MPLS Diff-Serv-aware Traffic Engineering over ATM

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This guide presents extensions made to Multiprotocol Label Switching Traffic Engineering (MPLS TE) that make it Diff-Serv aware and applicable across ATM networks. The bandwidth reservable on each link for constraint-based routing (CBR) purposes can now be managed through two bandwidth pools: a *global pool* and a *sub-pool*. The sub-pool can be limited to a smaller portion of the link bandwidth. Tunnels using the sub-pool bandwidth can then be used in conjunction with MPLS Quality of Service (QoS) mechanisms to deliver guaranteed bandwidth services end-to-end across the network.

Caution The Fast Reroute feature of traffic engineering is not supported on ATM interfaces.

Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see Bug Search Tool and the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the feature information table at the end of this module.

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

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Feature History

Release	Modification
12.0(11) ST	DS-TE feature introduced.
12.0(14) ST	Support added for IS-IS Interior Gateway Protocol.
12.0(14) ST-1	Support added for guaranteed bandwidth service directed to many destination prefixes (for example, guaranteed bandwidth service destined to an autonomous system or to a BGP community).
12.2(4) T	Support added for Cisco Series 7200 platform and for ATM-PVC interface.
12.2(8) T	Support added for LC-ATM interface.

Background and Overview

MPLS traffic engineering allows constraint-based routing of IP traffic. One of the constraints satisfied by CBR is the availability of required bandwidth over a selected path. Diff-Serv-aware Traffic Engineering extends MPLS traffic engineering to enable you to perform constraint-based routing of "guaranteed" traffic, which satisfies a more restrictive bandwidth constraint than that satisfied by CBR for regular traffic. The more restrictive bandwidth is termed a *sub-pool*, while the regular TE tunnel bandwidth is called the *global pool*. (The sub-pool is a portion of the global pool.) This ability to satisfy a more restrictive bandwidth constraint translates into an ability to achieve higher Quality of Service performance (in terms of delay, jitter, or loss) for the guaranteed traffic.

For example, DS-TE can be used to ensure that traffic is routed over the network so that, on every link, there is never more than 40 per cent (or any assigned percentage) of the link capacity of guaranteed traffic (for example, voice), while there can be up to 100 per cent of the link capacity of regular traffic. Assuming QoS mechanisms are also used on every link to queue guaranteed traffic separately from regular traffic, it then becomes possible to enforce separate "overbooking" ratios for guaranteed and regular traffic. (In fact, for the guaranteed traffic it becomes possible to enforce no overbooking at all--or even an underbooking--so that very high QoS can be achieved end-to-end for that traffic, even while for the regular traffic a significant overbooking continues to be enforced.)

Also, through the ability to enforce a maximum percentage of guaranteed traffic on any link, the network administrator can directly control the end-to-end QoS performance parameters without having to rely on over-engineering or on expected shortest path routing behavior. This is essential for transport of applications that have very high QoS requirements (such as real-time voice, virtual IP leased line, and bandwidth trading), where over-engineering cannot be assumed everywhere in the network.

DS-TE involves extending OSPF (Open Shortest Path First routing protocol), so that the available sub-pool bandwidth at each preemption level is advertised in addition to the available global pool bandwidth at each preemption level. And DS-TE modifies constraint-based routing to take this more complex advertised information into account during path computation.

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Benefits

Diff-Serv-aware Traffic Engineering enables service providers to perform separate admission control and separate route computation for discrete subsets of traffic (for example, voice and data traffic).

Therefore, by combining DS-TE with other IOS features such as QoS, the service provider can:

- Develop QoS services for end customers based on *signaled* rather than *provisioned* QoS
- Build the higher-revenue generating "strict-commitment" QoS services, without over-provisioning
- Offer virtual IP leased-line, Layer 2 service emulation, and point-to-point guaranteed bandwidth services including voice-trunking
- Enjoy the scalability properties offered by MPLS

Related Features and Technologies

The DS-TE feature is related to OSPF, IS-IS, RSVP (Resource reSerVation Protocol), QoS, and MPLS traffic engineering. Cisco documentation for all of these features is listed in the next section.

Related Documents

For OSPF:

- "Configuring OSPF" in Cisco IOS Release 12.1 *IP and IP Routing Configuration Guide*.
- "OSPF Commands" in Cisco IOS Release 12.1 IP and *IP Routing Command Reference*.

For IS-IS:

- "Configuring Integrated IS-IS" in Cisco IOS Release 12.1 *IP and IP Routing Configuration Guide*.
- "Integrated IS-IS Commands" in Cisco IOS Release 12.1 *Cisco IOS IP and IP Routing Command Reference*.

For RSVP:

- "Configuring RSVP" in Cisco IOS Release 12.1 *Quality of Service Solutions Configuration Guide*.
- IP RSVP commands section in Cisco IOS Release 12.1 *Quality of Service Solutions Command Reference*.

For QoS:

- Cisco IOS Release 12.1 *Quality of Service Solutions Configuration Guide*.
- Cisco IOS Release 12.1 *Quality of Service Solutions Command Reference*.

For MPLS Traffic Engineering:

- Cisco IOS Release 12.1(3)T *MPLS Traffic Engineering and Enhancements*
- "Multiprotocol Label Switching" in Cisco IOS Release 12.1 *Switching Services Configuration Guide*.
- Section containing MPLS commands in Cisco IOS Release 12.1 *Switching Services Command Reference*.

For ATM:

- ATM-PVC: the "Configuring ATM" chapter of the Release 12.2 *Cisco IOS Wide-Area Networking Configuration Guide*.
- ATM-LSR: the "Configuring Trunks and Adding Interface Shelves" chapter of the Release 9.3.30 *BPX 8600 Series Installation and Configuration Guide* http://www.cisco.com/univercd/cc/td/doc/product/

wanbu/bpx8600/9_3_3/iandc/bpxi18.htm and the Release 9.3.10 *Update to the Cisco WAN Switch Command Reference Guide* http://www.cisco.com/univercd/cc/td/doc/product/wanbu/bpx8600/9_3_1/update/udcmdref.htm

Platforms and Interfaces Supported

This release supports DS-TE together with QoS on the POS, ATM-PVC, and LC-ATM interfaces of the Cisco 7200 and 7500 Series Routers.

To carry DS-TE tunnels through an MPLS ATM cloud, an ATM-LSR should contain a Cisco 7200 router (functioning as its Label Switch Controller) and any one of the following ATM switches:

- Cisco BPX 8600, 8650, or 8680
- Cisco IGX 8410, 8420, or 8430

To check for changes in platform support since the publication of this document, access *Feature Navigator* at http://www.cisco.com/go/fn . You must have an account on Cisco.com . Qualified users can establish an account by following directions at http://www.cisco.com/register .

If you have forgotten or lost your account information, send a blank e-mail to cco-locksmith@cisco.com. An automatic check will verify that your e-mail address is registered, and account details with a new random password will then be e-mailed to you.

Supported Standards

Standardization of Diff-Serv-aware MPLS Traffic Engineering is still in progress in the IETF (Internet Engineering Task Force). At the time of publication of this feature guide, DS-TE has been documented in the following IETF drafts:

- *Requirements for Support of Diff-Serv-aware MPLS Traffic Engineering* by F. Le Faucheur, T. Nadeau, A. Chiu, W. Townsend, D. Skalecki & M. Tatham*http://search.ietf.org/internet-drafts/draft-ietf-tewg-diff-te-reqts-nn.txt*
- *Protocol Extensions for Support of Diff-Serv-aware MPLS Traffic Engineering* by F. Le Faucheur, T. Nadeau, J. Boyle, K. Kompella, W. Townsend & D. Skalecki*http://search.ietf.org/internet-drafts/draft-ietf-tewg-diff-te-proto-01.txt*

As the IETF work is still in progress, details are still under definition and subject to change, so DS-TE should be considered as a pre-standard implementation of IETF DiffServ-aware MPLS Traffic Engineering. However, it is in line with the requirements described in the first document above.The concept of "Class-Type" defined in that IETF draft corresponds to the concept of bandwidth pool implemented by DS-TE. And because DS-TE supports two bandwidth pools (global pool and sub-pool), DS-TE should be seen as supporting two Class-Types (Class-Type 0 and Class-Type 1).

Prerequisites

Your network must support the following Cisco IOS features in order to support guaranteed bandwidth services based on Diff-Serv-aware Traffic Engineering:

- MPLS
- IP Cisco Express Forwarding (CEF)
- OSPF or ISIS

- RSVP-TE
- QoS

Configuration Tasks

This section lists the minimum set of commands you need to implement the Diff-Serv-aware Traffic Engineering feature--in other words, to establish a tunnel that reserves bandwidth from the sub-pool.

The subsequent "Configuration Examples" section (page 14), presents these same commands in context and shows how, by combining them with QoS commands, you can build guaranteed bandwidth services.

New Commands

DS-TE commands were developed from the existing command set that configures MPLS traffic engineering. The only difference introduced to create DS-TE was the expansion of two commands:

- **ip rsvp bandwidth** was expanded to configure the size of the sub-pool on every link.
- **tunnel mpls traffic-eng bandwidth** was expanded to enable a TE tunnel to reserve bandwidth from the sub-pool.

The ip rsvp bandwidth command

The old command was

```
ip rsvp bandwidth x y
```

where x = the size of the only possible pool, and y = the size of a single traffic flow (ignored by traffic engineering)

Now the extended command is

```
ip rsvp bandwidth x y sub-pool z
```

where x = the size of the global pool, and z = the size of the sub-pool.

(Remember, the sub-pool’s bandwidth is less than--because it is part of--the global pool’s bandwidth.)

The tunnel mpls traffic-eng bandwidth command

The old command was

```
tunnel mpls traffic-eng bandwidth b
```

where b = the amount of bandwidth this tunnel requires.

Now you specify from which pool (global or sub) the tunnel's bandwidth is to come. You can enter

```
tunnel mpls traffic-eng bandwidth sub-pool b
```

This indicates that the tunnel should use bandwidth from the sub-pool. Alternatively, you can enter

```
tunnel mpls traffic-eng bandwidth b
```

This indicates that the tunnel should use bandwidth from the global pool (the default).

Note As can be seen in the Guaranteed Bandwidth Service Examples section (page 24), when QoS commands are added to DS-TE commands, guaranteed bandwidth tunnels can be created. To accomplish that across an MPLS ATM cloud, two more commands were created (beginning with Release 12.2(8)T): **mpls traffic-eng atm cos global-poo l** and **mpls traffic-eng atm cos sub-pool**.

The Configuration Procedure

To establish a sub-pool TE tunnel, you must enter configurations at three levels:

- the device (router, switch router, or label switch router)
- the physical interface (network interface)
- the tunnel interface

On the first two levels, you activate traffic engineering (and certain ATM settings if the tunnel will cross an ATM cloud). On the third level--the tunnel interface--you establish the sub-pool tunnel. Therefore, it is only at the tunnel headend device that you need to configure all three levels. At the tunnel midpoints and tail, it is sufficient to configure the first two levels.

In the tables below, each command is explained in brief. For a more complete explanation of any command, refer to the page given in the right-hand column.

Level 1: Configuring the Device

At this level, you tell the device (router or switch router) to use accelerated packet-forwarding (known as Cisco Express Forwarding or CEF), MultiProtocol Label Switching (MPLS), traffic-engineering tunneling, and either the OSPF or IS-IS routing algorithm (Open Shortest Path First or Intermediate System to Intermediate System). This level is often called global configuration mode because the configuration is applied globally, to the entire device, rather than to a specific interface or routing instance.

You enter the following commands:

SUMMARY STEPS

1. Router(config)# **ip cef**
2. Router(config)# **mpls traffic-eng tunnels**
3. Router(config)# **mpls traffic-eng atm cos sub-pool**
4. Router(config)# **router ospf**
5. Router (config-router)# **net** *network-entity-title*
6. Router (config-router)# **metric-style wide**
7. Router (config-router)# **is-type level** *-n*
8. Router (config-router)# **mpls traffic-eng level** *-n*
9. Router (config-router)# **passive-interface loopback0**
10. Router(config-router)# **mpls traffic-eng router-id loopback0**
11. Router(config-router)# **mpls traffic-eng area** *num*

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **ip cef**	Enables CEF--which accelerates the flow of packets through the device.
Step 2	Router(config)# **mpls traffic-eng tunnels**	Enables MPLS, and specifically its traffic engineering tunnel capability.
Step 3	Router(config)# **mpls traffic-eng atm cos sub-pool** **Example:** **Example:** **Example:** `Router(config)#` **mpls traffic-eng atm cos global-pool**	[To be used only on ATM-LSR devices that are midpoints of a DS-TE tunnel]. Maps the queue carrying sub-pool traffic onto the highest cell-based class of service. (Optional). Maps the queue carrying global pool traffic onto one of the remaining three classes of service.

	Command or Action	Purpose
Step 4	Router(config)# **router ospf** **Example:** **Example:** **Example:** `[or]` **Example:** `Router(config)#` **router isis**	Invokes the OSPF routing process for IP and puts the device into router configuration mode. Proceed now to Steps 10and 11. Alternatively, you may invoke the ISIS routing process with this command and continue with Step 5.
Step 5	Router (config-router)# **net** *network-entity-title*	Specifies the IS-IS network entity title (NET) for the routing process.
Step 6	Router (config-router)# **metric-style wide**	Enables the router to generate and accept IS-IS new-style TLVs (type, length, and value objects).
Step 7	Router (config-router)# **is-type level** *-n*	Configures the router to learn about destinations inside its own area or "IS-IS level".
Step 8	Router (config-router)# **mpls traffic-eng level** *-n*	Specifies the IS-IS level (which must be the same level as in the preceding step) to which the router will flood MPLS traffic- engineering link information.
Step 9	Router (config-router)# **passive-interface loopback0**	Instructs IS-IS to advertise the IP address of the loopback interface without actually running IS-IS on that interface. Continue with Step 10 but don't do Step 11--because Step 11 refers to OSPF.
Step 10	Router(config-router)# **mpls traffic-eng router-id loopback0**	Specifies that the traffic engineering router identifier is the IP address associated with the *loopback0* interface.
Step 11	Router(config-router)# **mpls traffic-eng area** *num*	Turns on MPLS traffic engineering for a particular OSPF area.

Level 2: Configuring the Network Interface

Having configured the device, you now must configure the interface on that device through which the tunnel will run. To do that, you first put the router into interface-configuration mode.

You then enable Resource Reservation Protocol (RSVP). RSVP is used to signal (set up) a traffic engineering tunnel, and to tell devices along the tunnel path to reserve a specific amount of bandwidth for the traffic that will flow through that tunnel. It is with this command that you establish the maximum size of the sub-pool.

Finally, you enable the MPLS traffic engineering tunnel feature on this network interface--and if you will be relying on the IS-IS routing protocol, you enable that as well. (In the case of ATM-PVC and LC-ATM interfaces you must enable IS-IS on a *sub* -interface level, and you must enable MPLS on *both* the interface and the sub-interface levels.)

To accomplish these tasks, you enter the following commands. (Step 7 or 8 is entered only when the interface you are configuring is either an ATM-PVC - Step 7 - or an LC-ATM - Step 8).

SUMMARY STEPS

1. Router(config)# **interface** *interface-id*
2. Router(config-if)# **ip rsvp bandwidth** *interface-kbps* **sub-pool** *kbps*
3. Router(config-if)# **mpls traffic-eng tunnels**
4. Router(config-if)# **interface** *interface-id.int-sub* **[mpls]**
5. Router(config-subif)# **ip rsvp bandwidth** *interface-kbps* **sub-pool** *kbps*
6. Router(config-subif)# **mpls traffic-eng tunnels**
7. Router(config-subif)# **atm pvc** *vcd vpi vci aal5snap*
8. Router(config-subif)# **mpls atm** *vpi-vpi*
9. Router(config-subif)# **ip router isis**
10. Router(config-subif)# **exit**
11. Router(config-if)# **ip router isis**

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **interface** *interface-id*	Moves configuration to the interface level, directing subsequent configuration commands to the specific interface identified by the *interface-id*.
Step 2	Router(config-if)# **ip rsvp bandwidth** *interface-kbps* **sub-pool** *kbps*	Enables RSVP on this interface and limits the amount of bandwidth RSVP can reserve on this interface. The sum of bandwidth used by all tunnels on this interface cannot exceed *interface-kbps*, and the sum of bandwidth used by all sub-pool tunnels cannot exceed sub-pool *kbps*.
Step 3	Router(config-if)# **mpls traffic-eng tunnels**	Enables the MPLS traffic engineering tunnel feature on this interface. If the tunnel will go through an ATM-PVC or LC-ATM interface, continue on through Steps 4 through 11. However, if the tunnel will go through a POS interface, skip immediately to Step 11.
Step 4	Router(config-if)# **interface** *interface-id.int-sub* **[mpls]**	Moves configuration to the sub-interface level, directing subsequent configuration commands to the specific sub-interface identified by the *interface-id.sub-int*. Needed when the tunnel will traverse an ATM-PVC or LC-ATM interface. The keyword **mpls** is needed only with the LC-ATM interface.
Step 5	Router(config-subif)# **ip rsvp bandwidth** *interface-kbps* **sub-pool** *kbps*	Enables RSVP on the sub-interface and limits the amount of bandwidth RSVP can reserve on the sub-interface. The sum of bandwidth used by all tunnels on this sub-interface cannot exceed *interface-kbps*, and the sum of bandwidth used by all sub-pool tunnels cannot exceed sub-pool *kbps*.
Step 6	Router(config-subif)# **mpls traffic-eng tunnels**	Enables the MPLS traffic engineering tunnel feature on this sub-interface. If interface is ATM-PVC, continue with Step 7. If instead the interface is LC-ATM, skip to Step 8.]

	Command or Action	Purpose
Step 7	Router(config-subif)# **atm pvc** *vcd vpi vci aal5snap*	Sets the ATM PVC descriptor, path identifier, and channel identifier. Also sets the encapsulation as AAL5SNAP. [Now skip ahead to Step 9.]
Step 8	Router(config-subif)# **mpls atm** *vpi-vpi*	Sets the range of Virtual Path Identifiers on the LC-ATM interface.
Step 9	Router(config-subif)# **ip router isis**	Enables the IS-IS routing protocol on the sub-interface. Do not enter this command if you are configuring for OSPF.
Step 10	Router(config-subif)# **exit**	Exits the sub-interface level, returning to the interface level.
Step 11	Router(config-if)# **ip router isis**	If you are configuring an interface that does not have sub-interfaces, like POS, you enable IS-IS routing protocol at this step, on the interface level. (More on page 68.) Do not enter this command if you are configuring for OSPF.

