

Segment Routing with IS-IS v4 Node SID

This chapter describes how Segment Routing works with IS-IS and contains the following sections:

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Feature Information for Segment Routing with IS-IS v4 Node SID

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to https://cfnng.cisco.com/. An account on Cisco.com is not required.

Restrictions for Segment Routing with IS-IS v4 Node SID

- Segment routing must be configured at the top level before any routing protocol configuration is allowed under its router configuration sub mode.
- IS-IS protocol SR command is based on per topology (IPv4 address family).
- Effective Cisco IOS-XE Release 3.16, ISIS supports segment routing for IPv4 only.

Information About Segment Routing with IS-IS v4 Node SID

Segment Routing IS-IS v4 Node SID

Segment Routing relies on a small number of extensions to Cisco Intermediate System-to-Intermediate System (IS-IS) and Open Shortest Path First (OSPF) protocols. There are two levels of configuration required to enable segment routing for a routing protocol instance. The top level segment routing configuration which is managed by segment routing infrastructure component enables segment routing, whereas, segment routing configuration at the router level enables segment routing for a specific address-family of a routing protocol instance. There are three segment routing states:

- SR_NOT_CONFIGURED
- SR_DISABLED
- SR_ENABLED

Segment routing configuration under the IGPs is allowed only if the SR state is either SR_DISABLED or SR_ENABLED. The SR_ENABLED state indicates that there is at least a valid SRGB range reserved through the MFI successfully. You can enable segment routing for IGPs under the router configuration sub mode, through commands. However, IGP segment routing are enabled only after the global SR is configured.

The SR_ENABLED is a necessary state for any protocol to enable SR, however, it is not a sufficient for enabling SR for a protocol instance. The reason being that the IS-IS still does not have any information about segment routing global block (SRGB) information. When the request to receive information about the SRGB is processed successfully, the IS-IS SR operational state is enabled.

Segment Routing requires each router to advertise its segment routing data-plane capability and the range of MPLS label values that are used for segment routing in the case where global SIDs are allocated. Data-plane capabilities and label ranges are advertised using the SR-capabilities sub-TLV inserted into the IS-IS Router Capability TLV-242 that is defined in RFC4971.

ISIS SR-capabilities sub TLV includes all reserved SRGB ranges. However, the Cisco implementation supports only one SRGB range. The supported IPv4 prefix-SID sub TLV are TLV-135 and TLV-235.

Prefix SIDs Received in Label-Switched Path from Remote Routers

Prefix SIDs received in a label switched path (LSP) with a reachability TLV (TLV 135 and 235) are downloaded to the routing information base (RIB) in the same way as BGP downloads per prefix VPN labels, only if the following conditions are met:

- Segment routing is enabled for the topology and address-family.
- Prefix-SID is valid.
- The local label binding to MFI is successful.

Note

- For SIDs that do not fit in the specified SID range, labels are not used when updating the RIB. For the cases, where SID fits in the SID range, but does not fit the next-hop neighbor SID range, remote label associated with that path is not installed.
- Node SIDs received in an LSP with reachability TLVs (TLV 135 and 235) are downloaded to RIB only if segment routing is enabled under the corresponding address-family.
- In case of multiple best next hops, if all the next hops do not support segment routing, ISIS treats the instance similar to mismatched labels assigned to the same prefix. That means, IS-IS ignores the labels and installs unlabeled paths for all ECMP paths into the global RIB.

Segment Routing Adjacency SID Advertisement

Effective with Cisco IOS-XE Release 3.17, IS-IS supports the advertisement of segment routing adjacency SID. An Adjacency Segment Identifier (Adj-SID) represents a router adjacency in Segment Routing.

A segment routing-capable router may allocate an Adj-SID for each of its adjacencies and an Adj-SID sub-TLV is defined to carry this SID in the Adjacency TLVs. IS-IS adjacencies are advertised using one of the IS-Neighbor TLVs below:

- TLV-22 [RFC5305]
- TLV-23 [RFC5311]

IS-IS allocates the adjacency SID for each IS-IS neighbor only if the IS-IS adjacency state is up and IS-IS segment routing internal operational state is enabled. If an adjacency SID allocation failure is due to out-of-label resource, IS-IS retries to allocate the Adj-SID periodically in a default interval (30 seconds).

