



## Configure Segment Routing for OSPF Protocol

Open Shortest Path First (OSPF) is an Interior Gateway Protocol (IGP) developed by the OSPF working group of the Internet Engineering Task Force (IETF). Designed expressly for IP networks, OSPF supports IP subnetting and tagging of externally derived routing information. OSPF also allows packet authentication and uses IP multicast when sending and receiving packets.

This module provides the configuration information to enable segment routing for OSPF.



**Note** For additional information on implementing OSPF on your , see the *Implementing OSPF* module in the .

- [Enabling Segment Routing for OSPF Protocol, on page 1](#)
- [Configuring a Prefix-SID on the OSPF-Enabled Loopback Interface, on page 3](#)
- [Configuring an Adjacency SID, on page 5](#)
- [Segment Routing ECMP-FEC Optimization, on page 8](#)

## Enabling Segment Routing for OSPF Protocol

Segment routing on the OSPF control plane supports the following:

- OSPFv2 control plane
- Multi-area
- IPv4 prefix SIDs for host prefixes on loopback interfaces
- Adjacency SIDs for adjacencies
- MPLS penultimate hop popping (PHP) and explicit-null signaling

This section describes how to enable segment routing MPLS and MPLS forwarding in OSPF. Segment routing can be configured at the instance, area, or interface level.

### Before you begin

Your network must support the MPLS Cisco IOS XR software feature before you enable segment routing for OSPF on your router.



**Note** You must enter the commands in the following task list on every OSPF router in the traffic-engineered portion of your network.

### Procedure

|               | Command or Action                                                                                                                     | Purpose                                                                                                                                                                                                                                                                          |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router# <b>configure</b>                                                         | Enters mode.                                                                                                                                                                                                                                                                     |
| <b>Step 2</b> | <b>router ospf process-name</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config)# <b>router ospf 1</b>                              | Enables OSPF routing for the specified routing process and places the router in router configuration mode.                                                                                                                                                                       |
| <b>Step 3</b> | <b>segment-routing mpls</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf)# <b>segment-routing mpls</b>                      | Enables segment routing using the MPLS data plane on the routing process and all areas and interfaces in the routing process.<br><br>Enables segment routing forwarding on all interfaces in the routing process and installs the SIDs received by OSPF in the forwarding table. |
| <b>Step 4</b> | <b>segment-routing sr-prefer</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf)# <b>segment-routing sr-prefer</b>            | Sets the preference of segment routing (SR) labels over label distribution protocol (LDP) labels.                                                                                                                                                                                |
| <b>Step 5</b> | <b>area area</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf)# <b>area 0</b>                                               | Enters area configuration mode.                                                                                                                                                                                                                                                  |
| <b>Step 6</b> | <b>segment-routing mpls</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf-ar)# <b>segment-routing mpls</b>                   | (Optional) Enables segment routing using the MPLS data plane on the area and all interfaces in the area. Enables segment routing forwarding on all interfaces in the area and installs the SIDs received by OSPF in the forwarding table.                                        |
| <b>Step 7</b> | <b>exit</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf-ar)# <b>exit</b><br>RP/0/RP0/CPU0:router(config-ospf)# <b>exit</b> |                                                                                                                                                                                                                                                                                  |

|               | Command or Action                            | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 8</b> | Use the <b>commit</b> or <b>end</b> command. | <p><b>commit</b> —Saves the configuration changes and remains within the configuration session.</p> <p><b>end</b> —Prompts user to take one of these actions:</p> <ul style="list-style-type: none"> <li>• <b>Yes</b> — Saves configuration changes and exits the configuration session.</li> <li>• <b>No</b> —Exits the configuration session without committing the configuration changes.</li> <li>• <b>Cancel</b> —Remains in the configuration session, without committing the configuration changes.</li> </ul> |

**What to do next**

Configure the prefix SID.

## Configuring a Prefix-SID on the OSPF-Enabled Loopback Interface

A prefix segment identifier (SID) is associated with an IP prefix. The prefix SID is manually configured from the segment routing global block (SRGB) range of labels. A prefix SID is configured under the loopback interface with the loopback address of the node as the prefix. The prefix segment steers the traffic along the shortest path to its destination.

A prefix SID can be a node SID or an Anycast SID. A node SID is a type of prefix SID that identifies a specific node. An Anycast SID is a type of prefix SID that identifies a set of nodes, and is configured with n-flag clear. The set of nodes (Anycast group) is configured to advertise a shared prefix address and prefix SID. Anycast routing enables the steering of traffic toward multiple advertising nodes. Packets addressed to an Anycast address are forwarded to the topologically nearest nodes.

The prefix SID is globally unique within the segment routing domain.

This task describes how to configure prefix segment identifier (SID) index or absolute value on the OSPF-enabled Loopback interface.

**Before you begin**

Ensure that segment routing is enabled on an instance, area, or interface.

