MPLS Traffic Engineering (TE): Path Protection

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The MPLS Traffic Engineering (TE): Path Protection feature provides an end-to-end failure recovery mechanism (that is, full path protection) for Multiprotocol Label Switching (MPLS) traffic engineering (TE) tunnels.

Note Cisco IOS Release 12.3(33)SRE and later releases support enhanced path protection, which is the ability to configure up to eight secondary path options for a given primary path option.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the "Feature Information for MPLS Traffic Engineering (TE): Path Protection" section on page 32.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

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Prerequisites for MPLS Traffic Engineering (TE): Path Protection

- Ensure that your network supports MPLS TE, Cisco Express Forwarding, and Intermediate System-to-Intermediate System (IS-IS) or Open Shortest Path First (OSPF) protocols.
- Enable MPLS.
- Configure TE on the routers.
- Configure a TE tunnel with a primary path option by using the **tunnel mpls traffic-eng path-option** command.
- If your router supports stateful switchover (SSO), configure Resource Reservation Protocol (RSVP) Graceful Restart in full mode on the routers.
- If your router supports SSO, for the Cisco nonstop forwarding (NSF) operation, you must have configured SSO on the device.

Restrictions for MPLS Traffic Engineering (TE): Path Protection

- The secondary path will not be signaled with the Fast Reroute (FRR) flag.
- Dynamic diverse paths are not supported.
- Do not use link and node protection with path protection on the headend router.
- Do not configure path protection on an automesh tunnel template because the destinations are different and you cannot use the same path option to reach multiple destinations.
- A lockdown option is not supported in protected path options.
- After an SSO event, path protection will not be immediately available on tunnels. Only a single label switched path (LSP) is checkpointed and recovered for the tunnel; the path-protected LSP will not be signaled until the end of the RSVP High Availability (HA) recovery period.

Information About MPLS Traffic Engineering (TE): Path Protection

Traffic Engineering Tunnels

MPLS TE lets you build LSPs across your network for forwarding traffic.

MPLS TE LSPs let the headend of a TE tunnel control the path the traffic takes to a particular destination. This method is more flexible than forwarding traffic based only on the destination address.

Interarea tunnels allow you to do the following:

- Build TE tunnels between areas (interarea tunnels).
- Build TE tunnels that start and end in the same area, or multiple areas on a router (intra-area tunnels).

Some tunnels are more important than others. For example, you may have tunnels carrying VoIP traffic and tunnels carrying data traffic that are competing for the same resources. MPLS TE allows you to have some tunnels preempt others. Each tunnel has a priority, and more-important tunnels take precedence over less-important tunnels.

Path Protection

Path protection provides an end-to-end failure recovery mechanism (that is, full path protection) for MPLS TE tunnels. A secondary LSP is established, in advance, to provide failure protection for the protected LSP that is carrying a tunnel's TE traffic. When there is a failure on the protected LSP, the headend router immediately enables the secondary LSP to temporarily carry the tunnel's traffic. If there is a failure on the secondary LSP, the tunnel no longer has path protection until the failure along the secondary path is cleared. Path protection can be used with a single area (OSPF or IS-IS), an interarea (OSPF or IS-IS), or an Inter-AS (Border Gateway Protocol [BGP], external BGP [eBGP,] and static).

The failure detection mechanisms that trigger switchover to a secondary tunnel include the following:

- Path error or ResvTear message from RSVP signaling
- Notification from the RSVP hello that a neighbor is lost
- Notification from the Bidirectional Forwarding Detection (BFD) protocol that a neighbor is lost
- Notification from the Interior Gateway Protocol (IGP) that an adjacency is down
- Local teardown of the protected tunnel's LSP due to preemption in order to signal higher priority LSPs, a Packet over SONET (POS) alarm, online insertion and removal (OIR), and so forth

An alternate recovery mechanism is Fast Reroute (FRR), which protects MPLS TE LSPs only from link and node failures by locally repairing the LSPs at the point of failure.

Although not as fast as link or node protection, presignaling a secondary LSP is faster than configuring a secondary primary path option or allowing the tunnel's headend router to dynamically recalculate a path. The actual recovery time is topology-dependent, and affected by delay factors such as propagation delay or switch-fabric latency.

Enhanced Path Protection

Enhanced path protection provides support of multiple backup path options per primary path option. You can configure up to eight backup path options for a given primary path option. Only one of the configured backup path options is actively signaled at any time.

After you enter the **mpls traffic-eng path-option list** command, you can enter the backup path priority in the *number* argument of the **path-option** command. A lower identifier represents a higher priority. Priorities are configurable for each backup path option. Multiple backup path options and a single backup path option cannot coexist to protect a primary path option.

ISSU

Cisco In Service Software Upgrade (ISSU) allows you to perform a Cisco IOS software upgrade or downgrade while the system continues to forward packets. ISSU takes advantage of the Cisco IOS high availability infrastructure—Cisco NSF with SSO and hardware redundancy—and eliminates the downtime associated with software upgrades or version changes by allowing changes while the system remains in service. Cisco ISSU lowers the impact that planned maintenance activities have on network service availability; there is less downtime and better access to critical systems.

When path protection is enabled and an ISSU upgrade is performed, path protection performance is similar to that of other TE features.

NSF/SSO

Cisco NSF with SSO provides continuous packet forwarding, even during a network processor hardware or software failure.

SSO takes advantage of Route Processor (RP) redundancy to increase network availability by establishing one of the RPs as the active processor and the other RP as the secondary processor, and then synchronizing critical state information between them. Following an initial synchronization between the two processors, SSO dynamically maintains RP state information between them. A switchover from the active to the secondary processor occurs when the active RP fails, is removed from the networking device, or is manually taken down for maintenance.

Cisco NSF works with SSO to minimize network outage to users after a switchover. The main purpose of NSF is to continue forwarding IP packets after an RP switchover. Cisco NSF helps to suppress routing flaps in SSO-enabled devices, thus reducing network instability.

The MPLS Traffic Engineering (TE): Path Protection feature can recover after SSO. A tunnel configured for path protection may have two LSPs signaled simultaneously: the primary LSP that carries the traffic and the secondary LSP that carries traffic in case there is a failure along the primary path. Only information associated with one of the LSPs, the one that is currently carrying traffic, is synched to the standby RP. The standby RP, upon recovery, can determine from the checkpointed information whether the LSP was the primary LSP or the secondary LSP.

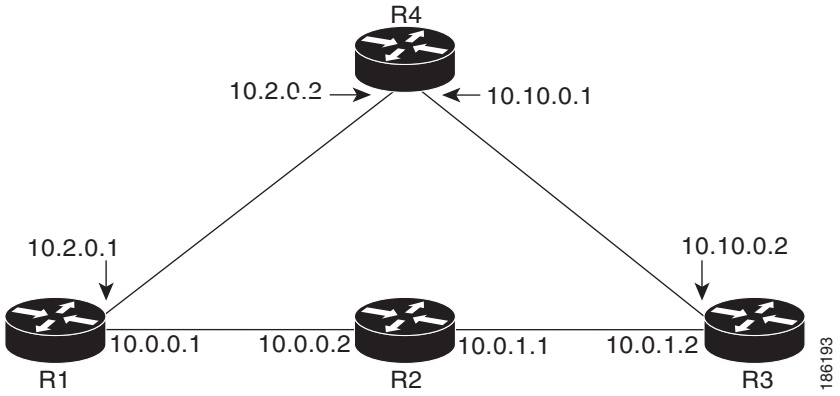
If the primary LSP was active during the switchover, only the primary LSP is recovered. The secondary LSP, which was signaled to provide path protection is resignaled after the TE recovery period is complete. This does not impact traffic on the tunnel because the secondary LSP was not carrying the traffic.

How to Configure MPLS Traffic Engineering (TE): Path Protection

In enhanced path protection, you can create and assign a path option list.

