# MPLS Traffic Engineering (TE): Class-based Tunnel Selection

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The MPLS Traffic Engineering (TE): Class-based Tunnel Selection feature enables you to dynamically route and forward traffic with different class of service (CoS) values onto different TE tunnels between the same tunnel headend and the same tailend. The TE tunnels can be regular TE or DiffServ-aware TE (DS-TE) tunnels.

The set of TE (or DS-TE) tunnels from the same headend to the same tailend that you configure to carry different CoS values is referred to as a "tunnel bundle." After configuration, CBTS dynamically routes and forwards each packet into the tunnel that:

- Is configured to carry the CoS of the packet
- Has the right headend for the destination of the packet

Because Class-Based Tunnel Selection (CBTS) offers dynamic routing over DS-TE tunnels and requires minimum configuration, it greatly eases deployment of DS-TE in large-scale networks.

CBTS can distribute all CoS values on eight different tunnels.

CBTS also allows the TE tunnels of a tunnel bundle to exit headend routers through different interfaces.

### Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for MPLS Traffic Engineering (TE): Class-based Tunnel Selection" section on page 54.

### Finding Support Information for Platforms and Cisco IOS Software Images

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

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# Prerequisites for MPLS Traffic Engineering (TE): Class-based Tunnel Selection

- Multiprotocol Label Switching (MPLS) must be enabled on all tunnel interfaces.
- Cisco Express Forwarding or distributed Cisco Express Forwarding must be enabled in global configuration mode.

# Restrictions for MPLS Traffic Engineering (TE): Class-based Tunnel Selection

- For a given destination, all CoS values are carried in tunnels terminating at the same tailend. Either all CoS values are carried in tunnels or no values are carried in tunnels. In other words, for a given destination, you cannot map some CoS values in a DS-TE tunnel and other CoS values in a Shortest Path First (SPF) Label Distribution Protocol (LDP) or SPF IP path.
- CBTS does not allow load-balancing of a given experimental (EXP) value in multiple tunnels. If two or more tunnels are configured to carry a given EXP value, CBTS picks one of those tunnels to carry this EXP value.
- The operation of CBTS is not supported with Any Transport over MPLS (AToM), MPLS TE Automesh, or label-controlled (LC)-ATM.

# Information About MPLS Traffic Engineering (TE): Class-based Tunnel Selection

To configure the MPLS Traffic Engineering (TE): Class-based Tunnel Selection feature, you should understand the following concepts:


- Incoming Traffic Supported by MPLS TE Class-based Tunnel Selection, page 3

- CoS Attributes for MPLS TE Class-based Tunnel Selection, page 3
- Routing Protocols and MPLS TE Class-based Tunnel Selection, page 3
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- DS-TE Tunnels and MPLS TE Class-based Tunnel Selection, page 10
- Reoptimization and MPLS TE Class-based Tunnel Selection, page 10
- Interarea and Inter-AS and MPLS TE Class-based Tunnel Selection, page 10
- ATM PVCs and MPLS TE Class-based Tunnel Selection, page 10


# Incoming Traffic Supported by MPLS TE Class-based Tunnel Selection

The CBTS feature supports the following kinds of incoming packets:

- At a provider edge (PE) router—Unlabeled packets that enter a Virtual Private Network (VPN) routing and forwarding (VRF) instance interface
- At a provider core (P) router—Unlabeled and MPLS-labeled packets that enter a non-VRF interface
- At a PE router in a Carrier Supporting Carrier (CSC) or interautonomous system (Inter-AS)—MPLS-labeled packets that enter a VRF interface

# CoS Attributes for MPLS TE Class-based Tunnel Selection

CBTS supports tunnel selection based on the value of the EXP field that the headend router imposes on the packet. Before imposing this value, the router considers the input modular quality of service (QoS) command-line interface (CLI) (MQC). If the input MQC modifies the EXP field value, CBTS uses the modified value for its tunnel selection.

Packets may enter the headend from multiple incoming interfaces. These interfaces can come from different customers that have different DiffServ policies. In such cases, service providers generally use input MQC to apply their own DiffServ policies and mark imposed EXP values accordingly. Thus, CBTS can operate consistently for all customers by considering the EXP values marked by the service provider.

**Note** If the output MQC modifies the EXP field, CBTS ignores the change in the EXP value.

CBTS allows up to eight different tunnels on which it can distribute all classes of service.

# Routing Protocols and MPLS TE Class-based Tunnel Selection

CBTS routes and forwards packets to MPLS TE tunnels for specified destinations through use of the following routing protocols:

- Intermediate System-to-Intermediate System (IS-IS) with Autoroute configured
- Open Shortest Path First (OSPF) with Autoroute configured
- Static routing
- Border Gateway Protocol (BGP) with recursion configured on the BGP next hop with packets forwarded on the tunnel through the use of IS-IS, OSPF, or static routing

# Tunnel Selection with MPLS TE Class-based Tunnel Selection

This section contains the following topics related to tunnel selection:


- EXP Mapping Configuration, page 4
- Tunnel Selection for EXP Values, page 4
- Tunnel Failure Handling, page 7
- Misordering of Packets, page 9


## EXP Mapping Configuration

With CBTS, you can configure each tunnel with any of the following:

- The same EXP information configured as it was before the CBTS feature was introduced, that is, with no EXP-related information
- One or more EXP values for the tunnel to carry
- A property that allows the carrying of all EXP values not currently allocated to any up-tunnel (default)
- One or more EXP values for the tunnel to carry, and the default property that allows the carrying of all EXP values not currently allocated to any up-tunnel

The default property (the carrying of all EXP values not currently allocated to any up-tunnel) effectively provides a way for the operator to avoid explicitly listing all possible EXP values. Even more important, the default property allows the operator to indicate tunnel preferences onto which to "bump" certain EXP values, should the tunnel carrying those EXP values go down. (See the **tunnel mpls traffic-eng exp** command for the command syntax.)

The configuration of each tunnel is independent of the configuration of any other tunnel. CBTS does not attempt to perform any consistency check for EXP configuration.

This feature allows configurations where:

- Not all EXP values are explicitly allocated to tunnels.
- Multiple tunnels have the default property.
- Some tunnels have EXP values configured and others do not have any values configured.
- A given EXP value is configured on multiple tunnels.

## Tunnel Selection for EXP Values

This section contains information about the following topics:


- Tunnel Selection Process, page 5
- Tunnel Selection Examples, page 5
- Multipath with Non-TE Paths and MPLS TE Class-Based Tunnel Selection, page 7
- MPLS TE Class-Based Tunnel Selection and Policy-Based Routing, page 7

## Tunnel Selection Process

Tunnel selection with this feature is a two-step process:

1. For a given prefix, routing (autoroute, static routes) occurs exactly as it did without the CBTS feature. The router selects the set of operating tunnels that have the best metrics, regardless of the EXP-related information configured on the tunnel.
2. CBTS maps all of the EXP values to the selected set of tunnels:

- If a given EXP value is configured:
  - On only one of the tunnels in the selected set, CBTS maps the EXP value onto that tunnel.
  - On two or more of the tunnels in the selected set, CBTS arbitrarily maps the EXP value onto one of these tunnels. First CBTS selects the tunnel on which the lowest EXP value is explicitly configured. Then CBTS picks the tunnel that has the lowest tunnel ID.
- If a given EXP value is not configured on any of the tunnels in the selected set:
  - And only one of the tunnels in the selected set is configured as a default, CBTS maps the EXP value onto that tunnel.
  - And two or more of the tunnels in the selected set are configured as defaults, CBTS arbitrarily maps the EXP value onto one of these tunnels.
  - And no tunnel in the selected set of tunnels is configured as a default, CBTS does not map this EXP value onto any specific tunnel. Instead, CBTS performs CoS-unaware load balancing of that EXP information across all tunnels in the selected set.

CBTS relies on autoroute to select the tunnel bundle. Autoroute selects only tunnels that are on the SPF to the destination. Therefore, similar to Autoroute, CBTS does not introduce any risk of routing loops.

## Tunnel Selection Examples

The following examples show various tunnel configurations that are set up by an operator and indicate how CBTS maps packets carrying EXP values onto these tunnels. Each example describes a different configuration: a default tunnel configured, more than one tunnel configured with the same EXP value, and so on.

### Example 1—Default Tunnel Configured

An operator configures the following parameters on tunnels T1 and T2:

- T1: exp = 5, autoroute
- T2: exp = default, autoroute

If T1 and T2 are next-hop interfaces for prefix P, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = 5> onto T1
- Packets with <Dest = P, exp = anything-other-than-5> onto T2

### Example 2— EXP Values Configured on Two Tunnels; One Default Tunnel

An operator configures the following parameters on tunnels T1, T2, and T3:

- T1: exp = 5, autoroute
- T2: exp = 3 and 4, autoroute
- T3: exp = default, autoroute

If T1, T2, and T3 are next-hop interfaces for prefix P, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = 5> onto T1
- Packets with <Dest = P, exp = 3 or 4> onto T2
- Packets with <Dest = P, exp = 0, 1, 2, 6, or 7> onto T3

#### Example 3—More than One Tunnel with the Same EXP

An operator configures the following parameters on tunnels T1, T2, and T3:

- T1: exp = 5, autoroute
- T2: exp = 5, autoroute
- T3: exp = default, autoroute

If T1, T2, and T3 are next-hop interfaces for prefix P, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = 5> onto T1 (arbitrary selection)
- Packets with <Dest = P, exp = anything-other-than-5> onto T3
- No packets onto T2

#### Example 4—Static Route Configured

An operator configures the following parameters on tunnels T1 and T2:

- T1: exp = 5, autoroute
- T2: exp = 3
- Static route to P on T2

If prefix P is behind the T1 and T2 tailend router, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = anything> onto T2
- No packets onto T1

Static routes are preferred over dynamic routes; therefore, the router chooses only T2 as the “selected set” of tunnels.

#### Example 5—Metrics Configured on Tunnels

An operator configures the following parameters on tunnels T1 and T2:

- T1: exp = 5, autoroute, relative metric –2
- T2: exp = 3, autoroute, relative metric –3

CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = anything> onto T2
- No packets onto T1

The autoroute tunnel selection algorithm selects the tunnel with the best metric. Therefore, the router selects only T2 as the “selected set” of tunnels.

#### Example 6—No Default or Metric Configuration

An operator configures the following parameters on tunnels T1 and T2:

- T1: exp = 5, autoroute
- T2: exp = 3, autoroute

If T1 and T2 are the next-hop interfaces for prefix P, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = 5> onto T1
- Packets with <Dest = P, exp = 3> onto T2
- Packets with <Dest = P, exp = anything-other-than-3-or-5> onto T2

If a packet arrives with an EXP value that is different from any value configured for a tunnel, the packet goes in to the default tunnel. If no default tunnel is configured, the packet goes in to the tunnel that is configured with the lowest EXP value.

### Multipath with Non-TE Paths and MPLS TE Class-Based Tunnel Selection

For a given prefix in the routing process, the router might select a set of paths that includes both TE tunnels and non-TE-tunnel paths (SPF paths). For example, internal Border Gateway Protocol (iBGP) Multipath might be activated and result in multiple BGP next hops for that prefix, where one BGP next hop is reachable through TE tunnels and other BGP next hops are reachable through non-TE-tunnel paths.

An equal cost IGP path might also exist over TE tunnels and over a non-TE tunnel path. For example, a TE tunnel metric might be modified to be equal to the SPF path.

In these situations, CBTS maps traffic in the following manner:

- If a given EXP value is configured on one or more of the tunnels in the selected set, CBTS maps the EXP value onto that tunnel or one of those tunnels.
- If a given EXP value is not configured on any of the tunnels in the selected set but one or more of the tunnels is configured as a default in the selected set, then CBTS maps the EXP value onto that tunnel or one of those tunnels.
- If a given EXP value is not configured on any of the tunnels from the selected set and no tunnel in the selected set is configured as a default, CBTS performs CoS-unaware load-balancing of that EXP value across all the possible paths, including all of the TE tunnels of the selected set and the non-TE paths.
- If the routing process allocates all EXP values to tunnels or if a default is used, then routing does not use the non-TE paths unless all TE tunnels are down.

### MPLS TE Class-Based Tunnel Selection and Policy-Based Routing

If you configure both policy-based routing (PBR) over TE tunnels (in non-VRF environments) and CBTS, the PBR decision overrides the CBTS decision. PBR is an input process that the router performs ahead of regular forwarding.

## Tunnel Failure Handling

This section contains the following sections:

- Tunnel Up or Down, page 7
- Behavior When a Tunnel Goes Down, page 8

### Tunnel Up or Down

For CBTS operation, the important question is whether the tunnel interface is up or down, not whether the current TE label switched path (LSP) is up or down. For example, a TE LSP might go down but is reestablished by the headend because another path option exists. The tunnel interface does not go down during the transient period while the TE LSP is reestablished. Because the tunnel interface does not go down, the corresponding EXP does not get rerouted onto another tunnel during the transient period.

## Behavior When a Tunnel Goes Down

When a tunnel used by CBTS for forwarding goes down, the feature adjusts its tunnel selection for the affected EXP values. It reapplies the tunnel selection algorithm to define the behavior of packets for all EXP values, as shown in the examples that follow.

