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Configuring MPLS Basic Traffic Engineering Using OSPF

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Introduction

This sample configuration shows how to implement traffic engineering (TE) on top of an existing Multiprotocol Label Switching (MPLS) network using Frame Relay and Open Shortest Path First (OSPF). Our example implements two dynamic tunnels (automatically set up by the ingress Label Switch Routers [LSR]) and two tunnels that use explicit paths.

TE is a generic name corresponding to the use of different technologies to optimize the utilization of a given backbone capacity and topology.

MPLS TE provides a way to integrate TE capabilities (such as those used on Layer 2 protocols like ATM) into Layer 3 protocols (IP). MPLS TE uses an extension to existing protocols (Intermediate System-to-Intermediate System (IS-IS), Resource Reservation Protocol (RSVP), OSPF) to calculate and establish unidirectional tunnels that are set according to the network constraint. Traffic flows are mapped on the different tunnels depending on their destination.

Functional Components

Component	Description
IP tunnel interfaces	Layer 2: an MPLS tunnel interface is the head of a Label Switched Path (LSP). It is configured with a set of resource requirements, such as bandwidth and priority. Layer 3: the LSP tunnel interface is the head-end of a unidirectional virtual link to the tunnel destination.
RSVP with TE extension	RSVP is used to establish and maintain LSP tunnels based on the calculated path using PATH and RSVP Reservation (RESV) messages. The RSVP protocol specification has been extended so that the RESV messages also distribute label information.
Link-State Interior Gateway Protocol (IGP) [IS-IS or OSPF with TE	Used to flood topology and resource information from the link management module. IS-IS uses new Type-Length-Values

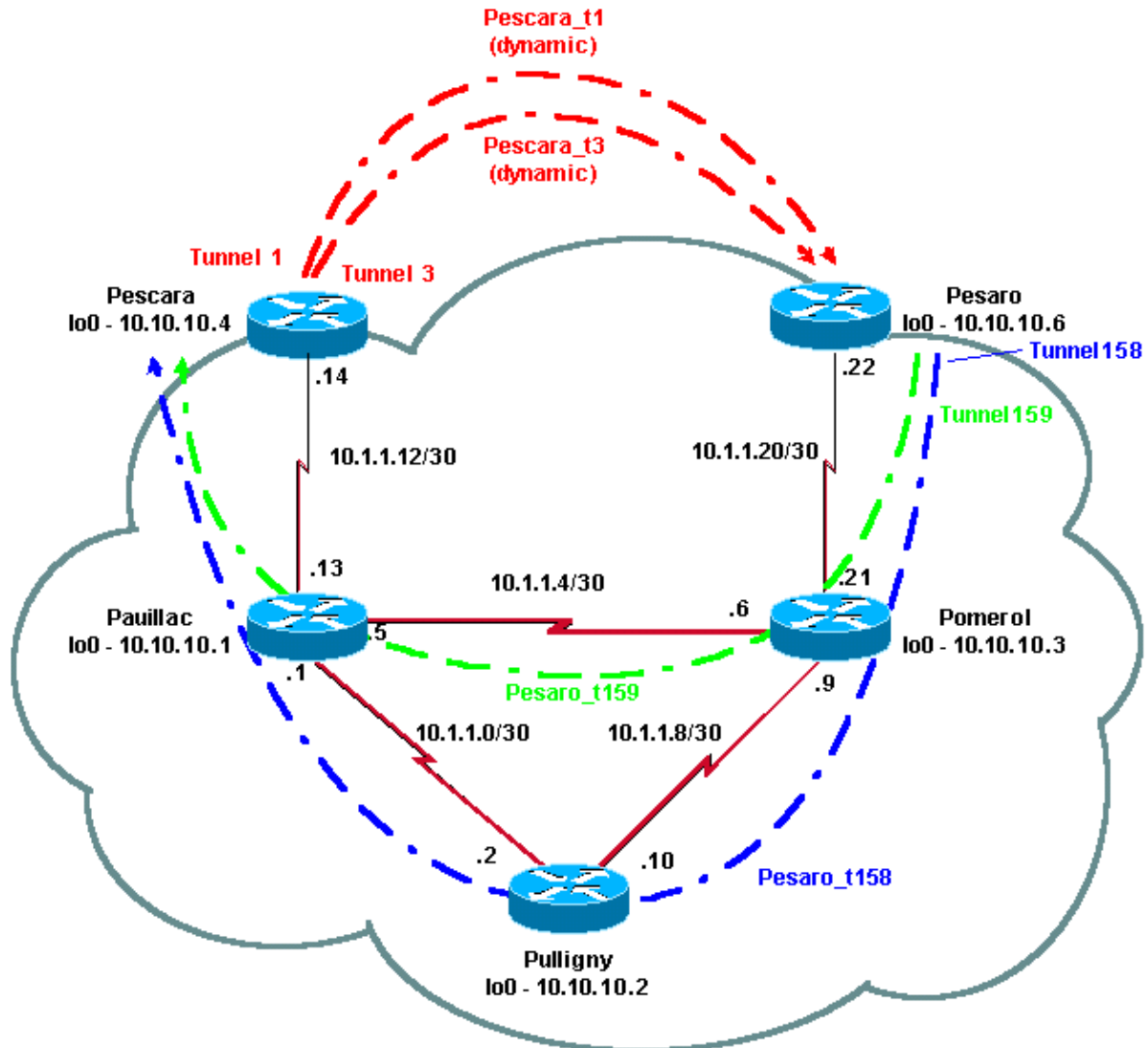
extension]	(TLVs); OSPF uses type 10 Link-State Advertisements (also called Opaque LSAs).
MPLS TE path calculation module	Operates at the LSP head only and determines a path using information from the link-state database.
MPLS TE link management module	At each LSP hop, this module performs link call admission on the RSVP signaling messages, and bookkeeping of topology and resource information to be flooded by OSPF or IS-IS.
Label switching forwarding	Basic MPLS forwarding mechanism based on labels.