Regular Path Protection Configuration Tasks

Figure 1 Network Topology—Path Protection



Configuring Explicit Paths for Secondary Paths

To specify a secondary path that does not include common links or nodes associated with the primary path in case those links or nodes go down, configure an explicit path by performing the following steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip explicit-path** {**name** *path-name* | **identifier** *number*} [**enable** | **disable**]
4. **index** *index command ip-address*
5. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip explicit-path** {**name** *path-name* | **identifier** *number*} [**enable** | **disable**] **Example:** `Router(config)# ip explicit-path name path3441 enable`	Creates or modifies the explicit path and enters IP explicit path configuration mode.
Step 4	**index** *index command ip-address* **Example:** `Router(cfg-ip-exp1-path)# index 1 next-address 10.0.0.1`	Inserts or modifies a path entry at a specific index. • The IP address represents the node ID. **Note** Enter this command once for each router.
Step 5	**exit** **Example:** `Router(cfg-ip-exp1-path)# exit`	Exits IP explicit path configuration mode and enters global configuration mode.

Assigning a Secondary Path Option to Protect a Primary Path Option

Assign a secondary path option in case there is a link or node failure along a path and all interfaces in your network are not protected.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *number*
4. **tunnel mpls traffic-eng path-option protect** *number* [**attributes** *lsp-attributes* | **bandwidth** {*kbps* | **subpool** *kbps*} | **explicit** {**identifier** *path-number* | **name** *path-name*} | **list** {**name** *pathlist-name* | **identifier** *pathlist-identifier*}]
5. **end**

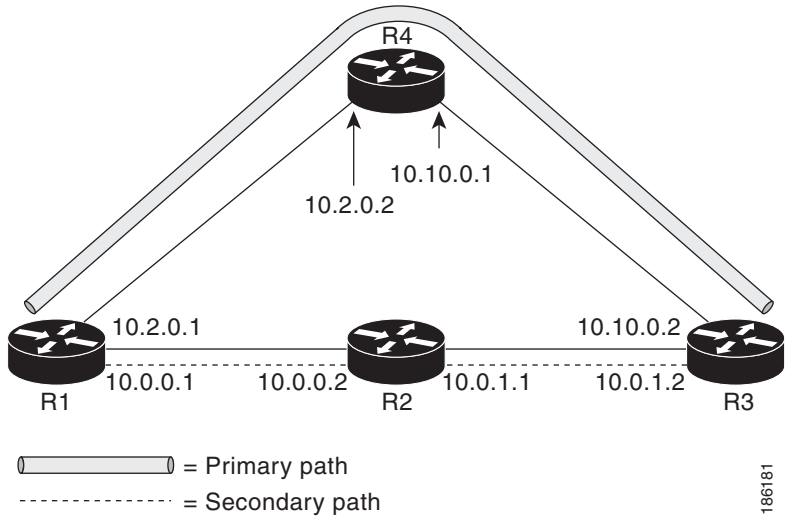
DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface tunnel** *number* **Example:** `Router(config)# interface tunnel500`	Configures a tunnel interface and enters interface configuration mode.
Step 4	**tunnel mpls traffic-eng path-option protect** *number* [**attributes** *lsp-attributes* | **bandwidth** {*kbps* | **subpool** *kbps*} | **explicit** {**identifier** *path-number* | **name** *path-name*} | **list** {**name** *pathlist-name* | **identifier** *pathlist-identifier*}] **Example:** `Router(config-if)# tunnel mpls traffic-eng path-option protect 10 explicit name path344`	Configures a secondary path option for an MPLS TE tunnel.
Step 5	**end** **Example:** `Router(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Verifying the Configuration of MPLS Traffic Engineering Regular Path Protection

To verify the configuration of regular path protection, perform the following steps. In Steps 1 and 2, refer to Figure 2.

Figure 2 Network Topology Verification



SUMMARY STEPS

1. **show running interface tunnel** *tunnel-number*
2. **show mpls traffic-eng tunnels tunnel** *tunnel-interface*
3. **show mpls traffic-eng tunnels tunnel** *number* [**brief**] [**protection**]
4. **show ip rsvp high-availability database** {**hello** | **link-management** {**interfaces** | **system**} | **lsp** [**filter destination** *ip-address* | **filter lsp-id** *lsp-id* | **filter source** *ip-address* | **filter tunnel-id** *tunnel-id*] | **lsp-head** [**filter** *number*] | **summary**}

DETAILED STEPS

Step 1 **show running interface tunnel** *tunnel-number*

This command displays the configuration of the primary path and protection path options.

Note To show the status of both LSPs (that is, both the primary path and the protected path), use the **show mpls traffic-eng tunnels** command with the **protection** keyword.

```
Router# show running interface tunnel500

Building configuration...

Current configuration : 497 bytes
!
interface Tunnel500
 ip unnumbered Loopback0
 tunnel destination 10.0.0.9
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 100
 tunnel mpls traffic-eng path-option 10 explicit name path344
 tunnel mpls traffic-eng path-option 20 explicit name path345
 tunnel mpls traffic-eng path-option protect 10 explicit name path3441
```

```
 tunnel mpls traffic-eng path-option protect 20 explicit name path348
end
```

Step 2 **show mpls traffic-eng tunnels** *tunnel-interface*

This command displays tunnel path information.

The Common Link(s) field shows the number of links shared by both the primary and secondary paths, from the headend router to the tailend router.

The Common Node(s) field shows the number of nodes shared by both the primary and secondary paths, excluding the headend and tailend routers.

As shown in the following output, there are no common links or nodes:

```
Router# show mpls traffic-eng tunnels tunnel500

Name: R1_t500 (Tunnel500) Destination: 10.0.0.9
 Status:
  Admin: up Oper: up Path: valid Signalling: connected
  path option 10, type explicit path344 (Basis for Setup, path weight 20)
  path option 20, type explicit path345
  Path Protection: 0 Common Link(s), 0 Common Node(s)
  path protect option 10, type explicit path3441 (Basis for Protect, path weight 20)
  path protect option 20, type explicit path348

 Config Parameters:
  Bandwidth: 100 kb/s (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
  Metric Type: TE (default)
  AutoRoute: enabled LockDown: disabled Loadshare: 100 bw-based
  auto-bw: disabled
 Active Path Option Parameters:
  State: explicit path option 10 is active
  BandwidthOverride: disabled LockDown: disabled Verbatim: disabled

 InLabel : -
 OutLabel : Ethernet1/0, 16
 RSVP Signalling Info:
    Src 10.1.1.1, Dst 10.0.0.9, Tun_Id 500, Tun_Instance 19
  RSVP Path Info:
    My Address: 10.2.0.1
    Explicit Route: 10.2.0.2  10.10.0.1  10.10.0.2  10.0.0.9
    Record Route: NONE
    Tspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
  RSVP Resv Info:
    Record Route: NONE
    Fspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
 Shortest Unconstrained Path Info:
  Path Weight: 20 (TE)
  Explicit Route: 10.2.0.1  10.2.0.2  10.10.0.1  10.10.0.2  10.0.0.9
 History:
  Tunnel:
    Time since created: 11 minutes, 17 seconds
    Time since path change: 8 minutes, 5 seconds
    Number of LSP IDs (Tun_Instances) used: 19
  Current LSP:
    Uptime: 8 minutes, 5 seconds
```

Step 3 **show mpls traffic-eng tunnels tunnel** *number* [**brief**] [**protection**]

Use this command, with the **protection** keyword, to display the status of both LSPs (that is, both the primary path and the protected path).

Note Deleting a primary path option has the same effect as shutting down a link. Traffic will move to the protected path in use.

