectional-associated concise** command in MPLS tunnel-te interface.

```
Router# show mpls traffic-eng tunnels summary
RP/0/RSP0/CPU0:NCS4K-R1#  show mpls traffic-eng tunnels summary

        Path Selection Tiebreaker:  Min-fill (default)
              LSP Tunnels Process:  running
                     RSVP Process:  running
                       Forwarding:  enabled
          Periodic reoptimization:  every 3600 seconds, next in 1716 seconds
            Periodic FRR Promotion:  every 300 seconds, next in 201 seconds
       Periodic auto-bw collection:  5 minute(s) (disabled)
```

```
Signalling Summary:
     Head: 1 interfaces, 1 active signalling attempts, 1 established
           0 explicit, 1 dynamic
           14 activations, 13 deactivations
           0 recovering, 0 recovered
     Mids: 0
     Tails: 1

Fast ReRoute Summary:
     Head:     0 FRR tunnels, 0 protected, 0 rerouted
     Mid:      0 FRR tunnels, 0 protected, 0 rerouted
     Summary:  0 protected, 0 link protected, 0 node protected, 0 bw protected
     Backup:   0 tunnels, 0 assigned
     Interface: 0 protected, 0 rerouted

 Path Protection Summary:
     1 configured, 1 Up, 0 ready
     0 link-diverse, 0 node-diverse, 0 node-link-diverse, 0 user defined

Bidirectional Tunnel Summary:
     Tunnel Head: 1 total, 1 connected, 1 associated, 1 co-routed<------ To check how many
 tunnels are connected
     Tunnel Tail: 1 total, 1 connected, 1 associated, 1 co-routed
     LSPs Head:  1 established, 0 proceeding, 1 associated, 0 standby
     LSPs Mid:   0 established, 0 proceeding, 0 associated, 0 standby
     LSPs Tail:  1 established, 0 proceeding, 1 associated, 0 standby

GMPLS UNI Summary:
     Heads:  0 up, 0 down
     Tails:  0 up, 0 down

GMPLS NNI Summary:
     Heads:  0 up, 0 down
     Mids :  0 up, 0 down
     Tails:  0 up, 0 down
 RP/0/RSP0/CPU0:NCS4K-R1#
```

To verify the co-routed LSP, use the **Show mpls traffic-eng tunnel bidirectional co-routed** command.

```
Router#Show mpls traffic-eng tunnel bidirectional co-routed

Name: tunnel-te2  Destination: 192.168.0.3

  Status:

    Admin:    up Oper:   up  Path:  valid   Signalling: connected

    path option 1,  type dynamic  (Basis for Setup, path weight 3 (reverse 3))

    Bandwidth Requested: 80000 kbps  CT0

Config Parameters:

    Association Type: Single Sided Bidirectional LSPs, Co-routed: Yes

    Association ID: 100, Source: 9.9.9.9[, Global ID: 9]

    Reverse Bandwidth: 2 kbps CT0, Standby: 2 kbps CT0

    BFD Fast Detection: Enabled

    BFD Parameters: Min-interval 10000 ms, Multiplier 3 (default)

     BFD Bringup Timeout: Interval 60 seconds (default)
```

```
        BFD Initial Dampening: 16000 ms (default)

        BFD Maximum Dampening: 600000 ms (default)

        BFD Secondary Dampening: 20000 ms (default)

        Periodic LSP Ping: Interval 120 seconds (default)

        BFD Encap Mode: IP (default) | GAL

     Soft Preemption: Enabled, Current Status: Preemption not pending
```

