



# Configure Segment Routing for IS-IS Protocol

Integrated Intermediate System-to-Intermediate System (IS-IS), Internet Protocol Version 4 (IPv4), is a standards-based Interior Gateway Protocol (IGP). The Cisco IOS XR software implements the IP routing capabilities described in International Organization for Standardization (ISO)/International Engineering Consortium (IEC) 10589 and RFC 1995, and adds the standard extensions for single topology and multitopology IS-IS for IP Version 6 (IPv6).

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



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**Note** For additional information on implementing IS-IS on your Cisco CRS Router, see the *Implementing IS-IS* module in the *Cisco IOS XR Routing Configuration Guide for the Cisco CRS Router*.

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## Enabling Segment Routing for IS-IS Protocol

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

- IPv4 and IPv6 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.



**Note** 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** | **ipv6** } [ **unicast** ]
4. **metric-style wide** [ **level** { **1** | **2** } ]
5. **router-id loopback** *loopback interface used for prefix-sid*
6. **segment-routing mpls**
7. **exit**
8. Use the **commit** or **end** command.

## DETAILED STEPS

|               | Command or Action  | Purpose   |
|---------------|--|---|
| <b>Step 1</b> | <b>configure</b><br><b>Example:</b><br><br>RP/0/RP0/CPU0:router# <b>configure</b>  | Enters global configuration mode.   |
| <b>Step 2</b> | <b>router isis</b> <i>instance-id</i><br><b>Example:</b><br><br>RP/0/RP0/CPU0:router(config)# <b>router isis</b> <b>isp</b>  | Enables IS-IS routing for the specified routing instance, and places the router in router configuration mode.<br><br><b>Note</b> You can change the level of routing to be performed by a particular routing instance by using the <b>is-type</b> router configuration command. |
| <b>Step 3</b> | <b>address-family</b> { <b>ipv4</b>   <b>ipv6</b> } [ <b>unicast</b> ]<br><b>Example:</b><br><br>RP/0/RP0/CPU0:router(config-isis)# <b>address-family</b><br><b>ipv4 unicast</b> | Specifies the IPv4 or IPv6 address family, and enters router address family configuration mode.   |
| <b>Step 4</b> | <b>metric-style wide</b> [ <b>level</b> { <b>1</b>   <b>2</b> } ]<br><b>Example:</b><br><br>RP/0/RP0/CPU0:router(config-isis-af)# <b>metric-style</b><br><b>wide level 1</b>     | Configures a router to generate and accept only wide link metrics in the Level 1 area.  |
| <b>Step 5</b> | <b>router-id loopback</b> <i>loopback interface used for prefix-sid</i><br><b>Example:</b><br><br>RP/0/RP0/CPU0:router(config-isis-af)# <b>router-id</b><br><b>loopback0</b>     | Configures router ID for each address-family (IPv4/IPv6). IS-IS advertises the router ID in TLVs 134 (for IPv4 address family) and 140 (for IPv6 address family). Required when traffic engineering is used.  |
| <b>Step 6</b> | <b>segment-routing mpls</b>  | Segment routing is enabled by the following actions:  |

|               | Command or Action   | Purpose   |
|---------------|---|---|
|               | <p><b>Example:</b></p> <pre>RP/0/RP0/CPU0:router(config-isis-af)# segment-routing mpls</pre>  | <ul style="list-style-type: none"> <li>• MPLS forwarding is enabled on all interfaces where IS-IS is active.</li> <li>• 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.</li> <li>• The prefix-SIDs locally configured are advertised.</li> </ul>   |
| <b>Step 7</b> | <p><b>exit</b></p> <p><b>Example:</b></p> <pre>RP/0/RP0/CPU0:router(config-isis-af)# exit RP/0/RP0/CPU0:router(config-isis)# exit</pre> |   |
| <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 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.

Strict-SPF SIDs are used to forward traffic strictly along the SPF path. Strict-SPF SIDs are not forwarded to SR-TE. IS-IS advertises the SR Algorithm sub Type Length Value (TLV) (in the SR Router Capability SubTLV) to include both algorithm 0 (SPF) and algorithm 1 (Strict-SPF). When the IS-IS area or level is Strict-SPF TE-capable, Strict-SPF SIDs are used to build the SR-TE Strict-SPF. Strict-SPF SIDs are also used to program the backup paths for prefixes, node SIDs, and adjacency SIDs.



**Note** The same SRGB is used for both regular SIDs and strict-SPF SIDs.

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** | **ipv6** } [ **unicast** ]
5. **prefix-sid** [**strict-spf** ] {**index** *SID-index* | **absolute** *SID-value*} [**n-flag-clear**] [**explicit-null** ]
6. Use the **commit** or **end** command.