**Procedure**

|               | Command or Action                       | Purpose      |
|---------------|-----------------------------------------|--------------|
| <b>Step 1</b> | <b>configure</b><br><br><b>Example:</b> | Enters mode. |

|               | Command or Action                                                                                                                                                                                                                                                                                                | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | RP/0/RP0/CPU0:router# configure                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Step 2</b> | <b>router ospf</b> <i>process-name</i><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config)# <b>router ospf</b> 1                                                                                                                                                                                                  | Enables OSPF routing for the specified routing process, and places the router in router configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Step 3</b> | <b>area</b> <i>value</i><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf)# <b>area</b> 0                                                                                                                                                                                                                  | Enters area configuration mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Step 4</b> | <b>interface Loopback</b> <i>interface-instance</i><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf-ar)#<br>interface loopback 0                                                                                                                                                                          | Specifies the loopback interface and instance.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Step 5</b> | <b>prefix-sid</b> { <b>index</b> <i>SID-index</i>   <b>absolute</b> <i>SID-value</i> } [ <b>n-flag-clear</b> ] [ <b>explicit-null</b> ]<br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf-ar)#<br><b>prefix-sid index</b> 1001<br>RP/0/RP0/CPU0:router(config-ospf-ar)#<br><b>prefix-sid absolute</b> 17001 | <p>Configures the prefix-SID index or absolute value for the interface.</p> <p>Specify <b>index</b> <i>SID-index</i> for each node to create a prefix SID based on the lower boundary of the SRGB + the index.</p> <p>Specify <b>absolute</b> <i>SID-value</i> for each node to create a specific prefix SID within the SRGB.</p> <p>By default, the n-flag is set on the prefix-SID, indicating that it is a node SID. For specific prefix-SID (for example, Anycast prefix-SID), enter the <b>n-flag-clear</b> keyword. OSPF does not set the N flag in the prefix-SID sub Type Length Value (TLV).</p> <p>To disable penultimate-hop-popping (PHP) and add an explicit-Null label, enter the <b>explicit-null</b> keyword. OSPF sets the E flag in the prefix-SID sub TLV.</p> |
| <b>Step 6</b> | Use the <b>commit</b> or <b>end</b> command.                                                                                                                                                                                                                                                                     | <p><b>commit</b> —Saves the configuration changes and remains within the configuration session.</p> <p><b>end</b> —Prompts user to take one of these actions:</p> <ul style="list-style-type: none"> <li>• <b>Yes</b> — Saves configuration changes and exits the configuration session.</li> <li>• <b>No</b> —Exits the configuration session without committing the configuration changes.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                           |

|  | Command or Action | Purpose                                                                                                                                                |
|--|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                   | <ul style="list-style-type: none"> <li>• <b>Cancel</b> —Remains in the configuration session, without committing the configuration changes.</li> </ul> |

Verify the prefix-SID configuration:

```
RP/0/RP0/CPU0:router# show ospf database opaque-area 7.0.0.1 self-originate
OSPF Router with ID (10.0.0.1) (Process ID 1)
Type-10 Opaque Link Area Link States (Area 0)
<...>
Extended Prefix TLV: Length: 20
Route-type: 1
AF          : 0
Flags       : 0x40
Prefix      : 10.0.0.1/32

SID sub-TLV: Length: 8
Flags       : 0x0
MTID        : 0
Algo        : 0
SID Index   : 1001
```

## Configuring an Adjacency SID

An adjacency SID (Adj-SID) is associated with an adjacency to a neighboring node. The adjacency SID steers the traffic to a specific adjacency. Adjacency SIDs have local significance and are only valid on the node that allocates them.

An adjacency SID can be allocated dynamically from the dynamic label range or configured manually from the segment routing local block (SRLB) range of labels.

Adjacency SIDs that are dynamically allocated do not require any special configuration, however there are some limitations:

- A dynamically allocated Adj-SID value is not known until it has been allocated, and a controller will not know the Adj-SID value until the information is flooded by the IGP.
- Dynamically allocated Adj-SIDs are not persistent and can be reallocated after a reload or a process restart.
- Each link is allocated a unique Adj-SID, so the same Adj-SID cannot be shared by multiple links.

Manually allocated Adj-SIDs are persistent over reloads and restarts. They can be provisioned for multiple adjacencies to the same neighbor or to different neighbors. You can specify that the Adj-SID is protected. If the Adj-SID is protected on the primary interface and a backup path is available, a backup path is installed. By default, manual Adj-SIDs are not protected.

Adjacency SIDs are advertised using the existing OSPF Adj-SID sub-TLV. The P-flag is defined for manually allocated Adj-SIDs.

0 1 2 3 4 5 6 7

```

+---+---+---+---+---+---+
|B|V|L|G|P|          |
+---+---+---+---+---+---+

```

**Table 1: Adjacency Segment Identifier (Adj-SID) Flags Sub-TLV Fields**

| Field          | Description                                                         |
|----------------|---------------------------------------------------------------------|
| P (Persistent) | This flag is set if the Adj-SID is persistent (manually allocated). |

This task explains how to configure an Adj-SID on an interface.