The following command output shows that the primary LSP is up, and the secondary LSP is up and is providing protection:

```
Router# show mpls traffic-eng tunnels tunnel500 protection

R1_t500
 LSP Head, Tunnel500, Admin: up, Oper: up
 Src 10.1.1.1, Dest 10.0.0.9, Instance 19
 Fast Reroute Protection: None
 Path Protection: 0 Common Link(s), 0 Common Node(s)
  Primary lsp path:10.2.0.1  10.2.0.2
                   10.10.0.1 10.10.0.2
                   10.0.0.9
  Protect lsp path:10.0.0.1  10.0.0.2
                   10.0.1.1  10.0.1.2
                   10.0.0.9
  Path Protect Parameters:
   Bandwidth: 100 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
   Metric Type: TE (default)
  InLabel : -
  OutLabel : Ethernet0/0, 16
  RSVP Signalling Info:
    Src 10.1.1.1, Dst 10.0.0.9, Tun_Id 500, Tun_Instance 27
   RSVP Path Info:
    My Address: 10.0.0.1
    Explicit Route: 10.0.0.2  10.0.1.1  10.0.1.2  10.0.0.9
    Record Route: NONE
    Tspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
   RSVP Resv Info:
    Record Route: NONE
    Fspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
```

The following command output shows that the primary LSP is down, and the secondary LSP is up and is actively carrying traffic:

```
Router# show mpls traffic-eng tunnels tunnel500 protection

R1_t500
 LSP Head, Tunnel500, Admin: up, Oper: up
 Src 10.1.1.1, Dest 10.0.0.9, Instance 27
 Fast Reroute Protection: None
 Path Protection: Backup lsp in use.
```

Step 4 **show ip rsvp high-availability database** {**hello** | **link-management** {**interfaces [fixed** | **variable]** | **system**} | **lsp** [**filter destination** *ip-address* | **filter lsp-id** *lsp-id* | **filter source** *ip-address* | **filter tunnel-id** *tunnel-id*] | **lsp-head** [**filter** *number*] | **summary**}

The **show ip rsvp high-availability database** command displays the contents of the RSVP HA read and write databases used in TE. If you specify the **lsp-head** keyword, the command output includes path protection information.

```
Router# show ip rsvp high-availability database lsp-head

LSP_HEAD WRITE DB
 Tun ID: 500
 Header:
  State: Checkpointed  Action: Add
  Seq #: 3             Flags:  0x0
```

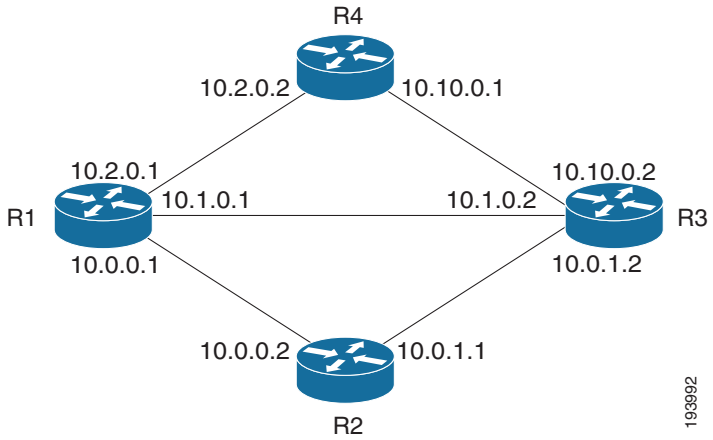
```
Data:
 lsp_id: 5, bandwidth: 100, thead_flags: 0x1, popt: 1
 feature_flags: path protection active
 output_if_num: 5, output_nhop: 10.0.0.1
 RRR path setup info
  Destination: 10.0.0.9, Id: 10.0.0.9 Router Node (ospf) flag:0x0
  IGP: ospf, IGP area: 0, Number of hops: 5, metric: 2
  Hop 0: 10.0.0.1, Id: 10.0.0.1 Router Node (ospf), flag:0x0
  Hop 1: 10.0.0.2, Id: 10.0.0.7 Router Node (ospf), flag:0x0
  Hop 2: 10.0.1.1, Id: 10.0.0.7 Router Node (ospf), flag:0x0
  Hop 3: 10.0.1.2, Id: 10.0.0.9 Router Node (ospf), flag:0x0
  Hop 4: 10.0.0.9, Id: 10.0.0.9 Router Node (ospf), flag:0x0
```

Enhanced Path Protection Configuration Tasks

This section contains the following tasks, which are shown in Figure 3.

- Creating a Path Option List, page 11 (required)
- Assigning a Path Option List to Protect a Primary Path Option, page 13 (required)
- Verifying the Configuration of MPLS TE Enhanced Path Protection, page 14 (optional)

Figure 3 Network Topology - Enhanced Path Protection in Cisco IOS Release 12.2(33)SRE



Creating a Path Option List

In Cisco IOS Release 12.2(33)SRE, perform the following task to create a path option list of backup paths for a primary path option.

Note To use a secondary path instead, perform the steps in the "Configuring Explicit Paths for Secondary Paths" section on page 5.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls traffic-eng path-option list** [**name** *pathlist-name* | **identifier** *pathlist-number*]
4. **path-option** *number* **explicit** [**name** *pathoption-name* | **identifier** *pathoption-number*]
5. **list**
6. **no** [*pathoption-name* | *pathoption-number*]
7. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mpls traffic-eng path-option list** [**name** *pathlist-name* | **identifier** *pathlist-number*] **Example:** `Router(config)# mpls traffic-eng path-option list name pathlist-01`	Configures a path option list, and enters path-option list configuration mode. • You can enter the following commands: **path-option**, **list**, **no**, and **exit**.
Step 4	**path-option** *number* **explicit** [**name** *pathoption-name* | **identifier** *pathoption-number*] **Example:** `Router(cfg-pathoption-list)# path-option 10 explicit identifier 200`	(Optional) Specifies the name or identification number of the path option to be added, edited, or deleted. The *pathoption-number* value can be from 1 through 65535.
Step 5	**list** **Example:** `Router(cfg-pathoption-list)# list`	(Optional) Lists all path options.
Step 6	**no** [*pathoption-name* | *pathoption-number*] **Example:** `Router(cfg-pathoption-list)# no 10`	(Optional) Deletes a specified path option.
Step 7	**exit** **Example:** `Router(cfg-pathoption-list)# exit`	(Optional) Exits path-option list configuration mode and enters global configuration mode.

Assigning a Path Option List to Protect a Primary Path Option

Assign a path option list in case there is a link or node failure along a path and all interfaces in your network are not protected. See Figure 3.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *number*

4. **tunnel mpls traffic-eng path-option protect** *number* [**attributes** *lsp-attributes* | **bandwidth** {*kbps* | **subpool** *kbps*} | **explicit** {**identifier** *path-number* | **name** *path-name*} | **list** {**name** *pathlist-name* | **identifier** *pathlist-identifier*}]
5. **exit**

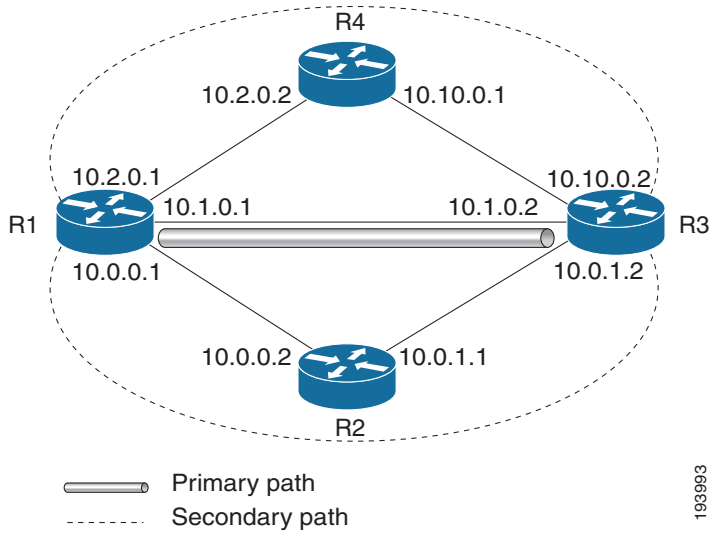
DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface tunnel** *number* **Example:** `Router(config)# interface tunnel500`	Configures a tunnel interface and enters interface configuration mode.
Step 4	**tunnel mpls traffic-eng path-option protect** *number* [**attributes** *lsp-attributes* | **bandwidth** {*kbps* | **subpool** *kbps*} | **explicit** {**identifier** *path-number* | **name** *path-name*} | **list** {**name** *pathlist-name* | **identifier** *pathlist-identifier*}] **Example:** `Router(config-if)# tunnel mpls traffic-eng path-option protect 10 list name pathlist-01`	Configures a path option list to protect primary path option 10.
Step 5	**exit** **Example:** `Router(config-if)# exit`	(Optional) Exits interface configuration mode and enters global configuration mode.

Verifying the Configuration of MPLS TE Enhanced Path Protection

To verify the configuration of MPLS TE enhanced path protection, refer to Figure 4 and perform the following steps.