Hardware and Software Versions

This configuration was developed and tested using the software and hardware versions below.

- Cisco IOS® Software Releases 12.0(11)S and 12.1(3a)T
- Cisco 3600 routers

Network Diagram



Configurations

Quick Configuration Guide

The following steps can be used to perform a quick configuration. For more detailed information, see [MPLS Traffic Engineering and Enhancements](#).

1. Set up your network with the usual configuration. (In this case, we used Frame Relay.)

Note: It is mandatory to set up a loopback interface with an IP mask of 32 bits. This address will be used for the setup of the MPLS network and TE by the routing protocol. This loopback address must be reachable via the global routing table.

2. Set up a routing protocol for the MPLS network. It must be a link–state protocol (IS–IS or OSPF). In the routing protocol configuration mode, enter the following commands:

- ◆ For IS–IS:

```
metric-style [wide | both]
mpls traffic-eng router-id LoopbackN
mpls traffic-eng [level-1 | level-2 |]
```

- ◆ For OSPF:

```
mpls traffic-eng area X
mpls traffic-eng router-id LoopbackN (must have a 255.255.255.255 mask)
```

3. Enable MPLS TE. Enter **ip cef** (or **ip cef distributed** if available in order to enhance performance) in the general configuration mode. Enable MPLS (**tag–switching ip**) on each concerned interface. Enter **mpls traffic–engineering tunnel** to enable MPLS TE.
4. Enable RSVP by entering **ip rsvp bandwidth XXX** on each concerned interface.
5. Set up tunnels to be used for TE. There are many options that can be configured for MPLS TE Tunnel, but the **tunnel mode mpls traffic–eng** command is mandatory. The **tunnel mpls traffic–eng autoroute announce** command announces the presence of the tunnel by the routing protocol.

Note: Don't forget to use **ip unnumbered loopbackN** for the IP address of the tunnel interfaces.

This sample configuration shows two dynamic tunnels (Pescara_t1 and Pescara_t3) with different bandwidth (and priorities) going from the Pescara router to the Pesaro router, and two tunnels (Pesaro_t158 and Pesaro_t159) using an explicit path going from Pesaro to Pescara.

Configuration Files

Only the relevant parts of the configuration files are included. Commands used to enable MPLS are underlined; commands specific to TE (including RSVP) are in **bold**.

Pesaro
Current configuration: ! version 12.1

```
!  
hostname Pesaro  
!  
ip cef  
!  
mpls traffic-eng tunnels  
!  
interface Loopback0  
ip address 10.10.10.6 255.255.255.255  
!  
interface Tunnel158  
ip unnumbered Loopback0  
tunnel destination 10.10.10.4  
tunnel mode mpls traffic-eng  
tunnel mpls traffic-eng autoroute announce  
tunnel mpls traffic-eng priority 2 2  
tunnel mpls traffic-eng bandwidth 158  
tunnel mpls traffic-eng path-option 1 explicit name low  
!  
interface Tunnel159  
ip unnumbered Loopback0  
tunnel destination 10.10.10.4  
tunnel mode mpls traffic-eng  
tunnel mpls traffic-eng autoroute announce  
tunnel mpls traffic-eng priority 4 4  
tunnel mpls traffic-eng bandwidth 159  
tunnel mpls traffic-eng path-option 1 explicit name straight  
!  
interface Serial0/0  
no ip address  
encapsulation frame-relay  
!
```

```

interface Serial0/0.1 point-to-point
bandwidth 512
ip address 10.1.1.22 255.255.255.252
tag-switching ip
mpls traffic-eng tunnels
frame-relay interface-dlci 603
ip rsvp bandwidth 512 512
!
router ospf
network 10.1.1.0 0.0.0.255 area 9
network 10.10.10.0 0.0.0.255 area 9
mpls traffic-eng area 9
mpls traffic-eng router-id Loopback0
!
ip classless
!
ip explicit-path name low enable
next-address 10.1.1.21
next-address 10.1.1.10
next-address 10.1.1.1
next-address 10.1.1.14
!
ip explicit-path name straight enable
next-address 10.1.1.21
next-address 10.1.1.5
next-address 10.1.1.14
!
end