Adjacency SIDs

Effective with Cisco IOS-XE Release 3.18, multiple adjacency-SIDs are supported. For each protected P2P/LAN adjacency, IS-IS allocates two Adj-SIDs. The backup Adj-SID is only allocated and advertised when FRR (local LFA) is enabled on the interface. If FRR is disabled, then the backup adjacency-SID is released. The persistence of protected adj-SID in forwarding plane is supported. When the primary link is down, IS-IS delays the release of its backup Adj-SID until the delay timer expires. This allows the forwarding plane to continue to forward the traffic through the backup path until the router is converged.

Cisco IOS-XE Release 3.18, IS-IS Adj-SID is changed to be per level based since the forwarding plane is unaware of protocol-specific levels. The allocated and advertised backup Adj-SIDs can be displayed in the output of **show isis neighbor detail** and **show isis data verbose** commands.

Segment Routing Mapping Server

Segment Routing Mapping Server (SRMS) allows configuration and maintenance of the Prefix-SID mapping policy entries. Effective with Cisco IOS-XE Release 3.17, the IGPs use the active policy of the SRMS to determine the SID values when programming the forwarding plane.

The SRMS provides prefixes to SID/Label mapping policy for the network. IGPs, on the other hand, are responsible for advertising prefixes to SID/Label mapping policy through the Prefix-SID/Label Binding TLV. Active policy information and changes are notified to the IGPs, which use active policy information to update forwarding information.

Connected Prefix SIDs

Sometimes, a router may install a prefix with a SID that is different than what it advertises to the LSP. For example, if more than one protocol or more than one IGP instance is announcing the same prefix with different SIDs to the SRMS, the SRMS resolves the conflict and announces the winning prefix and SID that may not be the same as the local instance. In that case, the IGP always advertises what it learns from its source LSP although it still tries to install the SID which may be different than what it learns in its LSP. This is done to prevent the IGP from redistributing the SIDs from another protocol or another protocol instance.

SRGB Range Changes

When IS-IS segment routing is configured, IS-IS must request an interaction with the SRGB before IS-IS SR operational state can be enabled. If no SRGB range is created, IS-IS will not be enabled.

When an SRGB change event occurs, IS-IS makes the corresponding changes in its sub-block entries. IS-IS also advertises the newly created or extended SRGB range in SR-capabilities sub-TLV and updates the prefix-sid sub TLV advertisement.



Note In Cisco IOS-XE Release 3.16 only one SRGB range and SRGB extension for the modification are supported.

SRGB Deletion

When IS-IS receives an SRGB deletion event, it looks for an SRGB entry in the IS-IS SRGB queue list. If an SRGB entry does not exist, IS-IS makes sure that there is no pending SRGB created event. If a pending SRGB creation event is found, then IS-IS removes the SRGB creation event, and completes the SRGB delete processing,

If an SRGB entry is found in the IS-IS SRGB queue, IS-IS locks the SRGB, redistributes the RIBs and un-advertises all prefixed-SIDs that have SID value within the pending delete SRGB range, and un-advertises the SRGB range from SR-capabilities sub TLV. Once IS-IS has completed the SRGB deletion processing, it unlocks the SRGB and deletes the SRGB from its SR sub-block entry.

If there is no valid SRGB after the deletion of the SRGB, IS-IS SR operational state becomes disabled.

MPLS Forwarding on an Interface

MPLS forwarding must be enabled before segment routing can use an interface. IS-IS is responsible for enabling MPLS forwarding on an interface.

When segment routing is enabled for a IS-IS topology, or IS-IS segment routing operational state is enabled, IS-IS enables MPLS for any interface on which the IS-IS topology is active. Similarly, when segment routing is disabled for a IS-IS topology, IS-IS disables the MPLS forwarding on all interfaces for that topology.

Segment Routing and LDP Preference

The command **sr-label-preferred** allows the forwarding interface to prefer the segment routing labels over LDP labels for all prefixes in a topology.

Segment Routing Traffic Engineering Announcements

IS-IS announces segment routing information to TE when it detects that both, IS-IS SR and TE are enabled for at least one level. IS-IS announce only the information that is obtained from the level for which TE is configured.

Similarly, IS-IS instructs TE to delete all announcements when it detects that segment routing is not enabled or TE is no longer configured on any level.

How to Configure Segment Routing with IS-IS v4 Node SID

Configuring Segment Routing

Before you begin

Before configuring IS-IS to support segment routing you must first configure the segment routing feature in global configuration mode.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **segment-routing mpls**
4. **connected-prefix-sid-map**
5. **address-family ipv4**
6. **10.1.1.1/32 index 100 range 1**
7. **exit-address-family**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**segment-routing mpls** **Example:**	Enables the segment feature using the MPLS data plane.