To verify the RSVP session details, use the **show rsvp session detail** command.

```
Router# show rsvp session detail
RP/0/0/CPU0:rtrA#show rsvp session detail dst-port 2

SESSION: IPv4-LSP Addr: 192.168.0.3, TunID: 2, ExtID: 192.168.0.1

 PSBs: 2, RSBs: 2, Requests: 0

 LSPId: 2

 Tunnel Name: rtrA_t2

  RSVP Path Info:

   InLabel: No intf, No label

   Incoming Address: Unknown

   Explicit Route:

     Strict, 10.10.10.2/32

     Strict, 14.14.14.2/32

     Strict, 14.14.14.4/32

     Strict, 16.16.16.4/32

     Strict, 16.16.16.3/32

     Strict, 192.168.0.3/32

   Record Route: None

   Tspec: avg rate=8K, burst=1K, peak rate=8K

   Association:

     Association Type: Single sided provisioned bidirectional LSPs

     Association ID: 100, Source: 1.1.1.1     Global source: 0, Extended ID length: 2
      Extended ID:
          0xc0a80004 (192.168.0.4)
          0x2 (0.0.0.2)    Protection:

     Secondary (S): 0, Protecting (P): 0, Notification (N): 0, Operation (O): 0

     Link Flags: [PROJECT:ANY], LSP Flags: [1:N PROTECTION EXTRA_TRAFFIC]
```

```
      Reverse LSP:

         Explicit Route:

            Strict, 17.17.17.3/32

            Strict, 17.17.17.4/32

            Strict, 14.14.14.4/32

            Strict, 14.14.14.2/32

            Strict, 11.11.11.2/32

            Strict, 11.11.11.1/32

            Strict, 192.168.0.1/32

         Tspec: avg rate=4K, burst=1K, peak rate=4K

RSVP Resv Info:

   OutLabel: GigabitEthernet0/2/0/2, 16012

   FRR OutLabel: No intf, No label

   Record Route: None

   Fspec: avg rate=8K, burst=1K, peak rate=8K
```

How to Configure Non Co-routed Inter-area Flex LSP Tunnels

Note   The working and protect LSPs for PE1 (head-end) is different from PE2 (tail-end).

At PE1 (head-end):

```
interface Tunnel1001
 ip unnumbered Loopback0
 mpls ip
 tunnel mode mpls traffic-eng
 tunnel destination 1.1.1.1
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 200
 tunnel mpls traffic-eng path-option 1 explicit name ThruHunG verbatim
 tunnel mpls traffic-eng path-option protect 1 explicit name PROT1 verbatim
 tunnel mpls traffic-eng bidirectional association id 1001 source-address 1.1.1.1 global-id
 1001
!
interface Tunnel1002
 ip unnumbered Loopback0
 mpls ip
 tunnel mode mpls traffic-eng
 tunnel destination 1.1.1.1
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 200
 tunnel mpls traffic-eng path-option 1 explicit name ThruHunG verbatim
 tunnel mpls traffic-eng path-option protect 1 explicit name PROT1 verbatim
```

```
 tunnel mpls traffic-eng bidirectional association id 1002 source-address 1.1.1.1 global-id
 1002

ip explicit-path name ThruTenG enable
 next-address loose 22.1.1.2
 next-address loose 10.1.1.1
 next-address loose 1.1.1.1
!
ip explicit-path name ThruHunG enable
 next-address loose 23.1.1.2
 next-address loose 10.1.1.1
 next-address loose 1.1.1.1

ip explicit-path name PROT1 enable
 next-address loose 30.1.1.2
 next-address loose 40.1.1.1
 next-address loose 1.1.1.1
```

At PE2 (tail-end):

```
interface Tunnel1001
 ip unnumbered Loopback0
 mpls ip
 tunnel mode mpls traffic-eng
 tunnel destination 4.4.4.4
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 200
 tunnel mpls traffic-eng path-option 1 explicit name ThruTenG verbatim
 tunnel mpls traffic-eng path-option protect 1 explicit name PROT2 verbatim
 tunnel mpls traffic-eng bidirectional association id 1001 source-address 1.1.1.1 global-id
 1001
!
interface Tunnel1002
 ip unnumbered Loopback0
 mpls ip
 tunnel mode mpls traffic-eng
 tunnel destination 4.4.4.4
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 200
 tunnel mpls traffic-eng path-option 1 explicit name ThruTenG verbatim
 tunnel mpls traffic-eng path-option protect 1 explicit name PROT2 verbatim
 tunnel mpls traffic-eng bidirectional association id 1002 source-address 1.1.1.1 global-id
 1002

ip explicit-path name ThruTenG enable
 next-address loose 10.1.1.2
 next-address loose 22.1.1.1
 next-address loose 4.4.4.4
!
ip explicit-path name ThruHunG enable
 next-address loose 10.1.1.2
 next-address loose 23.1.1.1
 next-address loose 4.4.4.4

ip explicit-path name PROT2 enable
 next-address loose 41.1.1.2
 next-address loose 31.1.1.1
 next-address loose 4.4.4.4
```

