Table of Contents

Configuring MPLS Basic Traffic Engineering Using OSPF

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

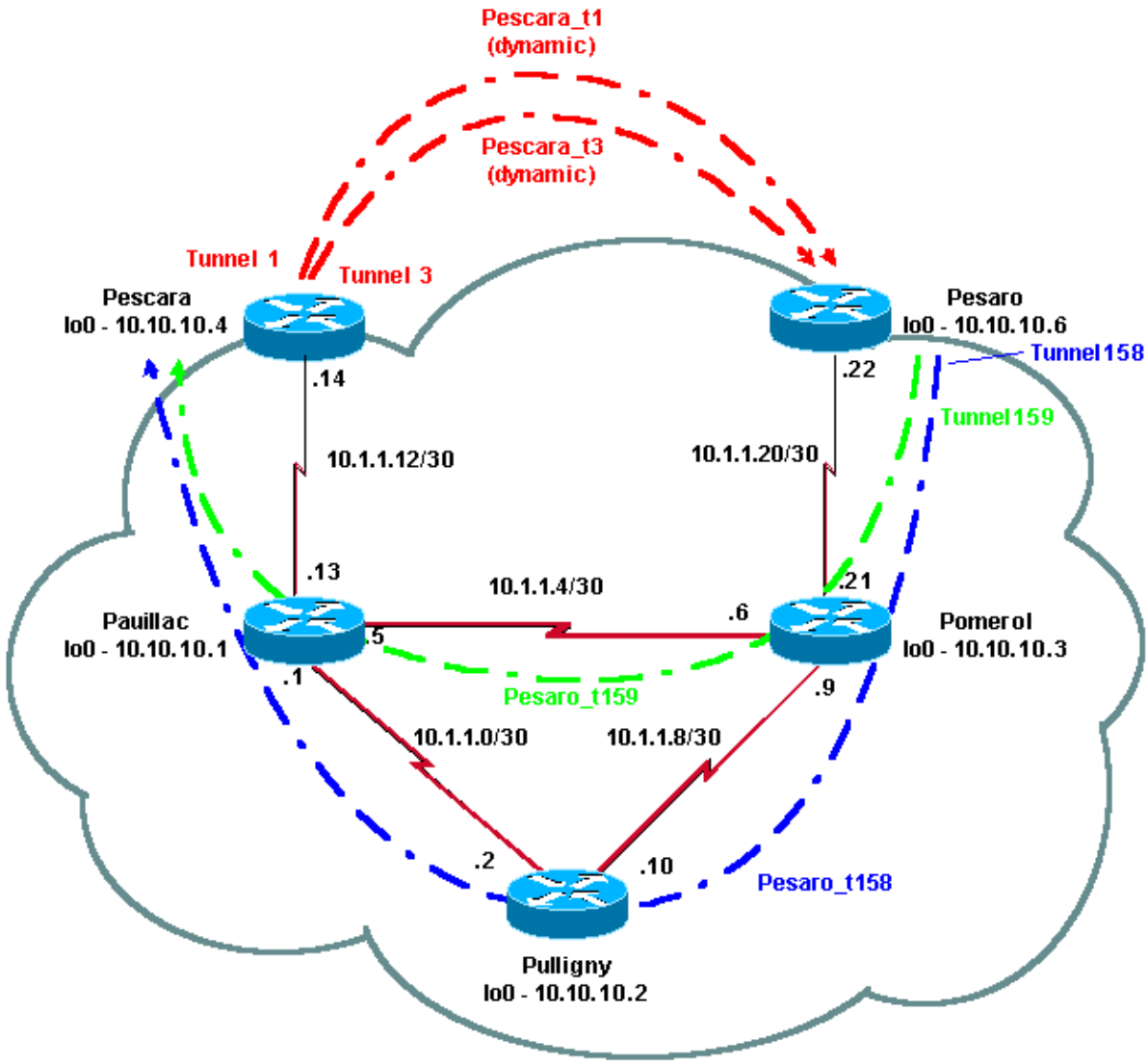
extension]	(TLVs); OSPF uses type 10 Link−State Advertisements (also called Opaque LSAs).
MPLS TE path calculation module	Operates at the LSP head only and determines a path using information from the link−state database.
MPLS TE link management module	At each LSP hop, this module performs link call 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
```

```
Fragment number : 0
```

Related Information

- **MPLS Support Page**
- **IP Routing Support Pages**
- **Technical Support − Cisco Systems**