	Command or Action	Purpose
	`Device(config-sr)# segment-routing mpls`	
Step 4	**connected-prefix-sid-map** **Example:** `Device(config-srmpls)# connected-prefix-sid-map`	Enters a sub-mode where you can configure address-family specific mappings for local prefixes and SIDs.
Step 5	**address-family ipv4** **Example:** `Device(config-srmpls-conn)# address-family ipv4`	Specifies IPv4 address prefixes.
Step 6	**10.1.1.1/32 index 100 range 1** **Example:** `Device(config-srmpls-conn-af)# 10.1.1.1/32 100 range 1`	Associates SID 100 with the address 10.1.1.1/32.
Step 7	**exit-address-family** **Example:** `Device(config-srmpls-conn-af)# exit-address-family`	Exits the address family.

Configuring Segment Routing on an IS-IS Network

Before you begin

Before you configure segment routing on IS-IS network, IS-IS must be enabled on your network.

SUMMARY STEPS

1. **router isis**
2. **net network-entity-title**
3. **metric-style wide**
4. **segment-routing** mpls
5. **exit**
6. **show isis segment-routing**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**router isis** **Example:**	Enables the IS-IS routing protocol and enters router configuration mode.

	Command or Action	Purpose
	`Device(config-router)# router isis`	
Step 2	**net network-entity-title** **Example:** `Device(config-router)# net 49.0000.0000.0003.00`	Configures network entity titles (NETs) for the routing instance.
Step 3	**metric-style wide** **Example:** `Device(config-router)# metric-style wide`	Configures the device to generate and accept only wide link metrics.
Step 4	**segment-routing** mpls **Example:** `Device(config-router)# segment-routing mpls`	Configures segment routing operation state.
Step 5	**exit** **Example:** `Device(config-router)# exit`	Exits segment routing mode and returns to the configuration terminal mode.
Step 6	**show isis segment-routing** **Example:** `Device# show is-is segment-routing`	Displays the current state of the IS-IS segment routing.

Example

The following example displays output from the **show isis segment-routing state** command for the segment routing under IS-IS:

```
Device# show isis segment-routing

ISIS protocol is registered with MFI
ISIS MFI Client ID:0x63
Tag 1 - Segment-Routing:
   SR State:SR_ENABLED
   Number of SRGB:1
   SRGB Start:16000, Range:8000, srgb_handle:0x4500AED0, srgb_state: created
   Address-family IPv4 unicast SR is configured
     Operational state:Enabled
```

Configuring Prefix-SID for IS-IS

This section explains how to configure prefix segment identifier (SID) index under each interface.

Before you begin

Segment routing must be enabled on the corresponding address family.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **segment-routing mpls**
4. **connected-prefix-sid-map**
5. **address-family ipv4**
6. **10.1.1.1/32 index 100 range 1**
7. **exit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables privileged EXEC mode.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**segment-routing mpls** **Example:** `Device(config)# segment-routing mpls`	Configures segment routing mpls mode.
Step 4	**connected-prefix-sid-map** **Example:** `Device(config-srmpls)# connected-prefix-sid-map`	Enters a sub-mode where you can configure address-family specific mappings for local prefixes and SIDs.
Step 5	**address-family ipv4** **Example:** `Device(config-srmpls-conn)# address-family ipv4`	Specifies the IPv4 address family and enters router address family configuration mode.
Step 6	**10.1.1.1/32 index 100 range 1** **Example:**	Associates SID 100 with the address 10.1.1.1/32.

	Command or Action	Purpose
	`Device(config-srmpls-conn-af)# 10.1.1.1/32 100 range 1`	
Step 7	**exit** **Example:** `Device(config-router)# exit`	Exits segment routing mode and returns to the configuration terminal mode.

Configuring Prefix Attribute N-Flag

By default, a flag called N-flag is set by IS-IS when advertising an SID that is associated with a loopback address. To clear this flag add explicit configuration.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface loopback3**
4. **isis prefix n-flag-clear**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface loopback3** **Example:** `Device(config)# interface loopback3`	Specifies the interface loopback.
Step 4	**isis prefix n-flag-clear** **Example:** `Device(config-if)# isis prefix n-flag-clear`	Clears the prefix N-flag.

Configuring the Explicit Null Attribute

To disable penultimate-hop-popping (PHP) and add explicit-Null label, explicit-null option needs to be specified. Once the option is given, IS-IS sets the E flag in the prefix-SID sub TLV.