## DETAILED STEPS

|               | 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 global configuration mode.  |
| <b>Step 2</b> | <b>router isis</b> <i>instance-id</i><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config)# <b>router isis</b> 1                | Enables IS-IS routing for the specified routing instance, and places the router in router configuration mode. <ul style="list-style-type: none"> <li>• You can change the level of routing to be performed by a particular routing instance by using the <b>is-type</b> router configuration command.</li> </ul> |
| <b>Step 3</b> | <b>interface Loopback</b> <i>instance</i><br><b>Example:</b><br>RP/0/RP0/CPU0:router(config-isis)# <b>interface Loopback0</b> | Specifies the loopback interface and instance.   |

|                      | Command or Action   | Purpose  |
|----------------------|---|--|
| <p><b>Step 4</b></p> | <p><b>address-family</b> { <b>ipv4</b>   <b>ipv6</b> } [ <b>unicast</b> ]</p> <p><b>Example:</b></p> <p>The following is an example for ipv4 address family:</p> <pre>RP/0/RP0/CPU0:router(config-isis-if)# address-family ipv4 unicast</pre>   | <p>Specifies the IPv4 or IPv6 address family, and enters router address family configuration mode.</p>   |
| <p><b>Step 5</b></p> | <p><b>prefix-sid</b> [<b>strict-spf</b>] {<b>index</b> <i>SID-index</i>   <b>absolute</b> <i>SID-value</i>} [<b>n-flag-clear</b>] [<b>explicit-null</b>]</p> <p><b>Example:</b></p> <pre>RP/0/RP0/CPU0:router(config-isis-if-af)# prefix-sid index 1001</pre> <pre>RP/0/RP0/CPU0:router(config-isis-if-af)# prefix-sid strict-spf index 101</pre> <pre>RP/0/RP0/CPU0:router(config-isis-if-af)# prefix-sid absolute 17001</pre> | <p>Configures the prefix-SID index or absolute value for the interface.</p> <p>Specify <b>strict-spf</b> to configure the prefix-SID to use the SPF path instead of the SR-TE .</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. IS-IS 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 explicit-Null label, enter <b>explicit-null</b> keyword. IS-IS sets the E flag in the prefix-SID sub TLV.</p> <p><b>Note</b> IS-IS does not advertise separate explicit-NULL or flags for regular SIDs and strict-SPF SIDs. The settings in the regular SID are used if the settings are different.</p> |
| <p><b>Step 6</b></p> | <p>Use the <b>commit</b> or <b>end</b> command.</p>   | <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>  |

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)
  MT:           IPv6 Unicast
  Hostname:     router
  IP Address:   10.0.0.1
  IPv6 Address: 2001:0db8:1234::0a00:0001
  Router Cap:   10.0.0.1, D:0, S:0
    Segment Routing: I:1 V:1, SRGB Base: 16000 Range: 8000
    SR Algorithm:
      Algorithm: 0
      Algorithm: 1
<...>
  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
    Prefix-SID Index: 101, Algorithm:1, 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

| Field                     | Description  |
|---------------------------|--|
| X (External Prefix Flag)  | 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.  |
| R (Re-advertisement Flag) | 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).<br><br>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).   |
| N (Node Flag)             | <p>For prefixes that are propagated from another level:</p> <ol style="list-style-type: none"> <li>1. Copy the N-flag from the prefix attribute sub-TLV, if present in the source level.</li> <li>2. Copy the N-flag from the prefix-SID sub-TLV, if present in the source level.</li> <li>3. Otherwise, set to 0.</li> </ol> <p>For connected prefixes:</p> <ol style="list-style-type: none"> <li>1. Set to 0 if <b>prefix-attributes n-flag-clear</b> is configured (see <a href="#">Configuring Prefix Attribute N-flag-clear</a>).</li> <li>2. Set to 0 if <b>n-flag-clear { n-flag-clearSID-index   n-flag-clearSID-value }</b> <b>n-flag-clear</b> is configured (see <a href="#">Configuring a Prefix-SID on the IS-IS Enabled Loopback Interface</a>).</li> <li>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.</li> </ol> <p><b>Note</b> If the flag is set and the prefix length is not a host prefix, then the flag must be ignored.</p> |

## 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 **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.

Table 1: Source Router Sub-TLV Format

|                       |   |
|-----------------------|---|
| IPv4 Source Router ID | Type: 11<br>Length: 4<br>Value: IPv4 Router ID of the source of the prefix advertisement  |
| IPv6 Source Router ID | Type: 12<br>Length: 16<br>Value: IPv6 Router ID of the source of the prefix advertisement |

## 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. Use the **commit** or **end** command.

### DETAILED STEPS

|        | Command or Action  | Purpose  |
|--------|--|--|
| Step 1 | <b>configure</b><br><b>Example:</b><br><br>RP/0/RP0/CPU0:router# <b>configure</b>  | Enters global configuration mode.              |
| Step 2 | <b>router isis</b> <i>instance-id</i><br><b>Example:</b><br><br>RP/0/RP0/CPU0:router(config)# <b>router isis 1</b>           |  |
| Step 3 | <b>interface Loopback</b> <i>instance</i><br><b>Example:</b><br><br>RP/0/RP0/CPU0:router(config)# <b>interface Loopback0</b> | Specifies the loopback interface.              |
| Step 4 | <b>prefix-attributes n-flag-clear</b> [Level-1   Level-2]<br><b>Example:</b>   | Clears the prefix attribute N-flag explicitly. |



|               | Command or Action   | Purpose   |
|---------------|---|---|
|               | RP/0/RP0/CPU0:router(config-if)# <b>isis prefix-attributes n-flag-clear</b> |   |
| <b>Step 5</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> |