```

Pescara

Current configuration:

```

!
version 12.0

```

```

!
hostname Pescara
!
ip cef
!
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 10.10.10.4 255.255.255.255
!
interface Tunnel1
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 10.10.10.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 5 5
 tunnel mpls traffic-eng bandwidth 25
 tunnel mpls traffic-eng path-option 2 dynamic
!
interface Tunnel3
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 10.10.10.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 6 6
 tunnel mpls traffic-eng bandwidth 69
 tunnel mpls traffic-eng path-option 1 dynamic
!
interface Serial0/1
 no ip address

```

```

encapsulation frame-relay
!
interface Serial0/1.1 point-to-point
bandwidth 512
ip address 10.1.1.14 255.255.255.252
mpls traffic-eng tunnels
tag-switching ip
frame-relay interface-dlci 401
ip rsvp bandwidth 512 512
!
router ospf
network 10.1.1.0 0.0.0.255 area 9
network 10.10.10.0 0.0.0.255 area 9
mpls traffic-eng area 9
mpls traffic-eng router-id Loopback0
!
end

```

Pomerol

Current configuration:

```

version 12.0
!
hostname Pomerol
!
ip cef
!
mpls traffic-eng tunnels
!
interface Loopback0
ip address 10.10.10.3 255.255.255.255
!
interface Serial0/1

```



```

no ip address
encapsulation frame-relay
!
interface Serial0/1.1 point-to-point
bandwidth 512
ip address 10.1.1.6 255.255.255.252
mpls traffic-eng tunnels
tag-switching ip
frame-relay interface-dlci 301
ip rsvp bandwidth 512 512
!
interface Serial0/1.2 point-to-point
bandwidth 512
ip address 10.1.1.9 255.255.255.252
mpls traffic-eng tunnels
tag-switching ip
frame-relay interface-dlci 302
ip rsvp bandwidth 512 512
!
interface Serial0/1.3 point-to-point
bandwidth 512
ip address 10.1.1.21 255.255.255.252
mpls traffic-eng tunnels
tag-switching ip
frame-relay interface-dlci 306
ip rsvp bandwidth 512 512
!
router ospf
network 10.1.1.0 0.0.0.255 area 9
network 10.10.10.0 0.0.0.255 area 9
mpls traffic-eng area 9
mpls traffic-eng router-id Loopback0

```

```
!  
ip classless  
!  
end
```

Pulligny

Current configuration:

```
!  
version 12.1  
!  
hostname Pulligny  
!  
ip cef  
!  
mpls traffic-eng tunnels  
!  
interface Loopback0  
ip address 10.10.10.2 255.255.255.255  
!  
interface Serial0/1  
no ip address  
encapsulation frame-relay  
!  
interface Serial0/1.1 point-to-point  
bandwidth 512  
ip address 10.1.1.2 255.255.255.252  
mpls traffic-eng tunnels  
tag-switching ip  
frame-relay interface-dlci 201  
ip rsvp bandwidth 512 512  
!  
interface Serial0/1.2 point-to-point  
bandwidth 512
```

```
ip address 10.1.1.10 255.255.255.252

mpls traffic-eng tunnels

tag-switching ip

frame-relay interface-dlci 203

ip rsvp bandwidth 512 512

!

router ospf

network 10.1.1.0 0.0.0.255 area 9

network 10.10.10.0 0.0.0.255 area 9

mpls traffic-eng area 9

mpls traffic-eng router-id Loopback0

!

ip classless

!

end
```

Pauillac

```
!

version 12.1

!

hostname pauillac

!

ip cef

!

mpls traffic-eng tunnels

!

interface Loopback0

ip address 10.10.10.1 255.255.255.255

!

interface Serial0/0

no ip address

encapsulation frame-relay

!
```

```

interface Serial0/0.1 point-to-point
bandwidth 512
ip address 10.1.1.1 255.255.255.252
mpls traffic-eng tunnels
tag-switching ip
frame-relay interface-dlci 102
ip rsvp bandwidth 512 512
!
interface Serial0/0.2 point-to-point
bandwidth 512
ip address 10.1.1.5 255.255.255.252
mpls traffic-eng tunnels
tag-switching ip
frame-relay interface-dlci 103
ip rsvp bandwidth 512 512
!
interface Serial0/0.3 point-to-point
bandwidth 512
ip address 10.1.1.13 255.255.255.252
mpls traffic-eng tunnels
tag-switching ip
frame-relay interface-dlci 104
ip rsvp bandwidth 512 512
!
router ospf
network 10.1.1.0 0.0.0.255 area 9
network 10.10.10.0 0.0.0.255 area 9
mpls traffic-eng area 9
mpls traffic-eng router-id Loopback0
!
ip classless
!