Level 3: Configuring the Tunnel Interface

Now you create a set of attributes for the tunnel itself; those attributes are configured on the "tunnel interface" (not to be confused with the network interface just configured above).

The only command at this level which was affected to create DS-TE is **tunnel mpls traffic-eng bandwidth** (described in detail on page 145).

You enter the following commands:

SUMMARY STEPS

1. Router(config)# **interface tunnel1**
2. Router(config-if)# **tunnel destination** *A.B.C.D*
3. Router(config-if)# **tunnel mode mpls traffic-eng**
4. Router(config-if)# **tunnel mpls traffic-eng bandwidth**{**sub-pool** | [**global**]} *bandwid*th
5. Router(config-if)# **tunnel mpls traffic-eng priority**
6. Router(config-if)# **tunnel mpls traffic-eng path-option**

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **interface tunnel1**	Creates a tunnel interface (named in this example **tunnel1**) and enters interface configuration mode. (More on page 62.)
Step 2	Router(config-if)# **tunnel destination** *A.B.C.D* **Example:**	Specifies the IP address of the tunnel tail device. (More on page 139.)
Step 3	Router(config-if)# **tunnel mode mpls traffic-eng**	Sets the tunnel's encapsulation mode to MPLS traffic engineering. (More on page 141.)

	Command or Action	Purpose
Step 4	Router(config-if)# **tunnel mpls traffic-eng bandwidth**{**sub-pool** | [**global**]} *bandwid*th	Configures the tunnel's bandwidth and assigns it either to the sub-pool or the global pool. (More on page 145).
Step 5	Router(config-if)# **tunnel mpls traffic-eng priority**	Sets the priority to be used when system determines which existing tunnels are eligible to be preempted. (More on page 148).
Step 6	Router(config-if)# **tunnel mpls traffic-eng path-option**	Configures the paths (hops) a tunnel should use. The user can enter an explicit path (can specify the IP addresses of the hops) or can specify a dynamic path (the router figures out the best set of hops). (More on page 147).

ATM-LSR Special Case

Because of the joint nature of the ATM-LSR device--being both a router running Cisco IOS and an ATM switch running its own, different operating system--distinct configuration tasks are required to have this device convey DS-TE tunnels across itself as a tunnel midpoint. (The ATM-LSR device cannot be the head nor tail of a DS-TE tunnel, only a midpoint).

Configuring the ATM-LSR midpoint device thus involves four tasks:

- Configuring a link between the router portion of the device and the switch portion
- Mapping router-level traffic pools to switch-level classes of service
- Mapping logical interfaces on the router to physical ports on the switch (the results are called XTagATM interfaces)
- Configuring resources within the switch (using the switch's own command language to address its operating system, different from Cisco IOS).

Establishing a link between the router and the switch control port

SUMMARY STEPS

1. Router(config)# **interface atm4/1 0/0/0**
2. Router(config-if)# **label-control-protocol vsi**

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **interface atm4/1 0/0/0**	Moves configuration to the interface level, directing subsequent configuration commands to a Virtual Switch Interface on the router portion of the device. (More on page 62.)

	Command or Action	Purpose
Step 2	Router(config-if)# **label-control-protocol vsi** **Example:**	Enables Virtual Switch Interface protocol as the means of communication between the router interface and the switch’s control port.

Mapping pools to classes of service

SUMMARY STEPS

1. Router(config)# **mpls traffic-eng atm cos sub-pool**
2. Router(config)# **mpls traffic-eng atm cos global-pool**[available | standard | premium]

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **mpls traffic-eng atm cos sub-pool**	Directs all sub-pool traffic entering the ATM-LSR to exit as the highest priority ATM class of service. (More on page 78.)
Step 2	Router(config)# **mpls traffic-eng atm cos global-pool**[available | standard | premium]	(Optional). Directs all global pool traffic entering the ATM-LSR to exit as one of the remaining three classes of service. (More on page 77.) If you don’t use this command, the default, lowest priority service--"**available**"--is assigned.

Mapping switch ports and configuring XTag-ATM interfaces

SUMMARY STEPS

1. Router(config)# **interface Xtagatm22**
2. Router(config-if)# **extended-port atm4/1 0/0/0 bpx2.2**
3. Router(config-if)# **ip address 10.1.1.2 255.0.0.0**
4. Router(config-if)# **ip rsvp bandwidth***interface-kbps***sub-pool** *kbps*
5. Router(config-if)# **mpls traffic-eng tunnels**
6. Router(config-if)# **mpls atm** *vpi-vpi*
7. Router(config-if)# **ip router isis**

DETAILED STEPS

	Command or Action	Purpose
Step 1	Router(config)# **interface Xtagatm22** **Example:**	Moves configuration to the interface level, directing subsequent configuration commands to the specified XTag-ATM interface. (More on page 62.)
Step 2	Router(config-if)# **extended-port atm4/1 0/0/0 bpx2.2**	Associates a port on the switch with this XTagATM interface. extended-port ctrl-if { bpxport.number | igxport.number | descriptor vsi-descriptor | vsi vsi-port-number}
Step 3	Router(config-if)# **ip address 10.1.1.2 255.0.0.0**	Gives a network IP address to the XTagATM interface.
Step 4	Router(config-if)# **ip rsvp bandwidth***interface-kbps***sub-pool** *kbps* **Example:**	Enables RSVP on the XTagAtm interface and limits the amount of bandwidth RSVP can reserve on the interface. The sum of bandwidth used by all tunnels on this interface cannot exceed *interface-kbps*, and the sum of bandwidth used by all sub-pool tunnels cannot exceed sub-pool *kbps*. (More on page 69.)
Step 5	Router(config-if)# **mpls traffic-eng tunnels**	Enables the MPLS traffic engineering tunnel feature on this interface. (More on page 88.)
Step 6	Router(config-if)# **mpls atm** *vpi-vpi*	Sets the range of Virtual Path Identifiers on this interface. (More on page 138.)
Step 7	Router(config-if)# **ip router isis**	Enables the IS-IS routing protocol on this interface. (More on page 68.) Do not enter this command if you are configuring for OSPF.

Configuring resources within the switch

(Reminder--the following commands are entered directly into the switch. They are not part of the router portion's Cisco IOS software.)

SUMMARY STEPS

1. BPX-12# **uptrk***slot.port[.vtrk]*
2. BPX-12# **addshelf***slot.port.* **v***slot.port.*
3. BPX-12# **cnfrsrc** *slot.port.vtrk maxpvclcns maxpvcbw y/n partition e/d minvsilcns maxvsilcns vsistartvpi vsiendvpi vsiminbw*

DETAILED STEPS

	Command or Action	Purpose
Step 1	BPX-12# **uptrk***slot.port[.vtrk]* **Example:**	Activates a trunk, to generate framing. (The optional virtual trunk specification--*vrtk* -- is not used in our example).
Step 2	BPX-12# **addshelf***slot.port.* **v***slot.port.* **Example:**	Creates an interface shelf, to drive ATM cells to and from the switch.
Step 3	BPX-12# **cnfrsrc** *slot.port.vtrk maxpvclcns maxpvcbw y/n partition e/d minvsilcns maxvsilcns vsistartvpi vsiendvpi vsiminbw* **Example:** *vsimaxbw*	Configures resources for ports and trunks.

Verifying the Configurations

To view the complete configuration you have entered, use the EXEC command **show running-config** and check its output display for correctness.

To check *just one tunnel*'s configuration , enter **show interfaces tunnel** followed by the tunnel interface number. And to see that tunnel's RSVP bandwidth and flow, enter **show ip rsvp interface** followed by the name or number of the network interface (and also, in the case of an ATM-PVC or LC-ATM interface, the name or number of the sub-interface).

Here is an example of the information displayed by these two commands. To see an explanation of each field used in the following displays turn to page 95 for **show interfaces tunnel** and page 109 for **show ip rsvp interface**.

```
RTR1#show interfaces tunnel 4
Tunnel4 is up, line protocol is down
  Hardware is Routing Tunnel
  MTU 1500 bytes, BW 9 Kbit, DLY 500000 usec, rely 255/255, load 1/255
  Encapsulation TUNNEL, loopback not set, keepalive set (10 sec)
  Tunnel source 0.0.0.0, destination 0.0.0.0
  Tunnel protocol/transport GRE/IP, key disabled, sequencing disabled
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Output queue 0/0, 0 drops; input queue 0/75, 0 drops
  Five minute input rate 0 bits/sec, 0 packets/sec
  Five minute output rate 0 bits/sec, 0 packets/sec
0 packets input, 0 bytes, 0 no buffer
Received 0 broadcasts, 0 runts, 0 giants
0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
0 packets output, 0 bytes, 0 underruns
```

```
0 output errors, 0 collisions, 0 interface resets, 0 restarts
RTR1#show ip rsvp interface pos4/0
interface    allocated  i/f max  flow max sub max
PO4/0        300K       466500K  466500K  0M
RTR1#show ip rsvp interface atm3/0
RTR1#show ip rsvp interface atm3/0.5
interface    allocated  i/f max  flow max sub max
AT3/0.5     110M     130M     130M     100
```

To view *all tunnels at once* on the router you have configured, enter **show mpls traffic-eng tunnels brief**. The information displayed when tunnels are functioning properly looks like this (a table explaining the display fields begins on page 136):

```
RTR1#show mpls traffic-eng tunnels brief
Signalling Summary:
LSP Tunnels Process:           running
RSVP Process:                  running
Forwarding:                    enabled
Periodic reoptimization:       every 3600 seconds, next in 3029 seconds
TUNNEL NAME     DESTINATION      UP IF     DOWN IF   STATE/PROT
RTR1_t0     192.168.1.13     -         SR3/0     up/up
RTR1_t1     192.168.1.13     -         SR3/0     up/up
RTR1_t2     192.168.1.13     -         PO4/0     up/up
[[RTR1_t3     192.168.1.13     -         AT3/0.5     up/up]]
Displayed 4(of 4) heads, 0 (of 0) midpoints, 0 (of 0) tails
```

When one or more tunnels are not functioning properly, the display could instead look like this. (In the following example, tunnels t0 and t1 are down, as indicated in the far right column).

```
RTR1#show mpls traffic-eng tunnels brief
Signalling Summary:
    LSP Tunnels Process:           running
    RSVP Process:                  running
    Forwarding:                    enabled
    Periodic reoptimization:       every 3600 seconds, next in 2279 seconds
TUNNEL NAME     DESTINATION      UP IF     DOWN IF   STATE/PROT
RTR1_t0     192.168.1.13     -         SR3/0     up/down
RTR1_t1     192.168.1.13     -         SR3/0     up/down
RTR1_t2     192.168.1.13     -         PO4/0     up/up
Displayed 3 (of 3) heads, 0 (of 0) midpoints, 0 (of 0) tails
```

To find out *why* a tunnel is down, insert its name into this same command, after adding the keyword **name** and omitting the keyword **brief**. For example:

```
RTR1#show mpls traffic-eng tunnels name RTR1_t0

Name:RTR1_t0                            (Tunnel0) Destination:192.168.1.13
  Status:
    Admin:up         Oper:down     Path: not valid       Signalling:connected
```

If, as in this example, the Path is displayed as **not valid**, use the **show mpls traffic-eng topology** commandto make sure the router has received the needed updates. (That command is described on page 133.)

Additionally, you can use any of the following **show** commands to inspect particular aspects of the network, router, or interface concerned:

To see information about...	Use this command	
this level	and this item...	
Network	Advertised bandwidth allocation information	**show mpls traffic-eng link-management advertisements** (described on page 121)

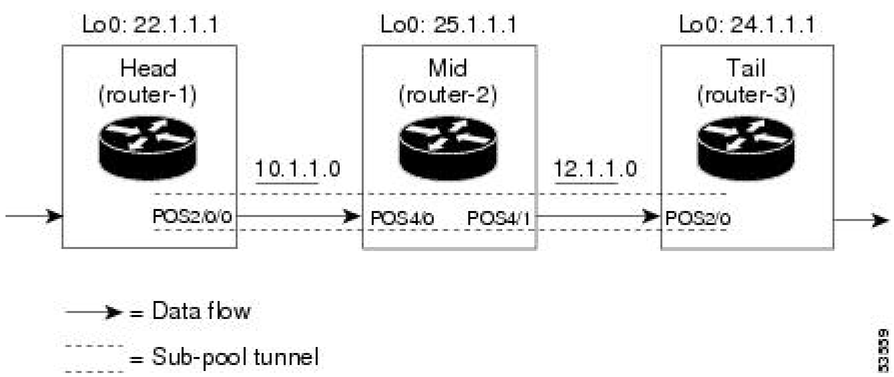
To see information about...	Use this command	
	Preemptions along the tunnel path	**debug mpls traffic-eng link-management preemption** (described on page 61)
	Available TE link band- width on all head routers	**show mpls traffic-eng topology** (described on page 133)
Router	Status of all tunnels cur- rently signalled by this router	**show mpls traffic-eng link-management admission-control** (described on page 119)
	Tunnels configured on midpoint routers	**show mpls traffic-eng link-management summary** (described on page 131)
Interface	Detailed information on current bandwidth pools	**show mpls traffic-eng link-management bandwidth-allocation [interface-name**] (described on page 124
	TE RSVP bookkeeping	**show mpls traffic-eng link-management interfaces** (described on page 129)
	Entire configuration of one interface	**show run interface**

Configuration Examples

First this section presents the DS-TE configurations needed to create the sub-pool tunnel. Then it presents the more comprehensive design for building end-to-end guaranteed bandwidth service, which involves configuring Quality of Service as well.

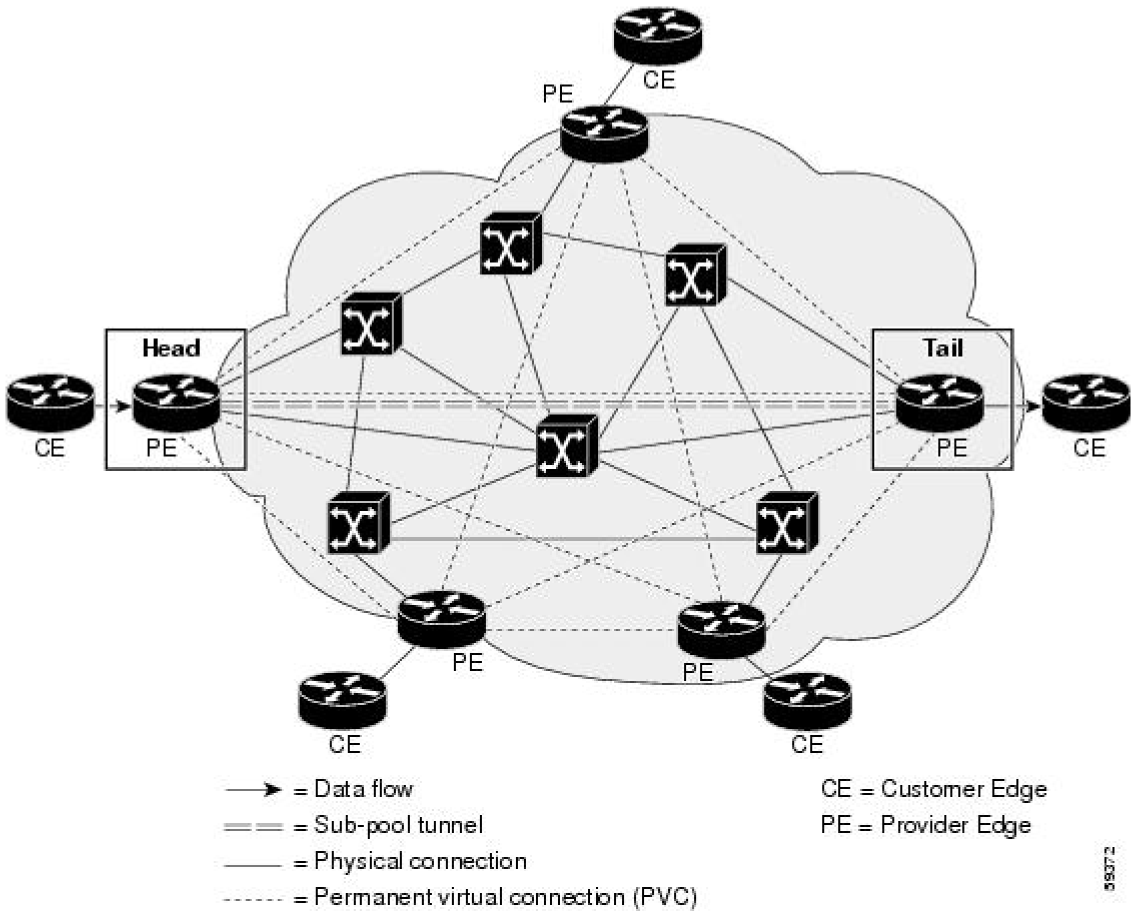
As shown in the figure below, the tunnel configuration involves at least three devices--tunnel head, midpoint, and tail. On each of those devices one or two network interfaces must be configured, for traffic ingress and egress.