### Example 1—Tunnel Other than the Default Tunnel Goes Down

An operator configures the following parameters on tunnels T1, T2, and T3:

- T1: exp = 5, autoroute
- T2: exp = 3 and 4, autoroute
- T3: exp = default, autoroute

If T1, T2, and T3 are next-hop interfaces for prefix P and Tunnel T1 goes down, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = 3, 4> onto T2 (as before)
- Packets with <Dest = P, exp = 0, 1, 2, 6, or 7> onto T3 (as before)
- Packets with <Dest = P, exp = 5> onto T3

### Example 2—Default Tunnel Goes Down

An operator configures the following parameters on tunnels T1, T2, and T3:

- T1: exp = 5, autoroute
- T2: exp = 3 and 4, autoroute
- T3: exp = default, autoroute

If T1, T2, and T3 are next-hop interfaces for prefix P and Tunnel T3 goes down, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = 5> onto T1 (as before)
- Packets with <Dest = P, exp = 3, 4> onto T2 (as before)
- Packets with <Dest = P, exp = 0, 1, 2, 6, or 7> onto T1 and T2, following existing CoS-unaware load balancing

### Example 3—Two Default Tunnels Are Configured

An operator configures the following parameters on tunnels T1, T2, and T3:

- T1: exp = 5, autoroute
- T2: exp = 3, 4, and default, autoroute
- T3: exp = 0, 1, 2, 6, 7, and default, autoroute

If T1, T2, and T3 are next-hop interfaces for prefix P and Tunnel T3 goes down, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = 5> onto T1 (as before)
- Packets with <Dest = P, exp = 3, 4> onto T2 (as before)
- Packets with <Dest = P, exp = 0, 1, 2, 6, or 7> onto T2

If tunnel T2 goes down, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = 5> onto T1 (as before)
- Packets with <Dest = P, exp = 0, 1, 2, 6, or 7> onto T3 (as before)

- Packets with <Dest = P, exp = 3, or 4> onto T3

If tunnel T1 goes down, CBTS maps the packets onto the tunnels in this way:

- Packets with <Dest = P, exp = 3, or 4> onto T2 (as before)
- Packets with <Dest = P, exp = 0, 1, 2, 6, or 7> onto T3 (as before)
- Packets with <Dest = P, exp = 5> onto either T2 or T3, but not both

In Example 3, the operator configures the EXP default option on two tunnels to ensure that nonvoice traffic is never redirected onto the voice tunnel (T1).

## Misordering of Packets

In DiffServ, packets from a given flow might get marked with EXP values that are different from each other but belong to the same CoS value because of in-contract and out-of-contract marking of packets. We can refer to these values of EXP bits as EXP-in and EXP-out.

If packets for EXP-in are sent on a different tunnel than packets for EXP-out, then misordering of packets within the same flows could occur. For that reason, CBTS allows operators to ensure that EXP-in and EXP-out never get mapped onto different tunnels.

The CBTS feature allows the operator to configure EXP-in and EXP-out to be transported on the same tunnel when that tunnel is up. This ensures that the feature does not introduce misordering of packets. In case of tunnel failure, the tunnel selection algorithm ensures that if EXP-in and EXP-out were carried on the same tunnel before the failure, they are still carried on a single tunnel after the failure. Thus, CBTS protects against nontransient misordering even in the event of tunnel failure.

**Note** CBTS does not attempt to force EXP-in and EXP-out to be carried on the same tunnel. The operator must configure CBTS so that EXP-in and EXP-out are carried on the same tunnel. This is comparable to the regular DiffServ situation, where the operator must ensure that EXP-in and EXP-out are configured to go in the same queue.

# Fast Reroute and MPLS TE Class-based Tunnel Selection

CBTS allows Fast Reroute (FRR) protection on tunnels for which you configure CoS-based selection.

CBTS operation with FRR does not change the number of or the way in which FRR backup tunnels might be used. The operation of FFR is the same as when CBTS is not activated. After you configure primary tunnels from a given headend to a given tailend, you can use FRR in the same way whether you activate CoS-based tunnel selection or not. This includes the following possibilities:

- None of the tunnels use FRR.
- All of the *x* tunnels are FRR-protected and share the same backup tunnel, if the traffic goes out the same interface.
- Some of the *x* tunnels are not FRR-protected; the remaining tunnels are FRR-protected and share the same backup tunnel, if the traffic goes out the same interface.
- Some of the *x* tunnels are not FRR-protected; the remaining tunnels are FRR-protected and are protected by different backup tunnels (for example, if the traffic goes out different interfaces, or if the traffic goes out the same interface). Bandwidth guarantees exist on the backup tunnels.

The important question for CBTS operation is only whether a tunnel interface goes down or stays up. FRR protects a given tunnel in exactly the same way as if CBTS were not configured on the tunnel.

## DS-TE Tunnels and MPLS TE Class-based Tunnel Selection

CBTS operates over tunnels using DS-TE. Therefore, the tunnels on which CoS-based selection is performed can each arbitrarily and independently use a bandwidth from the global pool or the subpool.

## Reoptimization and MPLS TE Class-based Tunnel Selection

CBTS allows tunnels on which CoS-based selection is performed to be reoptimized. Reoptimization does not affect CBTS operation.

## Interarea and Inter-AS and MPLS TE Class-based Tunnel Selection

The CBTS operates over tunnels that are interarea when the interarea tunnels use static routes on destination prefixes or on the BGP next hops.

## ATM PVCs and MPLS TE Class-based Tunnel Selection

CBTS operates over ATM permanent virtual circuits (PVCs). This means that TE or DS-TE tunnels handled by CBTS can span links that are ATM PVCs. ATM PVCs might be used on the headend router that is running CBTS and on transit label switch routers (LSRs).

# How to Configure MPLS Traffic Engineering (TE): Class-based Tunnel Selection

This section contains the following procedures:

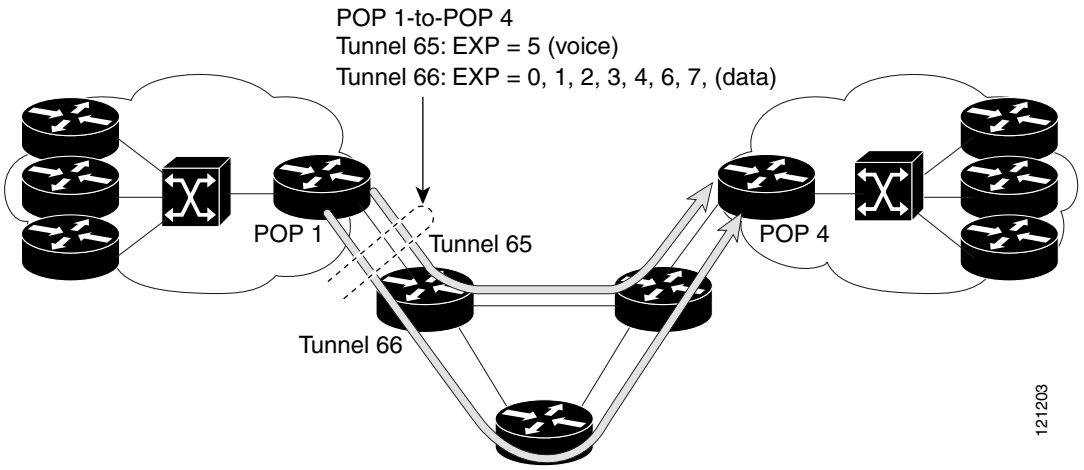

- Creating Multiple MPLS TE or DS-TE Tunnels from the Same Headend to the Same Tailend, page 10
- Configuring EXP Values to Be Carried by Each MPLS TE or DS-TE Tunnel, page 13
- Making the MPLS TE or DS-TE Tunnels Visible for Routing, page 14
- Verifying That the MPLS TE or DS-TE Tunnels Are Operating and Announced to the IGP, page 15
- Configuring a Master Tunnel, page 18


You need to configure the CBTS feature only on the tunnel headend. No CBTS configuration is required on the tailend or transit LSR.

## Creating Multiple MPLS TE or DS-TE Tunnels from the Same Headend to the Same Tailend

Figure 1 shows an example of two tunnels, Tunnel 65 and Tunnel 66, transporting different classes of traffic between the same headend and the same tailend.

*Figure 1 Tunnels Transporting Different Classes of Service Between the Same Headend and Tailend*




To create multiple MPLS TE or DS-TE tunnels with the same headend and same tailend, perform the following steps.

## SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *number*
4. **ip unnumbered** *type number*
5. **tunnel destination** {*hostname* | *ip-address*}
6. **tunnel mode mpls traffic-eng**
7. **tunnel mpls traffic-eng bandwidth** [**sub-pool** | **global**] *bandwidth*
8. **exit**
9. Repeat steps 3 through 8 on the same headend router to create additional tunnels from this headend to the same tailend.
10. **end**

## DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br><br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br><br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **interface tunnel** *number*<br><br>**Example:**<br>`Router(config)# interface tunnel 65` | Configures an interface type and enters interface configuration mode. |
| **Step 4** | **ip unnumbered** *type number*<br><br>**Example:**<br>`Router(config-if)# ip unnumbered loopback0` | Enables IP processing on an interface without assigning an explicit IP address to the interface. |
| **Step 5** | **tunnel destination** {*hostname* \| *ip-address*}<br><br>**Example:**<br>`Router(config-if)# tunnel destination 10.10.10.12` | Specifies the destination of the tunnel for this path option. |
| **Step 6** | **tunnel mode mpls traffic-eng**<br><br>**Example:**<br>`Router(config-if)# tunnel mode mpls traffic-eng` | Sets the mode of a tunnel to MPLS for TE. |
| **Step 7** | **tunnel mpls traffic-eng bandwidth** [**sub-pool** \| **global**] *bandwidth*<br><br>**Example:**<br>`Router(config-if)# tunnel mpls traffic-eng bandwidth sub-pool 3000` | Configures the bandwidth for the MPLS TE tunnel. If automatic bandwidth is configured for the tunnel, use the **tunnel mpls traffic-eng bandwidth** command to configure the initial tunnel bandwidth, which is adjusted by the autobandwidth mechanism.<br>**Note** You can configure any existing MPLS TE command on these TE or DS-TE tunnels. |
| **Step 8** | **exit**<br><br>**Example:**<br>`Router(config-if)# exit` | Returns to global configuration mode. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 9** | Repeat steps 3 through 8 on the same headend router to create additional tunnels from this headend to the same tailend. | — |
| **Step 10** | **end**<br><br>**Example:**<br>`Router(config)# end` | Returns to privileged EXEC mode. |

# Configuring EXP Values to Be Carried by Each MPLS TE or DS-TE Tunnel

To configure EXP values to be carried by each MPLS TE or DS-TE tunnel, perform the following steps.

For each tunnel that you create, you must indicate which EXP values the tunnel carries.

## SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **tunnel mpls traffic-eng exp** [*list-of-exp-values*] [**default**]
5. **exit**
6. Repeat steps 3 through 5 for all MPLS TE tunnels that you created in the "Creating Multiple MPLS TE or DS-TE Tunnels from the Same Headend to the Same Tailend" section on page 10.
7. **end**

## DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br><br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br><br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **interface** *type number*<br><br>**Example:**<br>`Router(config)# interface tunnel65` | Configures an interface type and enters interface configuration mode. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 4** | **tunnel mpls traffic-eng exp** [*list-of-exp-values*] [**default**]<br><br>**Example:**<br>`Router(config-if)# tunnel mpls traffic-eng exp 5` | Specifies the EXP bits that will be forwarded over a member tunnel that is part of the CBTS bundle. |
| **Step 5** | **exit**<br><br>**Example:**<br>`Router(config-if)# exit` | Returns to global configuration mode. |
| **Step 6** | Repeat steps 3 through 5 for all MPLS TE tunnels that you created in the "Creating Multiple MPLS TE or DS-TE Tunnels from the Same Headend to the Same Tailend" section on page 10. | — |
| **Step 7** | **end**<br><br>**Example:**<br>`Router(config-if)# end` | Returns to privileged EXEC mode. |

# Making the MPLS TE or DS-TE Tunnels Visible for Routing

Perform the following task to make the MPLS TE or DS-TE tunnels visible for routing.

**Note** Alternatively, static routing could be used instead of autoroute to make the TE or DS-TE tunnels visible for routing.

## SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **tunnel mpls traffic-eng autoroute announce**
5. **tunnel mpls traffic-eng autoroute metric** {**absolute** | **relative**} *value*
6. **end**

### DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br><br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br><br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **interface** *type number*<br><br>**Example:**<br>`Router(config)# interface tunnel 65` | Configures an interface type and enters interface configuration mode. |
| **Step 4** | **tunnel mpls traffic-eng autoroute announce**<br><br>**Example:**<br>`Router(config-if)# tunnel mpls traffic-eng autoroute announce` | Specifies that the Interior Gateway Protocol (IGP) should use the tunnel (if the tunnel is up) in its enhanced SPF calculation. |
| **Step 5** | **tunnel mpls traffic-eng autoroute metric** {**absolute** \| **relative**} *value*<br><br>**Example:**<br>`Router(config-if)# tunnel mpls traffic-eng autoroute metric relative 2` | Specifies the MPLS TE tunnel metric that the IGP enhanced SPF calculation uses.<br>**Note** Even though the value for a relative metric can be from –10 to +10, configuring a tunnel metric with a negative value is considered a misconfiguration. If the metric to the tunnel tailend appears to be 4 from the routing table, then the cost to the tunnel tailend router is actually 3 because 1 is added to the cost for getting to the loopback address. In this instance, the lowest value that you can configure for the relative metric is –3. |
| **Step 6** | **end**<br><br>**Example:**<br>`Router(config-if)# end` | Returns to privileged EXEC mode. |

# Verifying That the MPLS TE or DS-TE Tunnels Are Operating and Announced to the IGP

To verify that the MPLS TE or DS-TE tunnels are operating and announced to the IGP, perform the following steps.