Configuring OSFP for Non Co-routed Flex LSP

```
router ospf 1
 router-id 3.3.3.3
 nsr
 nsf cisco
 microloop avoidance
 passive-interface Loopback0
 network 3.3.3.3 0.0.0.0 area 0
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 mpls traffic-eng area 1
```

Verifying the Non Co-routed Inter-area Flex LSP Tunnels

At the PE1

Router# **show mpls traffic-eng tunnels tunnel 1001**

```
Name: PE1_t1001                        (Tunnel1001) Destination: 4.4.4.4
  Status:
    Admin: up        Oper: up     Path: valid      Signalling: connected
    path option 1, type explicit (verbatim) ThruTenG (Basis for Setup, path weight 0)
    Path Protection: Requested
    path protect option 1, type explicit (verbatim) PROT2 (Basis for Protect, path weight
0)

  Config Parameters:
    Bandwidth: 200      kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: disabled LockDown: disabled Loadshare: 200 [10000000] bw-based
    auto-bw: disabled
    Association Type: Double Sided Bidirectional LSPs, Co-routed: NO
    Association ID: 1001, Source: 1.1.1.1, Global ID: 1001
    Fault-OAM: disabled, Wrap-Protection: disabled, Wrap-Capable: No
  Active Path Option Parameters:
    State: explicit path option 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: enabled

  InLabel  :  -
  OutLabel : BDI100, 242
  Next Hop : 10.1.1.2
  Reverse Associated LSP Information:
    Signaled Name: 4.4.4.4 1001
    Tunnel: 1001, Source: 4.4.4.4, Dest: 1.1.1.1, LSP: 9 State: Up
  Lockout Info:
    Locked out: No
    Lockout Originated By: None
  Association:
    Association Type: Double Sided Bidirectional LSPs
    Association ID: 1001 Source: 1.1.1.1
  Extended Association:
    Global source: 1001
    Extended ID: None
  RSVP Signalling Info:
      Src 1.1.1.1, Dst 4.4.4.4, Tun_Id 1001, Tun_Instance 9
```

```
    RSVP Path Info:
      My Address: 10.1.1.1
      Explicit Route: 10.1.1.2 10.1.1.2* 22.1.1.1* 4.4.4.4*
      Record    Route:
      Tspec: ave rate=200 kbits, burst=1000 bytes, peak rate=200 kbits
    RSVP Resv Info:
      Record    Route:  22.1.1.2 22.1.1.1
      Fspec: ave rate=200 kbits, burst=1000 bytes, peak rate=200 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 2 (TE)
    Explicit Route: 11.1.1.2 20.1.1.1 4.4.4.4
  Reason for the tunnel being down: Bidirectional: standby error from [1.1.1.1][UNK] LSP[8]


  History:
    Tunnel:
      Time since created: 7 minutes, 51 seconds
      Number of LSP IDs (Tun_Instances) used: 9
    Current LSP: [ID: 9]
      Uptime: 5 minutes, 59 seconds
```

