Configure Segment Routing for IS-IS Protocol


This module provides the configuration information used to enable segment routing for IS-IS.

For additional information on implementing IS-IS on your Cisco NCS 5000 Series Router, see the Implementing IS-IS module in the Routing Configuration Guide for Cisco NCS 5000 Series Routers.

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• Configuring a Prefix-SID on the IS-IS Enabled Loopback Interface, on page 3
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Enabling Segment Routing for IS-IS Protocol

Segment routing on the IS-IS control plane supports the following:

• IPv4 control plane
• Level 1, level 2, and multi-level routing
• Prefix SIDs for host prefixes on loopback interfaces
• Adjacency SIDs for adjacencies
• MPLS penultimate hop popping (PHP) and explicit-null signaling

This task explains how to enable segment routing for IS-IS.

Before you begin

Your network must support the MPLS Cisco IOS XR software feature before you enable segment routing for IS-IS on your router.
You must enter the commands in the following task list on every IS-IS router in the traffic-engineered portion of your network.

### SUMMARY STEPS

1. `configure`
2. `router isis instance-id`
3. `address-family ipv4 [ unicast ]`
4. `metric-style wide [ level { 1 | 2 } ]`
5. `segment-routing mpls`
6. `exit`
7. `commit`

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> configure</td>
<td>Enables IS-IS routing for the specified routing instance, and places the router in router configuration mode.</td>
</tr>
</tbody>
</table>
| **Step 2** `router isis instance-id`  
  **Example:**  
  `RP/0/RF0/CPU0:router(config)# router isis isp` | Enables IS-IS routing for the specified routing instance, and places the router in router configuration mode.  
  **Note** You can change the level of routing to be performed by a particular routing instance by using the `is-type` router configuration command. |
| **Step 3** `address-family ipv4 [ unicast ]`  
  **Example:**  
  `RP/0/RF0/CPU0:router(config-isis)# address-family ipv4 unicast` | Specifies the IPv4 address family, and enters router address family configuration mode. |
| **Step 4** `metric-style wide [ level { 1 | 2 } ]`  
  **Example:**  
  `RP/0/RF0/CPU0:router(config-isis-af)# metric-style wide level 1` | Configures a router to generate and accept only wide link metrics in the Level 1 area. |
| **Step 5** `segment-routing mpls`  
  **Example:**  
  `RP/0/RF0/CPU0:router(config-isis-af)# segment-routing mpls` | Segment routing is enabled by the following actions:  
  - MPLS forwarding is enabled on all interfaces where IS-IS is active.  
  - All known prefix-SIDs in the forwarding plain are programmed, with the prefix-SIDs advertised by remote routers or learned through local or remote mapping server.  
  - The prefix-SIDs locally configured are advertised. |
Configuring a Prefix-SID on the IS-IS 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 explains how to configure prefix segment identifier (SID) index or absolute value on the IS-IS enabled Loopback interface.

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

**SUMMARY STEPS**

1. configure
2. router isis instance-id
3. interface Loopback instance
4. address-family ipv4 [unicast ]
5. commit

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 configure</td>
<td></td>
</tr>
</tbody>
</table>
Purpose

**Command or Action**

**Step 2**  
`router isis instance-id`  
*Example:*  
`RP/0/RP0/CPU0:router(config)# router isis 1`

**Step 3**  
`interface Loopback instance`  
*Example:*  
`RP/0/RP0/CPU0:router(config-isis)# interface Loopback0`

**Step 4**  
`address-family ipv4 [ unicast ]`  
*Example:*  
The following is an example for ipv4 address family:  
`RP/0/RP0/CPU0:router(config-isis-if)# address-family ipv4 unicast`

**Step 5**  
*commit*

**Purpose**

Enables IS-IS routing for the specified routing instance, and places the router in router configuration mode.

- You can change the level of routing to be performed by a particular routing instance by using the `is-type` router configuration command.