### Before you begin

Ensure that segment routing is enabled on the corresponding address family.

Use the **show mpls label table detail** command to verify the SRLB range.

### Procedure

|               | Command or Action                                                                                                                                                                      | Purpose                                                                                                                                                                                             |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | <b>configure</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router# <b>configure</b>                                                                                                          | Enters mode.                                                                                                                                                                                        |
| <b>Step 2</b> | <b>router ospf process-name</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config)# <b>router ospf</b><br><b>1</b>                                                                     | Enables OSPF routing for the specified routing instance, and places the router in router configuration mode.                                                                                        |
| <b>Step 3</b> | <b>area area</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf)# <b>area</b><br><b>0</b>                                                                                      | Enters area configuration mode.                                                                                                                                                                     |
| <b>Step 4</b> | <b>interface type interface-path-id</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-ospf-ar)#<br><b>interface HundredGigE0/0/0/1</b>                                             | Specifies the interface and enters interface configuration mode.                                                                                                                                    |
| <b>Step 5</b> | <b>adjacency-sid {index adj-SID-index   absolute adj-SID-value} [protected]</b><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-config-ospf-ar-if)#<br><b>adjacency-sid index 10</b> | Configures the Adj-SID index or absolute value for the interface.<br><br>Specify <b>index adj-SID-index</b> for each link to create an Adj-SID based on the lower boundary of the SRLB + the index. |

|               | Command or Action                                                               | Purpose                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | RP/0/RP0/CPU0:router(config-config-ospf-ar-if)#<br>adjacency-sid absolute 15010 | Specify <b>absolute</b> <i>adj-SID-value</i> for each link to create a specific Adj-SID within the SRLB.<br><br>Specify if the Adj-SID is <b>protected</b> . For each primary path, if the Adj-SID is protected on the primary interface and a backup path is available, a backup path is installed. By default, manual Adj-SIDs are not protected.                                                                                                                                                            |
| <b>Step 6</b> | Use the <b>commit</b> or <b>end</b> command.                                    | <b>commit</b> —Saves the configuration changes and remains within the configuration session.<br><br><b>end</b> —Prompts user to take one of these actions: <ul style="list-style-type: none"> <li>• <b>Yes</b> — Saves configuration changes and exits the configuration session.</li> <li>• <b>No</b> —Exits the configuration session without committing the configuration changes.</li> <li>• <b>Cancel</b> —Remains in the configuration session, without committing the configuration changes.</li> </ul> |

**What to do next**

Configure the SR-TE policy.

## Protected Adjacency SID Backup Timer

OSPF advertises a protected adjacency SID for an adjacency when a backup path is available. Primary and backup paths are programmed into the label switching database (LSD) as rewrites.

When an adjacency goes down, OSPF stops advertising the protected adjacency SID immediately, and the backup path is promoted and installed as LSD rewrite. After a specified amount of time, the LSD rewrite is deleted. If the installed path fails again, the protection ends there and traffic through the original protected adjacency SID is permanently lost.

The Protected Adjacency SID Backup Timer provides a configurable maintenance time period. During this time period, OSPF updates the LSD rewrite with primary and backup (if available) paths to the neighbor upon topology changes.

**Configuration**

Use the **segment-routing protected-adjacency-sid-delay** command in OSPF configuration mode. The range is from 30 to 3600 seconds; the default is 900 seconds (15 min).

```
Router(config)# router ospf 1
Router(config-ospf)# segment-routing protected-adjacency-sid-delay 360
```

**Running Configuration**

```

router ospf 1
 segment-routing protected-adjacency-sid-delay 360
 area 1
  interface HundredGigE0/0/0/1
   fast-reroute per-prefix
   fast-reroute per-prefix ti-lfa enable
  !
 !
 !

```

## Segment Routing ECMP-FEC Optimization

ECMP-FECs are used for any ECMP programming on the system, such as MPLS LSP ECMP, VPN multipath, and [EVPN multi-homing](#) EVPN multi-homing.

The SR ECMP-FEC optimization solution minimizes ECMP-FEC resource consumption during underlay programming for an SR-MPLS network. This feature supports sharing the same ECMP-FEC, regular FEC, and Egress Encapsulation DB (EEDB) entries for all IPv4 and IPv6 Segment Routing prefixes with the same set of next hops. ECMP-FEC optimization is triggered when all the out\_labels associated with the ECMP paths for a given prefix have the same value. If this rule is not met, then the prefix is programmed with a dedicated ECMP-FEC. Other prefixes that meet the rule are candidates for optimization.

Segment Routing Label Edge Router (LER) ECMP-FEC Optimization enables ECMP-FEC optimization originally developed for Label Switched Router (LSR) nodes (MPLS P) to be enabled on LER (Layer 3 MPLS PE) routers.

For usage guidelines, limitations, and configuration options, see [Segment Routing ECMP-FEC Optimization](#).