At PE2

Router# **show mpls traffic-eng tunnels tunnel 1001**

```
Name: PE2_t1001                              (Tunnel1001) Destination: 1.1.1.1
  Status:
    Admin: up          Oper: up      Path: valid      Signalling: connected
    path option 1, type explicit (verbatim) ThruHunG (Basis for Setup, path weight 0)
    Path Protection: Requested
    path protect option 1, type explicit (verbatim) PROT1 (Basis for Protect, path weight
0)

  Config Parameters:
    Bandwidth: 200       kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: disabled LockDown: disabled Loadshare: 200 [10000000] bw-based
    auto-bw: disabled
    Association Type: Double Sided Bidirectional LSPs, Co-routed: NO
    Association ID: 1001, Source: 1.1.1.1, Global ID: 1001
    Fault-OAM: disabled, Wrap-Protection: disabled, Wrap-Capable: No
  Active Path Option Parameters:
    State: explicit path option 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: enabled

  InLabel  :  -
  OutLabel : BDI221, 980
  Next Hop : 23.1.1.2
  Reverse Associated LSP Information:
    Signaled Name: 1.1.1.1 1001
    Tunnel: 1001, Source: 1.1.1.1, Dest: 4.4.4.4, LSP: 9 State: Up
  Lockout Info:
    Locked out: No
    Lockout Originated By: None
  Association:
    Association Type: Double Sided Bidirectional LSPs
    Association ID: 1001 Source: 1.1.1.1
  Extended Association:
    Global source: 1001
    Extended ID: None
  RSVP Signalling Info:
      Src 4.4.4.4, Dst 1.1.1.1, Tun_Id 1001, Tun_Instance 9
    RSVP Path Info:
      My Address: 23.1.1.1
      Explicit Route: 23.1.1.2 23.1.1.2* 10.1.1.1* 1.1.1.1*
```

```
      Record     Route:
        Tspec: ave rate=200 kbits, burst=1000 bytes, peak rate=200 kbits
      RSVP Resv Info:
        Record     Route:   10.1.1.2 10.1.1.1
        Fspec: ave rate=200 kbits, burst=1000 bytes, peak rate=200 kbits
    Shortest Unconstrained Path Info:
      Path Weight: 2 (TE)
      Explicit Route: 20.1.1.2 11.1.1.1 1.1.1.1
  Reason for the tunnel being down: Bidirectional: standby error from [4.4.4.4][UNK] LSP[8]


    History:
      Tunnel:
        Time since created: 8 minutes, 9 seconds
        Time since path change: 6 minutes, 10 seconds
        Number of LSP IDs (Tun_Instances) used: 9
      Current LSP: [ID: 9]
        Uptime: 6 minutes, 10 seconds
```

Troubleshooting Flex LSP

Step 1: Verifying that the Flex LSP Tunnel is in UP State

Router# **show mpls traffic-eng tunnels bidirectional-associated association id 1**

```
P2P TUNNELS/LSPs:
Name: RP1_t3                                    (Tunnel3) Destination: 10.5.0.1
  Status:
    Admin: up          Oper: up      Path: valid       Signalling: connected
    path option 2, type explicit expl_route_m2_tail (Basis for Setup, path weight 40)
    path option 3, type explicit expl_route_m3_tail
    Path Protection: 0 Common Link(s), 0 Common Node(s)
   path protect option 2, type explicit expl_route_m3_tail (Basis for Protect, path weight
 40)
    path protect option 3, type list name xtd
    Lockout Info:
      Locked Out: No
  Config Parameters:
    Bandwidth: 500       kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: disabled LockDown: disabled Loadshare: 500 [4000000] bw-based
    auto-bw: disabled
    Association Type: Single Sided Bidirectional LSPs, Co-routed: YES
    Association ID: 1, Source: 2.3.4.5, Global ID: 6
    Fault-OAM: disabled
  Active Path Option Parameters:
    State: explicit path option 2 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled
  InLabel  : -
  OutLabel : Ethernet0/0, 16
  Next Hop : 10.1.2.2
-------~Full Output not provided ~--------
```

Step 2: Verifying RSVP Signaling

Router# **show ip rsvp sender detail**
```
PATH:
  Tun Dest:   10.255.255.1  Tun ID: 15  Ext Tun ID: 10.255.255.8
  Tun Sender: 10.255.255.8  LSP ID: 40
  Path refreshes:
    arriving: from PHOP 10.5.2.1 on Et0/1 every 30000 msecs. Timeout in 136 sec
```

```
      sent:    to   NHOP 10.1.4.1 on Ethernet0/0
    Session Attr:
      Setup Prio: 7, Holding Prio: 7
      Flags: (0x4) SE Style
      Session Name: R3_t15
    ERO: (incoming)
      10.5.2.2 (Strict IPv4 Prefix, 8 bytes, /32)
      10.1.4.2 (Strict IPv4 Prefix, 8 bytes, /32)
      10.1.4.1 (Strict IPv4 Prefix, 8 bytes, /32)
      10.255.255.1 (Strict IPv4 Prefix, 8 bytes, /32)
    ERO: (outgoing)
      10.1.4.1 (Strict IPv4 Prefix, 8 bytes, /32)
      10.255.255.1 (Strict IPv4 Prefix, 8 bytes, /32)
    ASSOCIATION:
      Extended Association type: Single sided provisioned bidirectional LSPs IPv4
      Association ID: 1, Source: 1.1.1.1
      Global source: 0
      ExtID[0]: 0xAFFFF08
      ExtID[1]: 0x28
-------~Full Output not provided ~-------
```