Figure 4 Network Topology Verification for Enhanced Path Protection



SUMMARY STEPS

1. **show running interface tunnel** *tunnel-number*
2. **show mpls traffic-eng tunnels** *tunnel-number*
3. **show mpls traffic-eng tunnels tunnel** *number* [**brief**] [**protection**]
4. **show ip rsvp high-availability database** {**hello** | **link-management** {**interfaces** [**fixed** | **variable**] | **system**} | **lsp** [**filter destination** *ip-address* | **filter lsp-id** *lsp-id* | **filter source** *ip-address* | **filter tunnel-id** *tunnel-id*] | **lsp-head** [**filter** *number*] | **summary**}

DETAILED STEPS

Step 1 **show running interface tunnel** *tunnel-number*

This command displays the configuration of the path option and the backup path option.

Note To display the status of both LSPs (that is, both the primary path and the protected path), use the **show mpls traffic-eng tunnels** command with the **protection** keyword.

```
Router# show running interface tunnel2

Building configuration..

Current configuration : 296 bytes
!
interface Tunnel2
 ip unnumbered Loopback0
 tunnel mode mpls traffic-eng
 tunnel destination 10.10.0.2
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng path-option 10 explicit name primary1
```

```
 tunnel mpls traffic-eng path-option protect 10 list name pathlist-01
end
```

Step 2 **show mpls traffic-eng tunnels tunnel** *number*

This command displays tunnel path information.

The Common Link(s) field shows the number of links shared by both the primary and secondary paths, from the headend router to the tailend router.

The Common Node(s) field shows the number of nodes shared by both the primary and secondary paths, excluding the headend and tailend routers.

As shown in the following output, there are no common links or nodes:

```
Router# show mpls traffic-eng tunnels tunnel2

Name: iou-100_t2 (Tunnel2) Destination: 10.10.0.2
 Status:
  Admin: up Oper: up Path: valid Signalling: connected
  path option 10, type explicit primary1 (Basis for Setup, path weight 10)
  Path Protection: 0 Common Link(s), 0 Common Node(s)
  path protect option 10, type list name secondary-list
   Inuse path-option 10, type explicit secondary1 (Basis for Protect, path weight 20)

Config Parameters:
 Bandwidth: 0 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
 Metric Type: TE (default)
 AutoRoute announce: enabled LockDown: disabled Loadshare: 0 bw-based
 auto-bw: disabled
Active Path Option Parameters:
 State: explicit path option 10 is active
 BandwidthOverride: disabled LockDown: disabled Verbatim: disabled

InLabel : -
OutLabel : Ethernet7/0, implicit-null
RSVP Signalling Info:
 Src 100.100.100.100, Dst 10.10.0.2, Tun_Id 2, Tun_Instance 188
RSVP Path Info:
 My Address: 10.1.0.1
 Explicit Route: 10.1.0.2 10.10.0.2
 Record Route: NONE
 Tspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
RSVP Resv Info:
 Record Route: NONE
 Fspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
Shortest Unconstrained Path Info:
 Path Weight: 10 (TE)
 Explicit Route: 10.1.0.1 10.1.0.2 10.10.0.2
History:
 Tunnel:
  Time since created: 1 hours, 34 minutes
  Time since path change: 1 minutes, 50 seconds
  Number of LSP IDs (Tun_Instances) used: 188
 Current LSP:
  Uptime: 1 minutes, 50 seconds
 Prior LSP:
  ID: path option 10 [44]
  Removal Trigger: label reservation removed
```

Step 3 **show mpls traffic-eng tunnels tunnel** *number* [**brief**] [**protection**]

Use this command, with the **protection** keyword, to display the status of both LSPs (that is, both the primary path and the protected path).

The following command output shows that the primary LSP is up, and the secondary LSP is up and providing protection:

```
Router# show mpls traffic-eng tunnels tunnel2 protection

iou-100_t2
 LSP Head, Tunnel2, Admin: up, Oper: up
 Src 100.100.100.100, Dest 10.10.0.2, Instance 188
 Fast Reroute Protection: None
 Path Protection: 0 Common Link(s), 0 Common Node(s)
  Primary lsp path:10.1.0.1 10.1.0.2
                   10.10.0.2
  Protect lsp path:10.0.0.1 10.0.0.2
                   10.0.1.1 10.0.1.2
                   10.10.0.2
  Path Protect Parameters:
   Bandwidth: 0 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
   Metric Type: TE (default)
  InLabel : -
  OutLabel : Ethernet5/0, 16
  RSVP Signalling Info:
    Src 100.100.100.100, Dst 10.10.0.2, Tun_Id 2, Tun_Instance 189
   RSVP Path Info:
    My Address: 10.0.0.1
    Explicit Route: 10.0.0.2 10.0.1.1 10.0.1.2 10.10.0.2
    Record Route: NONE
    Tspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
   RSVP Resv Info:
    Record Route: NONE
    Fspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
```

The following command output shows that the primary LSP is down, and the secondary LSP is up and is actively carrying traffic:

```
Router# show mpls traffic-eng tunnels tunnel500 protection

R1_t500
 LSP Head, Tunnel500, Admin: up, Oper: up
 Src 10.1.1.1, Dest 10.0.0.9, Instance 27
 Fast Reroute Protection: None
 Path Protection: Backup lsp in use.
```

Step 4 **show ip rsvp high-availability database** {**hello** | **link-management** {**interfaces [fixed** | **variable}]** | **system**} | **lsp** [**filter destination** *ip-address* | **filter lsp-id** *lsp-id* | **filter source** *ip-address* | **filter tunnel-id** *tunnel-id*] | **lsp-head** [**filter** *number*] | **summary**}

The **show ip rsvp high-availability database** command displays the contents of the RSVP HA read and write databases used in TE. If you specify the **lsp-head** keyword, the command output includes path protection information.

```
Router# show ip rsvp high-availability database lsp-head

LSP_HEAD WRITE DB
 Tun ID: 2
 Header:
  State: Checkpointed Action: Add
  Seq #: 2 Flags: 0x0
 Data:
  lsp_id: 6, bandwidth: 0, thead_flags: 0x1, popt: 10
  feature flags: none
  output_if_num: 31, output_nhop: 10.1.0.2
 RRR path setup info
  Destination: 10.10.0.2, Id: .10.10.0.2 Router Node (ospf) flag:0x0
```

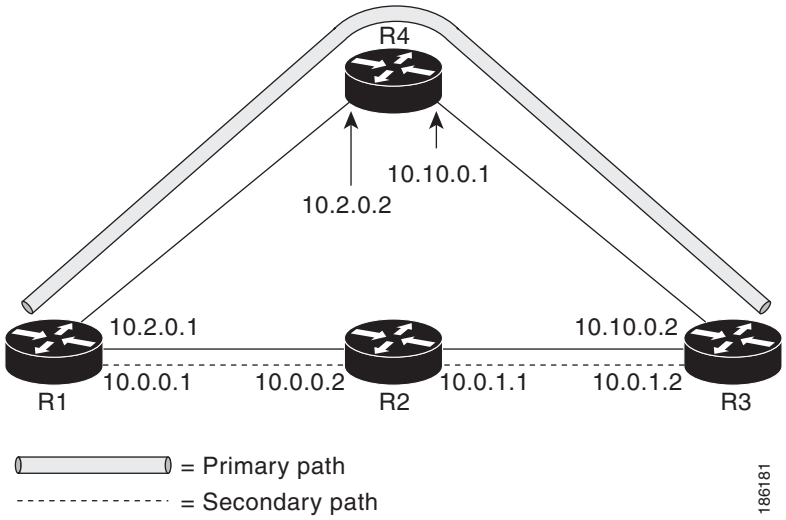
```
IGP: ospf, IGP area: 0, Number of hops: 3, metric: 10
Hop 0: 10.1.0.1, Id: 10.100.100.100 Router Node (ospf), flag:0x0
Hop 1: 10.1.0.2, Id: 10.10.0.2 Router Node (ospf), flag:0x0
Hop 2: 10.103.103.103, Id: 10.10.0.2 Router Node (ospf), flag:0x0
```

Configuration Examples for MPLS Traffic Engineering (TE): Regular Path Protection

Example: Configuring Explicit Paths for Secondary Paths

Figure 5 illustrates a primary path and a secondary path. If there is a failure, the secondary path is used.