Figure 1 Sample Tunnel Topology using POS Interfaces



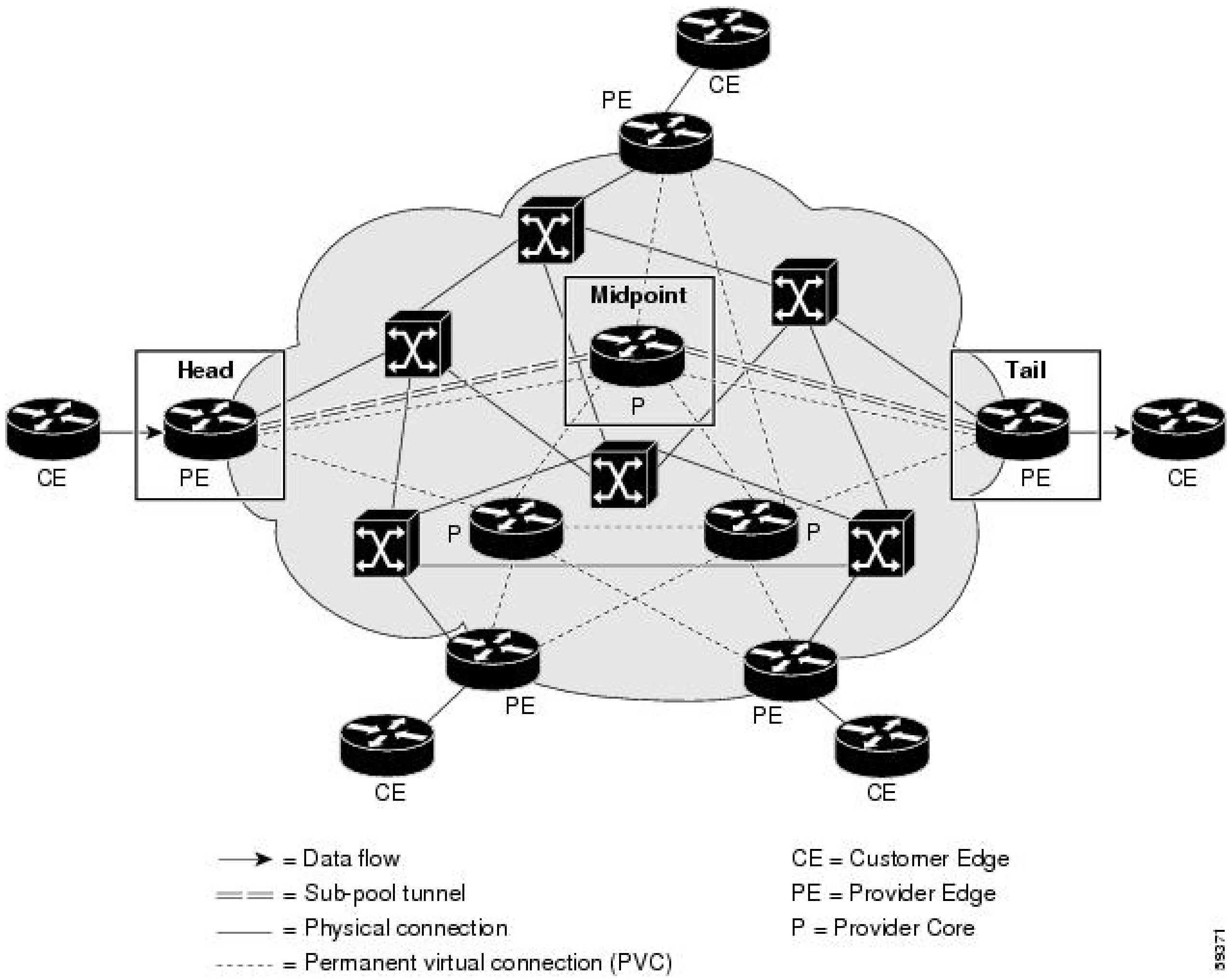
Sample topologies when the tunnel will run over ATM-PVCs are shown in the next two figures below.

Figure 2 *Sample Tunnel across ATM-PVC Interfaces -- Full Mesh Topology*



The full mesh topology shows no Midpoint device because the sub-pool tunnel can be routed along a direct PVC connecting the Head and Tail devices. However, if that particular PVC does not contain enough bandwidth, the tunnel can pass through alternate PVCs which may connect one or more PE routers. In that case the alternate PE router(s) will function as tunnel midpoint(s), and must be configured as shown in the Midpoint sections of the following configuration examples.

Figure 3 Sample Tunnel across ATM-PVC Interfaces -- Partial Mesh Topology

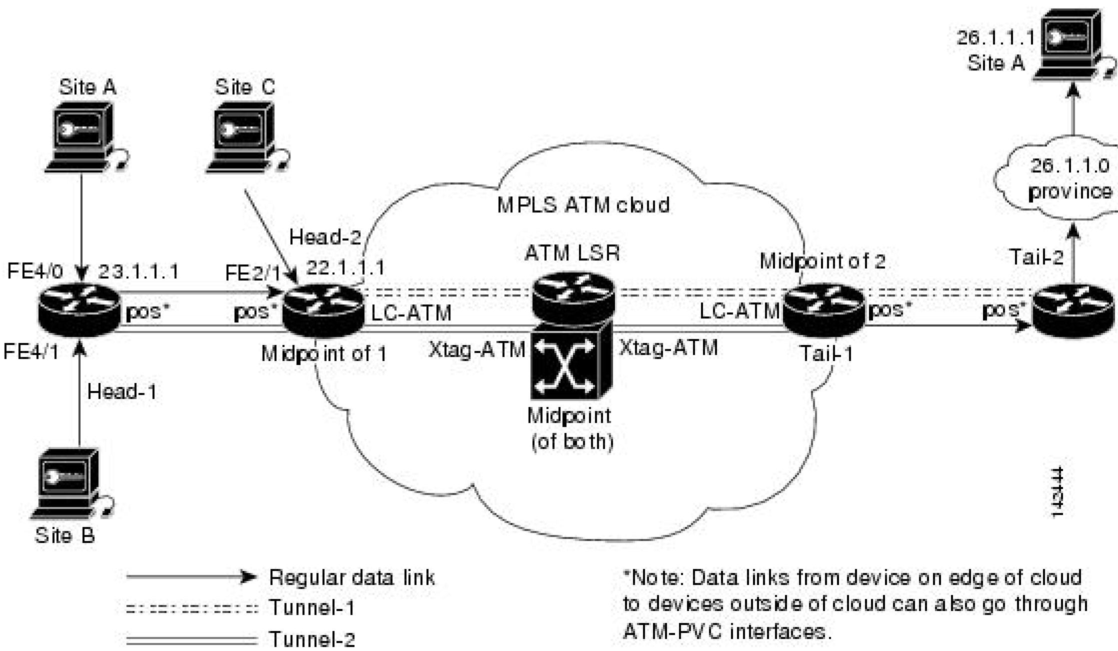


As shown in the figure below, DS-TE tunnels that travel through an MPLS ATM cloud can start either at a device outside the cloud or at one located on the edge of the cloud. Likewise, these tunnels can end either at a device on the edge of the cloud or one that is wholly outside the cloud. However, DS-TE tunnels cannot begin or end *inside* an MPLS ATM cloud.

On the edge of the cloud, the interface conveying the tunnel is an LC-ATM. Within the cloud, it is an XTag-ATM, residing on an ATM-LSR device.

A sample topology for tunnels that traverse LC-ATM interfaces is shown in the figure below

Figure 4 Sample Tunnels across LC-ATM Interfaces



The following example refers to all three figures. Where the language is specific to only one type of interface, that fact is indicated.

- Tunnel Head, page 19
- Midpoint Devices, page 21
- Tail-End Device, page 25
- Guaranteed Bandwidth Service Configuration, page 27
- Guaranteed Bandwidth Service Examples, page 28
- Example with Single Destination Prefix, page 28
- Example with Many Destination Prefixes, page 53

Tunnel Head

At the device level:

```
router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
router(config)# ip cef
router(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

`router(config)# router isis`	`router ospf 100`
`router(config-router)# net 49.0000.1000.0000.0010.00`	`redistribute connected`

router(config-router)# **metric-style wide**	**network 10.1.1.0 0.0.0.255 area 0**
router(config-router)# **is-type level-1**	**network 22.1.1.1 0.0.0.0 area 0**
router(config-router)# **mpls traffic-eng level-1**	**mpls traffic-eng area 0**
router(config-router)# **passive-interface Loopback0**	

[now one resumes the common command set]:

```
router(config-router)# mpls traffic-eng router-id Loopback0
router(config-router)# exit
router(config)# interface Loopback0
```

At the virtual interface level:

```
router(config-if)# ip address 22.1.1.1 255.255.255.255
router(config-if)# no ip directed-broadcast
router(config-if)# exit
```

At the device level: [ATM cases appear on the left; POS case on the right]:

router(config)# **interface atm3/0**	**interface POS2/0/0**

[continuing each case at the network interface level (egress)]:

router(config-if)# **mpls traffic-eng tunnels**	**ip address 10.1.1.1 255.255.255.0**
router(config-if)# **ip rsvp bandwidth 130000 130000/ sub-pool 80000**	**mpls traffic-eng tunnels**
router(config-if)# **interface atm3/0.5** [append the keyword **mpls** if LC-ATM]	**ip rsvp bandwidth 130000 130000/ sub-pool 80000**
router(config-subif)# **ip address 10.1.1.1 255.255.255.0**	
router(config-subif)#**ip rsvp bandwidth 130000 130000 sub-pool 80000**	
router(config-subif)# **mpls traffic-eng tunnels**	
router(config-subif)# [if ATM-PVC]: **atm pvc 10 10 100 aal5snap** [if LC-ATM]: **mpls atm vpi 2-5**	
[if using IS-IS instead of OSPF]:	

router(config-subif)# **ip router isis**	
router(config-subif)# **exit**	
router(config-if)#	[If using IS-IS instead of OSPF]: **ip router isis**

Continuing at the network interface level, regardless of interface type:

```
router(config-if)# exit
```

At the device level:

```
router(config)# interface Tunnel1
```

At the tunnel interface level:

```
router(config-if)# bandwidth 110000
router(config-if)# ip unnumbered Loopback0
router(config-if)# tunnel destination 24.1.1.1
router(config-if)# tunnel mode mpls traffic-eng
router(config-if)# tunnel mpls traffic-eng priority 0 0
router(config-if)# tunnel mpls traffic-eng bandwidth sub-pool 30000
router(config-if)# tunnel mpls traffic-eng path-option 1 dynamic
router(config-if)# exit
router(config)#
```

Midpoint Devices

At the device level:

```
router# configure terminal
router(config)# ip cef
router(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router(config)# **router isis**	**router ospf 100**
router(config-router)# **net 49.0000.1000.0000.0012.00**	**redistribute connected**
router(config-router)# **metric-style wide**	**network 11.1.1.0 0.0.0.255 area 0**
router(config-router)# **is-type level-1**	**network 12.1.1.0 0.0.0.255 area 0**
router(config-router)# **mpls traffic-eng level-1**	**network 25.1.1.1 0.0.0.0 area 0**
router(config-router)# **passive-interface Loopback0**	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router(config-router)# mpls traffic-eng router-id Loopback0
router(config-router)# exit
router(config)# interface Loopback0
```

At the virtual interface level:

```
router(config-if)# ip address 25.1.1.1 255.255.255.255
router(config-if)# no ip directed-broadcast
router(config-if)# exit
```

[And if the device is an ATM-LSR:

```
router(config)#interface atm9/0 0/0/0
router(config-if)# label-control-protocol vsi
router(config-if)# exit
router(config)#mpls traffic-eng atm cos sub-pool
 ]
```

On all devices, for the ingress interface: [ATM-LSR appears on the left; ATM-PVC and LC-ATM cases in the middle; POS on the right]

`router(config)#` **interface Xtagatm22**	**interface atm3/0**	**interface POS4/0**

[continuing each case at the network interface level]

`router(config-if)# extended-port atm9/0 bpx2.2`	**mpls traffic-eng tunnels**	`ip address 11.1.1.2 255.255.255.0`
`router(config-if)# ip address 11.1.1.2 255.255.255.0`	`ip rsvp bandwidth 130000 130000/ sub-pool 80000`	**mpls traffic-eng tunnels**
`router(config-if)# ip rsvp bandwidth 130000 130000 sub-pool 80000`		**ip rsvp bandwidth 130000 130000/ sub-pool 80000**
`router(config-if)# mpls traffic-eng tunnels`		`[If using IS-IS instead of OSPF]:` **ip router isis**
`router(config-if)# mpls atm vpi 2-15`		

router(config-if)# **ip rsvp isis** [only if using IS-IS instead of OSPF]	**interface atm3/0.5** [append the keyword **mpls** if LC-ATM]
router(config-subif)#	**ip address 11.1.1.2 255.255.255.0**
router(config-subif)#	**ip rsvp bandwidth 130000 130000 sub-pool 80000**
router(config-subif)#	**mpls traffic-eng tunnels**
router(config-subif)#	[if ATM-PVC]: **atm pvc 10 10 100 aal5snap** [or if LC-ATM]: **mpls atm vpi 2-15**
router(config-subif)#	[If using IS-IS instead of OSPF]: **ip router isis**
router(config-subif)#	**exit**

Continuing at the network interface level, regardless of interface type:

```
router(config-if)# exit
```

At the device level, for the egress interface: [ATM-LSR appears on the left; ATM-PVC and LC-ATM cases in the middle; POS on the right]

router(config)# **interface Xtagatm44**	**interface atm4/0**	**interface POS4/1**

[continuing each case at the network interface level]

router(config-if)# **extended-port atm9/0 bpx4.4**	**mpls traffic-eng tunnels**	**ip address 12.1.1.2 255.255.255.0**
router(config-if)# **ip address 12.1.1.2 255.255.255.0**	**ip rsvp bandwidth 130000 130000/ sub-pool 80000**	**mpls traffic-eng tunnels**
router(config-if)# **ip rsvp bandwidth 130000 130000 sub-pool 80000**		**ip rsvp bandwidth 130000 130000/ sub-pool 80000**
router(config-if)# **mpls traffic-eng tunnels**		[If using IS-IS instead of OSPF]: **ip router isis**
router(config-if)# **mpls atm vpi 2-15**		
router(config-if)# **ip router isis** [only if using IS-IS instead of OSPF]	**interface atm4/0.5** [append the keyword **mpls** if LC-ATM]	
router(config-subif)#	**ip address 12.1.1.2 255.255.255.0**	
router(config-subif)#	**ip rsvp bandwidth 130000 130000 sub-pool 80000**	
router(config-subif)#	**mpls traffic-eng tunnels**	
router(config-subif)#	[if ATM-PVC]: **atm pvc 10 10 100 aal5snap** [or if LC-ATM]: **mpls atm vpi 2-15**	

`router(config-subif)#`	[If using IS-IS instead of OSPF]: **ip router isis**
`router(config-subif)#`	**exit**

Continuing at the network interface level, regardless of interface type:

```
router(config-if)# exit
```

Note that there is no configuring of tunnel interfaces at the mid-point devices, only network interfaces, sub-interfaces, and the device globally.

When the midpoint device is an ATM-LSR, the following commands are also required. They are entered directly into the switch device, bypassing Cisco IOS:

```
BPX-12# uptrk 1.1
BPX-12# addshelf 1.1 v l.1
BPX-12# cnfrsrc
 1.1 256 252207 y 1 e 512 6144 2 15 26000 100000
BPX-12# uptrk 2.2
BPX-12# cnfrsrc
 2.2 256 252207 y 1 e 512 4096 2 5 26000 100000
BPX-12# uptrk 3.3
BPX-12# cnfrsrc
 3.3 256 252207 y 1 e 512 4096 2 5 26000 100000
BPX-12# uptrk 4.4
BPX-12# cnfrsrc
 4.4 256 252207 y 1 e 512 4096 2 5 26000 100000
BPX-12# uptrk 5.5
BPX-12# cnfrsrc
 5.5 256 252207 y 1 e 512 4096 2 5 26000 100000
```

Tail-End Device

At the device level:

```
router# configure terminal
router(config)# ip cef
router(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

`router(config)# router isis`	**router ospf 100**
`router(config-router)# net 49.0000.1000.0000.0013.00`	**redistribute connected**
`router(config-router)# metric-style wide`	**network 12.1.1.0 0.0.0.255 area 0**

router(config-router)# **is-type level-1**	**network 24.1.1.1 0.0.0.0 area 0**
router(config-router)# **mpls traffic-eng level-1**	**mpls traffic-eng area 0**
router(config-router)# **passive-interface Loopback0**	

[now one resumes the common command set]:

```
router(config-router)# mpls traffic-eng router-id Loopback0
router(config-router)# exit
router(config)# interface Loopback0
```

At the virtual interface level:

```
router(config-if)# ip address 24.1.1.1 255.255.255.255
router(config-if)# no ip directed-broadcast
[and if using IS-IS instead of OSPF]:
router(config-if)# ip router isis
[and in all cases]:
router(config-if)# exit
```

At the device level: [ATM cases appear on the left; POS case on the right]:

router(config)# **interface atm2/0**	**interface POS2/0/0**

[continuing each case at the network interface level (ingress)]:

router(config-if)# **mpls traffic-eng tunnels**	**ip address 12.1.1.3 255.255.255.0**
router(config-if)# **ip rsvp bandwidth 130000 130000/ sub-pool 80000**	**mpls traffic-eng tunnels**
router(config-if)# **interface atm2/0.4** [append the keyword **mpls** if LC-ATM]	**ip rsvp bandwidth 130000 130000/ sub-pool 80000**
router(config-subif)# **ip address 12.1.1.3 255.255.255.0**	
router(config-subif)#**ip rsvp bandwidth 130000 130000 sub-pool 80000**	
router(config-subif)# **mpls traffic-eng tunnels**	
router(config-subif)# [if ATM-PVC]: **atm pvc 10 10 100 aal5snap** [if LC-ATM]: **mpls atm vpi 2-5**	
[if using IS-IS instead of OSPF]:	

`router(config-subif)# **ip router isis**`	
`router(config-subif)# **exit**`	
`router(config-if)#`	`[If using IS-IS instead of OSPF]:` **`ip router isis`**

Continuing at the network interface level, regardless of interface type:

```
router(config-if)# exit
```

Guaranteed Bandwidth Service Configuration

Having configured two bandwidth pools, you now can

- Use one pool, the sub-pool, for tunnels that carry traffic requiring strict bandwidth guarantees or delay guarantees
- Use the other pool, the global pool, for tunnels that carry traffic requiring only Differentiated Service.

Having a separate pool for traffic requiring strict guarantees allows you to limit the amount of such traffic admitted on any given link. Often, it is possible to achieve strict QoS guarantees only if the amount of guaranteed traffic is limited to a portion of the total link bandwidth.

Having a separate pool for other traffic (best-effort or diffserv traffic) allows you to have a separate limit for the amount of such traffic admitted on any given link. This is useful because it allows you to fill up links with best-effort/diffserv traffic, thereby achieving a greater utilization of those links.

Providing Strict QoS Guarantees Using DS-TE Sub-pool Tunnels

A tunnel using sub-pool bandwidth can satisfy the stricter requirements if you do all of the following:

1 Select a queue--or in diffserv terminology, select a PHB (per-hop behavior)--to be used exclusively by the strict guarantee traffic. This shall be called the "GB queue."

If delay/jitter guarantees are sought, the diffserv Expedited Forwarding queue (EF PHB) is used. On the Cisco 7200 it is the "priority" queue. You must configure the bandwidth of the queue to be at least equal to the bandwidth of the sub-pool.

If only bandwidth guarantees are sought, the diffserv Assured Forwarding PHB (AF PHB) is used. On the Cisco 7200 you use one of the existing Class-Based Weighted Fair Queuing (CBWFQ) queues.

1 Ensure that the guaranteed traffic sent through the sub-pool tunnel is placed in the GB queue *at the outbound interface of every tunnel hop* , and that no other traffic is placed in this queue.