By default, a flag called E-flag (Explicit-Null flag) is set to 0 by ISIS when advertising a Prefix SID which is associated with a loopback address. If you wish to set this flag add explicit configuration.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **segment-routing mpls**
4. **set-attributes**
5. **address-family ipv4**
6. **explicit-null**
7. **exit-address-family**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**segment-routing mpls** **Example:** `Device(config)# segment-routing mpls`	Configures segment routing mpls mode.
Step 4	**set-attributes** **Example:** `Device(config-srmpls)# set-attributes`	Sets the attribute.
Step 5	**address-family ipv4** **Example:** `Device(config-srmpls-attr)# address-family ipv4`	Specifies the IPv4 address family and enters router address family configuration mode.

	Command or Action	Purpose
Step 6	**explicit-null** **Example:** `Device(config-srmpls-attr-af)# explicit-null`	Enables the explicit-null label.
Step 7	**exit-address-family** **Example:** `Device(config-srmpls-attr-af)# exit-address-family`	Exits the address family.

Configuring Segment Routing Label Distribution Protocol Preference

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **segment-routing mpls**
4. **set-attributes**
5. **address-family ipv4**
6. **sr-label-preferred**
7. **exit-address-family**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**segment-routing mpls** **Example:** `Device(config)# segment-routing mpls`	Configures segment routing mpls mode.
Step 4	**set-attributes** **Example:**	Sets the attribute.

	Command or Action	Purpose
	`Device(config-srmpls)# set-attributes`	
Step 5	**address-family ipv4** **Example:** `Device(config-srmpls-attr)# address-family ipv4`	Specifies the IPv4 address family and enters router address family configuration mode.
Step 6	**sr-label-preferred** **Example:** `Device(config-srmpls-attr-af)# sr-label-preferred`	Specifies SR label to be preferred over the LDP.
Step 7	**exit-address-family** **Example:** `Device(config-srmpls-attr-af)# exit-address-family`	Exits the address family.

Configuring IS-IS SRMS

The following command enables the IS-IS SRMS and allows IS-IS to advertise local mapping entries. IS-IS does not send remote entries to the SRMS library. However, IS-IS uses the SRMS active policy, which is computed based only on the locally configured mapping entries.

```
[no] segment-routing prefix-sid-map advertise-local
```

Configuring IS-IS SRMS Client

By default, the IS-IS SRMS client mode is enabled. IS-IS always sends remote prefix-sid-mapping entries received through LSP to SRMS. The SRMS active policy is calculated based on local and remote mapping entries.

The following command disables the prefix-sid-mapping client functionality and it is configured on the receiver side:

```
segment-routing prefix-sid-map receive [disable]
```

Configuring IS-IS SID Binding TLV Domain Flooding

By default, the IS-IS SRMS server does not flood SID binding entries within the routing domain. From Cisco IOS-XE Release 3.18, the optional keyword **domain-wide** is added in the IS-IS SRMS server mode command to enable the SID and Label binding TLV flooding functionality:

```
segment-routing prefix-sid-map advertise-local [domain-wide]
```

The **domain-wide** keyword enables the IS-IS SRMS server to advertise SID binding TLV across the entire routing domain.

Note The option is valid only if IS-IS SRMS performs in the SRMS server mode.

Configuration Examples for Segment Routing —IS-IS v4 Node SID

Example: Configuring Segment Routing on IS-IS Network

The following example shows how to configure prefix segment identifier (SID) index under each interface:

```
Device(config)#segment-routing mpls
 Device(config-srmpls)#connected-prefix-sid-map
  Device(config-srmpls-conn)#address-family ipv4
   Device(config-srmpls-conn-af)#10.1.2.2/32 index 2 range 1
  Device(config-srmpls-conn-af)#exit-address-family
 Device(config-srmpls-conn-af)#end
```

Example: Configuring an Explicit Null Attribute

The following is an example of configuring an explicit null attribute:

```
Device(config)# segment-routing mpls
Device(config-srmpls)# set-attributes
 Device(config-srmpls-attr)# address-family ipv4
  Device(config-srmpls-attr-af)# explicit-null
 Device (config-srmpls-attr-af)# exit-address-family
```

Additional References for Segment Routing with IS-IS v4 Node SID

Related Documents

Related Topic	Document Title
IP Routing ISIS commands	Cisco IOS IP Routing ISIS commands

RFCs

RFC	Title
RFC4971	Intermediate System to Intermediate System (IS-IS) Extensions for Advertising Router Information
RFC5305	IS-IS Extensions for Traffic Engineering. Defines the advertisement of router IDs for IPv4.

RFC	Title
RFC6119	IPv6 Traffic Engineering in IS-IS. Defines the advertisement of router IDs for IPv6.