Figure 5 Primary Path and Secondary Path



In the following example, the explicit path is named path3441. There is an **index** command for each router. If there is failure, the secondary path is used.

```
Router(config)# ip explicit-path name path3441 enable
Router(cfg-ip-expl-path)# index 1 next 10.0.0.1
Explicit Path name path3441:
    1: next-address 10.0.0.1

Router(cfg-ip-expl-path)# index 2 next 10.0.0.2
Explicit Path name path3441:
    1: next-address 10.0.0.1
    2: next-address 10.0.0.2

Router(cfg-ip-expl-path)# index 3 next 10.0.1.1
Explicit Path name path3441:
```

```
    1: next-address 10.0.0.1
    2: next-address 10.0.0.2
    3: next-address 10.0.1.1

Router(cfg-ip-expl-path)# index 4 next 10.0.1.2
Explicit Path name path3441:
    1: next-address 10.0.0.1
    2: next-address 10.0.0.2
    3: next-address 10.0.1.1
    4: next-address 10.0.1.2

Router(cfg-ip-expl-path)# exit
```

Example: Assigning a Secondary Path Option to Protect a Primary Path Option

In the following example, a TE tunnel is configured:

```
Router> enable
Router# configure terminal
Router(config-if)# interface tunnel500
Router(config-if)# tunnel mpls traffic-eng path-option protect 10 explicit name path344
```

The following **show running interface** command output shows that path protection has been configured. Tunnel 500 has path option 10 using path344 and protected by path 3441, and path option 20 using path345 and protected by path348.

```
Router# show running interface tunnel500

Router# interface tunnel 500

Building configuration...

Current configuration : 497 bytes
!
interface Tunnel500
 ip unnumbered Loopback0
 tunnel destination 10.0.0.9
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 100
 tunnel mpls traffic-eng path-option 10 explicit name path344
 tunnel mpls traffic-eng path-option 20 explicit name path345
 tunnel mpls traffic-eng path-option protect 10 explicit name path3441
 tunnel mpls traffic-eng path-option protect 20 explicit name path348
end
```

Example: Configuring Tunnels Before and After Path Protection

The **show mpls traffic-eng tunnels** command displays information about the primary (protected) path. The following sample output shows that path protection has been configured.

```
Router# show mpls traffic-eng tunnels tunnel500

Name: R1_t500   (Tunnel500)   Destination: 10.0.0.9
 Status:
  Admin: up  Oper: up  Path: valid  Signalling: connected
  path option 10, type explicit path344 (Basis for Setup, path weight 20)
  path option 20, type explicit path345
  Path Protection: 0 Common Link(s), 0 Common Node(s)
```

```
  path protect option 10, type explicit path3441 (Basis for Protect, path weight 20)
  path protect option 20, type explicit path348

 Config Parameters:
  Bandwidth: 100 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
  Metric Type: TE (default)
  AutoRoute: enabled LockDown: disabled Loadshare: 100 bw-based
  auto-bw: disabled
 Active Path Option Parameters:
    State: explicit path option 10 is active
BandwidthOverride: disabled LockDown: disabled Verbatim: disabled

 InLabel : -
 OutLabel : Ethernet1/0, 16
 RSVP Signalling Info:
   Src 10.1.1.1, Dst 10.0.0.9, Tun_Id 500, Tun_Instance 43
  RSVP Path Info:
   My Address: 10.2.0.1
   Explicit Route: 10.2.0.2  10.10.0.1  10.10.0.2  10.0.0.9
   Record Route: NONE
   Tspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
  RSVP Resv Info:
   Record Route: NONE
   Fspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
  Shortest Unconstrained Path Info:
   Path Weight: 20 (TE)
   Explicit Route: 10.0.0.1  10.0.0.2  10.0.1.1  10.0.1.2
                   10.0.0.9
 History:
  Tunnel:
   Time since created: 18 minutes, 22 seconds
   Time since path change: 19 seconds
   Number of LSP IDs (Tun_Instances) used: 43
  Current LSP:
   Uptime: 22 seconds
   Selection: reoptimization
  Prior LSP:
   ID: path option 10 [27]
   Removal Trigger: reoptimization completed
```

The following **show mpls traffic-eng tunnels** command output shows information about the secondary path. Tunnel500 is protected. The protection path is used, and the primary path is down. The command output shows the IP explicit paths of the primary LSP and the secondary LSP.

```
Router# show mpls traffic-eng tunnels tunnel500 protection

R1_t500
 LSP Head, Tunnel500, Admin: up, Oper: up
 Src 10.1.1.1, Dest 10.0.0.9, Instance 43
 Fast Reroute Protection: None
 Path Protection: 0 Common Link(s), 0 Common Node(s)
  Primary lsp path:10.2.0.1  10.2.0.2
                   10.10.0.1 10.10.0.2
                   10.0.0.9
  Protect lsp path:10.0.0.1  10.0.0.2
                   10.0.1.1  10.0.1.2
                   10.0.0.9
  Path Protect Parameters:
   Bandwidth: 100 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
   Metric Type: TE (default)
  InLabel : -
  OutLabel : Ethernet0/0, 17
  RSVP Signalling Info:
```

```
   Src 10.1.1.1,  Dst 10.0.0.9,  Tun_Id 500,  Tun_Instance 44
  RSVP Path Info:
   My Address: 10.0.0.1
   Explicit Route: 10.0.0.2  10.0.1.1  10.0.1.2  10.0.0.9
   Record Route: NONE
   Tspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
  RSVP Resv Info:
   Record Route: NONE
   Fspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
R1#
```

The following **shutdown** command shuts down the interface to use path protection:

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# interface e1/0
Router(config-if)# shutdown
Router(config-if)# end
Router#
```

The following **show mpls traffic-eng tunnels** command output shows that the protection path is used and the primary path is down:

```
Router# show mpls traffic-eng tunnels tunnel500

Name: R1_t500 (Tunnel500) Destination: 10.0.0.9
 Status:
  Admin: up Oper: up Path: valid Signalling: connected
  path protect option 10, type explicit path3441 (Basis for Protect, path weight 20)
  path option 10, type explicit path344
  path option 20, type explicit path345
  Path Protection: Backup lsp in use.
  path protect option 10, type explicit path3441 (Basis for Protect, path weight 20)
  path protect option 20, type explicit path348

 Config Parameters:
  Bandwidth: 100 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
  Metric Type: TE (default)
  AutoRoute: enabled LockDown: disabled Loadshare: 100 bw-based
  auto-bw: disabled
 Active Path Option Parameters:
  State: explicit path option 10 is active
  BandwidthOverride: disabled LockDown: disabled Verbatim: disabled

 InLabel : -
 OutLabel : Ethernet0/0, 17
 RSVP Signalling Info:
    Src 10.1.1.1,  Dst 10.0.0.9,  Tun_Id 500,  Tun_Instance 44
  RSVP Path Info:
    My Address: 10.0.0.1
    Explicit Route: 10.0.0.2 10.0.1.1 10.0.1.2 10.0.0.9
    Record Route: NONE
    Tspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
  RSVP Resv Info:
    Record Route: NONE
    Fspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
 Shortest Unconstrained Path Info:
  Path Weight: 20 (TE)
  Explicit Route: 10.0.0.1  10.0.0.2  10.0.1.1  10.0.1.2  10.0.0.9
 History:
  Tunnel:
    Time since created: 23 minutes, 28 seconds
    Time since path change: 50 seconds
    Number of LSP IDs (Tun_Instances) used: 44
```

```
 Current LSP:
  Uptime: 5 minutes, 24 seconds
  Selection:
 Prior LSP:
  ID: path option 10 [43]
  Removal Trigger: path error
  Last Error: PCALC:: Explicit path has unknown address, 10.2.0.1
R1#
```

The **up** value in the Oper field of the **show mpls traffic-eng tunnels** command, with the **protection** keyword specified, shows that protection is enabled.