Verify the prefix attribute configuration:

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

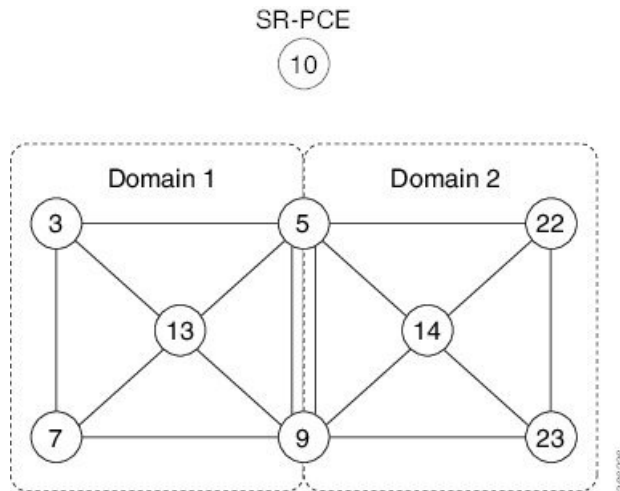
IS-IS 1 (Level-2) Link State Database
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
router.00-00   * 0x0000039b  0xfc27        1079           0/0/0
  Area Address: 49.0001
  NLPID:        0xcc
  NLPID:        0x8e
  MT:           Standard (IPv4 Unicast)
  MT:           IPv6 Unicast                               0/0/0
  Hostname:     router
  IP Address:   10.0.0.1
  IPv6 Address: 2001:0db8:1234::0a00:0001
  Router Cap:   10.0.0.1, D:0, S:0
    Segment Routing: I:1 V:1, SRGB Base: 16000 Range: 8000
    SR Algorithm:
      Algorithm: 0
      Algorithm: 1
<...>
Metric: 0      IP-Extended 10.0.0.1/32
  Prefix-SID Index: 1001, Algorithm:0, R:1 N:0 P:1 E:0 V:0 L:0
  Prefix Attribute Flags: X:0 R:1 N:0
Metric: 10     IP-Extended 10.0.0.2/32
  Prefix-SID Index: 1002, Algorithm:0, R:0 N:1 P:0 E:0 V:0 L:0
  Prefix Attribute Flags: X:0 R:0 N:1
  Source Router ID: 10.0.0.2
<...>
```

## 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
router isis Domain1
 interface Loopback0
  address-family ipv4 unicast
  prefix-sid absolute 16005

router isis Domain2
 interface Loopback0
  address-family ipv4 unicast
  prefix-sid absolute 16005

```

```

Example: Border Node 9
router isis Domain1
 interface Loopback0
  address-family ipv4 unicast
  prefix-sid absolute 16009

router isis Domain2
 interface Loopback0
  address-family ipv4 unicast
  prefix-sid absolute 16009

```

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**

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

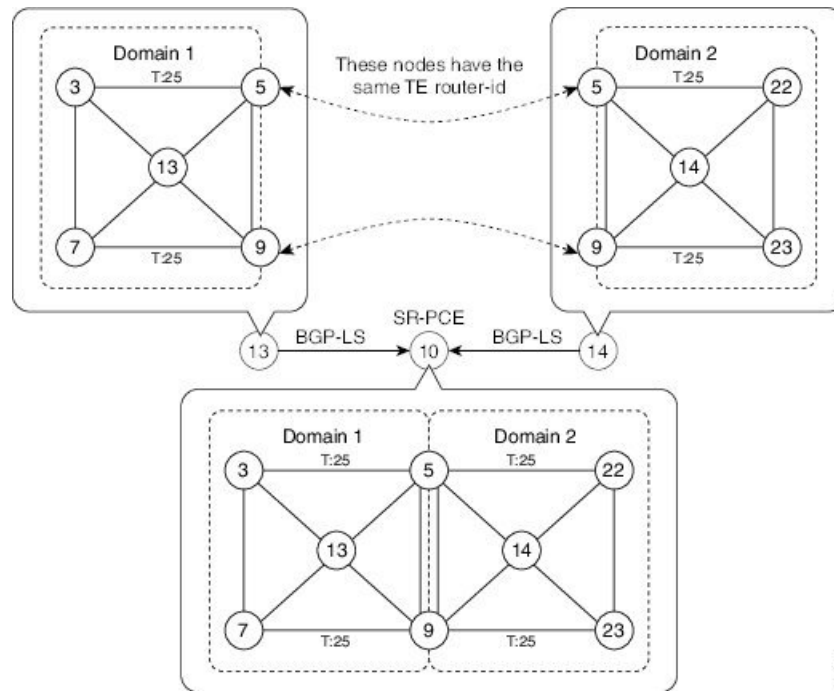
router isis Domain2
 address-family ipv4 unicast
  router-id loopback0
```

**Example: Border Node 9**

```
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**

```
router isis Domain1
 distribute link-state instance-id instance-id
```

**Example: Node 14**

```
router isis Domain2
  distribute link-state instance-id instance-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.