### SUMMARY STEPS

1. **show mpls traffic-eng topology** {*A.B.C.D* | **igp-id** {**isis** *nsap-address* | **ospf** *A.B.C.D*} [**brief**]
2. **show mpls traffic-eng tunnels** *number* [**brief**] **protect**

3. **show ip cef** [**vrf** *vrf-name*] [**unresolved** [**detail**] | [**detail** | **summary**]]
4. **show mpls forwarding-table** [*network* {*mask* | *length*} | **labels** *label* [**-** *label*] | **interface** *interface* | **next-hop** *address* | **lsp-tunnel** [*tunnel-id*]] [**vrf** *vrf-name*] [**detail**]
5. **show mpls traffic-eng autoroute**

## DETAILED STEPS

**Step 1** **show mpls traffic-eng topology** {*A.B.C.D* | **igp-id** {**isis** *nsap-address* | **ospf** *A.B.C.D*} [**brief**]

Use this command to display the MPLS TE global topology currently known at this node:

```
Router# show mpls traffic-eng topology

My_System_id: 0000.0025.0003.00

IGP Id: 0000.0024.0004.00, MPLS TE Id:172.16.4.4 Router Node
      link[0 ]:Intf Address: 10.1.1.4
                  Nbr IGP Id: 0000.0024.0004.02,
                 admin_weight:10, affinity_bits:0x0
                 max_link_bw:10000 max_link_reservable: 10000
        globalpoolsubpool
                total allocatedreservable reservable
                --------------- ---------- ----------
    bw[0]: 0 1000500
    bw[1]:10 990490
    bw[2]: 600 390390
    bw[3]: 0 390390
    bw[4]: 0 390390
    bw[5]: 0 390390
```

**Step 2** **show mpls traffic-eng tunnels** *number* [**brief**] [**protection**]

Use this command to display information for a specified tunneling interface:

```
Router# show mpls traffic-eng tunnels 500 brief protection

Router#_t500
  LSP Head, Tunnel500, Admin: up, Oper: up
  Src 172.16.0.5, Dest 172.16.0.8, Instance 17
  Fast Reroute Protection: None
  Path Protection: 1 Common Link(s) , 1 Common Node(s)
    Primary lsp path:192.168.6.6 192.168.7.7
                     192.168.8.8 192.168.0.8

    Protect lsp path:172.16.7.7 192.168.8.8
                     10.0.0.8
    Path Protect Parameters:
      Bandwidth: 50       kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
      Metric Type: TE (default)
    InLabel  :  -
    OutLabel : Serial5/3, 46
    RSVP Signalling Info:
         Src 172.16.0.5, Dst 172.16.0.8, Tun_Id 500, Tun_Instance 18
      RSVP Path Info:
        My Address: 172.16.0.5
        Explicit Route: 192.168.7.7 192.168.8.8
        Record   Route:   NONE
        Tspec: ave rate=50 kbits, burst=1000 bytes, peak rate=50 kbits
      RSVP Resv Info:
```

```
        Record   Route:   NONE
        Fspec: ave rate=50 kbits, burst=1000 bytes, peak rate=50 kbits
```

**Step 3** **show ip cef summary**

Use this command to display a summary of the IP CEF table:

```
Router# show ip cef summary

IP Distributed CEF with switching (Table Version 25), flags=0x0
 21 routes, 0 reresolve, 0 unresolved (0 old, 0 new), peak 1
 21 leaves, 16 nodes, 19496 bytes, 36 inserts, 15 invalidations
 0 load sharing elements, 0 bytes, 0 references
 universal per-destination load sharing algorithm, id 5163EC15
 3(0) CEF resets, 0 revisions of existing leaves
 Resolution Timer: Exponential (currently 1s, peak 1s)
 0 in-place/0 aborted modifications
 refcounts:  4377 leaf, 4352 node

 Table epoch: 0 (21 entries at this epoch)

 Adjacency Table has 9 adjacencies
```

**Step 4** **show mpls forwarding-table** [*network* {*mask* | *length*} | **labels** *label* [**-** *label*] | **interface** *interface* | **next-hop** *address* | **lsp-tunnel** [*tunnel-id*]] [**vrf** *vrf-name*] [**detail**]

Use this command to display the contents of the MPLS Label Forwarding Information Base (LFIB):

```
Router# show mpls forwarding-table

Local Outgoing      Prefix            Bytes tag Outgoing       Next Hop
Label Label or VC   or Tunnel Id      switched  interface
26    No Label      10.253.0.0/16     0         Et4/0/0       10.27.32.4
28    1/33          10.15.0.0/16      0         AT0/0.1       point2point
29    Pop Label     10.91.0.0/16      0         Hs5/0         point2point
      1/36          10.91.0.0/16      0         AT0/0.1       point2point
30    32            10.250.0.97/32    0         Et4/0/2       10.92.0.7
      32            10.250.0.97/32    0         Hs5/0         point2point
34    26            10.77.0.0/24      0         Et4/0/2       10.92.0.7
      26            10.77.0.0/24      0         Hs5/0         point2point
35    No Label[T]   10.100.100.101/32 0         Tu301         point2point
36    Pop Label     10.1.0.0/16       0         Hs5/0         point2point
      1/37          10.1.0.0/16       0         AT0/0.1       point2point

[T]     Forwarding through a TSP tunnel.
        View additional tagging info with the 'detail' option
```

**Step 5** **show mpls traffic-eng autoroute**

Use this command to display tunnels that are announced to the IGP, including interface, destination, and bandwidth:

```
Router# show mpls traffic-eng autoroute

MPLS TE autorouting enabled
  destination 0002.0002.0002.00 has 2 tunnels
    Tunnel1021 (traffic share 10000, nexthop 10.2.2.2, absolute metric 11)
    Tunnel1022 (traffic share 3333, nexthop 10.2.2.2, relative metric -3)
  destination 0003.0003.0003.00 has 2 tunnels
    Tunnel1032 (traffic share 10000, nexthop 172.16.3.3)
    Tunnel1031 (traffic share 10000, nexthop 172.16.3.3, relative metric -1)
```

# Configuring a Master Tunnel

To configure a master tunnel to which other tunnels can be members, perform the following steps.

## SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface tunnel** *number*
4. **ip unnumbered** *type number*
5. **tunnel destination** {*hostname* | *ip-address*}
6. **tunnel mode mpls traffic-eng**
7. **tunnel mpls traffic-eng exp-bundle master**
8. **tunnel mpls traffic-eng exp-bundle member** *tunnel-number*
9. **exit**

## DETAILED STEPS

| | Command or Action | Purpose |
|---|---|---|
| **Step 1** | **enable**<br><br>**Example:**<br>`Router> enable` | Enables privileged EXEC mode.<br>• Enter your password if prompted. |
| **Step 2** | **configure terminal**<br><br>**Example:**<br>`Router# configure terminal` | Enters global configuration mode. |
| **Step 3** | **interface tunnel** *number*<br><br>**Example:**<br>`Router(config)# interface tunnel 65` | Configures an interface type and enters interface configuration mode. |
| **Step 4** | **ip unnumbered** *type number*<br><br>**Example:**<br>`Router(config-if)# ip unnumbered loopback0` | Enables IP processing on an interface without assigning an explicit IP address to the interface. |
| **Step 5** | **tunnel destination** {*hostname* \| *ip-address*}<br><br>**Example:**<br>`Router(config-if)# tunnel destination 10.10.10.12` | Specifies the destination of the tunnel for this path option. |
| **Step 6** | **tunnel mode mpls traffic-eng**<br><br>**Example:**<br>`Router(config-if)# tunnel mode mpls traffic-eng` | Sets the mode of a tunnel to MPLS for TE. |

| | Command or Action | Purpose |
|---|---|---|
| **Step 7** | **tunnel mpls traffic-eng exp-bundle master**<br><br>**Example:**<br>`Router(config-if)# tunnel mpls traffic-eng exp-bundle master` | Configures a master tunnel. |
| **Step 8** | **tunnel mpls traffic-eng exp-bundle member** *tunnel-number*<br><br>**Example:**<br>`Router(config-if)# tunnel mpls traffic-eng exp-bundle member tunnel1` | Identifies which tunnel is a member of a master tunnel. |
| **Step 9** | **exit**<br><br>**Example:**<br>`Router(config-if)# exit` | Exits to global configuration mode. |

# Configuration Examples for MPLS Traffic Engineering (TE): Class-based Tunnel Selection

This section contains the following configuration examples:


- Creating Multiple MPLS TE or DS-TE Tunnels from the Same Headend to the Same Tailend: Example, page 19
- Configuring EXP Values to Be Carried by Each MPLS TE or DS-TE Tunnel: Example, page 20
- Making the MPLS TE or DS-TE Tunnels Visible for Routing: Example, page 20
- Verifying That the MPLS TE or DS-TE Tunnels Are Operating and Announced to the IGP: Example, page 20
- Configuring a Master Tunnel: Example, page 27


## Creating Multiple MPLS TE or DS-TE Tunnels from the Same Headend to the Same Tailend: Example

The following example shows how to create multiple MPLS TE or DS-TE tunnels from the same headend to the same tailend:

```
Router(config)# interface Tunnel 65
Router(config-if)# ip numbered loopback0
Router(config-if)# tunnel destination 10.1.1.1
Router(config-if)# tunnel mode mpls traffic-eng
Router(config-if)# tunnel mpls traffic-eng bandwidth sub-pool 30000
Router(config-if)# ^Z
Router(config)# interface Tunnel 66
Router(config-if)# ip numbered loopback0
Router(config-if)# tunnel destination 10.1.1.1
Router(config-if)# tunnel mode mpls traffic-eng
Router(config-if)# tunnel mpls traffic-eng bandwidth 50000
Router(config-if)# end
```

```
Router#
```

# Configuring EXP Values to Be Carried by Each MPLS TE or DS-TE Tunnel: Example

The following example shows how to configure EXP values to be carried by each MPLS TE or DS-TE tunnel that you created:

```
Router(config)# interface Tunnel 65
Router(config-if)# tunnel mpls traffic-eng exp 5
Router(config-if)# ^Z
Router(config)#
Router(config)# interface Tunnel 66
Router(config-if)# tunnel mpls traffic-eng exp 0 1 2 3 4 6 7
Router(config-if)# end
Router#
```

# Making the MPLS TE or DS-TE Tunnels Visible for Routing: Example

The following example shows how to make the MPLS TE or DS-TE tunnels visible for routing:

```
Router(config)# interface Tunnel 65
Router(config-if)# tunnel mpls traffic-eng autoroute announce
Router(config-if)# tunnel mpls traffic-eng autoroute metric relative -2
Router(config-if)# ^Z
Router(config)#
Router(config)# interface Tunnel 66
Router(config-if)# tunnel mpls traffic-eng autoroute announce
Router(config-if)# tunnel mpls traffic-eng autoroute metric relative -2
Router(config-if)# end
Router#
```

Packets destined beyond 10.1.1.1 are sent on:

- Tunnel 65 if their EXP value after input MQC is 5.
- Tunnel 66 if their EXP value after input MQC is 0, 1, 2, 3, 4, 6, or 7.

# Verifying That the MPLS TE or DS-TE Tunnels Are Operating and Announced to the IGP: Example

The output for each of the following examples helps verify that the MPLS TE or DS-TE tunnels are operating and visible.

The **show mpls traffic-eng topology** command output displays the MPLS TE global topology:

```
Router# show mpls traffic-eng topology 10.0.0.1

IGP Id: 10.0.0.1, MPLS TE Id:10.0.0.1 Router Node  (ospf 10  area 0) id 1
      link[0]: Broadcast, DR: 10.0.1.2, nbr_node_id:6, gen:18
      frag_id 0, Intf Address:10.1.1.1
      TE metric:1, IGP metric:1, attribute_flags:0x0
      SRLGs: None
      physical_bw: 100000 (kbps), max_reservable_bw_global: 1000 (kbps)
      max_reservable_bw_sub: 0 (kbps)

                                 Global Pool       Sub Pool
```

```
                Total Allocated   Reservable        Reservable
                BW (kbps)         BW (kbps)         BW (kbps)
                ---------------   -----------       ----------
          bw[0]:            0             1000               0
          bw[1]:            0             1000               0
          bw[2]:            0             1000               0
          bw[3]:            0             1000               0
          bw[4]:            0             1000               0
          bw[5]:            0             1000               0
          bw[6]:            0             1000               0
          bw[7]:          100              900               0

            link[1]: Broadcast, DR: 10.0.2.2, nbr_node_id:7, gen:19
            frag_id 1, Intf Address:10.0.2.1
            TE metric:1, IGP metric:1, attribute_flags:0x0
            SRLGs: None
            physical_bw: 100000 (kbps), max_reservable_bw_global: 1000 (kbps)
            max_reservable_bw_sub: 0 (kbps)

                                Global Pool       Sub Pool
                Total Allocated   Reservable        Reservable
                BW (kbps)         BW (kbps)         BW (kbps)
                ---------------   -----------       ----------
          bw[0]:            0             1000               0
          bw[1]:            0             1000               0
          bw[2]:            0             1000               0
          bw[3]:            0             1000               0
          bw[4]:            0             1000               0
          bw[5]:            0             1000               0
          bw[6]:            0             1000               0
          bw[7]:          300              700               0
Router#

Router# show mpls traffic-eng topology 10.0.0.9

IGP Id: 10.0.0.9, MPLS TE Id:10.0.0.9 Router Node  (ospf 10  area 0) id 3
      link[0]: Point-to-Point, Nbr IGP Id: 10.0.0.5, nbr_node_id:5, gen:9
      frag_id 1, Intf Address:10.0.5.2, Nbr Intf Address:10.0.5.1
      TE metric:1, IGP metric:1, attribute_flags:0x0
      SRLGs: None
      physical_bw: 155000 (kbps), max_reservable_bw_global: 1000 (kbps)
      max_reservable_bw_sub: 0 (kbps)

                                Global Pool       Sub Pool
                Total Allocated   Reservable        Reservable
                BW (kbps)         BW (kbps)         BW (kbps)
                ---------------   -----------       ----------
          bw[0]:            0             1000               0
          bw[1]:            0             1000               0
          bw[2]:            0             1000               0
          bw[3]:            0             1000               0
          bw[4]:            0             1000               0
          bw[5]:            0             1000               0
          bw[6]:            0             1000               0
          bw[7]:            0             1000               0

            link[1]: Point-to-Point, Nbr IGP Id: 10.0.0.7, nbr_node_id:4, gen:9
            frag_id 0, Intf Address:10.0.6.2, Nbr Intf Address:10.0.6.1
            TE metric:1, IGP metric:1, attribute_flags:0x0
            SRLGs: None
            physical_bw: 155000 (kbps), max_reservable_bw_global: 1000 (kbps)
            max_reservable_bw_sub: 0 (kbps)

                                Global Pool       Sub Pool
```

```
            Total Allocated   Reservable        Reservable
            BW (kbps)         BW (kbps)         BW (kbps)
            ---------------   -----------       ----------
     bw[0]:            0             1000               0
     bw[1]:            0             1000               0
     bw[2]:            0             1000               0
     bw[3]:            0             1000               0
     bw[4]:            0             1000               0
     bw[5]:            0             1000               0
     bw[6]:            0             1000               0
     bw[7]:            0             1000               0
Router#
```