```
Router# show mpls traffic-eng tunnels tunnel500 protection

R1_t500
 LSP Head, Tunnel500, Admin: up, Oper: up
 Src 10.1.1.1, Dest 10.0.0.9, Instance 44
 Fast Reroute Protection: None
 Path Protection: Backup lsp in use.
R1#
```

The **no shutdown** command in the following command sequence causes the interface to be up again and activates the primary path:

```
Router> enable
Router# configure terminal

Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# interface ethernet1/0
Router(config-if)# no shutdown
Router(config-if)# end
```

The following sample output shows that path protection has been reestablished and the primary path is being used:

```
Router# show mpls traffic-eng tunnels tunnel500

Name: R1_t500 (Tunnel500) Destination: 10.0.0.9
 Status:
  Admin: up Oper: up Path: valid Signalling: connected
  path option 10, type explicit path344 (Basis for Setup, path weight 20)
  path option 20, type explicit path345
  Path Protection: 0 Common Link(s), 0 Common Node(s)
  path protect option 10, type explicit path3441 (Basis for Protect, path weight 20)
  path protect option 20, type explicit path348

 Config Parameters:
  Bandwidth: 100 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
  Metric Type: TE (default)
  AutoRoute: enabled LockDown: disabled Loadshare: 100 bw-based
  auto-bw: disabled
 Active Path Option Parameters:
  State: explicit path option 10 is active
  BandwidthOverride: disabled LockDown: disabled Verbatim: disabled

 InLabel : -
 OutLabel : Ethernet1/0, 16
 RSVP Signalling Info:
   Src 10.1.1.1, Dst 10.0.0.9, Tun_Id 500, Tun_Instance 52
  RSVP Path Info:
   My Address: 10.2.0.1
   Explicit Route: 10.2.0.2  10.10.0.1  10.10.0.2  10.0.0.9
   Record Route: NONE
```

```
   Tspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
  RSVP Resv Info:
   Record Route: NONE
   Fspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
  Shortest Unconstrained Path Info:
   Path Weight: 20 (TE)
   Explicit Route: 10.0.0.1  10.0.0.2  10.0.1.1  10.0.1.2  10.0.0.9
  History:
   Tunnel:
    Time since created: 25 minutes, 26 seconds
    Time since path change: 23 seconds
    Number of LSP IDs (Tun_Instances) used: 52
   Current LSP:
   Uptime: 26 seconds
    Selection: reoptimization
   Prior LSP:
    ID: path option 10 [44]
    Removal Trigger: reoptimization completed
R1#
```

The following is sample output from the **show mpls traffic-eng tunnels** command. Tunnel500 is protected. After a failure, the primary LSP is protected.

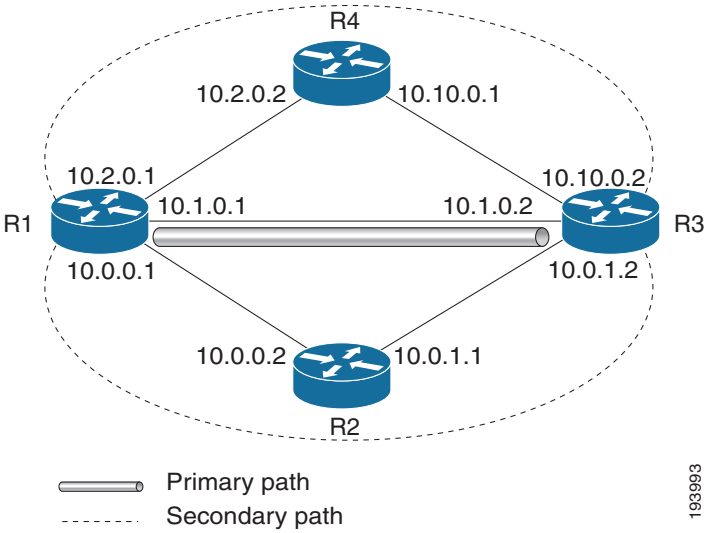
```
Router# show mpls traffic-eng tunnels tunnel500 protection

R1_t500
 LSP Head, Tunnel500, Admin: up, Oper: up
 Src 10.1.1.1, Dest 10.0.0.9, Instance 52
 Fast Reroute Protection: None
 Path Protection: 0 Common Link(s), 0 Common Node(s)
  Primary lsp path:10.2.0.1   10.2.0.2
                   10.10.0.1  10.10.0.2
                   10.0.0.9
  Protect lsp path:10.0.0.1   10.0.2
                   10.0.1.1 10.0.1.2
                   10.0.0.9
  Path Protect Parameters:
   Bandwidth: 100 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
   Metric Type: TE (default)
  InLabel : -
  OutLabel : Ethernet0/0, 16
  RSVP Signalling Info:
    Src 10.1.1.1, Dst 10.0.0.9, Tun_Id 500, Tun_Instance 53
   RSVP Path Info:
    My Address: 10.0.0.1
    Explicit Route: 10.0.0.2  10.0.1.1  10.0.1.2  10.0.0.9
    Record Route: NONE
    Tspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
   RSVP Resv Info:
    Record Route: NONE
    Fspec: ave rate=100 kbits, burst=1000 bytes, peak rate=100 kbits
R1#
```

Configuration Examples for MPLS Traffic Engineering (TE): Enhanced Path Protection

Example: Creating a Path Option List

Figure 6 shows the network topology for enhanced path protection.

Figure 6 Network Topology for Enhanced Path Protection



The following example configures two explicit paths named **secondary1** and **secondary2**.

```
Router(config)# ip explicit-path name secondary1
Router(cfg-ip-expl-path)# index 1 next 10.0.0.2
Explicit Path name secondary1:
 1: next-address 10.0.0.2

Router(cfg-ip-expl-path)# index 2 next 10.0.1.2
Explicit Path name secondary1:
 1: next-address 10.0.0.2
 2: next-address 10.0.1.2

Router(cfg-ip-expl-path)# ip explicit-path name secondary2
Router(cfg-ip-expl-path)# index 1 next 10.2.0.2
Explicit Path name secondary2:
 1: next-address 10.2.0.2

Router(cfg-ip-expl-path)# index 2 next 10.10.0.2
Explicit Path name secondary2:
 1: next-address 10.2.0.2
 2: next-address 10.10.0.2

Router(cfg-ip-expl-path)# exit
```

In the following example, a path option list of backup paths is created. You can define the path option list by using the explicit paths.

```
Router(config)# mpls traffic-eng path-option list name pathlist-01
Router(cfg-pathoption-list)# path-option 10 explicit name secondary1
path-option 10 explicit name secondary1

Router(cfg-pathoption-list)# path-option 20 explicit name secondary2
path-option 10 explicit name secondary1
path-option 20 explicit name secondary2

Router(cfg-pathoption-list)# exit
```

Example: Assigning a Path Option List to Protect a Primary Path Option

In the following example, a TE tunnel is configured:

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# interface tunnel 2
Router(config-if)# tunnel mpls traffic-eng path-option protect 10 list name secondary-list
```

The following **show running interface** command output shows that path protection has been configured; Tunnel 2 has path option 10, which uses the primary1 path and is protected by the secondary list.

```
Router# show running-config interface tunnel 2

Building configuration...

Current configuration : 296 bytes
!
interface Tunnel2
 ip unnumbered Loopback0
 tunnel mode mpls traffic-eng
 tunnel destination 103.103.103.103
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng path-option 10 explicit name primary1
 tunnel mpls traffic-eng path-option protect 10 list name secondary-list
```

Example: Configuring Tunnels Before and After Path Protection

The **show mpls traffic-eng tunnels** command shows information about the primary (protected) path. The following sample output shows that path protection has been configured:

```
Router# show mpls traffic-eng tunnels tunnel 2

Name: Router_t2 (Tunnel2) Destination: 103.103.103.103
 Status:
  Admin: up Oper: up Path: valid Signalling: connected
  path option 10, type explicit primary1 (Basis for Setup, path weight 10)
  Path Protection: 0 Common Link(s), 0 Common Node(s)
  path protect option 10, type list name secondary-list
  Inuse path-option 10, type explicit secondary1 (Basis for Protect, path weight 20)

 Config Parameters:
  Bandwidth: 0 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
  Metric Type: TE (default)
  AutoRoute announce: enabled LockDown: disabled Loadshare: 0 bw-based
  auto-bw: disabled
 Active Path Option Parameters:
  State: explicit path option 10 is active
  BandwidthOverride: disabled LockDown: disabled Verbatim: disabled
```

```
 InLabel : -
 OutLabel : Ethernet7/0, implicit-null
 RSVP Signalling Info:
  Src 100.100.100.100, Dst 103.103.103.103, Tun_Id 2, Tun_Instance 11
 RSVP Path Info:
  My Address: 10.1.0.1
  Explicit Route: 10.1.0.2 103.103.103.103
  Record Route: NONE
  Tspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
 RSVP Resv Info:
  Record Route: NONE
  Fspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
 Shortest Unconstrained Path Info:
  Path Weight: 10 (TE)
  Explicit Route: 10.1.0.1 10.1.0.2 103.103.103.103
 History:
  Tunnel:
   Time since created: 24 minutes, 15 seconds
   Time since path change: 23 minutes, 30 seconds
  Number of LSP IDs (Tun_Instances) used: 11
  Current LSP:
   Uptime: 23 minutes, 30 seconds
```