**Example:**

Step 2  
RP/0/RP0/CPU0:router(config)# router isis 1

Step 3  
RP/0/RP0/CPU0:router(config-isis)# interface Loopback0

Step 4  
RP/0/RP0/CPU0:router(config-isis-if)# address-family ipv4 unicast

Verify the prefix-SID configuration:

```
RP/0/RP0/CPU0:router# show isis database verbose
```

Is-IS 1 (Level-2) Link State Database  
LSPID LSP Seq Num LSP Checksum LSP Holdtime ATT/P/OL  
router.00-00 * 0x0000039b 0xfc27 1079 0/0/0  
Area Address: 49.0001  
NLPID: 0xcc  
NLPID: 0x8e  
MT: Standard (IPV4 Unicast)  
Hostname: router  
IP Address: 10.0.0.1  
Router Cap: 10.0.0.1, D:0, S:0  
Segment Routing: I:1 V:1, SRGB Base: 16000 Range: 8000  
Metric: 0  
IP-Extended 10.0.0.1/32  
Prefix-SID Index: 1001, Algorithm:0, R:0 N:1 P:0 E:0 V:0 L:0

**IS-IS Prefix Attributes for Extended IPv4 and IPv6 Reachability**

The following sub-TLVs support the advertisement of IPv4 and IPv6 prefix attribute flags and the source router ID of the router that originated a prefix advertisement, as described in RFC 7794.

- Prefix Attribute Flags
- IPv4 and IPv6 Source Router ID
Prefix Attribute Flags

The Prefix Attribute Flag sub-TLV supports the advertisement of attribute flags associated with prefix advertisements. Knowing if an advertised prefix is directly connected to the advertising router helps to determine how labels that are associated with an incoming packet should be processed.

This section describes the behavior of each flag when a prefix advertisement is learned from one level to another.

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**Note**

Prefix attributes are only added when wide metric is used.

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**Prefix Attribute Flags Sub-TLV Format**

```
0 1 2 3 4 5 6 7 ...
+-+-+-+-+-+-+-+-+...
|X|R|N|...
+-+-+-+-+-+-+-+-+...
```

**Prefix Attribute Flags Sub-TLV Fields**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X (External Prefix Flag)</td>
<td>This flag is set if the prefix has been redistributed from another protocol. The value of the flag is preserved when the prefix is propagated to another level.</td>
</tr>
<tr>
<td>R (Re-advertisement Flag)</td>
<td>This flag is set to 1 by the Level 1-2 router when the prefix is propagated between IS-IS levels (from Level 1 to Level 2, or from Level 2 to Level 1). This flag is set to 0 when the prefix is connected locally to an IS-IS-enabled interface (regardless of the level configured on the interface).</td>
</tr>
</tbody>
</table>
For prefixes that are propagated from another level:
1. Copy the N-flag from the prefix attribute sub-TLV, if present in the source level.
2. Copy the N-flag from the prefix-SID sub-TLV, if present in the source level.
3. Otherwise, set to 0.

For connected prefixes:
1. Set to 0 if \texttt{prefix-attributes n-flag-clear} is configured (see Configuring Prefix Attribute N-flag-clear).
2. Set to 0 if \texttt{n-flag-clear \{ n-flag-clearSID-index \mid n-flag-clearSID-value\} n-flag-clear} is configured (see Configuring a Prefix-SID on the IS-IS Enabled Loopback Interface).
3. Otherwise, set to 1 when the prefix is a host prefix (/32 for IPV4, /128 for IPv6) that is associated with a loopback address.

\textbf{Note} If the flag is set and the prefix length is not a host prefix, then the flag must be ignored.

**IPv4 and IPv6 Source Router ID**

The Source Router ID sub-TLV identifies the source of the prefix advertisement. The IPv4 and IPv6 source router ID is displayed in the output of the \texttt{show isis database verbose} command.

The Source Router ID sub-TLV is added when the following conditions are met:
1. The prefix is locally connected.
2. The N-flag is set to 1 (when it's a host prefix and the n-flag-clear configuration is not used).
3. The router ID is configured in the corresponding address family.

The source router ID is propagated between levels.