The **show mpls traffic-eng tunnels** command output displays information about a tunnel:

```
Router# show mpls traffic-eng tunnels tunnel1

Name: Router_t1                           (Tunnel1) Destination: 10.0.0.9
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 1, type explicit path1 (Basis for Setup, path weight 3)

  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 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled


  InLabel  :  -
  OutLabel : FastEthernet6/0, 12304
  RSVP Signalling Info:
       Src 10.0.0.1, Dst 10.0.0.9, Tun_Id 1, Tun_Instance 10
    RSVP Path Info:
      My Address: 10.0.1.1
      Explicit Route: 10.0.1.2 10.0.3.2 10.0.5.2 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=17179869 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 3 (TE)
    Explicit Route: 10.0.2.1 180.0.2.2 10.0.3.2 180.0.5.2
                    10.0.0.9
  History:
    Tunnel:
      Time since created: 15 minutes, 18 seconds
      Time since path change: 15 minutes, 5 seconds
    Current LSP:
      Uptime: 15 minutes, 5 seconds

Router# show mpls traffic-eng tunnel tunnel2

Name: Router_t2                           (Tunnel2) Destination: 10.0.0.9
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 1, type explicit path2 (Basis for Setup, path weight 3)

  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 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled


  InLabel  :  -
  OutLabel : FastEthernet6/1, 12305
  RSVP Signalling Info:
       Src 10.0.0.1, Dst 10.0.0.9, Tun_Id 2, Tun_Instance 10
    RSVP Path Info:
      My Address: 10.0.2.1
      Explicit Route: 10.0.2.2  10.0.4.2  10.0.6.2 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=17179869 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 3 (TE)
    Explicit Route: 10.0.2.1 10.0.2.2 10.0.3.2 10.0.5.2
                    10.0.0.9
  History:
    Tunnel:
      Time since created: 15 minutes, 19 seconds
      Time since path change: 15 minutes, 6 seconds
    Current LSP:
      Uptime: 15 minutes, 6 seconds


Router# show mpls traffic-eng tunnels tunnel3

Name: Router_t3                           (Tunnel3) Destination: 10.0.0.9
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 1, type explicit path2 (Basis for Setup, path weight 3)

  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 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled

  InLabel  :  -
  OutLabel : FastEthernet6/1, 12306
  RSVP Signalling Info:
       Src 10.0.0.1, Dst 10.0.0.9, Tun_Id 3, Tun_Instance 8
    RSVP Path Info:
      My Address: 10.0.2.1
'     Explicit Route: 10.0.2.2 10.0.4.2 10.0.6.2 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=17179869 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 3 (TE)
    Explicit Route: 10.0.2.1 10.0.2.2 10.0.3.2 10.0.5.2
                    10.0.0.9
```

```
  History:
    Tunnel:
      Time since created: 15 minutes, 19 seconds
      Time since path change: 15 minutes, 7 seconds
    Current LSP:
      Uptime: 15 minutes, 7 seconds


Router# show mpls traffic-eng tunnels tunnel4

Name: Router_t4                           (Tunnel4) Destination: 10.0.0.9
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 1, type explicit path2 (Basis for Setup, path weight 3)

  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 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled

  InLabel  :  -
  OutLabel : FastEthernet6/1, 12307
  RSVP Signalling Info:
       Src 10.0.0.1, Dst 10.0.0.9, Tun_Id 4, Tun_Instance 6
    RSVP Path Info:
      My Address: 10.0.2.1
      Explicit Route: 10.0.2.2 10.0.4.2 10.0.6.2 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=17179869 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 3 (TE)
    Explicit Route: 10.0.2.1 10.0.2.2 10.0.3.2 10.0.5.2
                    10.0.0.9
  History:
    Tunnel:
      Time since created: 15 minutes, 20 seconds
      Time since path change: 15 minutes, 8 seconds
    Current LSP:
      Uptime: 15 minutes, 8 seconds
```

The **show ip cef detail** command output displays detailed FIB entry information for a tunnel:

```
Router# show ip cef tunnel1 detail

IP CEF with switching (Table Version 46), flags=0x0
  31 routes, 0 reresolve, 0 unresolved (0 old, 0 new), peak 2
  2 instant recursive resolutions, 0 used background process
  8 load sharing elements, 8 references
  6 in-place/0 aborted modifications
  34696 bytes allocated to the FIB table data structures
  universal per-destination load sharing algorithm, id 9EDD49E1
  1(0) CEF resets
  Resolution Timer: Exponential (currently 1s, peak 1s)
  Tree summary:
   8-8-8-8 stride pattern
   short mask protection disabled
```

```
   31 leaves, 23 nodes using 26428 bytes

  Table epoch: 0 (31 entries at this epoch)

Adjacency Table has 13 adjacencies
10.0.0.9/32, version 45, epoch 0, per-destination sharing
0 packets, 0 bytes
  tag information set, all rewrites inherited
    local tag: tunnel head
  via 0.0.0.0, Tunnel1, 0 dependencies
    traffic share 1
    next hop 0.0.0.0, Tunnel1
    valid adjacency
    tag rewrite with Tu1, point2point, tags imposed {12304}
  0 packets, 0 bytes switched through the prefix
  tmstats: external 0 packets, 0 bytes
           internal 0 packets, 0 bytes


Router# show ip cef tunnel2 detail

IP CEF with switching (Table Version 46), flags=0x0
  31 routes, 0 reresolve, 0 unresolved (0 old, 0 new), peak 2
  2 instant recursive resolutions, 0 used background process
  8 load sharing elements, 8 references
  6 in-place/0 aborted modifications
  34696 bytes allocated to the FIB table data structures
  universal per-destination load sharing algorithm, id 9EDD49E1
  1(0) CEF resets
  Resolution Timer: Exponential (currently 1s, peak 1s)
  Tree summary:
   8-8-8-8 stride pattern
   short mask protection disabled
   31 leaves, 23 nodes using 26428 bytes

  Table epoch: 0 (31 entries at this epoch)

Adjacency Table has 13 adjacencies
10.0.0.9/32, version 45, epoch 0, per-destination sharing
0 packets, 0 bytes
  tag information set, all rewrites inherited
    local tag: tunnel head
  via 0.0.0.0, Tunnel2, 0 dependencies
    traffic share 1
    next hop 0.0.0.0, Tunnel2
    valid adjacency
    tag rewrite with Tu2, point2point, tags imposed {12305}
  0 packets, 0 bytes switched through the prefix
  tmstats: external 0 packets, 0 bytes
           internal 0 packets, 0 bytes


Router# show ip cef tunnel3 detail

IP CEF with switching (Table Version 46), flags=0x0
  31 routes, 0 reresolve, 0 unresolved (0 old, 0 new), peak 2
  2 instant recursive resolutions, 0 used background process
  8 load sharing elements, 8 references
  6 in-place/0 aborted modifications
  34696 bytes allocated to the FIB table data structures
  universal per-destination load sharing algorithm, id 9EDD49E1
  1(0) CEF resets
  Resolution Timer: Exponential (currently 1s, peak 1s)
  Tree summary:
```

```
   8-8-8-8 stride pattern
   short mask protection disabled
   31 leaves, 23 nodes using 26428 bytes

  Table epoch: 0 (31 entries at this epoch)

Adjacency Table has 13 adjacencies
10.0.0.9/32, version 45, epoch 0, per-destination sharing
0 packets, 0 bytes
  tag information set, all rewrites inherited
    local tag: tunnel head
  via 0.0.0.0, Tunnel3, 0 dependencies
    traffic share 1
    next hop 0.0.0.0, Tunnel3
    valid adjacency
    tag rewrite with Tu3, point2point, tags imposed {12306}
  0 packets, 0 bytes switched through the prefix
  tmstats: external 0 packets, 0 bytes
           internal 0 packets, 0 bytes


Router# show ip cef tunnel4 detail

IP CEF with switching (Table Version 46), flags=0x0
  31 routes, 0 reresolve, 0 unresolved (0 old, 0 new), peak 2
  2 instant recursive resolutions, 0 used background process
  8 load sharing elements, 8 references
  6 in-place/0 aborted modifications
  34696 bytes allocated to the FIB table data structures
  universal per-destination load sharing algorithm, id 9EDD49E1
  1(0) CEF resets
  Resolution Timer: Exponential (currently 1s, peak 1s)
  Tree summary:
   8-8-8-8 stride pattern
   short mask protection disabled
   31 leaves, 23 nodes using 26428 bytes

  Table epoch: 0 (31 entries at this epoch)

Adjacency Table has 13 adjacencies
10.0.0.9/32, version 45, epoch 0, per-destination sharing
0 packets, 0 bytes
  tag information set, all rewrites inherited
    local tag: tunnel head
  via 0.0.0.0, Tunnel4, 0 dependencies
    traffic share 1
    next hop 0.0.0.0, Tunnel4
    valid adjacency
    tag rewrite with Tu4, point2point, tags imposed {12307}
  0 packets, 0 bytes switched through the prefix
  tmstats: external 0 packets, 0 bytes
           internal 0 packets, 0 bytes
```

The **show mpls forwarding-table detail** command output displays detailed information from the MPLS LFIB:

```
Router# show mpls forwarding-table detail

Local  Outgoing    Prefix           Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id     switched   interface
Router#

Router# show mpls forwarding-table 10.0.0.9 detail
```

```
Local  Outgoing    Prefix            Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id      switched   interface
Tun hd Untagged    10.0.0.9/32       0          Tu1        point2point
    MAC/Encaps=14/18, MRU=1500, Tag Stack{12304}, via Fa6/0
    00027D884000000ED70178A88847 03010000
    No output feature configured
        Per-exp selection: 1
       Untagged    10.0.0.9/32       0          Tu2        point2point
    MAC/Encaps=14/18, MRU=1500, Tag Stack{12305}, via Fa6/1
    00027D884001000ED70178A98847 03011000
    No output feature configured
        Per-exp selection: 2  3
       Untagged    10.0.0.9/32       0          Tu3        point2point
    MAC/Encaps=14/18, MRU=1500, Tag Stack{12306}, via Fa6/1
    00027D884001000ED70178A98847 03012000
    No output feature configured
        Per-exp selection: 4  5
       Untagged    10.0.0.9/32       0          Tu4        point2point
    MAC/Encaps=14/18, MRU=1500, Tag Stack{12307}, via Fa6/1
    00027D884001000ED70178A98847 03013000
    No output feature configured
        Per-exp selection: 0  6  7
Router#
```

The **show mpls traffic-eng autoroute** command output displays tunnels that are announced to the IGP:

```
Router# show mpls traffic-eng autoroute

MPLS TE autorouting enabled
  destination 10.0.0.9, area ospf 10  area 0, has 4 tunnels
    Tunnel1     (load balancing metric 20000000, nexthop 10.0.0.9)
                (flags: Announce)
    Tunnel2     (load balancing metric 20000000, nexthop 10.0.0.9)
                (flags: Announce)
    Tunnel3     (load balancing metric 20000000, nexthop 10.0.0.9)
                (flags: Announce)
    Tunnel4     (load balancing metric 20000000, nexthop 10.0.0.9)
                (flags: Announce)
Router#
```

# Configuring a Master Tunnel: Example

The following example specifies that there is a master tunnel that includes tunnels Tunnel20000 through Tunnel20005:

```
interface Tunnel 200
 ip unnumbered Loopback0
 tunnel destination 10.10.10.10
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng exp-bundle master
 tunnel mpls traffic-eng exp-bundle member Tunnel20000
 tunnel mpls traffic-eng exp-bundle member Tunnel20001
 tunnel mpls traffic-eng exp-bundle member Tunnel20002
 tunnel mpls traffic-eng exp-bundle member Tunnel20003
 tunnel mpls traffic-eng exp-bundle member Tunnel20004
 tunnel mpls traffic-eng exp-bundle member Tunnel20005
```

# Additional References

The following sections provide references related to the MPLS Traffic Engineering (TE): Class-based Tunnel Selection feature.