Step 3: Verifying RSVP Reservation

```
Router# show ip rsvp reservation detail
Reservation:
  Tun Dest:   10.255.255.1  Tun ID: 15  Ext Tun ID: 10.255.255.8
  Tun Sender: 10.255.255.8  LSP ID: 327
  Resv refreshes:
    arriving: from NHOP 10.1.4.1 on Et0/0 every 30000 msecs. Timeout in 382 sec
  Next Hop: 10.1.4.1 on Ethernet0/0
  Label: 23 (outgoing)
  Reservation Style is Shared-Explicit, QoS Service is Controlled-Load
  Resv ID handle: 1200040C.
  Created: 11:08:07 EST Fri Aug 28 2015
  Average Bitrate is 0 bits/sec, Maximum Burst is 1K bytes
  Min Policed Unit: 0 bytes, Max Pkt Size: 1500 bytes
  Status:
  Policy: Accepted. Policy source(s): MPLS/TE
Reservation:
  Tun Dest:   10.255.255.8  Tun ID: 15  Ext Tun ID: 10.255.255.1
  Tun Sender: 10.255.255.1  LSP ID: 338
  Resv refreshes:
    arriving: from NHOP 10.5.2.1 on Et0/1 every 30000 msecs. Timeout in 382 sec
  Next Hop: 10.5.2.1 on Ethernet0/1
  Label: 17 (outgoing)
  Reservation Style is Shared-Explicit, QoS Service is Controlled-Load
  Resv ID handle: 05000410.
  Created: 11:08:07 EST Fri Aug 28 2015
  Average Bitrate is 0 bits/sec, Maximum Burst is 1K bytes
  Min Policed Unit: 0 bytes, Max Pkt Size: 1500 bytes
  RRO:
    10.3.2.2/32, Flags:0x0 (No Local Protection)
    10.3.2.1/32, Flags:0x0 (No Local Protection)
  Status:
  Policy: Accepted. Policy source(s): MPLS/TE
```

Step 4: Verifying Wrap Functionality

```
Router# show mpls traffic-eng tunnels
P2P TUNNELS/LSPs:
Name: R1_t15                              (Tunnel15) Destination: 10.255.255.8
  Status:
    Admin: up       Oper: up     Path: valid      Signalling: connected
    path option 1, type explicit Primary (Basis for Setup, path weight 60)
    path option 2, type dynamic
```

```
      Path Protection: 0 Common Link(s), 0 Common Node(s)
      path protect option 1, type explicit Secondary (Basis for Protect, path weight 40)
      Lockout Info:
        Locked Out: No
  Config Parameters:
    Bandwidth: 0         kbps (Global)  Priority: 7  7    Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled  LockDown: disabled Loadshare: 0 [0] bw-based
    auto-bw: disabled
    Association Type: Single Sided Bidirectional LSPs, Co-routed: YES
    Association ID: 1, Source: 1.1.1.1
    Fault-OAM: enabled, Path-Protection: ready, Wrap-Protection: enabled, Wrap-Capable: Yes

    FlexLSP Event History:
  Active Path Option Parameters:
    State: explicit path option 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled
Router# show mpls traffic-eng tunnels protection
P2P TUNNELS:
R1_t15
  LSP Head, Tunnel15, Admin: up, Oper: up
  Src 10.255.255.1, Dest 10.255.255.8, Instance 34
  Fast Reroute Protection: None
  Lockout Info:
    Locked Out: No
  Path Protection: Backup lsp in use.
  Prior Working LSP details:
    LSP ID: 33 (Delayed Clean)
    Deactivates In: (2796) ms
    InLabel  :  -
    OutLabel : Ethernet0/1, 16
    Next Hop : 10.1.4.2
    Reverse Associated LSP Information:
        Signaled Name: 10.255.255.8 15
        Tunnel: 15, Source: 10.255.255.8, Dest: 10.255.255.1, LSP: 29 State: Up
    Lockout Info:
        Locked out: No
        Lockout Originated By: None
    Association:
        Association Type: Single Sided Bidirectional LSPs
        Association ID: 1 Source: 1.1.1.1
-------~Full Output not provided ~-------
```