The following **show mpls traffic-eng tunnels** command output displays information about the secondary path. Tunnel 2 is protected.

```
Router# show mpls traffic-eng tunnels tunnel 2 protection

Router_t2
 LSP Head, Tunnel2, Admin: up, Oper: up
 Src 100.100.100.100, Dest 103.103.103.103, Instance 11
 Fast Reroute Protection: None
 Path Protection: 0 Common Link(s), 0 Common Node(s)
  Primary lsp path:10.1.0.1 10.1.0.2
                   103.103.103.103
  Protect lsp path:10.0.0.1 10.0.0.2
                   10.0.1.1 10.0.1.2
                   103.103.103.103
   Path Protect Parameters:
    Bandwidth: 0 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
   InLabel : -
   OutLabel : Ethernet5/0, 16
   RSVP Signalling Info:
    Src 100.100.100.100, Dst 103.103.103.103, Tun_Id 2, Tun_Instance 20
   RSVP Path Info:
    My Address: 10.0.0.1
    Explicit Route: 10.0.0.2 10.0.1.1 10.0.1.2 103.103.103.103
    Record Route: NONE
    Tspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
   RSVP Resv Info:
    Record Route: NONE
    Fspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
```

The following **shutdown** command shuts down the interface to use path protection:

```
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# interface e7/0
Router(config-if)# shutdown
Router(config-if)# end
```

The following **show mpls traffic-eng tunnels** command shows that the protection path is used, and the primary path is down:

```
Router# show mpls traffic-eng tunnels tunnel 2

Name: Router_t2 (Tunnel2) Destination: 103.103.103.103
 Status:
  Admin: up Oper: up Path: valid Signalling: connected
  path protect option 10, type list name secondary-list
  Inuse path-option 10, type explicit secondary1 (Basis for Protect, path weight 20)
  path option 10, type explicit primary1
  Path Protection: Backup lsp in use.
  path protect option 10, type list name secondary-list
  Inuse path-option 10, type explicit secondary1 (Basis for Protect, path weight 20)

 Config Parameters:
  Bandwidth: 0 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
  Metric Type: TE (default)
  AutoRoute announce: enabled LockDown: disabled Loadshare: 0 bw-based
  auto-bw: disabled
 Active Path Option Parameters:
  State: list path option 10 is active
  BandwidthOverride: disabled LockDown: disabled Verbatim: disabled

 InLabel : -
 OutLabel : Ethernet5/0, 16
 RSVP Signalling Info:
  Src 100.100.100.100, Dst 103.103.103.103, Tun_Id 2, Tun_Instance 20
 RSVP Path Info:
  My Address: 10.0.0.1
  Explicit Route: 10.0.0.2 10.0.1.1 10.0.1.2 103.103.103.103
  Record Route: NONE
  Tspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
 RSVP Resv Info:
  Record Route: NONE
  Fspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
 Shortest Unconstrained Path Info:
  Path Weight: 20 (TE)
  Explicit Route: 10.0.0.1 10.0.0.2 10.0.1.1 10.0.1.2 103.103.103.103

 History:
  Tunnel:
   Time since created: 32 minutes, 27 seconds
   Time since path change: 1 minutes, 7 seconds
   Number of LSP IDs (Tun_Instances) used: 20
  Current LSP:
   Uptime: 8 minutes, 56 seconds
   Selection:
  Prior LSP:
   ID: path option 10 [11]
   Removal Trigger: path error
   Last Error: PCALC:: No addresses to connect 100.100.100.100 to 10.1.0.2
```

The up value in the Oper field of the **show mpls traffic-eng tunnels** command, with the **protection** keyword specified, shows that protection is enabled.

```
Router# show mpls traffic-eng tunnels tunnel 2 protection

Router_t2
 LSP Head, Tunnel2, Admin: up, Oper: up
 Src 100.100.100.100, Dest 103.103.103.103, Instance 20
 Fast Reroute Protection: None
 Path Protection: Backup lsp in use.
```

The **no shutdown** command in the following command sequence causes the interface to be up again and activates the primary path:

```
Router# configure terminal

Enter configuration commands, one per line. End with CNTL/Z.
Router(config-if)# interface ethernet7/0
Router(config-if)# no shutdown
Router(config-if)# end
```

The following command output shows that path protection has been reestablished and the primary path is being used:

```
Router# show mpls traffic-eng tunnels tunnel 2

Name: Router_t2 (Tunnel2) Destination: 103.103.103.103
 Status:
  Admin: up Oper: up Path: valid Signalling: connected
  path option 10, type explicit primary1 (Basis for Setup, path weight 10)
  Path Protection: 0 Common Link(s), 0 Common Node(s)
  path protect option 10, type list name secondary-list
  Inuse path-option 10, type explicit secondary1 (Basis for Protect, path weight 20)

 Config Parameters:
  Bandwidth: 0 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
  Metric Type: TE (default)
  AutoRoute announce: enabled LockDown: disabled Loadshare: 0 bw-based
  auto-bw: disabled
 Active Path Option Parameters:
  State: explicit path option 10 is active
  BandwidthOverride: disabled LockDown: disabled Verbatim: disabled

 InLabel : -
 OutLabel : Ethernet7/0, implicit-null
 RSVP Signalling Info:
   Src 100.100.100.100, Dst 103.103.103.103, Tun_Id 2, Tun_Instance 39
  RSVP Path Info:
   My Address: 10.1.0.1
   Explicit Route: 10.1.0.2 103.103.103.103
   Record Route: NONE
   Tspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
  RSVP Resv Info:
   Record Route: NONE
   Fspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
  Shortest Unconstrained Path Info:
   Path Weight: 10 (TE)
   Explicit Route: 10.1.0.1 10.1.0.2 103.103.103.103
  History:
   Tunnel:
   Time since created: 40 minutes, 59 seconds
   Time since path change: 1 minutes, 24 seconds
   Number of LSP IDs (Tun_Instances) used: 39
  Current LSP:
   Uptime: 1 minutes, 27 seconds
   Selection: reoptimization
  Prior LSP:
   ID: path option 10 [20]
   Removal Trigger: reoptimization completed

Router# show mpls traffic-eng tunnels tunnel 2 protection

Router_t2
 LSP Head, Tunnel2, Admin: up, Oper: up
 Src 100.100.100.100, Dest 103.103.103.103, Instance 39
```

```
 Fast Reroute Protection: None
 Path Protection: 0 Common Link(s), 0 Common Node(s)
  Primary lsp path:10.1.0.1 10.1.0.2
                   103.103.103.103
  Protect lsp path:10.0.0.1 10.0.0.2
                   10.0.1.1 10.0.1.2
                   103.103.103.103
  Path Protect Parameters:
   Bandwidth: 0 kbps (Global) Priority: 7 7 Affinity: 0x0/0xFFFF
   Metric Type: TE (default)
  InLabel : -
  OutLabel : Ethernet5/0, 17
  RSVP Signalling Info:
   Src 100.100.100.100, Dst 103.103.103.103, Tun_Id 2, Tun_Instance 40
  RSVP Path Info:
   My Address: 10.0.0.1
   Explicit Route: 10.0.0.2 10.0.1.1 10.0.1.2 103.103.103.103
   Record Route: NONE
   Tspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
  RSVP Resv Info:
   Record Route: NONE
   Fspec: ave rate=0 kbits, burst=1000 bytes, peak rate=0 kbits
```

The following command displays the contents of RSVP high availability read and write databases used in TE:

```
Router# show ip rsvp high-availability database lsp-head

LSP_HEAD WRITE DB
 Tun ID: 2
 Header:
  State: Checkpointed Action: Modify
  Seq #: 17 Flags: 0x0
 Data:
  lsp_id: 39, bandwidth: 0, thead_flags: 0x1, popt: 10
  feature flags: none
  output_if_num: 31, output_nhop: 10.1.0.2
 RRR path setup info
   Destination: 103.103.103.103, Id: 103.103.103.103 Router Node (ospf) flag:0x0
   IGP: ospf, IGP area: 0, Number of hops: 3, metric: 10
   Hop 0: 10.1.0.1, Id: 100.100.100.100 Router Node (ospf), flag:0x0
   Hop 1: 10.1.0.2, Id: 103.103.103.103 Router Node (ospf), flag:0x0
   Hop 2: 103.103.103.103, Id: 103.103.103.103 Router Node (ospf), flag:0x0

LSP_HEAD READ DB
```