\textbf{Table 1: Source Router Sub-TLV Format}

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPv4 Source Router ID</td>
<td>Type: 11&lt;br&gt;Length: 4&lt;br&gt;Value: IPv4 Router ID of the source of the prefix advertisement</td>
</tr>
<tr>
<td>IPv6 Source Router ID</td>
<td>Type: 12&lt;br&gt;Length: 16&lt;br&gt;Value: IPv6 Router ID of the source of the prefix advertisement</td>
</tr>
</tbody>
</table>
Configuring Prefix Attribute N-flag-clear

The N-flag is set to 1 when the prefix is a host prefix (/32 for IPv4, /128 for IPv6) that is associated with a loopback address. The advertising router can be configured to not set this flag. This task explains how to clear the N-flag.

**SUMMARY STEPS**

1. `configure`
2. `router isis instance-id`
3. `interface Loopback instance`
4. `prefix-attributes n-flag-clear [Level-1 | Level-2]`
5. `commit`

**DETAILED STEPS**

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<tr>
<td><strong>Step 1</strong></td>
<td><code>configure</code></td>
</tr>
</tbody>
</table>
| **Step 2** | `router isis instance-id`  
**Example:**  
RP/0/RP0/CPU0:router(config)# `router isis 1` |
| **Step 3** | `interface Loopback instance`  
**Example:**  
RP/0/RP0/CPU0:router(config)# `interface Loopback0` |
| **Step 4** | `prefix-attributes n-flag-clear [Level-1 | Level-2]`  
**Example:**  
RP/0/RP0/CPU0:router(config-if)# `isis prefix-attributes n-flag-clear` |
| **Step 5** | `commit` |

Verify the prefix attribute configuration:

```
RP/0/RP0/CPU0:router# `show isis database verbose`
```

<table>
<thead>
<tr>
<th>IS-IS 1 (Level-2) Link State Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSPID</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>router.00-00 * 0x0000039b 0xfc27</td>
</tr>
</tbody>
</table>

Area Address: 49.0001
NLPID: 0xcc
NLPID: 0x8e
MT: Standard (IPv4 Unicast)
MT: IPv6 Unicast 0/0/0
Hostname: router
IP Address: 10.0.0.1
IPv6 Address: 2001:0db8:1234::0a00:0001
IS-IS Multi-Domain Prefix SID and Domain Stitching: Example

IS-IS Multi-Domain Prefix SID and Domain Stitching allows you to configure multiple IS-IS instances on the same loopback interface for domain border nodes. You specify a loopback interface and prefix SID under multiple IS-IS instances to make the prefix and prefix SID reachable in different domains.

This example uses the following topology. Node 5 and 9 are border nodes between two IS-IS domains (Domain1 and Domain2). Node 10 is configured as the Segment Routing Path Computation Element (SR-PCE).

*Figure 1: Multi-Domain Topology*

Configure IS-IS Multi-Domain Prefix SID

Specify a loopback interface and prefix SID under multiple IS-IS instances on each border node:

*Example: Border Node 5*
Border nodes 5 and 9 each run two IS-IS instances (Domain1 and Domain2) and advertise their Loopback0 prefix and prefix SID in both domains.

Nodes in both domains can reach the border nodes by using the same prefix and prefix SID. For example, Node 3 and Node 22 can reach Node 5 using prefix SID 16005.

## Configure Common Router ID

On each border node, configure a common TE router ID under each IS-IS instance:

**Example: Border Node 5**

```bash
router isis Domain1
  address-family ipv4 unicast
  router-id loopback0

router isis Domain2
  address-family ipv4 unicast
  router-id loopback0
```

**Example: Border Node 9**

```bash
router isis Domain1
  address-family ipv4 unicast
  router-id loopback0

router isis Domain2
  address-family ipv4 unicast
  router-id loopback0
```
Distribute IS-IS Link-State Data

Configure BGP Link-state (BGP-LS) on Node 13 and Node 14 to report their local domain to Node 10:

**Example: Node 13**
```bash
router isis Domain1
    distribute link-state id
```

**Example: Node 14**
```bash
router isis Domain2
    distribute link-state id
```

Link-state ID starts from 32. One ID is required per IGP domain. Different domain IDs are essential to identify that the SR-TE TED belongs to a particular IGP domain.

Nodes 13 and 14 each reports its local domain in BGP-LS to Node 10.

Node 10 identifies the border nodes (Nodes 5 and 9) by their common advertised TE router ID, then combines (stitches) the domains on these border nodes for end-to-end path computations.