Step 5: Verifying BFD and OAM Operations

```
Router# show mpls traffic-eng tunnels detail | sec Fault
    Fault-OAM: enabled, Path-Protection: no protection, Wrap-Protection: disabled,
Wrap-Capable: No
    Fault-OAM Events:
      LSP 4638 (deleted) bfd-delete,
          at 07:32:08 IST Fri Jun 3 2016 (1 days, 8 hours, 35 mins, 30 secs ago)
      LSP 4638 (deleted) fault-delete,
          at 07:32:08 IST Fri Jun 3 2016 (1 days, 8 hours, 35 mins, 30 secs ago)
      LSP 4638 (working) bfd-up,
          at 10:15:31 IST Thu Jun 2 2016 (2 days, 5 hours, 52 mins, 7 secs ago)
      LSP 4637 (working) bfd-delete,
          at 10:15:20 IST Thu Jun 2 2016 (2 days, 5 hours, 52 mins, 18 secs ago)
      LSP 4637 (working) fault-delete,
          at 10:15:20 IST Thu Jun 2 2016 (2 days, 5 hours, 52 mins, 18 secs ago)
      LSP 4636 (working) bfd-delete,
          at 10:15:17 IST Thu Jun 2 2016 (2 days, 5 hours, 52 mins, 21 secs ago)
      LSP 4636 (working) fault-delete,
          at 10:15:17 IST Thu Jun 2 2016 (2 days, 5 hours, 52 mins, 21 secs ago)
-------~Full Output not provided ~-------
```

```
Router# show mpls fault-oam session end-point detail
 MPLS Fault-OAM End-point Sessions
=====================================
    Session handle : 0x6
    Client handle : 0x2B9FAE02B750
    Local label : 18
    Tunnel interface : Tunnel3 (0x15)
    Tunnel number : 3
    LSP number : 49
    Global ID : 0
    Node ID : 10.1.0.1
    Local event : Fault Clear
    Sender Information
        Fault source : End-point
        Refresh seconds : 20
        Initial count : 0
        Fault type : CLR
        Tx Fault-CLR count : 0
        Tx Fault-AIS count : 0
        Tx Fault-LDI count : 0
        Tx Fault-LKR count : 0
        Tx Lockout-CLR count : 0
        Tx Lockout count : 0
        Tx Error count : 0
    Receiver Information
        Source global ID : 0
        Source node ID : 0
        Source intf number : 0
        Fault type : CLR
        Rx Fault-CLR count : 0
        Rx Fault-AIS count : 0
        Rx Fault-LDI count : 0
        Rx Fault-LKR count : 0
        Rx Lockout-CLR count : 0
        Rx Lockout count : 0
        Rx Error count : 0
    -------~Full Output not provided ~-------
```

Step 6: Verifying that Pseudowire is in UP State

```
Router# show mpls l2transport vc vcid 1              (HEAD router)


Local intf     Local circuit              Dest address    VC ID      Status
-------------  -------------------------  --------------- ---------- ----------
Gi6            Eth VLAN 30                53.0.0.1         1          UP
 #show mpls l2transport vc vcid 1 detail
Local interface: Gi6 up, line protocol up, Eth VLAN 30 up
  Interworking type is Ethernet
  Destination address: 53.0.0.1, VC ID: 1, VC status: up
    Output interface: Tu10, imposed label stack {29 29780}
    Preferred path: Tunnel10,  active
    Required BW = 15000, Admitted BW = 15000
    Default path: ready
    Next hop: point2point
  Create time: 00:01:13, last status change time: 00:01:13
    Last label FSM state change time: 00:01:13
  Signaling protocol: LDP, peer 53.0.0.1:0 up
    Targeted Hello: 52.0.0.1(LDP Id) -> 53.0.0.1, LDP is UP
    Graceful restart: configured and enabled
    Non stop routing: configured and not enabled

    -------~Full Output not provided ~-------
```

Use the **show adjacency tunnel internal** command to view the software forwarding of the tunnel:

```
Router# show adjacency tunnel1 internal | i lsp-num

          GigabitEthernet0/5/2 55.0.0.1 label 21 lsp-num 20
          Path protected by GigabitEthernet0/5/3 label 22 lsp-num 21
          Reopt of working: Null0 0.0.0.0 label none lsp-num 0
          Reopt of protect: Null0 label none lsp-num 0
```