Additional References

Related Documents

Related Topic	Document Title
Cisco IOS commands	*Cisco IOS Master Commands List, All Releases*
MPLS traffic engineering commands: complete command syntax, command mode, command history, defaults, usage guidelines, and examples	*Cisco IOS Multiprotocol Label Switching Command Reference*
RSVP	*Cisco IOS Quality of Service Solutions Command Reference*
IS-IS	• *Cisco IOS IP Routing Protocols Command Reference* • *Configuring a Basic IS-IS Network*
OSPF	• *Cisco IOS IP Routing Protocols Command Reference* • *Configuring OSPF*
ISSU	• *ISSU MPLS Clients* • *ISSU and eFSU on Cisco 7600 Series Routers*
NSF/SSO	*ISSU and eFSU on Cisco 7600 Series Routers*

Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	http://www.cisco.com/cisco/web/support/index.html

Feature Information for MPLS Traffic Engineering (TE): Path Protection

Table 1 lists the release history for this feature.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 1 Feature Information for MPLS Traffic Engineering (TE): Path Protection

Feature Name	Releases	Feature Information
MPLS Traffic Engineering (TE): Path Protection	12.0(30)S 12.2(18)SXD 12.2(33)SRC 12.2(33)SRE 12,2(50)SY 12.4(20)T	The MPLS Traffic Engineering (TE): Path Protection feature provides an end-to-end failure recovery mechanism (that is, full path protection) for MPLS TE tunnels. In Cisco IOS Release 12.0(30)S, this feature was introduced. In Cisco IOS Release 12.2(18)SXD, this feature was integrated. In Cisco IOS Release 12.2(33)SRC, support was added for In Service Software Upgrade (ISSU) and Cisco nonstop forwarding with stateful switchover (NSF/SSO). The following commands were introduced or modified: **show ip rsvp high-availability database**, **tunnel mpls traffic-eng path-option protect**. In Cisco IOS Release 12.4(20)T, this feature was integrated. ISSU was not supported, and NSF with SSO was not supported. The following commands were introduced or modified: **show ip rsvp high-availability database, tunnel mpls traffic-eng path-option, tunnel mpls traffic-eng path-option protect.** In Cisco IOS Release 12.2(33)SRE, support was added for enhanced path protection. The following commands were added or modified: **mpls traffic-eng path option list, show mpls traffic-eng path-option list, show mpls traffic-eng tunnels, tunnel mpls traffic-eng path-option protect.**

Glossary

autotunnel mesh group—An autotunnel mesh group (referred to as a mesh group) is a set of connections between edge Label Switch Routers in a network.

backup LSP—Backup Label Switched Path. The LSP that is signaled to provide path protection. A backup LSP carries traffic only after the failure of the primary LSP.

backup tunnel—An MPLS TE tunnel used to protect other (primary) tunnels' traffic when a link or node failure occurs.

BGP—Border Gateway Protocol. An interdomain routing protocol designed to provide loop-free routing between separate routing domains that contain independent routing policies (autonomous systems).

Cisco Express Forwarding—A means for accelerating the forwarding of packets within a router, by storing route lookup.

Fast Reroute—Procedures that enable temporary routing around a failed link or node while a new LSP is being established at the headend.

graceful restart—A process for helping a Route Processor (RP) restart after a node failure has occurred.

headend—The router that originates and maintains a given LSP. This is the first router in the LSP's path.

hop—Passage of a data packet between two network nodes (for example, between two routers).

interface—A network connection.

IS-IS—Intermediate System-to-Intermediate System. Link-state hierarchical routing protocol that calls for intermediate system (IS) routers to exchange routing information based on a single metric to determine network topology.

ISSU—In Service Software Upgrade. The ISSU process allows the Cisco IOS software at the router level to be updated or otherwise modified while packet forwarding continues. At the line-card level, an enhanced Fast Software Upgrade (eFSU) process minimizes line-card downtime during such upgrades to between 30 and 90 seconds by preloading the new line-card image before the ISSU switchover occurs from the active to the standby RP.

link—A point-to-point connection between adjacent nodes. There can be more than one link between adjacent nodes. A link is a network communications channel consisting of a circuit or transmission path and all related equipment between a sender and a receiver. It is sometimes referred to as a line or a transmission link.

LSP—label switched path. A configured connection between two routers, in which label switching is used to carry the packets. The purpose of an LSP is to carry data packets.

MPLS—Multiprotocol Label Switching. A packet-forwarding technology, used in the network core, that applies data link layer labels to packets. This labeling helps switching nodes to take appropriate packet-forwarding decisions, resulting in faster and more scalable forwarding than network layer routing normally does.

NHOP—next hop. The next downstream node along an LSP's path.

NHOP backup tunnel—next-hop backup tunnel. The backup tunnel terminating at the LSP's next hop beyond the point of failure, and originating at the hop immediately upstream of the point of failure. It bypasses a failed link, and is used to protect primary LSPs that were using this link before the failure.

NNHOP—next-next hop. The node after the next downstream node along an LSP's path.

NNHOP backup tunnel—next-next-hop backup tunnel. The backup tunnel terminating at the LSP's next-next hop beyond the point of failure, and originating at the hop immediately upstream of the point of failure. It bypasses a failed link or node, and is used to protect primary LSPs that were using this link or node before the failure.

node—The endpoint of a network connection or a junction common to two or more lines in a network. Nodes can be interconnected by links, and serve as control points in the network. Nodes can be processors, controllers, or workstations.

NSF—Cisco nonstop forwarding. Cisco NSF always runs with stateful switchover (SSO) and provides redundancy for Layer 3 traffic. NSF works with SSO to minimize the amount of time that a network is unavailable to its users following a switchover. The main purpose of NSF is to continue forwarding IP packets following a supervisor engine switchover.

OSPF—Open Shortest Path First. A link-state hierarchical Interior Gateway Protocol routing algorithm, derived from the IS-IS protocol. OSPF features include least-cost routing, multipath routing, and load balancing.

path option—A path that a TE tunnel uses to reach a destination.

path option list—A list of backup paths as a secondary path option to protect a primary path option.

primary LSP—The last LSP originally signaled over the protected interface before the failure. A primary LSP is signaled by configuring a primary path option.

primary path option—A path that a TE tunnel uses originally to transport packets.

primary tunnel—A tunnel whose LSP may be fast rerouted if there is a failure. Backup tunnels cannot be primary tunnels.

protected interface—An interface that has one or more backup tunnels associated with it.

router—A network layer device that uses one or more metrics to determine the optimal path along which network traffic should be forwarded. Routers forward packets from one network to another based on network layer information.

RP—Route Processor. A generic term for the centralized control unit in a chassis.

RSVP—Resource Reservation Protocol. An IETF protocol used for signaling requests (setting up reservations) for Internet services by a customer before that customer is permitted to transmit data over that portion of the network.

secondary LSP—The LSP signaled over the protected interface before the failure. A secondary LSP is signaled by configuring a secondary path option or a path option list.

secondary path—A path that a TE tunnel uses to protect a primary path.

secondary path option—Configuration of the path option that provides protection.

SRLG—Shared Risk Link Group. Sets of links that are likely to go down together (for example, because they have the same underlying fiber).

state—Information that a router must maintain about each LSP. The information is used for rerouting tunnels.

tailend—The router upon which an LSP is terminated. This is the last router in the LSP's path.

TE—traffic engineering. The techniques and processes used to cause routed traffic to travel through the network on a path other than the one that would have been chosen if standard routing methods had been used.

topology—The physical arrangement of network nodes and media within an enterprise networking structure.

traffic engineering—The techniques and processes used to cause routed traffic to travel through the network on a path other than the one that would have been chosen if standard routing methods had been used.

tunnel—Secure communications path between two peers, such as two routers.

VoIP—Voice over IP. The capability of a router to carry voice traffic (for example, telephone calls and faxes) over an IP network. Cisco's voice support is implemented by using the voice packet technology.