## Related Documents

| Related Topic | Document Title |
|---|---|
| MPLS traffic engineering | *Cisco IOS Multiprotocol Label Switching Command Reference*, Release 12.4 |

## 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:<br>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 website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.<br><br>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.<br><br>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password. | http://www.cisco.com/techsupport |

# Command Reference

This section documents modified commands only.

- **show ip cef**
- **show mpls forwarding-table**
- **show mpls traffic-eng tunnels**
- **tunnel mpls traffic-eng exp**
- **tunnel mpls traffic-eng exp-bundle master**
- **tunnel mpls traffic-eng exp-bundle member**

# show ip cef

To display entries in the Forwarding Information Base (FIB) or to display a summary of the FIB, use the **show ip cef** command in user EXEC or privileged EXEC mode.

**show ip cef** [**vrf** *vrf-name*] [**unresolved** [**detail**] | [**detail** | **summary**]]

### Specific FIB Entries Based on IP Address Information

**show ip cef** [**vrf** *vrf-name*] [*network* [*mask*]] [**longer-prefixes**] [**detail**]

### Specific FIB Entries Based on Interface Information

**show ip cef** [**vrf** *vrf-name*] [*interface-type interface-number*] [**detail**]

### Specific FIB Entries Based on Nonrecursive Routes

**show ip cef** [**vrf** *vrf-name*] **non-recursive** [**detail**]

## Syntax Description

| | |
|---|---|
| **vrf** | (Optional) Specifies a Virtual Private Network (VPN) routing and forwarding (VRF) instance. |
| *vrf-name* | (Optional) Name assigned to the VRF. |
| **unresolved** | (Optional) Displays unresolved FIB entries. |
| **detail** | (Optional) Displays detailed FIB entry information. |
| **summary** | (Optional) Displays a summary of the FIB. |
| *network* | (Optional) Network number for which to display a FIB entry. |
| *mask* | (Optional) Network mask to be used with the specified *network* value. |
| **longer-prefixes** | (Optional) Displays FIB entries for more specific destinations. |
| *interface-type interface-number* | (Optional) Interface type and number for which to display FIB entries. |
| **non-recursive** | Displays only nonrecursive routes. |

## Command Modes

User EXEC
Privileged EXEC

## Command History

| Release | Modification |
|---|---|
| 11.2GS | This command was introduced for the Cisco 12012 Internet router. |
| 11.1CC | Multiple platform support was added. |
| 12.0(5)T | The **vrf** keyword was added. |
| 12.0(17)ST | The display of a message indicating support for Border Gateway Protocol (BGP) policy accounting was added. |
| 12.2(13)T | This command was integrated into Cisco IOS Release 12.2(13)T. |
| 12.0(26)S | Output display was added for the **summary** keyword. |

| Release | Modification |
|---|---|
| 12.2(28)SB | This command was integrated into Cisco IOS Release 12.2(28)SB. |
| 12.2(33)SRA | This command was integrated into Cisco IOS Release 12.2(33)SRA. |
| 12.2(33)SXH | This command was integrated into Cisco IOS Release 12.2(33)SXH. |

## Usage Guidelines

Use of the **show ip cef** command without any keywords or arguments shows a brief display of all FIB entries.

The **show ip cef detail** command shows detailed FIB entry information for all FIB entries.

## Examples

The following is sample output from the **show ip cef unresolved** command:

```
Router# show ip cef unresolved

IP Distributed CEF with switching (Table Version 136632)
45776 routes, 13 unresolved routes (0 old, 13 new)
45776 leaves, 2868 nodes, 8441480 bytes, 136632 inserts, 90856 invalidations
1 load sharing elements, 208 bytes, 1 references
1 CEF resets, 1 revisions of existing leaves
refcounts: 527292 leaf, 465617 node

10.214.0.0/16, version 136622
0 packets, 0 bytes
  via 172.17.233.56, 0 dependencies, recursive
  unresolved
10.215.0.0/16, version 136623
0 packets, 0 bytes
  via 172.17.233.56, 0 dependencies, recursive
  unresolved
10.218.0.0/16, version 136624
0 packets, 0 bytes
```

Table 1 describes the significant fields shown in the display.

***Table 1 show ip cef unresolved Field Descriptions***

| Field | Description |
|---|---|
| routes | Total number of entries in the Cisco Express Forwarding table. |
| unresolved routes | Number of entries in the Cisco Express Forwarding table that do not have resolved recursions categorized by old and new routes. |
| leaves, nodes, bytes | Number of elements in the Cisco Express Forwarding table and how much memory they use. |
| inserts | Number of nodes inserted. |
| invalidations | Number of entries that have been invalidated. |
| load sharing elements, bytes, references | Information about load sharing elements: how many, number of associated bytes, and number of associated references. |
| version | Version of the Cisco Express Forwarding table. |
| packets, bytes | Number of packets and bytes switched through the name entry. |
| dependencies | Number of table entries that point to the named entry. |

*Table 1 show ip cef unresolved Field Descriptions (continued)*

| Field | Description |
|---|---|
| recursive | Indicates that the destination is reachable through another route. |
| unresolved | Number of entries that do not have resolved recursions. |

The following is sample output from the **show ip cef summary** command:

```
Router# show ip cef summary

IP Distributed CEF with switching (Table Version 135165)
45788 routes, 0 reresolve, 4 unresolved routes (0 old, 4 new)
45788 leaves, 2868 nodes, 8442864 bytes, 135165 inserts, 89377 invalidations
0 load sharing elements, 0 bytes, 0 references
1 CEF resets, 0 revisions of existing leaves
refcounts: 527870 leaf, 466167 node
```

For a description of significant fields in this display, see Table 1.

The following is sample output from the **show ip cef summary** command for Cisco IOS Release 12.0(26)S and later releases that displays a summary of the IP Cisco Express Forwarding table information, which includes the percentage of memory used and current alarm status of Cisco Express Forwarding hardware resources on all E2 and Cisco IP Services Engine (ISE) line cards in a Cisco 12000 series Internet router:

```
Router# show ip cef summary

IP Distributed CEF with switching (Table Version 2283113), flags=0x0
  164413 routes, 0 reresolve, 0 unresolved (0 old, 0 new), peak 3451
  2234324 instant recursive resolutions, 0 used background process
  304 load sharing elements, 336 references
  14758 in-place/0 aborted modifications
  36745512 bytes allocated to the FIB table data structures
  universal per-destination load sharing algorithm, id B03E8BB3
  2(0) CEF resets
  Resolution Timer: Exponential (currently 1s, peak 1s)
  Tree summary:
   8-8-8-8 stride pattern
   short mask protection disabled
   164413 leaves, 11622 nodes using 16691988 bytes
  Transient memory used: 168, max: 865064

  Table epoch: 0 (164413 entries at this epoch)

Hardware resource allocation status summary
Green (Normal), Yellow (Caution) Red (Alarm)
Slot HW Resource Name        Util     Alert
1    E3 Rx PLU                22        G
1    E3_Rx_TLU                6         G
2    E3 Rx PLU                22        G
2    E3_Rx_TLU                6         G
3    E3 Rx PLU                22        G
3    E3_Rx_TLU                6         G
9    E3 Rx PLU                22        G
9    E3_Rx_TLU                6         G

Adjacency Table has 11 adjacencies
```

Table 2 describes the significant fields shown in the display.

***Table 2 show ip cef summary Field Descriptions***

| Field | Description |
|---|---|
| routes | Total number of entries in the Cisco Express Forwarding table. |
| unresolved routes | Number of entries in the Cisco Express Forwarding table that do not have resolved recursions categorized by old and new routes. |
| peak | Highest number of unresolved recursions. |
| load sharing elements, bytes, references | Information about load sharing elements: how many, number of associated bytes, and number of associated references. |
| load sharing algorithm, id | Type of load sharing, whether the router is configured for per destination or per packet and the identifier. |
| leaves, nodes, bytes | Number of elements in the Cisco Express Forwarding table and how much memory they use. |
| Table epoch | Number indicating the version of a Cisco Express Forwarding table from 0 to 255. |
| Slot | Slot number in which an E2 or ISE line card is installed. |
| Hw Resource Name | Internal name of each hardware resource used by Cisco Express Forwarding:<br>• E2: Cisco 12000 series Engine 2 line card<br>• E3: Cisco 12000 series ISE line card<br>• Rx: Received by the router<br>• Tx: Transmitted by the router<br>• PLU: Pointer lookup memory<br>• TLU: Table lookup memory |
| Util | Percentage of the resource used for Cisco Express Forwarding fast-path forwarding. |
| Alert | Operational status of the resource, based on utilization percentage:<br>• G: Green (Normal)—Less than the yellow threshold percentage is used.<br>• Y: Yellow (Caution)—80 percent to 95 percent is used (configurable).<br>• R: Red (Alarm)—95 percent or more is used. |

The following is sample output from the **show ip cef detail** command for Ethernet interface 0. It shows all the prefixes resolving through adjacency pointing to next hop Ethernet interface 0/0 and next hop interface IP address 172.19.233.33.

```
Router# show ip cef e0/0 172.19.233.33 detail

IP Distributed CEF with switching (Table Version 136808)
45800 routes, 8 unresolved routes (0 old, 8 new) 45800 leaves, 2868 nodes, 8444360 bytes,
136808 inserts, 91008 invalidations 1 load sharing elements, 208 bytes, 1 references 1 CEF
resets, 1 revisions of existing leaves refcounts: 527343 leaf, 465638 node
```

```
172.19.233.33/32, version 7417, cached adjacency 172.19.233.33 0 packets, 0 bytes,
Adjacency-prefix
via 172.19.233.33, Ethernet0/0, 0 dependencies
next hop 172.19.233.33, Ethernet0/0
valid cached adjacency
```

Table 3 describes the significant fields shown in the display.

***Table 3 show ip cef detail Field Descriptions***

| Field | Description |
|---|---|
| routes | Total number of entries in the Cisco Express Forwarding table. |
| unresolved routes | Number of entries in the Cisco Express Forwarding table that do not have resolved recursions categorized by old and new routes. |
| leaves, nodes, bytes | Number of elements in the Cisco Express Forwarding table and how much memory they use. |
| inserts | Number of nodes inserted. |
| invalidations | Number of entries that have been invalidated. |
| load sharing elements, bytes, references | Information about load sharing elements: how many, number of associated bytes, and number of associated references. |
| version | Version of the Cisco Express Forwarding table. |
| cached adjacency | Type of adjacency to which this Cisco Express Forwarding table entry points. |
| packets, bytes | Number of packets and bytes switched through the name entry. |
| dependencies | Number of table entries that point to the named entry. |
| next hop | Type of adjacency or the next hop toward the destination. |

The following is sample output from the **show ip cef detail** command for the prefix 192.168.5.0, showing that the Border Gateway Protocol (BGP) policy accounting bucket number 4 (traffic_index 4) is assigned to this prefix:

```
Router# show ip cef 192.168.5.0 detail

192.168.5.0/24, version 21, cached adjacency to POS7/2
0 packets, 0 bytes, traffic_index 4
via 10.14.1.1, 0 dependencies, recursive
next hop 10.14.1.1, POS7/2 via 10.14.1.0/30
valid cached adjacency
```

The following example shows the forwarding table associated with the VRF named vrf1:

```
Router# show ip cef vrf vrf1

Prefix              Next Hop            Interface
0.0.0.0/32          receive
10.11.0.0/16        10.50.0.1           Ethernet1/3
10.12.0.0/16        10.52.0.2           POS6/0
10.50.0.0/16        attached            Ethernet1/3
10.50.0.0/32        receive
10.50.0.1/32        10.50.0.1           Ethernet1/3
10.50.0.2/32        receive
10.255.255.255/32   receive
10.51.0.0/16        10.52.0.2           POS6/0
224.0.0.0/24        receive
```

```
255.255.255.255/32 receive
```

Table 4 describes the significant fields shown in the display.

***Table 4 show ip cef vrf Field Descriptions***

| Field | Description |
|---|---|
| Prefix | Specifies the network prefix. |
| Next Hop | Specifies the BGP next hop address. |
| Interface | Specifies the VRF interface. |

## Related Commands

| Command | Description |
|---|---|
| **show cef** | Displays which packets the line cards dropped, or displays which packets were not express forwarded. |
| **show cef interface** | Displays Cisco Express Forwarding-related interface information. |

# show mpls forwarding-table

To display the contents of the Multiprotocol Label Switching (MPLS) Label Forwarding Information Base (LFIB), use the **show mpls forwarding-table** command in privileged EXEC mode.