You do this by marking the traffic that enters the tunnel with a unique value in the mpls exp bits field, and steering only traffic with that marking into the GB queue.

1 Ensure that this GB queue is never oversubscribed; that is, see that no more traffic is sent into the sub-pool tunnel than the GB queue can handle.

You do this by rate-limiting the guaranteed traffic before it enters the sub-pool tunnel. The aggregate rate of all traffic entering the sub-pool tunnel should be less than or equal to the bandwidth capacity of the sub-pool tunnel. Excess traffic can be dropped (in the case of delay/jitter guarantees) or can be marked differently for preferential discard (in the case of bandwidth guarantees).

1 Ensure that the amount of traffic entering the GB queue is limited to an appropriate percentage of the total bandwidth of the corresponding outbound link. The exact percentage to use depends on several factors that can contribute to accumulated delay in your network: your QoS performance objective, the total number of tunnel hops, the amount of link fan-in along the tunnel path, burstiness of the input traffic, and so on.

You do this by setting the sub-pool bandwidth of each outbound link to the appropriate percentage of the total link bandwidth (that is, by adjusting the z parameter of the **ip rsvp bandwidth** command).

Providing Differentiated Service Using DS-TE Global Pool Tunnels

You can configure a tunnel using global pool bandwidth to carry best-effort as well as several other classes of traffic. Traffic from each class can receive differentiated service if you do all of the following:

1 Select a separate queue (a distinct diffserv PHB) for each traffic class. For example, if there are three classes (gold, silver, and bronze) there must be three queues (diffserv AF2, AF3, and AF4). [If the tunnel is to cross an MPLS ATM cloud, only one class of global pool traffic may be configured.]
2 Mark each class of traffic using a unique value in the MPLS experimental bits field (for example gold = 4, silver = 5, bronze = 6). [On the ATM-LSR, you specify the class of service desired **--premium**, **standard**, or the default service, **available**--using the command **mpls traffic-eng atm cos global-pool**].
3 Ensure that packets marked as Gold are placed in the gold queue, Silver in the silver queue, and so on. The tunnel bandwidth is set based on the expected aggregate traffic across all classes of service.

To control the amount of diffserv tunnel traffic you intend to support on a given link, adjust the size of the global pool on that link.

Providing Strict Guarantees and Differentiated Service in the Same Network

Because DS-TE allows simultaneous constraint-based routing of sub-pool and global pool tunnels, strict guarantees and diffserv can be supported simultaneously in a given network.

Guaranteed Bandwidth Service Examples

Given the many topologies in which Guaranteed Bandwidth Services can be applied, there is space here only to present two examples. They illustrate opposite ends of the spectrum of possibilities.

In the first example, the guaranteed bandwidth tunnel can be easily specified by its destination. So the forwarding criteria refer to a single destination prefix.

In the second example, there can be many final destinations for the guaranteed bandwidth traffic, including a dynamically changing number of destination prefixes. So the forwarding criteria are specified by Border Gateway Protocol (BGP) policies.

Example with Single Destination Prefix

The three figures below illustrate topologies for guaranteed bandwidth services whose destination is specified by a single prefix. In the first figure below, the interfaces to be configured are POS (Packet over SONET), while in second figure below the interfaces are ATM-PVC (Asynchronous Transfer Mode - Permanent Virtual Circuit), and in the third figure below, they are LC-ATM (Label Controlled - Asynchronous Transfer Mode) and, within the MPLS ATM cloud, XTag-ATM. In all three illustrations, the destination for the guaranteed bandwidth service is either a single host (like a voice gateway, here designated "Site D" and bearing prefix 26.1.1.1) or a subnet (like a web farm, here called "Province" and bearing prefix 26.1.1.0). Three services are offered in each sample topology:

- From Site A (defined as all traffic arriving at interface FE4/0): to host 26.1.1.1, 8 Mbps of guaranteed bandwidth with low loss, low delay and low jitter
- From Site B (defined as all traffic arriving at interface FE4/1): towards subnet 26.1.1.0, 32 Mbps of guaranteed bandwidth with low loss

- From Site C (defined as all traffic arriving at interface FE2/1): towards subnet 26.1.1.0, 30 Mbps of guaranteed bandwidth with low loss.

Figure 5 Sample Topology for Guaranteed Bandwidth Services (traversing POS interfaces) to a Single Destination Prefix

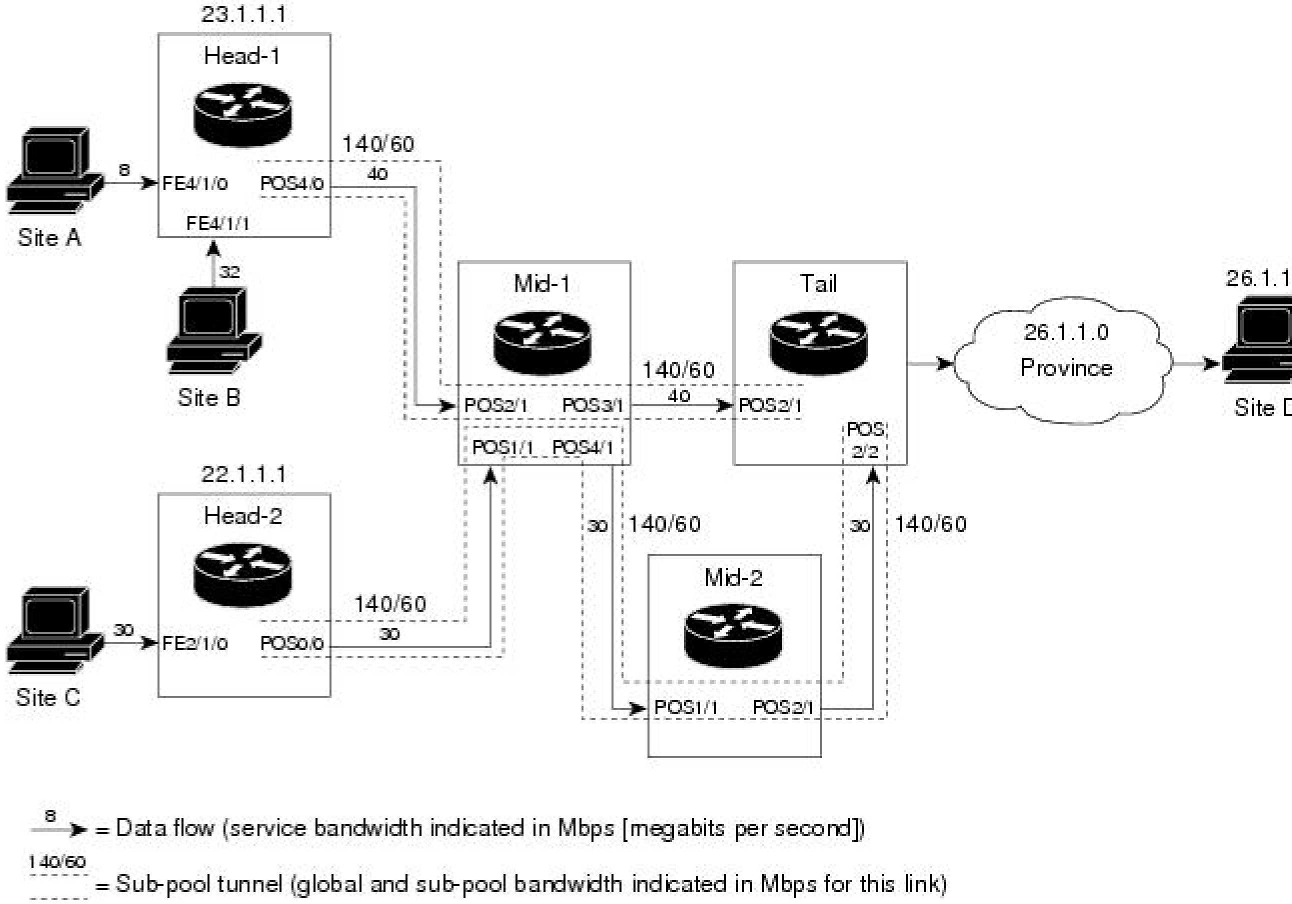
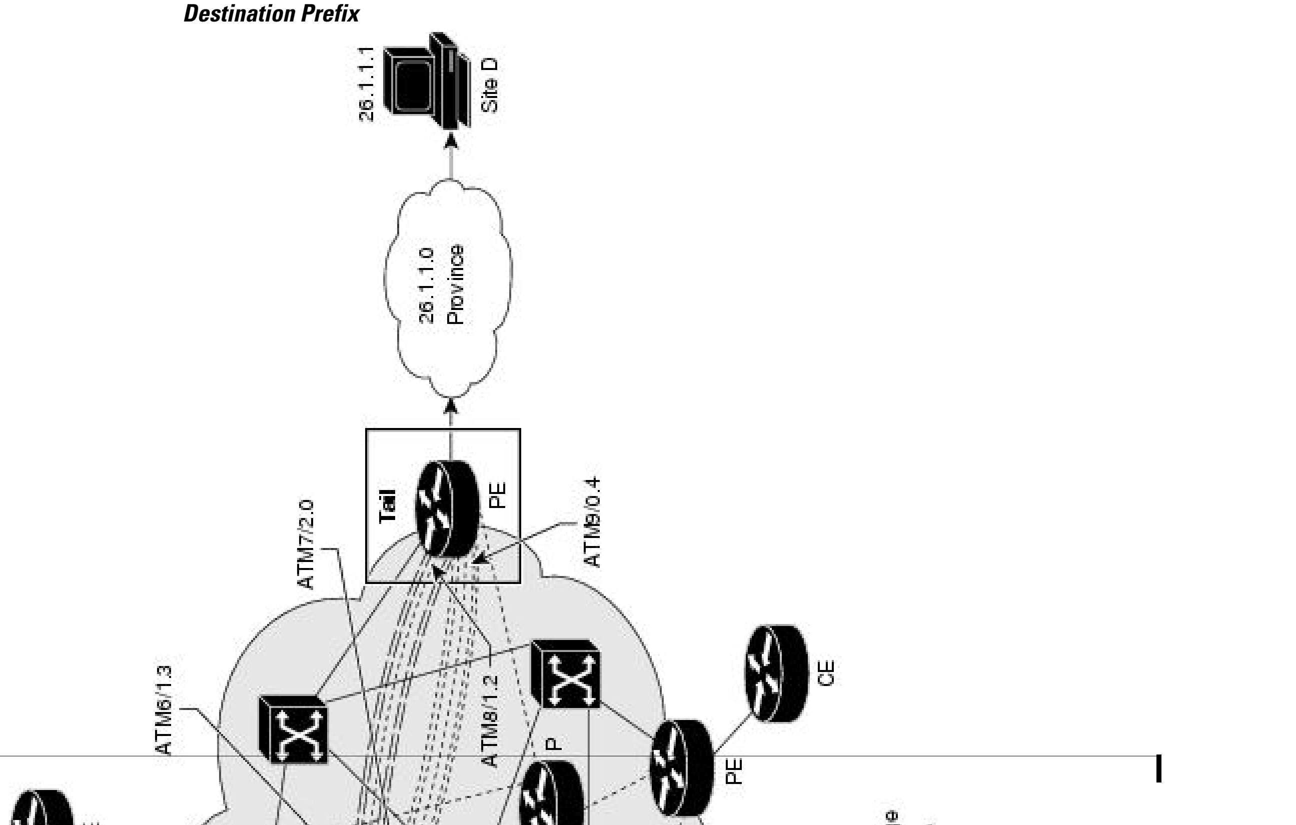


Figure 6 Sample Topology for Guaranteed Bandwidth Services (traversing ATM-PVC interfaces) to a Single Destination Prefix



These three services run through two sub-pool tunnels:

- From the Head-1 router, 23.1.1.1, to the router-4 tail (in our LC-ATM example, to tail router-8)
- From the Head-2 router, 22.1.1.1, to the router-4 tail (in our LC-ATM example, to tail router-7)

In the POS and ATM-PVC examples, both tunnels use the same tail router, though they have different heads. This is to illustrate that many combinations are possible. (In Figure 5 one midpoint router is shared by both tunnels. In the real world there could of course be many more midpoints.)

All POS, ATM-PVC, LC-ATM, and XTagATM interfaces in this example are OC3, whose capacity is 155 Mbps.

- Configuring Tunnel Head-1, page 31
- Configuring Tunnel Head-2, page 36
- Tunnel Midpoint Configurations, page 40
- Tunnel Midpoint Configuration POS ingress and LC-ATM egress, page 45
- Tunnel Midpoint Configuration all POS, page 46
- Tunnel Midpoint Configurationz all XTag-ATM, page 47
- Tunnel Midpoint Configuration LC-ATM Ingress, page 49
- Tunnel Tail Configuration, page 51

Configuring Tunnel Head-1

First we recapitulate commands that establish two bandwidth pools and a sub-pool tunnel (as presented earlier on page 14). Then we present the QoS commands that guarantee end-to-end service on the subpool tunnel. With the 7200 router, Modular QoS CLI is used.

- Configuring the Pools and Tunnel, page 31
- For Service from Site A to Site D, page 33
- For Service from Site B to Subnet Province, page 34
- For Both Services, page 35

Configuring the Pools and Tunnel

At the device level:

```
router-1(config)# ip cef
router-1(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

`router-1(config)# router isis`	`router ospf 100`
`router-1(config-router)# net 49.0000.1000.0000.0010.00`	`redistribute connected`
`router-1(config-router)# metric-style wide`	`network 10.1.1.0 0.0.0.255 area 0`
`router-1(config-router)# is-type level-1`	`network 23.1.1.1 0.0.0.0 area 0`

router-1(config-router)# **mpls traffic-eng level-1**	**mpls traffic-eng area 0**
router-1(config-router)# **passive-interface Loopback0**	

[now one resumes the common command set]:

```
router-1(config-router)# mpls traffic-eng router-id Loopback0
router-1(config-router)# exit
```

Create a virtual interface:

```
router-1(config)# interface Loopback0
router-1(config-if)# ip address 23.1.1.1 255.255.255.255
router-1(config-if)# no ip directed-broadcast
router-1(config-if)# exit
```

For the outgoing network interface:

[ATM-PVC case appears on the left; POS case on the right]:

router-1(config)# **interface atm2/0**	**interface POS4/0**

[then continue each case at the network interface level:

router-1(config-if)# **mpls traffic-eng tunnels**	**ip address 10.1.1.1 255.255.255.0**
router-1(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 60000**	**mpls traffic-eng tunnels**
router-1(config-if)# **interface atm2/0.4**	**ip rsvp bandwidth 140000 140000\ sub-pool 60000**
router-1(config-subif)# **ip address 10.1.1.1 255.255.255.0**	
router-1(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 60000**	
router-1(config-subif)# **mpls traffic-eng tunnels**	
router-1(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-1(config-subif)# **ip router isis**	
router-1(config-subif)# **exit**	

router-1(config-if)#	[If using IS-IS instead of OSPF]: **ip router isis**

Continuing at the network interface level, regardless of interface type:

```
router-1(config-if)# exit
```

At the tunnel interface:

```
router-1(config)# interface Tunnel1
router-1(config-if)# bandwidth 110000
router-1(config-if)# ip unnumbered Loopback0
router-1(config-if)# tunnel destination 27.1.1.1
router-1(config-if)# tunnel mode mpls traffic-eng
router-1(config-if)# tunnel mpls traffic-eng priority 0 0
router-1(config-if)# tunnel mpls traffic-eng bandwidth sub-pool 40000
router-1(config-if)# tunnel mpls traffic-eng path-option 1 dynamic
```

To ensure that packets destined to host 26.1.1.1 and subnet 26.1.1.0 are sent into the sub-pool tunnel, we create a static route. At the device level:

```
router-1(config)# ip route 26.1.1.0 255.255.255.0 Tunnel1
router-1(config)# exit
```

And in order to make sure that the Interior Gateway Protocol (IGP) will not send any other traffic down this tunnel, we disable autoroute announce:

```
router-1(config)# no tunnel mpls traffic-eng autoroute announce
```

For Service from Site A to Site D

At the inbound network interface (FE4/0):

SUMMARY STEPS

1. In global configuration mode, create a class of traffic matching ACL 100, called "sla-1-class":
2. Create an ACL 100 to refer to all packets destined to 26.1.1.1:
3. Create a policy named "sla-1-input-policy", and according to that policy:
4. The policy is applied to packets entering interface FE4/0.

DETAILED STEPS

Step 1 In global configuration mode, create a class of traffic matching ACL 100, called "sla-1-class":

Example:

```
class-map match-all sla-1-class
match access-group 100
```

Step 2 Create an ACL 100 to refer to all packets destined to 26.1.1.1:

Example:

```
access-list 100 permit ip any host 26.1.1.1
```

Step 3 Create a policy named "sla-1-input-policy", and according to that policy:
Packets in the class called "sla-1-class" are rate-limited to

- a rate of 8 million bits per second
- a normal burst of 1 million bytes
- a maximum burst of 2 million bytes

Packets which conform to this rate are marked with MPLS experimental bit 5 and are forwarded.

Packets which exceed this rate are dropped.

All other packets are marked with experimental bit 0 and are forwarded.

Example:

```
policy-map sla-1-input-policy
class sla-1-class
police 8000000 1000000 2000000 conform-action set-mpls-exp-transmit 5 \ exceed-action drop
class class-default
set-mpls-exp-transmit 0
```

Step 4 The policy is applied to packets entering interface FE4/0.

Example:

```
interface FastEthernet4/0
service-policy input sla-1-input-policy
```

For Service from Site B to Subnet Province

At the inbound network interface (FE4/1):

SUMMARY STEPS

1. In global configuration mode, create a class of traffic matching ACL 120, called "sla-2-class":
2. Create an ACL, 120, to refer to all packets destined to subnet 26.1.1.0:
3. Create a policy named "sla-2-input-policy", and according to that policy
4. The policy is applied to packets entering interface FE4/1.

DETAILED STEPS

Step 1 In global configuration mode, create a class of traffic matching ACL 120, called "sla-2-class":

Example:

```
class-map match-all sla-2-class
match access-group 120
```

Step 2 Create an ACL, 120, to refer to all packets destined to subnet 26.1.1.0:

Example:

```
access-list 120 permit ip any 26.1.1.0 0.0.0.255
```

Step 3 Create a policy named "sla-2-input-policy", and according to that policy
Packets in the class called "sla-2-class" are rate-limited to:

- a rate of 32 million bits per second
- a normal burst of 1 million bytes
- a maximum burst of 2 million bytes

Packets which conform to this rate are marked with MPLS experimental bit 5 and are forwarded.

Packets which exceed this rate are dropped.

All other packets are marked with experimental bit 0 and are forwarded.

Example:

```
policy-map sla-2-input-policy
class sla-2-class
police 32000000 1000000 2000000 conform-action set-mpls-exp-transmit 5 \ exceed-action drop
class class-default
set-mpls-exp-transmit 0
```

Step 4 The policy is applied to packets entering interface FE4/1.

Example:

```
interface FastEthernet4/1
service-policy input sla-2-input-policy
```

For Both Services

The outbound interface (POS4/0 in Figure 5 and Figure 7, and ATM2/0.4 in Figure 6) is configured as follows:

SUMMARY STEPS

1. In global configuration mode, create a class of traffic matching experimental bit 5, called "exp-5-traffic".
2. Create a policy named "output-interface-policy". According to that policy, packets in the class "exp-5-traffic" are put in the priority queue (which is rate-limited to 62 kbits/sec).
3. The policy is applied to packets exiting subinterface ATM2/0.4 (first example) or interface POS4/0 (second example):

DETAILED STEPS

Step 1 In global configuration mode, create a class of traffic matching experimental bit 5, called "exp-5-traffic".

Example:

```
class-map match-all exp-5-traffic
match mpls experimental 5
```

Step 2 Create a policy named "output-interface-policy". According to that policy, packets in the class "exp-5-traffic" are put in the priority queue (which is rate-limited to 62 kbits/sec).

Example:

```
policy-map output-interface-policy
class exp-5-traffic
priority 62
```

Step 3 The policy is applied to packets exiting subinterface ATM2/0.4 (first example) or interface POS4/0 (second example):

Example:

```
interface atm2/0
interface atm2/0.4
service-policy output output-interface-policy
```

Example:

```
interface POS4/0
service-policy output\ output-interface-policy
```

The result of the above configuration lines is that packets entering the router via interface FE4/0 destined to host 26.1.1.1, or entering the router via interface FE4/1 destined to subnet 26.1.1.0, will have their MPLS experimental bit set to 5. We assume that no other packets entering the router (on any interface) are using this value. (If this cannot be assumed, an additional configuration must be added to mark all such packets to another experimental value.) Packets marked with experimental bit 5, when exiting the router via interface POS4/0 or subinterface ATM2/0.4, will be placed into the priority queue.

Configuring Tunnel Head-2

First we recapitulate commands that establish two bandwidth pools and a sub-pool tunnel (as presented earlier on page 16). Then we present the QoS commands that guarantee end-to-end service on the subpool tunnel. With the 7200 router, Modular QoS CLI is used. [And because this router is on the edge of the MPLS ATM cloud in Figure 7, an LC-ATM interface is configured in that example.]

- Configuring the Pools and Tunnel, page 37
- For Service from Site C to Subnet Province, page 38

Configuring the Pools and Tunnel

At the device level:

```
router-2(config)# ip cef
router-2(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router-2(config)# **router isis**	**router ospf 100**
router-2(config-router)# **net 49.0000.1000.0000.0011.00**	**redistribute connected**
router-2(config-router)# **metric-style wide**	**network 11.1.1.0 0.0.0.255 area 0**
router-2(config-router)# **is-type level-1**	**network 22.1.1.1 0.0.0.0 area 0**
router-2(config-router)# **mpls traffic-eng level-1**	**mpls traffic-eng area 0**
router-2(config-router)# **passive-interface Loopback0**	

[now one resumes the common command set]:

```
router-2(config-router)# mpls traffic-eng router-id Loopback0
router-2(config-router)# exit
```

Create a virtual interface:

```
router-2(config)# interface Loopback0
router-2(config-if)# ip address 22.1.1.1 255.255.255.255
router-2(config-if)# no ip directed-broadcast
router-2(config-if)# exit
```

For the outgoing network interface:

[ATM cases appear on the left; POS case on the right]:

router-2(config)# **interface atm3/0**	**interface POS0/0**

[then continue each case at the network interface level]:

router-2(config-if)# **mpls traffic-eng tunnels**	**ip address 11.1.1.1 255.0.0.0**
router-2(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 60000**	**mpls traffic-eng tunnels**
router-2(config-if)# **interface atm3/0.2** [append the keyword **mpls** if LC-ATM]	**ip rsvp bandwidth 140000 140000\ sub-pool 60000**

router-2(config-subif)# **ip address 11.1.1.1 255.0.0.0**	
router-2(config-subif)#**ip rsvp bandwidth 140000 140000 sub-pool 60000**	
router-2(config-subif)# **mpls traffic-eng tunnels**	
router-2(config-subif)# [if ATM-PVC]: **atm pvc 10 10 100 aal5snap** [if LC-ATM]: **mpls atm vpi 2-5**	
[if using IS-IS instead of OSPF]:	
router-2(config-subif)# **ip router isis**	
router-2(config-subif)# **exit**	
router-2(config-if)#	[If using IS-IS instead of OSPF]: **ip router isis**

Continuing at the network interface level, regardless of interface type:

```
router-2(config-if)# exit
```

At the tunnel interface:

```
router-2(config)# interface Tunnel2
router-2(config-if)# ip unnumbered Loopback0
router-2(config-if)# tunnel destination 27.1.1.1

[though in Figure 7:
tunnel destination 28.1.1.1
]
router-2(config-if)# tunnel mode mpls traffic-eng
router-2(config-if)# tunnel mpls traffic-eng priority 0 0
router-2(config-if)# tunnel mpls traffic-eng bandwidth sub-pool 30000
router-2(config-if)# tunnel mpls traffic-eng path-option 1 dynamic
```

To ensure that packets destined to subnet 26.1.1.0 are sent into the sub-pool tunnel, we create a static route. At the device level:

```
router-2(config)# ip route 26.1.1.0 255.255.255.0 Tunnel2
router-2(config)# exit
```

And in order to make sure that the Interior Gateway Protocol (IGP) will not send any other traffic down this tunnel, we disable autoroute announce:

```
router-2(config)# no tunnel mpls traffic-eng autoroute announce
```

For Service from Site C to Subnet Province

At the inbound network interface (FE2/1):

SUMMARY STEPS

1. In global configuration mode, create a class of traffic matching ACL 130, called "sla-3-class":
2. Create an ACL, 130, to refer to all packets destined to subnet 26.1.1.0:
3. Create a policy named "sla-3-input-policy", and according to that policy:
4. The policy is applied to packets entering interface FE2/1.
5. The outbound interface (POS0/0 or ATM3/0.2) is configured as follows:
6. In global configuration mode, create a class of traffic matching experimental bit 5, called "exp-5-traffic".
7. Create a policy named "output-interface-policy". According to that policy, packets in the class "exp-5-traffic" are put in the priority queue (which is rate-limited to 32 kbits/sec).
8. The policy is applied to packets exiting interface ATM3/0.2 (first example) or POS0/0 (second example):

DETAILED STEPS

Step 1 In global configuration mode, create a class of traffic matching ACL 130, called "sla-3-class":

Example:

```
class-map match-all sla-3-class
match access-group 130
```

Step 2 Create an ACL, 130, to refer to all packets destined to subnet 26.1.1.0:

Example:

```
access-list 130 permit ip any 26.1.1.0 0.0.0.255
```

Step 3 Create a policy named "sla-3-input-policy", and according to that policy:
Packets in the class called "sla-3-class" are rate-limited to:

- a rate of 30 million bits per second
- a normal burst of 1 million bytes
- a maximum burst of 2 million bytes

Packets which conform to this rate are marked with MPLS experimental bit 5 and are forwarded.

Packets which exceed this rate are dropped.

All other packets are marked with experimental bit 0 and are forwarded.

Example:

```
policy-map sla-3-input-policy
class sla-3-class
police 30000000 1000000 2000000 conform-action set-mpls-exp-transmit 5 \ exceed-action drop
class class-default
set-mpls-exp-transmit 0
```

Step 4 The policy is applied to packets entering interface FE2/1.

Example:

```
interface FastEthernet2/1
service-policy input sla-3-input-policy
```

Step 5 The outbound interface (POS0/0 or ATM3/0.2) is configured as follows:

Step 6 In global configuration mode, create a class of traffic matching experimental bit 5, called "exp-5-traffic".

Example:

```
class-map match-all exp-5-traffic
match mpls experimental 5
```

Step 7 Create a policy named "output-interface-policy". According to that policy, packets in the class "exp-5-traffic" are put in the priority queue (which is rate-limited to 32 kbits/sec).

Example:

```
policy-map output-interface-policy
class exp-5-traffic
priority 32
```

Step 8 The policy is applied to packets exiting interface ATM3/0.2 (first example) or POS0/0 (second example):

Example:

```
interface atm3/0
interface atm3/0.2
service-policy output output-interface-policy
```

Example:

```
interface POS0/0
service-policy output\ output-interface-policy
```

The result of the above configuration lines is that packets entering the router via interface FE2/1 destined to subnet 26.1.1.0, will have their MPLS experimental bit set to 5. We assume that no other packets entering the router (on any interface) are using this value. (If this cannot be assumed, an additional configuration must be added to mark all such packets to another experimental value.) Packets marked with experimental bit 5, when exiting the router via interface POS0/0 or ATM3/0.2, will be placed into the priority queue.

Tunnel Midpoint Configurations

All four interfaces on the 7200 midpoint router ("**Mid-1**" in Figure 5, "**Midpoint**" in Figure 6) are configured identically to the outbound interface of the head router (except, of course, for the IDs of the individual interfaces).

When an ATM-LSR serves as a midpoint (as in Figure 7), its XTagATM interfaces and BPX or IGX switching resources must be configured. Also, two new MPLS commands are used. The details of this configuration are presented in the ATM-LSR section which begins on page 38.

The LC-ATM midpoint configuration (on the left edge of the ATM cloud in Figure 7) is presented on page 35. LC-ATM at a midpoint on the right edge of the cloud in Figure 7 is presented on page 39.

• Configuring the Pools and Tunnels, page 41

Configuring the Pools and Tunnels

At the device level:

```
router-3(config)# ip cef
router-3(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router-3(config)# **router isis**	**router ospf 100**
router-3(config-router)# **net 49.0000.2400.0000.0011.00**	**redistribute connected**
router-3(config-router)# **metric-style wide**	**network 10.1.1.0 0.0.0.255 area 0**
router-3(config-router)# **is-type level-1**	**network 11.1.1.0 0.0.0.255 area 0**
router-3(config-router)# **mpls traffic-eng level-1**	**network 24.1.1.1 0.0.0.0 area 0**
router-3(config-router)# **passive-interface Loopback0**	**network 12.1.1.0 0.0.0.255 area 0**
router-3(config-router)#	**network 13.1.1.0 0.0.0.255 area 0**
router-3(config-router)#	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router-3(config-router)# mpls traffic-eng router-id Loopback0
router-3(config-router)# exit
```

Create a virtual interface:

```
router-3(config)# interface Loopback0
router-3(config-if)# ip address 22.1.1.1 255.255.255.255
router-3(config-if)# exit
```

For one incoming network interface, first at the device level:

[ATM-PVC case appears on the left; POS case on the right]:

router-3(config)# **interface atm4/1**	**interface POS2/1**

[then continue each case at the network interface level]:

router-3(config-if)# **mpls traffic-eng tunnels**	**ip address 10.1.1.2 255.0.0.0**
router-3(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 60000**	**mpls traffic-eng tunnels**
router-3(config-if)# **interface atm4/1.0**	**ip rsvp bandwidth 140000 140000\ sub-pool 60000**
router-3(config-subif)# **ip address 10.1.1.2 255.0.0.0**	
router-3(config-subif)#**ip rsvp bandwidth 140000 140000 sub-pool 60000**	
router-3(config-subif)# **mpls traffic-eng tunnels**	
router-3(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-3(config-subif)# **ip router isis**	
router-3(config-subif)# **exit**	
router-3(config-if)#	[If using IS-IS instead of OSPF]: **ip router isis**

Continuing at the network interface level, regardless of interface type:

```
router-3(config-if)# exit
```

For the other incoming network interface, first at the device level:

[ATM-PVC case appears on the left; POS case on the right]:

router-3(config)# **interface atm5/2**	**interface POS1/1**

[then continuing each case at the network interface level]:

router-3(config-if)# **mpls traffic-eng tunnels**	**ip address 11.1.1.2 255.0.0.0**
router-3(config-if)# **ip rsvp bandwidth 140000 140000/ sub-pool 60000**	**mpls traffic-eng tunnels**
router-3(config-if)# **interface atm5/2.1**	**ip rsvp bandwidth 140000 140000/ sub-pool 60000**

router-3(config-subif)# **ip address 11.1.1.2 255.0.0.0**	
router-3(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 60000**	
router-3(config-subif)# **mpls traffic-eng tunnels**	
router-3(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-3(config-subif)# **ip router isis**	
router-3(config-subif)# **exit**	
router-3(config-if)#	[If using IS-IS instead of OSPF]: **ip router isis**

Continuing at the network interface level, regardless of interface type:

router-3(config-if)# **exit**

For one outgoing network interface:

[ATM-PVC case appears on the left; POS case on the right]:

router-3(config)# **interface atm6/1**	**interface POS3/1**

[then continue each case at the network interface level]:

router-3(config-if)# **mpls traffic-eng tunnels**	**ip address 11.1.1.2 255.0.0.0**
router-3(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 60000**	**mpls traffic-eng tunnels**
router-3(config-if)# **interface atm6/1.3**	**ip rsvp bandwidth 140000 140000\ sub-pool 60000**
router-3(config-subif)# **ip address 11.1.1.2 255.0.0.0**	
router-3(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 60000**	
router-3(config-subif)# **mpls traffic-eng tunnels**	

router-3(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-3(config-subif)# **ip router isis**	
router-3(config-subif)# **exit**	
router-3(config-if)#	[If using IS-IS instead of OSPF]: **ip router isis**

Continuing at the network interface level, regardless of interface type:

```
router-3(config-if)# exit
```

For the other outgoing network interface, first at the device level:

[ATM-PVC case appears on the left; POS case on the right]:

router-3(config)# **interface atm7/2**	**interface POS3/1**

[then, continuing each case at the network interface level]:

router-3(config-if)# **mpls traffic-eng tunnels**	**ip address 12.1.1.1 255.0.0.0**
router-3(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 60000**	**mpls traffic-eng tunnels**
router-3(config-if)# **interface atm7/2.0**	**ip rsvp bandwidth 140000 140000\ sub-pool 60000**
router-3(config-subif)# **ip address 12.1.1.1 255.0.0.0**	
router-3(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 60000**	
router-3(config-subif)# **mpls traffic-eng tunnels**	
router-3(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-3(config-subif)# **ip router isis**	
router-3(config-subif)# **exit**	

`router-3(config-if)#`	`[If using IS-IS instead of OSPF]:` **`ip router isis`**

Continuing at the network interface level, regardless of interface type:

```
router-3(config-if)# exit
```

Tunnel Midpoint Configuration POS ingress and LC-ATM egress

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Configuring the Pools and Tunnels

At the device level:

```
router-2(config)# ip cef
router-2(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

`router-2(config)#` **`router isis`**	**`router ospf 100`**
`router-2(config-router)#` **`net 49.0000.2400.0000.0011.00`**	**`redistribute connected`**
`router-2(config-router)#` **`metric-style wide`**	**`network 10.1.1.0 0.0.0.255 area 0`**
`router-2(config-router)#` **`is-type level-1`**	**`network 11.1.1.0 0.0.0.255 area 0`**
`router-2(config-router)#` **`mpls traffic-eng level-1`**	**`network 24.1.1.1 0.0.0.0 area 0`**
`router-2(config-router)#` **`passive-interface Loopback0`**	**`network 12.1.1.0 0.0.0.255 area 0`**
`router-2(config-router)#`	**`network 13.1.1.0 0.0.0.255 area 0`**
`router-2(config-router)#`	**`mpls traffic-eng area 0`**

[now one resumes the common command set]:

```
router-2(config-router)# mpls traffic-eng router-id Loopback0
router-2(config-router)# exit
```

Create a virtual interface:

```
router-2(config)# interface Loopback0
router-2(config-if)# ip address 22.1.1.1 255.255.255.255
router-2(config-if)# exit
```

For the incoming network interface, first at the device level:

```
router-2(config)# interface POS2/1
```

[then continuing at the network interface level]:

```
router-2(config-if)# ip address 11.1.1.2 255.0.0.0
router-2(config-if)# mpls traffic-eng tunnels
router-2(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 60000
```

[If using IS-IS instead of OSPF]:

```
router-2(config-if)# ip router isis
[and in both cases]:
router-2(config-if)# exit
```

For the outgoing network interface:

```
router-2(config)# interface atm6/1
router-2(config-if)# mpls traffic-eng tunnels
router-2(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 60000
router-2(config-if)# interface atm6/1.3 mpls
router-2(config-subif)# ip address 11.1.1.2 255.0.0.0
router-2(config-subif)#ip rsvp bandwidth 140000 140000 sub-pool 60000
router-2(config-subif)# mpls traffic-eng tunnels
router-2(config-subif)# mpls atm vpi 2-15
[if using IS-IS instead of OSPF]:
router-2(config-subif)# ip router isis
router-2(config-subif)# exit
[and in bothcases]:
router-2(config-if)# exit
```

Tunnel Midpoint Configuration all POS

[For the sake of simplicity, the ATM-PVC example (Figure 6) was illustrated with only one midpoint router.]

Both interfaces on the second 7200 midpoint router are configured identically to the outbound interface of the head router (except, of course, for the IDs of the individual interfaces):

- Configuring the Pools and Tunnel, page 46

Configuring the Pools and Tunnel

At the device level:

```
router-5(config)# ip cef
router-5(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router-5(config)# **router isis**	**router ospf 100**
router-5(config-router)# **net 49.2500.1000.0000.0012.00**	**redistribute connected**
router-5(config-router)# **metric-style wide**	**network 13.1.1.0 0.0.0.255 area 0**
router-5(config-router)# **is-type level-1**	**network 14.1.1.0 0.0.0.255 area 0**
router-5(config-router)# **mpls traffic-eng level-1**	**network 25.1.1.1 0.0.0.0 area 0**

router-5(config-router)# **passive-interface Loopback0**	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router-5(config-router)# mpls traffic-eng router-id Loopback0
router-5(config-router)# exit
```

Create a virtual interface:

```
router-5(config)# interface Loopback0
router-5(config-if)# ip address 25.1.1.1 255.255.255.255
router-5(config-if)# exit
```

At the incoming network interface level:

```
router-5(config)# interface pos1/1
router-5(config-if)# ip address 13.1.1.2 255.0.0.0
router-5(config-if)# mpls traffic-eng tunnels
router-5(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 60000
[and if using IS-IS instead of OSPF]:
router-5(config-if)# ip router isis
[and in all cases]:
router-5(config-if)# exit
```

At the outgoing network interface level:

```
router-5(config)# interface pos2/1
router-5(config-if)# ip address 14.1.1.1 255.0.0.0
router-5(config-if)# mpls traffic-eng tunnels
router-5(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 60000
[and if using IS-IS instead of OSPF]:
router-5(config-if)# ip router isis
[and in all cases]:
router-5(config-if)# exit
```

Tunnel Midpoint Configurationz all XTag-ATM

When an ATM-LSR serves as a midpoint, its Virtual Switch Interface, XTagATM interfaces, and BPX or IGX switching resources must be configured. Also, one or two new MPLS commands are used on the ATM-LSR (namely, **mpls traffic-eng atm cos sub-pool** and **mpls traffic-eng atm cos global-pool**), to transfer traffic from priority queues into class-of-service (since the cell-based switch cannot examine packets).

• Configuring the Pools and Tunnel, page 47

Configuring the Pools and Tunnel

At the device level:

```
router-6(config)# ip cef
router-6(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router-6(config)# **router isis**	**router ospf 100**

router-6(config-router)# **net 49.0000.2400.0000.0011.00**	**redistribute connected**
router-6(config-router)# **metric-style wide**	**network 10.1.1.0 0.0.0.255 area 0**
router-6(config-router)# **is-type level-1**	**network 11.1.1.0 0.0.0.255 area 0**
router-6(config-router)# **mpls traffic-eng level-1**	**network 24.1.1.1 0.0.0.0 area 0**
router-6(config-router)# **passive-interface Loopback0**	**network 12.1.1.0 0.0.0.255 area 0**
router-6(config-router)#	**network 13.1.1.0 0.0.0.255 area 0**
router-6(config-router)#	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router-6(config-router)# mpls traffic-eng router-id Loopback0
router-6(config-router)# exit
```

Create a virtual interface:

```
router-6(config)# interface Loopback0
router-6(config-if)# ip address 25.1.1.1 255.255.255.255
router-6(config-if)# exit
At the device level, to coordinate traffic across the router and switch portions of the
device:
router-6(config)# interface atm9/0 0/0/0
router-6(config-if)# label-control-protocol vsi
router-6(config-if)# exit
router-6(config)# mpls traffic-eng atm cos sub-pool
router-6(config)# mpls traffic-eng atm cos global-pool premiun
```

For one incoming network interface:

router-6(config)# **interface Xtagatm22**

```
router-6(config-if)# extended-port atm9/0 bpx2.2
router-6(config-if)# ip address 10.1.1.2 255.0.0.0
router-6(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 60000
router-6(config-if)# mpls traffic-eng tunnels
router-6(config-if)# mpls atm vpi 2-15
```

[If using IS-IS instead of OSPF]:

```
router-6(config-if)# ip router isis
[and in either case]:
router-6(config-if)# exit
```

For the other incoming network interface: router-6(config)# **interface xtagatm55**

```
router-6(config-if)# extended-port atm9/0 bpx5.5
router-6(config-if)# ip address 11.1.1.2 255.0.0.0
router-6(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 60000
router-6(config-if)# mpls traffic-eng tunnels
router-6(config-if)# mpls atm vpi 2-15
```

[If using IS-IS instead of OSPF]:

```
router-6(config-if)# ip router isis
[and in either case]:
router-6(config-if)# exit
```

For one outgoing network interface: router-6(config)# **interface Xtagatm33**

```
router-6(config-if)# extended-port atm9/0 bpx3.3
router-6(config-if)# ip address 11.1.1.2 255.0.0.0
router-6(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 60000
router-6(config-if)# mpls traffic-eng tunnels
router-6(config-if)# mpls atm vpi 2-15
```

[If using IS-IS instead of OSPF]:

```
router-6(config-if)# ip router isis
[and in either case]:
router-6(config-if)# exit
```

For the other outgoing network interface: router-6(config)# **interface Xtagatm44**

```
router-6(config-if)# extended-port atm9/0 bpx4.4
router-6(config-if)# ip address 12.1.1.1 255.0.0.0
router-6(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 60000
router-6(config-if)# mpls traffic-eng tunnels
router-6(config-if)# mpls atm vpi 2-15
```

[If using IS-IS instead of OSPF]:

```
router-6(config-if)# ip router isis
[and in either case]:
router-6(config-if)# exit
```

Tunnel Midpoint Configuration LC-ATM Ingress

This 7200 midpoint router sits at the right-side edge of the MPLS ATM cloud in Figure 7. Therefore its ingress interface is LC-ATM and its egress can be either POS or ACM-PVC.

• Configuring the Pools and Tunnels, page 49

Configuring the Pools and Tunnels

At the device level:

```
router-8(config)# ip cef
router-8(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router-8(config)# **router isis**	**router ospf 100**
router-8(config-router)# **net 49.2500.1000.0000.0012.00**	**redistribute connected**
router-8(config-router)# **metric-style wide**	**network 13.1.1.0 0.0.0.255 area 0**

router-8(config-router)# **is-type level-1**	**network 14.1.1.0 0.0.0.255 area 0**
router-8(config-router)# **mpls traffic-eng level-1**	**network 25.1.1.1 0.0.0.0 area 0**
router-8(config-router)# **passive-interface Loopback0**	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router-8(config-router)# mpls traffic-eng router-id Loopback0
router-8(config-router)# exit
```

Create a virtual interface:

```
router-8(config)# interface Loopback0
router-8(config-if)# ip address 27.1.1.1 255.255.255.255
router-8(config-if)# exit
```

At the incoming network interface level:

```
router-8(config)# interface atm8/2
router-8(config-if)# mpls traffic-eng tunnels
router-8(config-if)# ip rsvp bandwidth 140000 140000\ sub-pool 60000
router-8(config-if)# interface atm8/2.0 mpls
router-8(config-subif)# ip address 13.1.1.2 255.0.0.0
router-8(config-subif)# ip rsvp bandwidth 140000 140000 sub-pool 60000
router-8(config-subif)# mpls traffic-eng tunnels
router-8(config-subif)# mpls atm vpi 2-15
[if using IS-IS instead of OSPF]:
router-8(config-subif)# ip router isis
router-8(config-subif)# exit
```

And in all cases:

```
router-8(config-if)# exit
```

For the outgoing network interface:

[ATM-PVC case appears on the left; POS case on the right]:

router-8(config)# **interface atm6/1**	**interface POS3/1**

[then continue each case at the network interface level]:

router-8(config-if)# **mpls traffic-eng tunnels**	**ip address 14.1.1.1 255.0.0.0**
router-8(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 60000**	**mpls traffic-eng tunnels**
router-8(config-if)# **interface atm6/1.3**	**ip rsvp bandwidth 140000 140000\ sub-pool 60000**
router-8(config-subif)# **ip address 14.1.1.1 255.0.0.0**	

`router-8(config-subif)#`**`ip rsvp bandwidth 140000 140000\ sub-pool 60000`**	
`router-8(config-subif)#` **`mpls traffic-eng tunnels`**	
`router-8(config-subif)#` **`atm pvc 10 10 100 aal5snap`**	
`[if using IS-IS instead of OSPF]:`	
`router-8(config-subif)#` **`ip router isis`**	
`router-8(config-subif)#` **`exit`**	
`router-8(config-if)#`	`[If using IS-IS instead of OSPF]:` **`ip router isis`**

Continuing at the network interface level, regardless of interface type:

```
router-8(config-if)# exit
```

Tunnel Tail Configuration

The inbound interfaces on the 7200 tail router are configured identically to the inbound interfaces of the midpoint routers (except, of course, for the ID of each particular interface):

• Configuring the Pools and Tunnels, page 51

Configuring the Pools and Tunnels

At the device level:

```
router-4-8-or-7(config)# ip cef
router-4-8-or-7(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

`router-4-8-or-7(config)#` **`router isis`**	**`router ospf 100`**
`router-4-8-or-7(config-router)#` **`net 49.0000.2700.0000.0000.00`**	**`redistribute connected`**
`router-4-8-or-7(config-router)#` **`metric-style wide`**	**`network 12.1.1.0 0.0.0.255 area 0`**
`router-4-8-or-7(config-router)#` **`is-type level-1`**	**`network 14.1.1.0 0.0.0.255 area 0`**

router-4-8-or-7(config-router)# **mpls traffic-eng level-1**	**network 27.1.1.1 0.0.0.0 area 0**
router-4-8-or-7(config-router)# **passive-interface Loopback0**	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router-4-8-or-7(config-router)# mpls traffic-eng router-id Loopback0
router-4-8-or-7(config-router)# exit
```

Create a virtual interface:

```
router-4-8-or-7(config)# interface Loopback0
router-4-8-or-7(config-if)# ip address 27.1.1.1 255.255.255.255
[but on router-7 in Figure 7 use ip address 28.1.1.1 255.255.255.255
]
router-4-8-or-7(config-if)# exit
```

For the incoming network interface, first at the device level:

[LC-ATM case appears on the left; POS case on the right]:

router-4-8-or-7(config)# **interface atm8/1**	**interface POS2/1**

[then continue each case at the network interface level]:

router-4-8-or-7(config-if)# **mpls traffic-eng tunnels**	**ip address 12.1.1.2 255.0.0.0**
router-4-8-or-7(config-if)# **ip rsvp bandwidth 140000\ 140000 sub-pool 60000**	**mpls traffic-eng tunnels**
router-4-8-or-7(config-if)# **interface atm8/1.2 mpls**	**ip rsvp bandwidth 140000 140000\ sub-pool 60000**
router-4-8-or-7(config-subif)# **ip address 12.1.1.2 255.0.0.0**	
router-4-8-or-7(config-subif)#**ip rsvp bandwidth 140000\ 140000 sub-pool 60000**	
router-4-8-or-7(config-subif)# **mpls traffic-eng tunnels**	
router-4-8-or-7(config-subif)# **mpls atm vpi 2-5**	
[if using IS-IS instead of OSPF]:	
router-4-8-or-7(config-subif)# **ip router isis**	
router-4-8-or-7(config-subif)# **exit**	

`router-4-8-or-7(config-if)#`	`[If using IS-IS instead of OSPF]:` **`ip router isis`**

Continuing at the network interface level, regardless of interface type:

```
router-4-8-or-7(config-if)# exit
```

Because the tunnel ends on the tail (does not include any outbound interfaces of the tail router), no outbound QoS configuration is used.

Example with Many Destination Prefixes

The two figures below illustrate topologies for guaranteed bandwidth services whose destinations are a set of prefixes. In the first figure below the interfaces to be configured are POS (Packet over SONET), while in second figure below the interfaces are ATM-PVC (Asynchronous Transfer Mode – Permanent Virtual Circuit). In both illustrations, the destinations' prefixes usually share some common properties such as belonging to the same Autonomous System (AS) or transiting through the same AS. Although the individual prefixes may change dynamically because of route flaps in the downstream autonomous systems, the properties the prefixes share will not change. Policies addressing the destination prefix set are enforced through Border Gateway Protocol (BGP), which is described in the following documents:

- "Configuring QoS Policy Propagation via Border Gateway Protocol" in the *Cisco IOS Quality of Service Solutions Configuration Guide*, Release 12.1 (http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/qos_c/qcprt1/qcdprop.htm)
- "Configuring BGP" in the *Cisco IOS IP and IP Routing Configuration Guide*, Release 12.1 (http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/ip_c/ipcprt2/1cdbgp.htm)
- "BGP Commands" in the *Cisco IOS IP and IP Routing Command Reference*, Release 12.1 (http://www.cisco.com/univercd/cc/td/doc/product/software/ios121/121cgcr/ip_r/iprprt2/1rdbgp.htm)

In this example, three guaranteed bandwidth services are offered:

- Traffic coming from Site A (defined as all traffic arriving at interface FE4/0) and from Site C (defined as all traffic arriving at interface FE2/1) destined to AS5
- Traffic coming from Sites A and C that transits AS5 but is not destined to AS5. (In the figure, the transiting traffic will go to AS6 and AS7)

- Traffic coming from Sites A and C destined to prefixes advertised with a particular BGP community attribute (100:1). In this example, Autonomous Systems #3, #5, and #8 are the BGP community assigned the attribute 100:1.

Figure 8 Sample Topology for Guaranteed Bandwidth Service (traversing POS interfaces) to Many Destination Prefixes

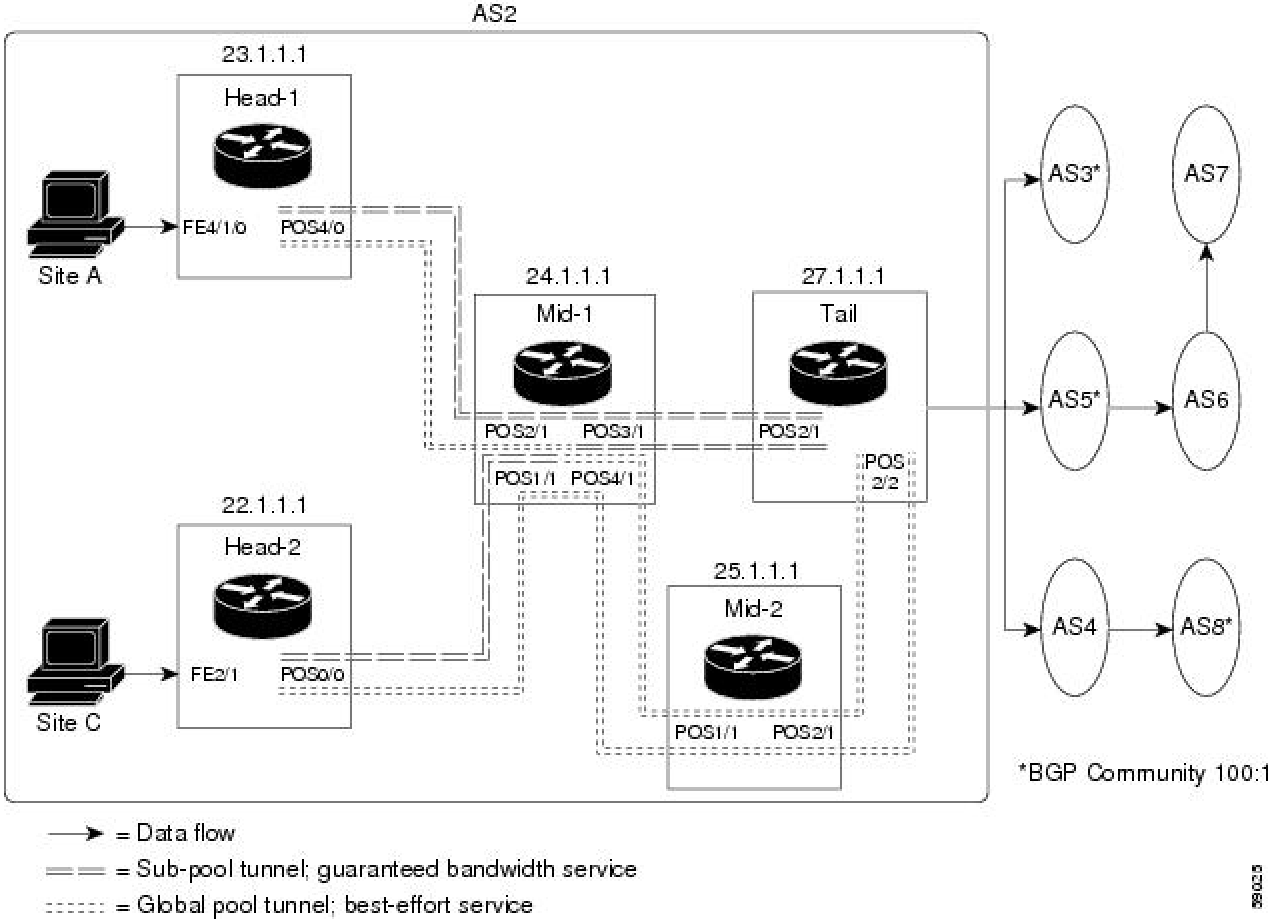
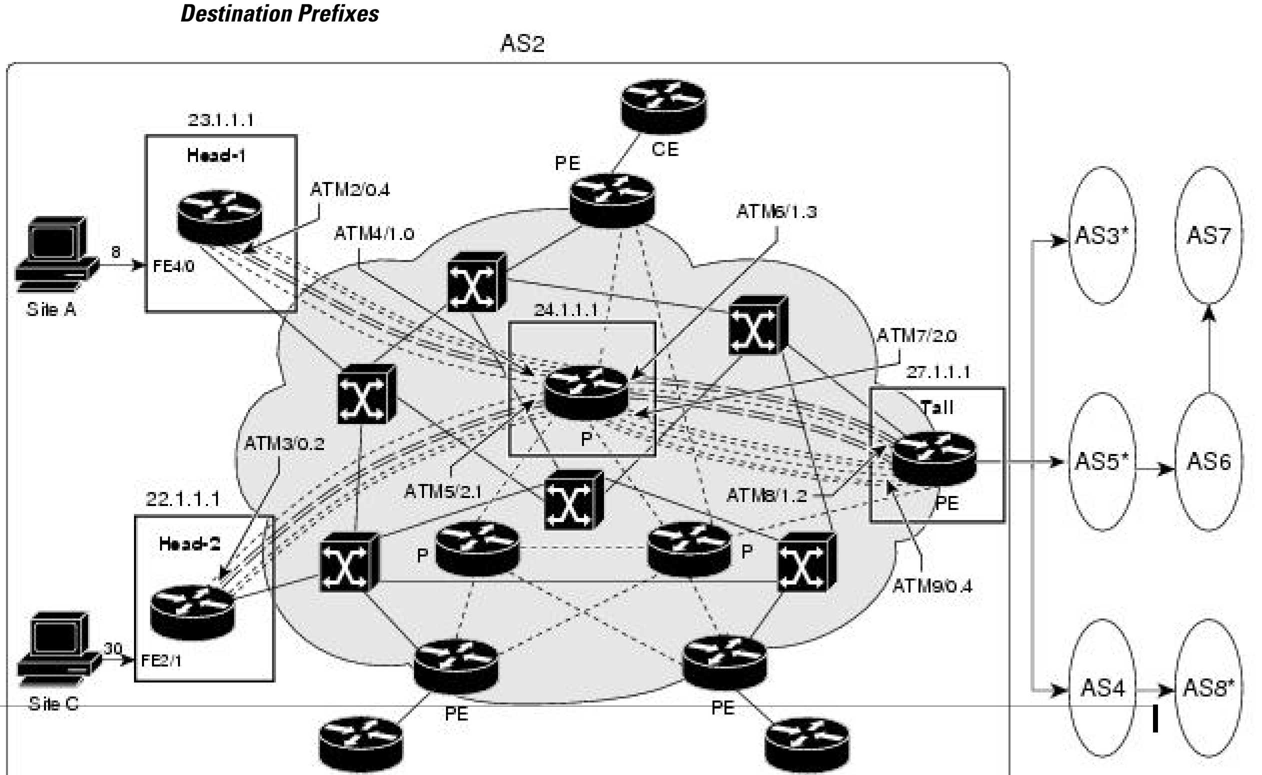


Figure 9 Sample Topology for Guaranteed Bandwidth Service (traversing ATM-PVC interfaces) to Many Destination Prefixes



The applicability of guaranteed bandwidth service is not limited to the three types of multiple destination scenarios described above. There is not room in this document to present all possible scenarios. These three were chosen as representative of the wide range of possible deployments.

The guaranteed bandwidth services run through two sub-pool tunnels:

- From the Head-1 router, 23.1.1.1, to the tail
- From the Head-2 router, 22.1.1.1, to that same tail

In addition, a global pool tunnel has been configured from each head end, to carry best-effort traffic to the same destinations. All four tunnels use the same tail router, even though they have different heads and differ in their passage through the midpoint(s). (Of course in the real world there would likely be many more midpoints than just the one or two shown here.)

All POS and ATM-PVC interfaces in this example are OC3, whose capacity is 155 Mbps.

Configuring a multi-destination guaranteed bandwidth service involves:

- Building a sub-pool MPLS-TE tunnel
- Configuring DiffServ QoS
- Configuring QoS Policy Propagation via BGP (QPPB)
- Mapping traffic onto the tunnels

All of these tasks are included in the following example.

Tunnel Head Configuration Head-1

First we recapitulate commands that establish a sub-pool tunnel (commands presented earlier on page 9) and now we also configure a global pool tunnel. Additionally, we present QoS and BGP commands that guarantee end-to-end service on the sub-pool tunnel. (With the 7200 router, Modular QoS CLI is used).

Configuring the Pools and Tunnels

At the device level:

```
router-1(config)# ip cef
router-1(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router-1(config)# **router isis**	**router ospf 100**
router-1(config-router)# **net 49.0000.1000.0000.0010.00**	**redistribute connected**
router-1(config-router)# **metric-style wide**	**network 10.1.1.0 0.0.0.255 area 0**
router-1(config-router)# **is-type level-1**	**network 23.1.1.1 0.0.0.0 area 0**
router-1(config-router)# **mpls traffic-eng level-1**	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router-1(config-router)# mpls traffic-eng router-id Loopback0
router-1(config-router)# exit
```

Create a virtual interface:

```
router-1(config)# interface Loopback0
router-1(config-if)# ip address 23.1.1.1 255.255.255.255
router-1(config-if)# exit
```

For the outgoing network interface:

[ATM-PVC case appears on the left; POS case on the right]:

router-1(config)# **interface atm2/0**	**interface POS4/0**

[then continue each case at the network interface level:

router-1(config-if)# **mpls traffic-eng tunnels**	**ip address 10.1.1.1 255.0.0.0**
router-1(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 60000**	**mpls traffic-eng tunnels**
router-1(config-if)# **interface atm2/0.4**	**ip rsvp bandwidth 140000 140000\ sub-pool 60000**
router-1(config-subif)# **ip address 10.1.1.1 0.0.0.0**	
router-1(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 60000**	
router-1(config-subif)# **mpls traffic-eng tunnels**	
router-1(config-subif)# **atm pvc 10 10 100 aal5snap**	

```
[if using IS-IS instead of OSPF]:
```

```
router-1(config-subif)# ip router isis
```

```
router-1(config-subif)# exit
```

Continuing at the network interface level, regardless of interface type: [If using IS-IS instead of OSPF]:

```
router-1(config-if)# ip router isis
[and in all cases]:
router-1(config-if)# exit
```

At one tunnel interface, create a sub-pool tunnel:

```
router-1(config)# interface Tunnel1
router-1(config-if)# ip unnumbered Loopback0
router-1(config-if)# tunnel destination 27.1.1.1
router-1(config-if)# tunnel mode mpls traffic-eng
router-1(config-if)# tunnel mpls traffic-eng priority 0 0
router-1(config-if)# tunnel mpls traffic-eng bandwidth sub-pool 40000
router-1(config-if)# tunnel mpls traffic-eng path-option 1 explicit name gbs-path1
router-1(config-if)# exit
```

and at a second tunnel interface, create a global pool tunnel:

```
router-1(config)# interface Tunnel2
router-1(config-if)# ip unnumbered Loopback0
router-1(config-if)# tunnel destination 27.1.1.1
router-1(config-if)# tunnel mode mpls traffic-eng
router-1(config-if)# tunnel mpls traffic-eng priority 0 0
router-1(config-if)# tunnel mpls traffic-eng bandwidth 80000
router-1(config-if)# tunnel mpls traffic-eng path-option 1 explicit name \ best-effort-
path1
router-1(config-if)# exit
```

In this example explicit paths are used instead of dynamic, to ensure that best-effort traffic and guaranteed bandwidth traffic will travel along different paths.

At the device level:

```
router-1(config)# ip explicit-path name gbs-path1
router-1(config-ip-expl-path)# next-address 24.1.1.1
router-1(config-ip-expl-path)# next-address 27.1.1.1
router-1(config-ip-expl-path)# exit
router-1(config)# ip explicit-path name best-effort-path1
router-1(config-ip-expl-path)# next-address 24.1.1.1
router-1(config-ip-expl-path)# next-address 25.1.1.1
router-1(config-ip-expl-path)# next-address 27.1.1.1
router-1(config-ip-expl-path)# exit
```

Note that autoroute is not used, as that could cause the Interior Gateway Protocol (IGP) to send other traffic down these tunnels.

Configuring DiffServ QoS

At the inbound network interface (in Figure 8 and Figure 9 this is FE4/0), packets received are rate-limited to:

- a rate of 30 Mbps
- a normal burst of 1 MB
- a maximum burst of 2 MB

Packets that are mapped to qos-group 6 and that conform to the rate-limit are marked with experimental value 5 and the BGP destination community string, and are forwarded; packets that do not conform (exceed action) are dropped:

```
router-1(config)# interface FastEthernet4/0
router-1(config-if)# rate-limit input qos-group 6 30000000 1000000 2000000 \
 conform-action set-mpls-exp-transmit 5 exceed-action drop
router-1(config-if)# bgp-policy destination ip-qos-map
router-1(config-if)# exit
```

At the device level create a class of traffic called "exp5-class" that has MPLS experimental bit set to 5:

```
router-1(config)# class-map match-all exp5-class
router-1(config-cmap)# match mpls experimental 5
router-1(config-cmap)# exit
```

Create a policy that creates a priority queue for "exp5-class":

```
router-1(config)# policy-map core-out-policy
router-1(config-pmap)# class exp5-class
router-1(config-pmap-c)# priority 100000
router-1(config-pmap-c)# exit
router-1(config-pmap)# class class-default
router-1(config-pmap-c)# bandwidth 55000
router-1(config-pmap-c)# exit
router-1(config-pmap)# exit
```

The policy is applied to packets exiting subinterface ATM2/0.4 (first example) or interface POS4/0 (second example)?:

```
interface atm2/0
interface atm2/0.4
service-policy output core-out-policy


interface POS4/0
service-policy output\ core-out-policy
```

Configuring QoS Policy Propagation via BGP

For All GB Services

Create a table map under BGP to map (tie) the prefixes to a qos-group. At the device level:

```
router-1(config)# router bgp 2
router-1(config-router)# no synchronization
router-1(config-router)# table-map set-qos-group
router-1(config-router)# bgp log-neighbor-changes
router-1(config-router)# neighbor 27.1.1.1 remote-as 2
router-1(config-router)# neighbor 27.1.1.1 update-source Loopback0
router-1(config-router)# no auto-summary
router-1(config-router)# exit
```

For GB Service Destined to AS5

Create a distinct route map for this service. This includes setting the next-hop of packets matching 29.1.1.1 (a virtual loopback configured in the tail router; see page 57) so they will be mapped onto Tunnel #1 (the guaranteed bandwidth service tunnel). At the device level:

```
router-1(config)# route-map set-qos-group permit 10
router-1(config-route-map)# match as-path 100
router-1(config-route-map)# set ip qos-group 6
router-1(config-route-map)# set ip next-hop 29.1.1.1
```

```
router-1(config-route-map)# exit
router-1(config)# ip as-path access-list 100 permit ^5$
```

For GB Service Transiting through AS5

Create a distinct route map for this service. (Its traffic will go to AS6 and AS7).

At the device level:

```
router-1(config)# route-map set-qos-group permit 10
router-1(config-route-map)# match as-path 101
router-1(config-route-map)# set ip qos-group 6
router-1(config-route-map)# set ip next-hop 29.1.1.1
router-1(config-route-map)# exit
router-1(config)# ip as-path access-list 101 permit _5_
```

For GB Service Destined to Community 100:1

Create a distinct route map for all traffic destined to prefixes that have community value 100:1. This traffic will go to AS3, AS5, and AS8.

At the device level:

```
router-1(config)# route-map set-qos-group permit 10
router-1(config-route-map)# match community 20
router-1(config-route-map)# set ip qos-group 6
router-1(config-route-map)# set ip next-hop 29.1.1.1
router-1(config-route-map)# exit
router-1(config)# ip community-list 20 permit 100:1
```

Mapping Traffic onto the Tunnels

Map all guaranteed bandwidth traffic onto Tunnel #1:

```
router-1(config)# ip route 29.1.1.1 255.255.255.255 Tunnel1
```

Map all best-effort traffic (traveling toward another virtual loopback interface, 30.1.1.1, configured in the tail router) onto Tunnel #2:

```
router-1(config)# ip route 30.1.1.1 255.255.255.255 Tunnel2
```

Tunnel Head Configuration Head-2

As with the Head-1 device and interfaces, the following Head-2 configuration first presents commands that establish a sub-pool tunnel (commands presented earlier on page 9) and then also configures a global pool tunnel. After that it presents QoS and BGP commands that guarantee end-to-end service on the sub-pool tunnel. (Because this is a 7200 router, Modular QoS CLI is used).

Configuring the Pools and Tunnels

At the device level:

```
router-2(config)# ip cef
router-2(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router-2(config)# **router isis**	**router ospf 100**
router-2(config-router)# **net 49.0000.1000.0000.0011.00**	**redistribute connected**
router-2(config-router)# **metric-style wide**	**network 11.1.1.0 0.0.0.255 area 0**
router-2(config-router)# **is-type level-1**	**network 22.1.1.1 0.0.0.0 area 0**
router-2(config-router)# **mpls traffic-eng level-1**	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router-2(config-router)# mpls traffic-eng router-id Loopback0
router-2(config-router)# exit
```

Create a virtual interface:

```
router-2(config)# interface Loopback0
router-2(config-if)# ip address 22.1.1.1 255.255.255.255
router-2(config-if)# exit
```

For the outgoing network interface:

[ATM-PVC case appears on the left; POS case on the right]:

router-2(config)# **interface atm3/0**	**interface POS0/0**

[then continue each case at the network interface level:

router-2(config-if)# **mpls traffic-eng tunnels**	**ip address 11.1.1.1 255.0.0.0**
router-2(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 60000**	**mpls traffic-eng tunnels**
router-2(config-if)# **interface atm3/0.2**	**ip rsvp bandwidth 140000 140000\ sub-pool 60000**
router-2(config-subif)# **ip address 11.1.1.1 255.0.0.0**	

router-2(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 60000**
router-2(config-subif)# **mpls traffic-eng tunnels**
router-2(config-subif)# **atm pvc 10 10 100 aal5snap**
[if using IS-IS instead of OSPF]:
router-2(config-subif)# **ip router isis**
router-2(config-subif)# **exit**

Continuing at the network interface level, regardless of interface type: [If using IS-IS instead of OSPF]:

```
router-2(config-if)# ip router isis
[and in all cases]:
router-2(config-if)# exit
```

At one tunnel interface, create a sub-pool tunnel:

```
router-2(config)# interface Tunnel3
router-2(config-if)# ip unnumbered Loopback0
router-2(config-if)# tunnel destination 27.1.1.1
router-2(config-if)# tunnel mode mpls traffic-eng
router-2(config-if)# tunnel mpls traffic-eng priority 0 0
router-2(config-if)# tunnel mpls traffic-eng bandwidth sub-pool 30000
router-2(config-if)# tunnel mpls traffic-eng path-option 1 explicit name gbs-path2
router-2(config-if)# exit
```

and at a second tunnel interface, create a global pool tunnel:

```
router-2(config)# interface Tunnel4
router-2(config-if)# ip unnumbered Loopback0
router-2(config-if)# tunnel destination 27.1.1.1
router-2(config-if)# tunnel mode mpls traffic-eng
router-2(config-if)# tunnel mpls traffic-eng priority 0 0
router-2(config-if)# tunnel mpls traffic-eng bandwidth 70000
router-2(config-if)# tunnel mpls traffic-eng path-option 1 explicit name \ best-effort-
path2
router-2(config-if)# exit
```

In this example explicit paths are used instead of dynamic, to ensure that best-effort traffic and guaranteed bandwidth traffic will travel along different paths.

At the device level:

```
router-2(config)# ip explicit-path name gbs-path2
router-2(config-ip-expl-path)# next-address 24.1.1.1
router-2(config-ip-expl-path)# next-address 27.1.1.1
router-2(config-ip-expl-path)# exit
router-2(config)# ip explicit-path name best-effort-path2
router-2(config-ip-expl-path)# next-address 24.1.1.1
router-2(config-ip-expl-path)# next-address 25.1.1.1
router-2(config-ip-expl-path)# next-address 27.1.1.1
router-2(config-ip-expl-path)# exit
```

Note that autoroute is not used, as that could cause the Interior Gateway Protocol (IGP) to send other traffic down these tunnels.

Configuring DiffServ QoS

At the inbound network interface (in Figure 8 and Figure 9 this is FE2/1), packets received are rate-limited to:

- a rate of 30 Mbps
- a normal burst of 1 MB
- a maximum burst of 2 MB

Packets that are mapped to qos-group 6 and that conform to the rate-limit are marked with experimental value 5 and the BGP destination community string, and are forwarded; packets that do not conform (exceed action) are dropped:

```
router-2(config)# interface FastEthernet2/1
router-2(config-if)# rate-limit input qos-group 6 30000000 1000000 2000000 \
 conform-action set-mpls-exp-transmit 5 exceed-action drop
router-2(config-if)# bgp-policy destination ip-qos-map
router-2(config-if)# exit
```

At the device level create a class of traffic called "exp5-class" that has MPLS experimental bit set to 5:

```
router-2(config)# class-map match-all exp5-class
router-2(config-cmap)# match mpls experimental 5
router-2(config-cmap)# exit
```

Create a policy that creates a priority queue for "exp5-class":

```
router-2(config)# policy-map core-out-policy
router-2(config-pmap)# class exp5-class
router-2(config-pmap-c)# priority 100000
router-2(config-pmap-c)# exit
router-2(config-pmap)# class class-default
router-2(config-pmap-c)# bandwidth 55000
router-2(config-pmap-c)# exit
router-2(config-pmap)# exit
```

The policy is applied to packets exiting subinterface ATM3/0.2 (left side) or interface POS0/0 (right side):

`interface atm3/0`	`interface POS0/0`
`interface atm3/0.2`	`service-policy output\ core-out-policy`
`service-policy output core-out-policy`	

Configuring QoS Policy Propagation via BGP

For All GB Services

Create a table map under BGP to map (tie) the prefixes to a qos-group. At the device level:

```
router-2(config)# router bgp 2
router-2(config-router)# no synchronization
router-2(config-router)# table-map set-qos-group
router-2(config-router)# bgp log-neighbor-changes
router-2(config-router)# neighbor 27.1.1.1 remote-as 2
router-2(config-router)# neighbor 27.1.1.1 update-source Loopback0
```

```
router-2(config-router)# no auto-summary
router-2(config-router)# exit
```

For GB Service Destined to AS5

Create a distinct route map for this service. This includes setting the next-hop of packets matching 29.1.1.1 (a virtual loopback configured in the tail router; see page 57) so they will be mapped onto Tunnel #3 (th e guaranteed bandwidth service tunnel). At the device level:

```
router-2(config)# route-map set-qos-group permit 10
router-2(config-route-map)# match as-path 100
router-2(config-route-map)# set ip qos-group 6
router-2(config-route-map)# set ip next-hop 29.1.1.1
router-2(config-route-map)# exit
router-2(config)# ip as-path access-list 100 permit ^5$
```

For GB Service Transiting through AS5

Create a distinct route map for this service. (Its traffic will go to AS6 and AS7).

At the device level:

```
router-2(config)# route-map set-qos-group permit 10
router-2(config-route-map)# match as-path 101
router-2(config-route-map)# set ip qos-group 6
router-2(config-route-map)# set ip next-hop 29.1.1.1
router-2(config-route-map)# exit
router-2(config)# ip as-path access-list 101 permit _5_
```

For GB Service Destined to Community 100:1

Create a distinct route map for all traffic destined to prefixes that have community value 100:1. This traffic will go to AS3, AS5, and AS8.

At the device level:

```
router-2(config)# route-map set-qos-group permit 10
router-2(config-route-map)# match community 20
router-2(config-route-map)# set ip qos-group 6
router-2(config-route-map)# set ip next-hop 29.1.1.1
router-2(config-route-map)# exit
router-2(config)# ip community-list 20 permit 100:1
```

Mapping Traffic onto the Tunnels

Map all guaranteed bandwidth traffic onto Tunnel #3:

```
router-2(config)# ip route 29.1.1.1 255.255.255.255 Tunnel3
```

Map all best-effort traffic onto Tunnel #4 (traveling toward another virtual loopback interface, 30.1.1.1, configured in the tail router):

```
router-2(config)# ip route 30.1.1.1 255.255.255.255 Tunnel4
```

Tunnel Midpoint Configuration Mid-1

All four interfaces on the midpoint router are configured very much like the outbound interface of the head router. The strategy is to have all mid-point routers in this Autonomous System ready to carry future as well as presently configured sub-pool and global pool tunnels.

• Configuring the Pools and Tunnels, page 64

Configuring the Pools and Tunnels

At the device level:

```
router-3(config)# ip cef
router-3(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router-3(config)# **router isis**	**router ospf 100**
router-3(config-router)# **net 49.0000.2400.0000.0011.00**	**redistribute connected**
router-3(config-router)# **metric-style wide**	**network 10.1.1.0 0.0.0.255 area 0**
router-3(config-router)# **is-type level-1**	**network 11.1.1.0 0.0.0.255 area 0**
router-3(config-router)# **mpls traffic-eng level-1**	**network 24.1.1.1 0.0.0.0 area 0**
router-3(config-router)#	**network 12.1.1.0 0.0.0.255 area 0**
router-3(config-router)#	**network 13.1.1.0 0.0.0.255 area 0**
router-3(config-router)#	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router-3(config-router)# mpls traffic-eng router-id Loopback0
router-3(config-router)# exit
```

Create a virtual interface:

```
router-3(config)# interface Loopback0
router-3(config-if)# ip address 24.1.1.1 255.255.255.255
router-3(config-if)# exit
```

At one incoming network interface:

[ATM-PVC case appears on the left; POS case on the right]:

router-3(config)# **interface atm4/1**	**interface POS2/1**

[then continue each case at the network interface level:

router-3(config-if)# **mpls traffic-eng tunnels**	**ip address 10.1.1.2 255.0.0.0**
router-3(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 70000**	**mpls traffic-eng tunnels**

router-3(config-if)# **interface atm4/1.0**	**ip rsvp bandwidth 140000 140000\ sub-pool 70000**
router-3(config-subif)# **ip address 10.1.1.2 255.0.0.0**	
router-3(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 70000**	
router-3(config-subif)# **mpls traffic-eng tunnels**	
router-3(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-3(config-subif)# **ip router isis**	
router-3(config-subif)# **exit**	

Continuing at the network interface level, regardless of interface type: [If using IS-IS instead of OSPF]:

```
router-3(config-if)# ip router isis
[and in all cases]:
router-3(config-if)# exit
```

At the other incoming network interface:

[ATM-PVC case appears on the left; POS case on the right]:

router-3(config)# **interface atm5/2**	**interface POS1/1**

[then continue each case at the network interface level:

router-3(config-if)# **mpls traffic-eng tunnels**	**ip address 11.1.1.2 255.0.0.0**
router-3(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 70000**	**mpls traffic-eng tunnels**
router-3(config-if)# **interface atm5/2.1**	**ip rsvp bandwidth 140000 140000\ sub-pool 70000**
router-3(config-subif)# **ip address 11.1.1.2 255.0.0.0**	
router-3(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 70000**	

router-3(config-subif)# **mpls traffic-eng tunnels**	
router-3(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-3(config-subif)# **ip router isis**	
router-3(config-subif)# **exit**	

Continuing at the network interface level, regardless of interface type: [If using IS-IS instead of OSPF]:

```
router-3(config-if)# ip router isis
[and in all cases]:
router-3(config-if)# exit
```

At the outgoing network interface through which two sub-pool tunnels currently exit:

[ATM-PVC case appears on the left; POS case on the right]:

router-3(config)# **interface atm6/1**	**interface POS3/1**

[then continue each case at the network interface level:

router-3(config-if)# **mpls traffic-eng tunnels**	**ip address 12.1.1.1 255.0.0.0**
router-3(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 70000**	**mpls traffic-eng tunnels**
router-3(config-if)# **interface atm6/1.3**	**ip rsvp bandwidth 140000 140000\ sub-pool 70000**
router-3(config-subif)# **ip address 12.1.1.1 255.0.0.0**	
router-3(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 70000**	
router-3(config-subif)# **mpls traffic-eng tunnels**	
router-3(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-3(config-subif)# **ip router isis**	

router-3(config-subif)# **exit**

Continuing at the network interface level, regardless of interface type: [If using IS-IS instead of OSPF]:

```
router-3(config-if)# ip router isis
[and in all cases]:
router-3(config-if)# exit
```

At the outgoing network interface through which two global pool tunnels currently exit:

[ATM-PVC case appears on the left; POS case on the right]:

router-3(config)# **interface atm7/2**	**interface POS4/1**

[then continue each case at the network interface level:

router-3(config-if)# **mpls traffic-eng tunnels**	**ip address 13.1.1.1 255.0.0.0**
router-3(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 70000**	**mpls traffic-eng tunnels**
router-3(config-if)# **interface atm7/2.0**	**ip rsvp bandwidth 140000 140000\ sub-pool 70000**
router-3(config-subif)# **ip address 13.1.1.1 255.0.0.0**	
router-3(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 70000**	
router-3(config-subif)# **mpls traffic-eng tunnels**	
router-3(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-3(config-subif)# **ip router isis**	
router-3(config-subif)# **exit**	

Continuing at the network interface level, regardless of interface type: [If using IS-IS instead of OSPF]:

```
router-3(config-if)# ip router isis
[and in all cases]:
router-3(config-if)# exit
```

Tunnel Midpoint Configuration Mid-2

[For the sake of simplicity, only the POS example (Figure 8) is illustrated with a second midpoint router.] Both interfaces on this midpoint router are configured like the outbound interfaces of the Mid-1 router.

• Configuring the Pools and Tunnels, page 68

Configuring the Pools and Tunnels

At the device level:

```
router-5(config)# ip cef
router-5(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right]:

router-5(config)# **router isis**	**router ospf 100**
router-5(config-router)# **net 49.2500.1000.0000.0012.00**	**redistribute connected**
router-5(config-router)# **metric-style wide**	**network 13.1.1.0 0.0.0.255 area 0**
router-5(config-router)# **is-type level-1**	**network 14.1.1.0 0.0.0.255 area 0**
router-5(config-router)# **mpls traffic-eng level-1**	**network 25.1.1.1 0.0.0.0 area 0**
router-5(config-router)#	**mpls traffic-eng area 0**

[now one resumes the common command set]:

```
router-5(config-router)# mpls traffic-eng router-id Loopback0
router-5(config-router)# exit
```

Create a virtual interface:

```
router-5(config)# interface Loopback0
router-5(config-if)# ip address 25.1.1.1 255.255.255.255
router-5(config-if)# exit
```

At the incoming network interface:

```
router-5(config)# interface pos1/1
router-5(config-if)# ip address 13.1.1.2 255.0.0.0
router-5(config-if)# mpls traffic-eng tunnels
router-5(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 70000
[and if using IS-IS instead of OSPF]:
router-5(config-if)# ip router isis
[and in all cases]:
router-5(config-if)# exit
```

At the outgoing network interface:

```
router-5(config)# interface pos2/1
router-5(config-if)# ip address 14.1.1.1 255.0.0.0
```

```
router-5(config-if)# mpls traffic-eng tunnels
router-5(config-if)# ip rsvp bandwidth 140000 140000 sub-pool 70000
[and if using IS-IS instead of OSPF]:
router-5(config-if)# ip router isis
[and in all cases]:
router-5(config-if)# exit
```

Tunnel Tail Configuration

The inbound interfaces on the tail router are configured much like the outbound interfaces of the midpoint routers:

- Configuring the Pools and Tunnels, page 69
- Configuring QoS Policy Propagation, page 71

Configuring the Pools and Tunnels

At the device level:

```
router-4(config)# ip cef
router-4(config)# mpls traffic-eng tunnels
```

[now one uses either the IS-IS commands on the left or the OSPF commands on the right. In the case of OSPF, one must advertise two new loopback interfaces--29.1.1.1 and 30.1.1.1 in our example--which are defined in the QoS Policy Propagation section, further along on this page]:

router-4(config)# **router isis**	**router ospf 100**
router-4(config-router)# **net 49.0000.2700.0000.0000.00**	**redistribute connected**
router-4(config-router)# **metric-style wide**	**network 12.1.1.0 0.0.0.255 area 0**
router-4(config-router)# **is-type level-1**	**network 14.1.1.0 0.0.0.255 area 0**
router-4(config-router)# **mpls traffic-eng level-1**	**network 27.1.1.1 0.0.0.0 area 0**
router-4(config-router)#	**network 29.1.1.1 0.0.0.0 area 0**
router-4(config-router)#	**network 30.1.1.1 0.0.0.0 area 0**
router-4(config-router)#	**mpls traffic-eng area 0**

[now one resumes the common command set, taking care to include the two additional loopback interfaces]:

```
router-4(config-router)# mpls traffic-eng router-id Loopback0
router-4(config-router)# mpls traffic-eng router-id Loopback1
router-4(config-router)# mpls traffic-eng router-id Loopback2
router-4(config-router)# exit
```

Create a virtual interface:

```
router-4(config)# interface Loopback0
```

```
router-4(config-if)# ip address 27.1.1.1 255.255.255.255
router-4(config-if)# exit
```

At one incoming network interface:

[ATM-PVC case appears on the left; POS case on the right]:

router-4(config)# **interface atm8/1**	**interface POS2/1**

[then continue each case at the network interface level:

router-4(config-if)# **mpls traffic-eng tunnels**	**ip address 12.1.1.2 255.0.0.0**
router-4(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 70000**	**mpls traffic-eng tunnels**
router-4(config-if)# **interface atm8/1.2**	**ip rsvp bandwidth 140000 140000\ sub-pool 70000**
router-4(config-subif)# **ip address 12.1.1.2 255.0.0.0**	
router-4(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 70000**	
router-4(config-subif)# **mpls traffic-eng tunnels**	
router-4(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-4(config-subif)# **ip router isis**	
router-4(config-subif)# **exit**	

Continuing at the network interface level, regardless of interface type: [If using IS-IS instead of OSPF]:

```
router-4(config-if)# ip router isis
[and in all cases]:
router-4(config-if)# exit
```

At the other incoming network interface:

[ATM-PVC case appears on the left; POS case on the right]:

router-4(config)# **interface atm8/1**	**interface POS2/2**

[then continue each case at the network interface level:

router-4(config-if)# **mpls traffic-eng tunnels**	**ip address 14.1.1.2 255.0.0.0**
router-4(config-if)# **ip rsvp bandwidth 140000 140000\ sub-pool 70000**	**mpls traffic-eng tunnels**
router-4(config-if)# **interface atm8/1.2**	**ip rsvp bandwidth 140000 140000\ sub-pool 70000**
router-4(config-subif)# **ip address 14.1.1.2 255.0.0.0**	
router-4(config-subif)#**ip rsvp bandwidth 140000 140000\ sub-pool 70000**	
router-4(config-subif)# **mpls traffic-eng tunnels**	
router-4(config-subif)# **atm pvc 10 10 100 aal5snap**	
[if using IS-IS instead of OSPF]:	
router-4(config-subif)# **ip router isis**	
router-4(config-subif)# **exit**	

Continuing at the network interface level, regardless of interface type: [If using IS-IS instead of OSPF]:

```
router-4(config-if)# ip router isis
[and in all cases]:
router-4(config-if)# exit
```

Configuring QoS Policy Propagation

On the tail device, one must configure a separate virtual loopback IP address for each class-of-service terminating here. The headend routers need these addresses to map traffic into the proper tunnels. In the current example, four tunnels terminate on the same tail device but they represent only two service classes, so only two additional loopback addresses are needed:

Create two virtual interfaces:

```
router-4(config)# interface Loopback1
router-4(config-if)# ip address 29.1.1.1 255.255.255.255
[and if using IS-IS instead of OSPF]:
router-4(config-if)# ip router isis
[and in all cases]:
router-4(config-if)# exit
router-4(config)# interface Loopback2
router-4(config-if)# ip address 30.1.1.1 255.255.255.255
[and if using IS-IS instead of OSPF]:
router-4(config-if)# ip router isis
[and in all cases]:
router-4(config-if)# exit
```

At the device level, configure BGP to send the community to each tunnel head:

```
router-4(config)# router bgp 2
router-4(config-router)# neighbor 23.1.1.1 send-community
router-4(config-router)# neighbor 22.1.1.1 send-community
router-4(config-router)# exit
```

Command Reference

The following commands are introduced or modified in the feature or features documented in this module. For information about these commands, see the *Cisco IOS Asynchronous Transfer Mode Command Reference*. For information about all Cisco IOS commands, go to the Command Lookup Tool at http://tools.cisco.com/Support/CLILookup or to the *Cisco IOS Master Commands List*.

- **debug mpls traffic-engineering link-management preemption**
- **extended-port**
- **interface**
- **ip cef**
- **ip router isis**
- **ip rsvp bandwidth**
- **is-type**
- **metric-style wide**
- **mpls traffic-eng**
- **mpls traffic-eng administrative-weight**
- **mpls traffic-eng area**
- **mpls traffic-eng atm cos global-pool**
- **mpls traffic-eng atm cos sub-pool**
- **mpls traffic-eng attribute-flags**
- **mpls traffic-eng backup-path tunnel**
- **mpls traffic-eng flooding thresholds**
- **mpls traffic-eng link timers bandwidth-hold**
- **mpls traffic-eng link timers periodic-flooding**
- **mpls traffic-eng reoptimize timers frequency**
- **mpls traffic-eng router-id**
- **mpls traffic-eng tunnels (configuration)**
- **mpls traffic-eng tunnels (interface)**
- **net**
- **passive-interface**
- **router isis**
- **router ospf**
- **show interfaces tunnel**
- **show ip ospf**
- **show ip route**
- **show ip rsvp host**
- **show ip rsvp interface**
- **show mpls traffic-eng autoroute**
- **show mpls traffic-eng fast-reroute database**
- **show mpls traffic-eng fast-reroute log reroutes**

- **show mpls traffic-eng link-management admission-control**
- **show mpls traffic-eng link-management advertisements**
- **show mpls traffic-eng link-management bandwidth-allocation**
- **show mpls traffic-eng link-management igp-neighbors**
- **show mpls traffic-eng link-management interfaces**
- **show mpls traffic-eng link-management summary**
- **show mpls traffic-eng topology**
- **show mpls traffic-eng tunnels**
- **mpls atm vpi**
- **tunnel destination**
- **tunnel mode mpls traffic-eng**
- **tunnel mpls traffic-eng affinity**
- **tunnel mpls traffic-eng autoroute announce**
- **tunnel mpls traffic-eng autoroute metric**
- **tunnel mpls traffic-eng bandwidth**
- **tunnel mpls traffic-eng fast-reroute**
- **tunnel mpls traffic-eng path-option**
- **tunnel mpls traffic-eng priority**

Glossary

This section defines acronyms and words that may not be readily understood.

AS --Autonomous System. A collection of networks under a common administration, sharing a common routing strategy and identified by a unique 16-bit number (assigned by the Internet Assigned Numbers Authority).

ATM --Asynchronous Transfer Mode. The international standard for cell relay in which several service types (such as voice, video or data) are conveyed in fixed-length (53-byte) cells. Fixed-length cells allow cell processing to occur in hardware, thereby reducing transit delays. ATM is designed to take advantage of high-speed transmission media, such as E3, SONET, and T3.

BGP --Border Gateway Protocol. The predominant interdomain routing protocol. It is defined by RFC 1163. Version 4 uses route aggregation mechanisms to reduce the size of routing tables.

BPX --A Cisco standards-based ATM switch that supports broadband, narrowband, and IP services.

CBR--Constraint Based Routing. The computation of traffic paths that simultaneously satisfy label-switched path attributes and current network resource limitations.

CEF --Cisco Express Forwarding. A means for accelerating the forwarding of packets within a router, by storing route lookup information in several data structures instead of in a route cache.

CLI--Command Line Interface. Cisco's interface for configuring and managing its routers.

DS-TE --Diff Serv-aware Traffic Engineering. The capability to configure two bandwidth pools on each link, a *global pool* and a *sub-pool*. MPLS traffic engineering tunnels using the sub-pool bandwidth can be configured with Quality of Service mechanisms to deliver guaranteed bandwidth services end-to-end across the network. Simultaneously, tunnels using the global pool can convey diff-serv traffic.

flooding --A traffic passing technique used by switches and bridges in which traffic received on an interface is sent out through all of the interfaces of that device except the interface on which the information was originally received.

GB queue --Guaranteed Bandwidth queue. A per-hop behavior (PHB) used exclusively by the strict guarantee traffic. If delay/jitter guarantees are sought, the diffserv Expedited Forwarding queue (EF PHB) is used. If only bandwidth guarantees are sought, the diffserv Assured Forwarding PHB (AF PHB) is used.

Global Pool --The total bandwidth allocated to an MPLS traffic engineering link.

IGP --Interior Gateway Protocol. An internet protocol used to exchange routing information within an autonomous system. Examples of common internet IGPs include IGRP, OSPF, and RIP.

label-switched path (LSP) tunnel --A configured connection between two routers, using label switching to carry the packets.

IS-IS --Intermediate System-to-Intermediate System. A link-state hierarchical routing protocol, based on DECnet Phase V routing, whereby nodes exchange routing information based on a single metric, to determine network topology.

LCAC --Link-level (per-hop) call admission control.

LC-ATM --Label switching Controlled ATM. The assignment of values into the VPI/VCI field of ATM cells by MPLS rather than by ATM control procedures.

LSP --Label-switched path (see above).*Also* Link-state packet--A broadcast packet used by link-state protocols that contains information about neighbors and path costs. LSPs are used by the receiving routers to maintain their routing tables. Also called link-state advertisement (LSA).

MPLS --Multi-Protocol Label Switching (formerly known as Tag Switching). A method for directing packets primarily through Layer 2 switching rather than Layer 3 routing, by assigning the packets short fixed-length labels at the ingress to an MPLS cloud, using the concept of forwarding equivalence classes. Within the MPLS domain, the labels are used to make forwarding decisions mostly without recourse to the original packet headers.

MPLS TE --MPLS Traffic Engineering (formerly known as "RRR" or Resource Reservation Routing). The use of label switching to improve traffic performance along with an efficient use of network resources.

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

POS --Packet over SONET (Synchronous Optical Network).

PVC --Permanent Virtual Connection. A circuit or channel through an ATM network provisioned by a carrier between two end points; used for dedicated long-term information transport between locations. PVCs save bandwidth associated with circuit establishment and tear down in situations where certain virtual circuits must exist all the time.

RSVP --Resource reSerVation Protocol. An IETF protocol used for signaling requests (to set aside internet services) by a customer before that customer is permitted to transmit data over that portion of the network.

Sub-pool --The more restrictive bandwidth in an MPLS traffic engineering link. The sub-pool is a portion of the link's overall global pool bandwidth.

TE --Traffic engineering. The application of scientific principles and technology to measure, model, and control internet traffic in order to simultaneously optimize traffic performance and network resource utilization.