```

```
end
```

show Commands

General **show** commands are illustrated on the sample configuration for MPLS TE with IS-IS.

The following commands are specific to MPLS TE with OSPF and are illustrated below:

- **show ip ospf mpls traffic-eng link**
- **show ip ospf database opaque-area**

Sample show Output

You can use the **show ip ospf mpls traffic-eng link** command to see what will be advertised by OSPF at a given router. The RSVP characteristics are shown in **blue** below, indicating the reservable bandwidth that is being advertised and used. You can see the bandwidth used by Pescara_t1 (at Priority 5) and Pescara_t3 (at Priority 6).

```
Pesaro# show ip ospf mpls traffic-eng link

OSPF Router with ID (10.10.10.61) (Process ID 9)

Area 9 has 1 MPLS TE links. Area instance is 3.

Links in hash bucket 48.
Link is associated with fragment 0. Link instance is 3
Link connected to Point-to-Point network
Link ID : 10.10.10.3 Pomerol
Interface Address : 10.1.1.22
Neighbor Address : 10.1.1.21
Admin Metric : 195
Maximum bandwidth : 64000
Maximum reservable bandwidth : 64000
Number of Priority : 8
Priority 0 : 64000      Priority 1 : 64000
Priority 2 : 64000      Priority 3 : 64000
Priority 4 : 64000      Priority 5 : 32000
Priority 6 : 24000      Priority 7 : 24000
Affinity Bit : 0x0
```

The **show ip ospf database** command can be restrained to Type 10 LSAs and shows the database that is used by the MPLS TE process to calculate the best route (for TE) for dynamic tunnels (Pescara_t1 and Pescara_t3 in this example). This can be seen in the following partial output:

```
Pesaro# show ip ospf database opaque-area

OSPF Router with ID (10.10.10.61) (Process ID 9)

Type-10 Opaque Link Area Link States (Area 9)

LS age: 397
Options: (No TOS-capability, DC)
LS Type: Opaque Area Link
Link State ID: 1.0.0.0
Opaque Type: 1
```

Opaque ID: 0
Advertising Router: 10.10.10.1
LS Seq Number: 80000003
Checksum: 0x12C9
Length: 132
Fragment number : 0

MPLS TE router ID : 10.10.10.1 *Pauillac*

Link connected to Point-to-Point network

Link ID : 10.10.10.3
Interface Address : 10.1.1.5
Neighbor Address : 10.1.1.6
Admin Metric : 195
Maximum bandwidth : 64000
Maximum reservable bandwidth : 48125
Number of Priority : 8
Priority 0 : 48125 Priority 1 : 48125
Priority 2 : 48125 Priority 3 : 48125
Priority 4 : 48125 Priority 5 : 16125
Priority 6 : 8125 Priority 7 : 8125
Affinity Bit : 0x0

Number of Links : 1

LS age: 339
Options: (No TOS-capability, DC)
LS Type: Opaque Area Link
Link State ID: 1.0.0.0
Opaque Type: 1
Opaque ID: 0
Advertising Router: 10.10.10.2
LS Seq Number: 80000001
Checksum: 0x80A7
Length: 132
Fragment number : 0

MPLS TE router ID : 10.10.10.2 *Pulligny*

Link connected to Point-to-Point network

Link ID : 10.10.10.1
Interface Address : 10.1.1.2
Neighbor Address : 10.1.1.1
Admin Metric : 195
Maximum bandwidth : 64000
Maximum reservable bandwidth : 64000
Number of Priority : 8
Priority 0 : 64000 Priority 1 : 64000
Priority 2 : 64000 Priority 3 : 64000
Priority 4 : 64000 Priority 5 : 64000
Priority 6 : 64000 Priority 7 : 64000
Affinity Bit : 0x0

Number of Links : 1

LS age: 249
Options: (No TOS-capability, DC)
LS Type: Opaque Area Link
Link State ID: 1.0.0.0
Opaque Type: 1
Opaque ID: 0
Advertising Router: 10.10.10.3
LS Seq Number: 80000004
Checksum: 0x3DDC
Length: 132

Related Information

- [MPLS Support Page](#)
 - [IP Routing Support Pages](#)
 - [Technical Support – Cisco Systems](#)
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