**show mpls forwarding-table** [*network* {*mask* | *length*} | **labels** *label* [**-** *label*] | **interface** *interface* | **next-hop** *address* | **lsp-tunnel** [*tunnel-id*]] [**vrf** *vrf-name*] [**detail**]

## Syntax Description

| | |
|---|---|
| *network* | (Optional) Destination network number. |
| *mask* | IP address of the destination mask whose entry is to be shown. |
| *length* | Number of bits in the mask of the destination. |
| **labels** *label* **-** *label* | (Optional) Displays only entries with the specified local labels. |
| **interface** *interface* | (Optional) Displays only entries with the specified outgoing interface. |
| **next-hop** *address* | (Optional) Displays only entries with the specified neighbor as the next hop. |
| **lsp-tunnel** | (Optional) Displays only entries with the specified label switched path (LSP) tunnel, or with all LSP tunnel entries. |
| *tunnel-id* | (Optional) Specifies the LSP tunnel for which to display entries. |
| **vrf** *vrf-name* | (Optional) Displays only entries with the specified VPN routing and forwarding (VRF) instance. |
| **detail** | (Optional) Displays information in long form (includes length of encapsulation, length of MAC string, maximum transmission unit (MTU), and all labels). |

## Command Modes

Privileged EXEC

## Command History

| Release | Modification |
|---|---|
| 11.1CT | This command was introduced. |
| 12.1(3)T | This command was updated with MPLS terminology and command syntax. |
| 12.2(8)T | The command was modified to accommodate use of the MPLS experimental (EXP) level as a selection criterion for packet forwarding. The output display was modified to include a bundle adjacency field and exp (vcd) values when the optional **detail** keyword is specified. |
| 12.0(22)S | IPv6 MPLS aggregate label and prefix information was added to the display. |
| 12.2(14)S | This command was integrated into Cisco IOS Release 12.2(14)S. |
| 12.0(27)S | The command output was modified to include explicit-null label information. |
| 12.2(25)S | The output was changed in the following ways:<br>• The term “tag” was replaced with the term “label.”<br>• The term “untagged” was replaced with the term “no label.” |
| 12.0(29)S | This command was integrated into Cisco IOS Release 12.0(29)S. |
| 12.2(28)SB | This command was integrated into Cisco IOS Release 12.2(28)SB and implemented on the Cisco 10000 series routers. |

| Release | Modification |
|---|---|
| 12.2(33)SRA | This command was integrated into Cisco IOS Release 12.2(33)SRA. |
| 12.2(33)SXH | This command was integrated into Cisco IOS Release 12.2(33)SXH. |

## Examples

The following is sample output from the **show mpls forwarding-table** command:

```
Router# show mpls forwarding-table

Local Outgoing      Prefix            Bytes label Outgoing       Next Hop
Label Label or VC   or Tunnel Id      switched  interface
26    No Label      10.253.0.0/16     0         Et4/0/0       10.27.32.4
28    1/33          10.15.0.0/16      0         AT0/0.1       point2point
29    Pop Label     10.91.0.0/16      0         Hs5/0         point2point
      1/36          10.91.0.0/16      0         AT0/0.1       point2point
30    32            10.250.0.97/32    0         Et4/0/2       10.92.0.7
      32            10.250.0.97/32    0         Hs5/0         point2point
34    26            10.77.0.0/24      0         Et4/0/2       10.92.0.7
      26            10.77.0.0/24      0         Hs5/0         point2point
35    No Label[T]   10.100.100.101/32 0         Tu301         point2point
36    Pop Label     10.1.0.0/16       0         Hs5/0         point2point
      1/37          10.1.0.0/16       0         AT0/0.1       point2point

[T]     Forwarding through a TSP tunnel.
        View additional labeling info with the 'detail' option
```

The following is sample output from the **show mpls forwarding-table** command when the IPv6 Provider Edge Router over MPLS feature is configured to allow IPv6 traffic to be transported across an IPv4 MPLS backbone. The labels are aggregated because there are several prefixes for one local label, and the prefix column contains “IPv6” instead of a target prefix.

```
Router# show mpls forwarding-table

Local Outgoing      Prefix            Bytes label Outgoing       Next Hop
Label Label or VC   or Tunnel Id      switched  interface
16    Aggregate     IPv6              0
17    Aggregate     IPv6              0
18    Aggregate     IPv6              0
19    Pop Label     192.168.99.64/30  0         Se0/0         point2point
20    Pop Label     192.168.99.70/32  0         Se0/0         point2point
21    Pop Label     192.168.99.200/32 0         Se0/0         point2point
22    Aggregate     IPv6              5424
23    Aggregate     IPv6              3576
24    Aggregate     IPv6              2600
```

The following is sample output from the **show mpls forwarding-table** command when you specify the **detail** keyword. If the MPLS EXP level is used as a selection criterion for packet forwarding, a bundle adjacency exp (vcd) field is included in the display. This field includes the EXP value and the corresponding virtual circuit descriptor (VCD) in parentheses. The line in the output that reads “No output feature configured” indicates that the MPLS egress NetFlow accounting feature is not enabled on the outgoing interface for this prefix.

```
Router# show mpls forwarding-table detail

Local Outgoing      Prefix            Bytes label Outgoing       Next Hop
label   label or VC     or Tunnel Id      switched  interface
16    Pop label       10.0.0.6/32       0         AT1/0.1       point2point
      Bundle adjacency exp(vcd)
      0(1) 1(1) 2(1) 3(1) 4(1) 5(1) 6(1) 7(1)
      MAC/Encaps=12/12, MTU=4474, label Stack{}
```

```
      00010000AAAA030000008847
      No output feature configured
17    18            10.0.0.9/32        0         AT1/0.1       point2point
      Bundle adjacency exp(vcd)
      0(1) 1(1) 2(1) 3(1) 4(1) 5(1) 6(1) 7(1)
      MAC/Encaps=12/16, MTU=4470, label Stack{18}
      00010000AAAA030000008847 00012000
      No output feature configured
18    19            10.0.0.10/32        0        AT1/0.1       point2point
      Bundle adjacency exp(vcd)
      0(1) 1(1) 2(1) 3(1) 4(1) 5(1) 6(1) 7(1)
      MAC/Encaps=12/16, MTU=4470, label Stack{19}
      00010000AAAA030000008847 00013000
      No output feature configured
19    17            10.0.0.0/8         0        AT1/0.1       point2point
      Bundle adjacency exp(vcd)
      0(1) 1(1) 2(1) 3(1) 4(1) 5(1) 6(1) 7(1)
      MAC/Encaps=12/16, MTU=4470, label Stack{17}
      00010000AAAA030000008847 00011000
      No output feature configured
20    20            10.0.0.0/8         0        AT1/0.1       point2point
      Bundle adjacency exp(vcd)
      0(1) 1(1) 2(1) 3(1) 4(1) 5(1) 6(1) 7(1)
      MAC/Encaps=12/16, MTU=4470, label Stack{20}
      00010000AAAA030000008847 00014000
      No output feature configured
21    Pop label       10.0.0.0/24        0        AT1/0.1       point2point
      Bundle adjacency exp(vcd)
      0(1) 1(1) 2(1) 3(1) 4(1) 5(1) 6(1) 7(1)
      MAC/Encaps=12/12, MTU=4474, label Stack{}
      00010000AAAA030000008847
      No output feature configured
22    Pop label       10.0.0.4/32         0        Et2/3         10.0.0.4
      MAC/Encaps=14/14, MTU=1504, label Stack{}
      000427AD10430005DDFE043B8847
      No output feature configured
```

The following is sample output from the **show mpls forwarding-table** command when you use the **detail** keyword. In this example, the MPLS egress NetFlow accounting feature is enabled on the first three prefixes, as indicated by the line in the output that reads “Feature Quick flag set.”

```
Router# show mpls forwarding-table detail

Local  Outgoing    Prefix            Bytes label  Outgoing   Next Hop
label    label or VC   or Tunnel Id      switched   interface
16     Aggregate   10.0.0.0/8[V]     0
        MAC/Encaps=0/0, MTU=0, label Stack{}
        VPN route: vpn1
        Feature Quick flag set
Per-packet load-sharing, slots: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
17     No label    10.0.0.0/8[V]      0          Et0/0/2    10.0.0.1
        MAC/Encaps=0/0, MTU=1500, label Stack{}
        VPN route: vpn1
        Feature Quick flag set
Per-packet load-sharing, slots: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
18     No label    10.42.42.42/32[V] 4185       Et0/0/2    10.0.0.1
        MAC/Encaps=0/0, MTU=1500, label Stack{}
        VPN route: vpn1
        Feature Quick flag set
Per-packet load-sharing, slots: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
19     2/33        10.41.41.41/32    0          AT1/0/0.1  point2point
        MAC/Encaps=4/8, MTU=4470, label Stack{2/33(vcd=2)}
        00028847 00002000
        No output feature configured
```

### Cisco 10000 Series Examples

The following is sample output from the **show mpls forwarding-table** command:

```
Router# show mpls forwarding-table

Local   Outgoing      Prefix            Bytes Label   Outgoing   Next Hop
Label   Label or VC   or Tunnel Id      Switched      interface
16      Pop Label     10.0.0.0/8        0             Fa1/0/0    10.0.0.2
        Pop Label     10.0.0.0/8        0             Fa1/1/0    10.0.0.2
17      Aggregate     10.0.0.0/8[V]     570           vpn2
21      Pop Label     10.11.11.11/32    0             Fa1/0/0    10.0.0.2
22      Pop Label     10.12.12.12/32    0             Fa1/1/0    10.0.0.2
23      No Label      10.3.0.0/16[V]     0             Fa4/1/0   10.0.0.2
```

The following is Cisco 10000 series sample output from the **show mpls forwarding-table** command when you specify the **detail** keyword:

```
Router# show mpls forwarding-table detail

Local   Outgoing      Prefix            Bytes Label   Outgoing   Next Hop
Label   Label or VC   or Tunnel Id      Switched      interface
16      Pop Label     10.0.0.0/8        0             Fa1/0/0    10.0.0.2
        MAC/Encaps=14/14, MRU=1500, Label Stack{}
        000B45C93889000B45C930218847
        No output feature configured
        Pop Label     10.0.0.0/8        0             Fa1/1/0     10.0.0.2
        MAC/Encaps=14/14, MRU=1500, Label Stack{}
        000B45C92881000B45C930288847
        No output feature configured
17      Aggregate    10.0.0.0/8[V]      570           vpn2
        MAC/Encaps=0/0, MRU=0, Label Stack{}
        VPN route: vpn2
        No output feature configured
21      Pop Label     10.11.11.11/32     0            Fa1/0/0     10.0.0.2
        MAC/Encaps=14/14, MRU=1500, Label Stack{}
       000B45C93889000B45C930218847
       No output feature configured
```

Table 5 describes the significant fields shown in the displays.

*Table 5 show mpls forwarding-table Field Descriptions*

| Field | Description |
|---|---|
| Local label | Label assigned by this router. |
| Outgoing Label or VC<br>**Note** VC is not applicable to the Cisco 10000 series routers. | Label assigned by the next hop or virtual path identifier (VPI)/virtual channel identifier (VCI) used to get to next hop. The entries in this column are the following:<br>• [T]—Means forwarding through an LSP tunnel.<br>• No Label—Means that there is no label for the destination from the next hop or that label switching is not enabled on the outgoing interface.<br>• Pop Label—Means that the next hop advertised an implicit NULL label for the destination and that the router popped the top label.<br>• Aggregate—Means there are several prefixes for one local label. This entry is used when IPv6 is configured on edge routers to transport IPv6 traffic over an IPv4 MPLS network. |
| Prefix or Tunnel Id | Address or tunnel to which packets with this label are sent.<br>**Note** If IPv6 is configured on edge routers to transport IPv6 traffic over an IPv4 MPLS network, "IPv6" is displayed here. |
| Bytes Label Switched | Number of bytes switched with this incoming label. |
| Outgoing interface | Interface through which packets with this label are sent. |
| Next Hop | IP address of the neighbor that assigned the outgoing label. |
| Bundle adjacency exp(vcd) | Bundle adjacency information. Includes the MPLS EXP value and the corresponding VCD. |
| MAC/Encaps | Length in bytes of the Layer 2 header and length in bytes of the packet encapsulation, including the Layer 2 header and label header. |
| MTU | MTU of the labeled packet. |
| Label Stack | All the outgoing labels. If the outgoing interface is transmission convergence (TC)-ATM, the VCD is also shown.<br>**Note** TC-ATM is not supported on Cisco 10000 series routers. |
| 00010000AAAA030000008847 00013000 | The actual encapsulation in hexadecimal form. A space is shown between Layer 2 and the label header. |

### Explicit-Null Label Example

The following example shows output, including the explicit-null label = 0 (commented in bold), from the **show mpls forwarding-table** command on a CSC-PE router:

```
Router# show mpls forwarding-table
```

```
Local  Outgoing      Prefix            Bytes label  Outgoing   Next Hop
label  label or VC   or Tunnel Id      switched     interface
17     Pop label     10.10.0.0/32      0            Et2/0      10.10.0.1
18     Pop label     10.10.10.0/24     0            Et2/0      10.10.0.1
19     Aggregate     10.10.20.0/24[V]  0
20     Pop label     10.10.200.1/32[V] 0            Et2/1      10.10.10.1
21     Aggregate     10.10.1.1/32[V]   0
22     0             192.168.101.101/32[V]   \
                                       0            Et2/1      192.168.101.101
23     0             192.168.101.100/32[V]   \
                                       0            Et2/1      192.168.101.100
25     0             192.168.102.125/32[V] 0        Et2/1      192.168.102.125 !outlabel
value 0
```

Table 6 describes the significant fields shown in the display.

***Table 6 show mpls forwarding-table Field Descriptions***

| Field | Description |
|---|---|
| Local label | Label assigned by this router. |
| Outgoing label or VC | Label assigned by the next hop or VPI/VCI used to get to next hop. The entries this column are the following:<br>• [T]—Means forwarding through an LSP tunnel.<br>• No label—Means that there is no label for the destination from the next hop or that label switching is not enabled on the outgoing interface.<br>• Pop label—Means that the next hop advertised an implicit NULL label for the destination and that this router popped the top label.<br>• Aggregate—Means there are several prefixes for one local label. This entry is used when IPv6 is configured on edge routers to transport IPv6 traffic over an IPv4 MPLS network.<br>• 0—Means the explicit null label value = 0. |
| Prefix or Tunnel Id | Address or tunnel to which packets with this label are going.<br>**Note** If IPv6 is configured on edge routers to transport IPv6 traffic over an IPv4 MPLS network, IPv6 is displayed here. |
| Bytes label switched | Number of bytes switched with this incoming label. |
| Outgoing interface | Interface through which packets with this label are sent. |
| Next Hop | IP address of the neighbor that assigned the outgoing label. |

**Related Commands**

| Command | Description |
|---|---|
| **neighbor send-label** | Enables a BGP router to send MPLS labels with BGP routes to a neighboring BGP router. |
| **neighbor send-label explicit-null** | Enables a BGP router to send MPLS labels with explicit-null information for a CSC-CE router and BGP routes to a neighboring CSC-PE router. |

# show mpls traffic-eng tunnels

To display information about tunnels, use the **show mpls traffic-eng tunnels** command in user EXEC or privileged EXEC mode.

**show mpls traffic-eng tunnels**
[**tunnel** *number*]
[**accounting**]
[**attributes**]
[**backup | brief | protection**]
[**destination** *address*]
[**interface in** *phys-intf*] [**interface out** *phys-intf* | **interface** *phys-intf*]
[**name** *name*]
[**name-regexp** *reg-exp*]
[**property** {**auto-tunnel | backup-tunnel | fast-reroute**}]
[**role** {**all | head | middle | tail | remote**}]
[**source-id** {*num* | *ipaddress* | *ipaddress num*}]
[**statistics**]
[**suboptimal constraints** {**none | current | max**}]
[**summary**]
[**up | down**]

## Syntax Description

| | |
|---|---|
| **tunnel** *number* | (Optional) Restricts the display to the specified tunnel interface. |
| **accounting** | (Optional) Displays accounting information (the rate of the traffic flow) for tunnels. |
| **attributes** | (Optional) Restricts the display to tunnels that use a matching attributes list. |
| **backup** | (Optional) Displays information about the Fast Reroute protection provided by each tunnel selected by other options specified with this command. The information includes the physical interface protected by the tunnel, the number of traffic engineering (TE) label-switched packets (LSPs) (that is, tunnels) protected, and the bandwidth protected. |
| **brief** | (Optional) Specifies a format with one line per tunnel. |
| **protection** | (Optional) Displays information about the protection provided by each tunnel selected by other options specified with this command. The information includes whether protection is configured for the tunnel, the protection (if any) provided to the tunnel by this router, and the bandwidth protected. |
| **destination** *address* | (Optional) Restricts the display to tunnels destined to the specified IP address. |
| **interface in** *phys-intf* | (Optional) Displays information for the specified input interface. |
| **interface out** *phys-intf* | (Optional) Displays information for the specified output interface. |
| **interface** *phys-intf* | (Optional) Displays tunnels that use the specified interface as an input or output interface. |
| **name** *name* | (Optional) Displays tunnel with the specified string. The tunnel string is derived from the interface description, if specified; otherwise, it is the interface name. The tunnel string is included in the signaling message so that it is available at all hops. |

| | |
|---|---|
| **name-regexp** *regexp* | (Optional) Displays tunnels whose descriptions match the specified regular expression. |
| **property auto-tunnel** | (Optional) Displays information about autotunnels. |
| **property backup-tunnel** | (Optional) Selects Multiprotocol Label Switching (MPLS) traffic engineering (TE) tunnels being used to protect physical interfaces on this router. A tunnel configured to protect a link against failure is a backup tunnel and has the backup tunnel property. |
| **property fast-reroute** | (Optional) Selects Fast Reroute-protected MPLS TE tunnels originating, transmitting, or terminating on this router. |
| **role** | (Optional) Restricts the display to tunnels with the indicated role (all, head, middle, tail, or remote). |
| **all** | Displays all tunnels. |
| **head** | Displays tunnels with their head at this router. |
| **middle** | Displays tunnels with a midpoint at this router. |
| **tail** | Displays tunnels with a tail at this router. |
| **remote** | Displays tunnels with their head at some other router; this is a combination of **middle** and **tail**. |
| **source-id** | (Optional) Restricts the display to tunnels with a matching source IP address or tunnel number. |
| *num* | Tunnel number. |
| *ipaddress* | Source IP address. |
| *ipaddress num* | Source IP address and tunnel number. |
| **statistics** | (Optional) Displays tunnel counters and statistics. |
| **suboptimal constraints none** | (Optional) Displays tunnels whose path metric is greater than the shortest unconstrained path. Selected tunnels have a longer path than the Interior Gateway Protocol's (IGP) shortest path. |
| **suboptimal constraints current** | (Optional) Displays tunnels whose path metric is greater than the current shortest path, constrained by the tunnel's configured options. Selected tunnels would have a shorter path if they were reoptimized immediately. |
| **suboptimal constraints max** | (Optional) Displays information for the specified tunneling interface. |
| **summary** | (Optional) Displays summary information about tunnels that provide Fast Reroute protection. |
| **up** | (Optional) Displays tunnels if the tunnel interface is up. Tunnel midpoints and tails are typically up or not present. |
| **down** | (Optional) Displays tunnels that are down. |

## Defaults

If you specify this command without any arguments or keywords, the command displays general information about each MPLS TE tunnel known to the router.

## Command Modes

User EXEC
Privileged EXEC

## Command History

| Release | Modification |
|---|---|
| 12.0(5)S | This command was introduced. |
| 12.1(3)T | Input and output interface information was added to the new **brief** form of the output. The **suboptimal** and **interface** keywords were added to the nonbrief format. The nonbrief, nonsummary formats contain the history of the LSP selection. |
| 12.0(10)ST | This command was integrated into Cisco IOS Release 12.0(10)ST. |
| 12.0(22)S | The **property** and **protection** keywords were added. The command is supported on the Cisco 10000 series routers. |
| 12.2(18)S | The following keywords were added: **accounting**, **attributes**, **name-regexp,** and **property auto-tunnel**. The **property backup** keyword was changed to **property backup-tunnel**. |
| 12.2(18)SXD1 | This command was integrated into Cisco IOS Release 12.2(18)SXD1. |
| 12.2(28)SB | This command was integrated into Cisco IOS Release 12.2(28)SB. |
| 12.2(33)SRA | This command was integrated into Cisco IOS Release 12.2(33)SRA. |
| 12.2(33)SXH | This command was integrated into Cisco IOS Release 12.2(33)SXH. |

## Usage Guidelines

To select the tunnels for which information is displayed, use the **tunnel**, **attributes**, **destination**, **interface**, **name**, **name-regexp**, **property**, **role**, **source-id**, **suboptimal constraints, up**, and **down** keywords and options singly or combined.

To select the type of information displayed about the selected tunnels, use the **accounting**, **backup**, **protection**, **statistics**, and **summary** keywords.

The **tunnel** and **property** keywords display the same information, except that the **property** keyword restricts the display to autotunnels, backup tunnels, or tunnels that are Fast Reroute-protected.

The **name-regexp** keyword displays output for each tunnel whose name contains a specified string. For example, if there are tunnels named iou-100-t1, iou-100-t2, and iou-100-t100, the following command displays output for the three tunnels whose name contains the string iou-100.

```
Router# show mpls traffic-eng tunnels name-regexp iou-100
```

If you specify the **name** keyword, there is command output only if the command name is an exact match; for example, iou-100-t1.

## Examples

The following is sample output from the **show mpls traffic-eng tunnels brief** command. It displays brief information about every MPLS TE tunnel known to the router.

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

Signalling Summary:
    LSP Tunnels Process:           running
    RSVP Process:                  running
    Forwarding:                    enabled
    Periodic reoptimization:       every 3600 seconds, next in 1706 seconds
TUNNEL NAME                      DESTINATION      UP IF     DOWN IF   STATE/PROT
Router_t1                        10.112.0.12      -         PO4/0/1   up/up
Router_t2                        10.112.0.12      -         unknown   up/down
Router_t3                        10.112.0.12      -         unknown   admin-down
Router_t1000                     10.110.0.10      -         unknown   up/down
Router_t2000                     10.110.0.10      -         PO4/0/1   up/up
Displayed 5 (of 5) heads, 0 (of 0) midpoints, 0 (of 0) tails
```

Table 7 describes the significant fields shown in the displays.

*Table 7 show mpls traffic-eng tunnels Field Descriptions*

| Field | Description |
|---|---|
| LSP Tunnels Process | Status of the LSP tunnels process. |
| RSVP Process | Status of the Resource Reservation Protocol (RSVP) process. |
| Forwarding | Status of forwarding (enabled or disabled). |
| Periodic reoptimization | Schedule for periodic reoptimization (in seconds). |
| TUNNEL NAME | Name of the interface that is configured at the tunnel head. |
| DESTINATION | Identifier of the tailend router. |
| UP IF | Upstream interface that the tunnel used. |
| DOWN IF | Downstream interface that the tunnel used. |
| STATE/PROT | For tunnel heads, admin-down. up, or down. For nonheads, signaled. |

The following is sample output from the **show mpls traffic-eng tunnels backup property fast-reroute brief** command. It displays brief information about all MPLS TE tunnels acting as Fast Reroute backup tunnels (**property backup-tunnel**) for interfaces on the router.

```
Router# show mpls traffic-eng tunnels backup property fast-reroute brief

Signalling Summary:
    LSP Tunnels Process:            running
    RSVP Process:                   running
    Forwarding:                     enabled
    Periodic reoptimization:        every 3600 seconds, next in 2231 seconds
    Periodic FRR Promotion:         every 300 seconds, next in 131 seconds
    Periodic auto-bw collection:    disabled
TUNNEL NAME                     DESTINATION      UP IF     DOWN IF   STATE/PROT
Router_t2000                    10.110.0.10      -         PO4/0/1   up/up
Router_t2                       10.112.0.12      -         unknown   up/down
Router_t3                       10.112.0.12      -         unknown   admin-down
Displayed 3 (of 9) heads, 0 (of 1) midpoints, 0 (of 0) tails
```

The following is sample output from the **show mpls traffic-eng tunnels backup** command. This command selects every MPLS TE tunnel known to the router and displays information about the Fast Reroute protection each selected tunnels provides for interfaces on this router; the command does not generate output for tunnels that do not provide Fast Reroute protection of interfaces on this router.

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

Router_t578
  LSP Head, Tunnel578, Admin: up, Oper: up
  Src 10.55.55.55, Dest 10.88.88.88, Instance 1
  Fast Reroute Backup Provided:
    Protected i/fs: PO1/0, PO1/1, PO3/3
    Protected lsps: 1
    Backup BW: any pool unlimited; inuse: 100 kbps
Router_t5710
  LSP Head, Tunnel5710, Admin: admin-down, Oper: down
  Src 10.55.55.55, Dest 192.168.7.7, Instance 0
```

```
  Fast Reroute Backup Provided:
    Protected i/fs: PO1/1
    Protected lsps: 0
    Backup BW: any pool unlimited; inuse: 0 kbps
Router_t5711
  LSP Head, Tunnel5711, Admin: up, Oper: up
  Src 10.55.55.55, Dest 10.7.7.7, Instance 1
  Fast Reroute Backup Provided:
    Protected i/fs: PO1/0
    Protected lsps: 2
    Backup BW: any pool unlimited; inuse: 6010 kbps
```

The following is sample output from the **show mpls traffic-eng tunnels property fast-reroute protection** command. This command selects every MPLS TE tunnel known to the router that was signaled as a Fast Reroute-protected LSP (**property fast-reroute**) and displays information about the protection this router provides each selected tunnel.

```
Router# show mpls traffic-eng tunnels property fast-reroute protection

Router_t1
  LSP Head, Tunnel1, Admin: up, Oper: up
  Src 10.55.55.55, Dest 10.88.88.88, Instance 25
  Fast Reroute Protection: Requested
    Outbound: FRR Ready
      Backup Tu5711 to LSP nhop
        Tu5711: out i/f: PO1/1, label: implicit-null
      LSP signalling info:
        Original: out i/f: PO1/0, label: 12304, nhop: 10.1.1.7
        With FRR: out i/f: Tu5711, label: 12304
      LSP bw: 6000 kbps, Backup level: any unlimited, type: any pool
Router_t2
  LSP Head, Tunnel2, Admin: up, Oper: up
  Src 10.55.55.55, Dest 10.88.88.88, Instance 2
  Fast Reroute Protection: Requested
    Outbound: FRR Ready
      Backup Tu578 to LSP nhop
        Tu578: out i/f: PO1/0, label: 12306
      LSP signalling info:
        Original: out i/f: PO3/3, label: implicit-null, nhop: 10.3.3.8
        With FRR: out i/f: Tu578, label: implicit-null
      LSP bw: 100 kbps, Backup level: any unlimited, type: any pool
r9_t1
  LSP Midpoint, signalled, connection up
  Src 10.9.9.9, Dest 10.88.88.88, Instance 2347
  Fast Reroute Protection: Requested
    Inbound:  FRR Inactive
      LSP signalling info:
        Original: in i/f: PO1/2, label: 12304, phop: 10.205.0.9
    Outbound: FRR Ready
      Backup Tu5711 to LSP nhop
        Tu5711: out i/f: PO1/1, label: implicit-null
      LSP signalling info:
        Original: out i/f: PO1/0, label: 12305, nhop: 10.1.1.7
        With FRR: out i/f: Tu5711, label: 12305
      LSP bw: 10 kbps, Backup level: any unlimited, type: any pool
```

The following is sample output from the **show mpls traffic-eng tunnels tunnel** command. This command displays information about just a single tunnel.

```
Router# show mpls traffic-eng tunnels tunnel 1

Name: swat76k1_t1                         (Tunnel1) Destination: 10.0.0.4
   Status:
     Admin: admin-down Oper: down   Path: not valid   Signalling: Down
     path option 1, type explicit gi7/4-R4

   Config Parameters:
     Bandwidth: 0        kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
     Metric Type: TE (default)
     AutoRoute:  disabled  LockDown: disabled  Loadshare: 0        bw-based
     auto-bw: disabled

   Shortest Unconstrained Path Info:
     Path Weight: 2 (TE)
     Explicit Route: 10.1.0.1 10.1.0.2 172.0.0.1 192.0.0.4
   History:
     Tunnel:
       Time since created: 13 days, 52 minutes
       Number of LSP IDs (Tun_Instances) used: 0 swat76k1#
swat76k1#sh mpls traf tun property ?
   auto-tunnel    auto-tunnel created tunnels
   backup-tunnel  Tunnels used as fast reroute
   fast-reroute   Tunnels protected by fast reroute
```

The following is sample output from the **show mpls traffic-eng tunnels accounting** command. This command displays the rate of the traffic flow for the tunnels.

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

Tunnel1 (Destination 10.103.103.103; Name iou-100_t1)
 5 minute output rate 0 kbits/sec, 0 packets/sec
Tunnel2 (Destination 10.103.103.103; Name iou-100_t2)
 5 minute output rate 0 kbits/sec, 0 packets/sec Tunnel100 (Destination 10.101.101.101;
Name iou-100_t100)
 5 minute output rate 0 kbits/sec, 0 packets/sec Totals for 3 Tunnels
 5 minute output rate 0 kbits/sec, 0 packets/sec
```

## Related Commands

| Command | Description |
|---|---|
| **mpls traffic-eng reoptimize timers frequency** | Controls the frequency with which tunnels with established LSPs are checked for better LSPs. |
| **mpls traffic-eng tunnels (configuration)** | Enables MPLS traffic engineering tunnel signaling on a device. |
| **mpls traffic-eng tunnels (interface)** | Enables MPLS traffic engineering tunnel signaling on an interface. |

# tunnel mpls traffic-eng exp

To specify the experimental (EXP) bits that will be forwarded over a member tunnel that is part of the Class-Based Tunnel Selection (CBTS) bundle, use the **tunnel mpls traffic-eng exp** command in interface configuration mode. To disable forwarding of the EXP bits, use the **no** form of this command.

**tunnel mpls traffic-eng exp** {*list-of-exp-values* | **default**}

**no tunnel mpls traffic-eng exp** {*list-of-exp-values*] | **default**}

## Syntax Description

| | |
|---|---|
| *list-of-exp-values* | EXP bits allowed for the interface. Enter up to eight EXP values separated by spaces. Values range from 0 to 7. The default is the EXP values that were not configured or a specific member tunnel. |
| **default** | The member tunnel will forward the packets with the EXP bits that are not being forwarded by other member tunnels that are part of the same bundle. |

## Command Default

No EXP value is assigned to a Multiprotocol Label Switching (MPLS) traffic engineering (TE) tunnel.

## Command Modes

Interface configuration

## Command History

| Release | Modification |
|---|---|
| 12.0(29)S | This command was introduced. |
| 12.2(33)SRA | This command was integrated into Cisco IOS Release 12.2(33)SRA. |
| 12.2(33)SXH | This command was integrated into Cisco IOS Release 12.2(33)SXH. |

## Usage Guidelines

You should enter the **tunnel mpls traffic-eng exp** command to specify the EXP bits for at least one member tunnel.

With the **tunnel mpls traffic-eng exp** command, you can configure each tunnel with any of the following:

- No EXP-related information
- One or more EXP values for the tunnel to carry (*list-of-exp-values* argument)
- All EXP values not currently allocated to any up tunnel (**default** keyword)
- One or more EXP values for the tunnel to carry, and the property that allows the carrying of all EXP values not currently allocated to any up tunnel (*list-of-exp-values* **default** argument-keyword pair)

The **default** keyword allows you to avoid explicitly listing all possible EXP values. You indicate a preference as to which tunnel to use for certain EXP values, should a tunnel other than the default tunnel go down.

This command allows configurations where:

- Not all EXP values are explicitly allocated to tunnels.
- Multiple tunnels have the default property.
- Some tunnels have EXP values configured and others do not have any configured.
- A given EXP value is configured on multiple tunnels.

The configuration of each tunnel is independent of the configuration of any other tunnel.

## Examples

The following example shows how to specify an EXP value of 5 for MPLS TE tunnel Tunnel1:

```
interface Tunnel1
 tunnel destination 10.0.1.1
 tunnel mpls traffic-eng exp 5
```

## Related Commands

| Command | Description |
|---|---|
| **tunnel mpls traffic-eng exp-bundle master** | Configures a master tunnel. |
| **tunnel mpls traffic-eng exp-bundle member** | Identifies which tunnel is a member (bundled tunnel) of a master tunnel. |

# tunnel mpls traffic-eng exp-bundle master

To configure a master tunnel, use the **tunnel mpls traffic-eng exp bundle master** command in interface configuration mode. To unconfigure a master tunnel, use the **no** form of this command.

**tunnel mpls traffic-eng exp-bundle master**

**no tunnel mpls traffic-eng exp-bundle master**

## Syntax Description

This command has no arguments or keywords.

## Command Default

There is no master tunnel for the bundle.

## Command Modes

Interface configuration

## Command History

| Release | Modification |
|---|---|
| 12.2(33)SRA | This command was introduced. |
| 12.2(33)SXH | This command was integrated into Cisco IOS Release 12.2(33)SXH. |

## Usage Guidelines

Use the **tunnel mpls traffic-eng exp-bundle master** command to configure a master tunnel. Then specify the **tunnel mpls traffic-eng exp-bundle member** command to identify which tunnels belong to that master tunnel. On the member tunnels, define which experimental (EXP) bit values should be used.

## Examples

The following example specifies that there is a master tunnel that includes tunnels Tunnel20000 through Tunnel20007:

```
interface Tunnel200
 ip unnumbered Loopback0
 ip ospf cost 1
 mpls ip
 tunnel destination 10.10.10.10
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng exp-bundle master
 tunnel mpls traffic-eng exp-bundle member Tunnel20000
 tunnel mpls traffic-eng exp-bundle member Tunnel20001
 tunnel mpls traffic-eng exp-bundle member Tunnel20002
 tunnel mpls traffic-eng exp-bundle member Tunnel20003
 tunnel mpls traffic-eng exp-bundle member Tunnel20004
 tunnel mpls traffic-eng exp-bundle member Tunnel20005
 tunnel mpls traffic-eng exp-bundle member Tunnel20006
 tunnel mpls traffic-eng exp-bundle member Tunnel20007
```

**Related Commands**

| Command | Description |
|---|---|
| **tunnel mpls traffic-eng exp-bundle member** | Identifies which tunnel is a member (bundled tunnel) of a master tunnel. |

# tunnel mpls traffic-eng exp-bundle member

To identify which tunnel is a member (bundled tunnel) of a master tunnel, use the **tunnel mpls traffic-eng exp-bundle member** command in interface configuration mode. To remove the specified tunnel from being a member of the master tunnel, use the **no** form of this command.

**tunnel mpls traffic-eng exp-bundle member** *tunnel-number*

**no tunnel mpls traffic-eng exp-bundle member** *tunnel-number*

## Syntax Description

| | |
|---|---|
| *tunnel-number* | The tunnel that belongs to a master tunnel. |

## Command Default

The master tunnel has no member tunnels.

## Command Modes

Interface configuration

## Command History

| Release | Modification |
|---|---|
| 12.2(33)SRA | This command was introduced. |
| 12.2(33)SXH | This command was integrated into Cisco IOS Release 12.2(33)SXH. |

## Usage Guidelines

Enter the **tunnel mpls traffic-eng exp-bundle member** command for each tunnel that you want to be a member of the master tunnel. You should enter this command at least once.

## Examples

The following example specifies that Tunnel1 is a member of the master tunnel:

```
interface Tunnel200
 ip unnumbered Loopback0
 ip ospf cost 1
 mpls ip
 tunnel destination 10.10.10.10
 tunnel mode mpls traffic-eng
tunnel mpls traffic-eng exp-bundle master
 tunnel mpls traffic-eng exp-bundle member Tunnel1
```

## Related Commands

| Command | Description |
|---|---|
| **tunnel mpls traffic-eng exp** | Specifies the EXP bits that will be forwarded over a member tunnel that is part of the CBTS bundle. |
| **tunnel mpls traffic-eng exp-bundle master** | Configures a master tunnel. |

# Feature Information for MPLS Traffic Engineering (TE): Class-based Tunnel Selection

Table 8 lists the release history for this feature.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Cisco IOS software images are specific to a Cisco IOS software release, a feature set, and a platform. Use Cisco Feature Navigator to find information about platform support and Cisco IOS software image support. Access Cisco Feature Navigator at http://www.cisco.com/go/fn. You must have an account on Cisco.com. If you do not have an account or have forgotten your username or password, click **Cancel** at the login dialog box and follow the instructions that appear.

**Note** Table 8 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

*Table 8 Feature Information for MPLS Traffic Engineering (TE): Class-based Tunnel Selection*

| Feature Name | Releases | Feature Configuration Information |
|---|---|---|
| MPLS Traffic Engineering (TE): Class-based Tunnel Selection | 12.0(29)S<br>12.2(33)SRA<br>12.2(32)SY<br>12.2(33)SXH | The MPLS Traffic Engineering (TE): Class-based Tunnel Selection feature enables you to dynamically route and forward traffic with different class of service (CoS) values onto different TE tunnels between the same tunnel headend and the same tailend. The TE tunnels can be regular TE or DiffServ-aware TE (DS-TE) tunnels.<br>In 12.0(29)S, this feature was introduced.<br>In 12.2(33)SRA, this feature was integrated and the following commands were added:<br>• **tunnel mpls traffic-eng exp-bundle master**<br>• **tunnel mpls traffic-eng exp-bundle member**<br>12.0(32)SY, support for this feature was added on the Cisco 12000 family of routers.<br>In 12.2(33)SXH, this feature was integrated. |

# Glossary

**BGP**—Border Gateway Protocol. Interdomain routing protocol that replaces External Gateway Protocol (EGP). BGP exchanges reachability information with other BGP systems. It is defined by RFC 116.3

**bundled tunnels**—Members of a master tunnel. You define the EXP bits that will be forwarded over each bundled tunnel.

**Cisco Express Forwarding**—An advanced Layer 3 IP switching technology. Cisco Express Forwarding optimizes network performance and scalability for networks with large and dynamic traffic patterns, such as the Internet and networks characterized by intensive web-based applications or interactive sessions.

**CoS**—class of service. An indication of how an upper-layer protocol requires a lower-layer protocol to treat its messages. In Systems Network Architecture (SNA) subarea routing, CoS definitions are used by subarea nodes to determine the optimal route for establishing a given session. A CoS definition comprises a virtual route number and a transmission priority field. Also called type of service (ToS).

**DS-TE**—DiffServ-aware traffic engineering. The configuring of two bandwidth pools on each link, a global pool and a subpool. Multiprotocol Label Switching (MPLS) traffic engineering tunnels using the subpool bandwidth can be configured with quality of service (QoS) mechanisms to deliver guaranteed bandwidth services end-to-end across the network. Simultaneously, tunnels using the global pool can convey DiffServ traffic.

**EXP**—experimental field or bits. A 3-bit field in the Multiprotocol Label Switching (MPLS) header widely known as the EXP field or EXP bits because, according to RFC 3032, that field is reserved for experimental use. However, the most common use of those bits is for quality of service (QoS) purposes.

**headend**—The upstream, transmitting end of a tunnel. This is the first router in the label switched path (LSP).

**LSP**—label switched path. A sequence of hops (R0...Rn) in which a packet travels from R0 to Rn through label switching mechanisms. A label switched path can be chosen dynamically, based on normal routing mechanisms, or through configuration.

**master tunnel**—A set of tunnels that have the same destination.

**MPLS traffic engineering**—Multiprotocol Label Switching traffic engineering. A constraint-based routing algorithm for routing label switched path (LSP) tunnels.

**MQC**—modular quality of service (QoS) command-line interface (CLI). A CLI structure that allows users to create traffic polices and attach those polices to interfaces.

**PBR**—policy-based routing. A routing scheme in which packets are forwarded to specific interfaces based on user-configured policies. A policy might specify, for example, that traffic sent from a particular network should be forwarded out one interface, and all other traffic should be forwarded out another interface.

**tailend**—The downstream, receiving end of a tunnel. The router that terminates the traffic engineering label switched path (LSP).

**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.

**ToS**—type of service. See CoS.

**tunnel**—A secure communication path between two peers, such as two routers. A traffic engineering tunnel is a label-switched tunnel that is used for traffic engineering. Such a tunnel is set up through means other than normal Layer 3 routing; it is used to direct traffic over a path different from the one that Layer 3 routing could cause the tunnel to take.

**VCD**—virtual circuit descriptor. A unique number for each ATM interface processor (AIP) that tells the AIP which virtual path identifier (VPI)/virtual channel identifier (VCI) to use for a particular packet. Valid values range from 1 to the value set with the **atm maxvc** command.

**Note** See *Internetworking Terms and Acronyms* for terms not included in this glossary.