



Using Segment Routing with IS-IS

We know that segment routing enables a node to select any path (explicit or derived from the computations of the internal gateway protocol's shortest path). This path is not dependent on a hop-by-hop signaling technique (through LDP or RSVP), but on a set of segments that are advertised by a routing protocol, such as IS-IS or OSPF. These segments act as topological sub-paths that can be combined to form the desired path.

Segment Routing must be enabled before any IGP, such as IS-IS or OSPF, can configure segment routing functionality. Similarly, when segment routing is disabled, all IGP-related configuration is also disabled.

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Restrictions for Using Segment Routing with IS-IS

- Effective Cisco IOS XE Release 3.16S, ISIS supports segment routing for IPv4 only.
- Segment routing must be configured at the "Router" or "Global" 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).
- Only network type = point-to-point is supported.

Enabling Segment Routing

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 IGP 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.

Enabling Segment Routing for IGP

You can enable segment routing for IGP under the router configuration sub mode, through commands. However, IGP segment routing are enabled only after the global SR is configured.



Note IS-IS protocol SR command is based on per topology (IPv4 address family).

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.

Configuring Segment Routing on IS-IS

This section describes configuring segment routing IPV4 for IS-IS protocol under the router configuration sub mode.

```
[no] segment-routing mpls
```



Note This command is allowed only when segment routing is configured at the top level.

The following is an example of configuring IS-IS segment routing:

```
segment-routing mpls
```

```
router isis
net 33.0001.0001.0001.00
metric-style wide
segment-routing mpls
passive-interface Loopback2
```

Prefix-SID Received in LSPs 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) if all of 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.

For a prefix-SID received with reachability TLVs (TLV 135 and 235), the label is downloaded through RIB the same way as BGP downloads per prefix VPN labels.

If the path is a remote LFA path, ISIS downloads the path the same way it downloads it before adding the segment routing functionality but does *not* download any label with this path. This behavior ensures that remote LFA functionality is still supported using LDP.

Limitations

- For SIDs that do not fit in the specified SID range, labels are not used when updating the RIB. For cases, where SID does fit 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 not all next hops support segment routing, ISIS will treat this instance similar to when mismatched labels are assigned to the same prefix. That is, 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 3.17S, 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).

Multiple Adjacency-SIDs

Effective with Cisco IOS XE Release 3.18S, 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 3.18S, 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 (SRMS)

Segment Routing Mapping Server (SRMS) allows configuration and maintenance of the Prefix-SID mapping policy entries. Effective with Cisco IOS XE Release 3.17S, the IGP's 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. IGP's, 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 IGP's, 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.

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 both, local and remote mapping entries.

The following command disables the prefix-sid-mapping client functionality.

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

This command is configured on the receiver side.

Configuring ISIS SID Binding TLV Domain Flooding

By default, the IS-IS SRMS server does not flood SID binding entries within the routing domain. In Cisco IOS XE Release 3.18S, the optional keyword **domain-wide** 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.

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 3.16S 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

In Cisco IOS XE Release 3.16S, the command **sr-prefer** is used to tell the forwarding interface to prefer using segment routing labels over LDP labels for all prefixes in a topology.

Segment Routing-TE

Segment Routing Traffic Engineering requires the IGP to provide segment routing related information to TE. The information includes SRGB, Adjacency-SID, Prefix-SID, primary and repair paths for all nodes in the topology.

The maximum number of allowed SR-TE tunnels are 510.

Enabling and Disabling SR-TE Announcements

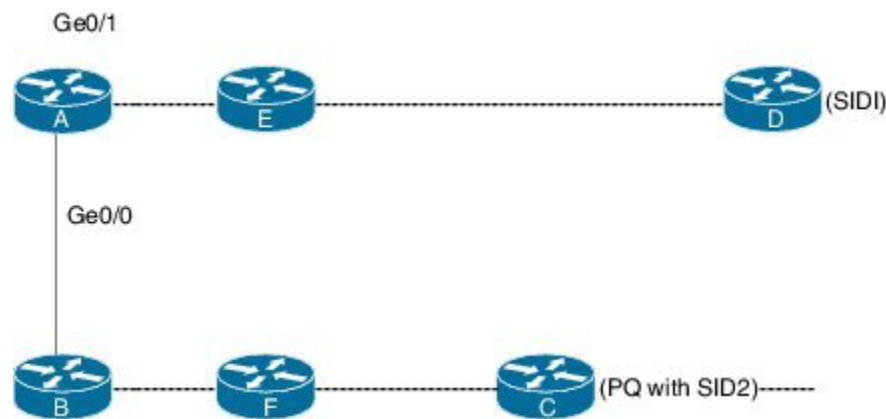
IS-IS announces the SR information to TE when it detects that both, IS-IS SR and TE are enabled for at least one level. IS-IS announce only the information that is obtained from the level for which TE is configured.

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

RLFA LDP and SR

Consider the following topology.

Figure 1: Sample Topology



The traffic flows from A to D. The primary path is A-E-D and the primary next hop interface is Ge0/1. The secondary path is A-B-F-C-D, and C is the PQ node. The repair tunnel ends at PQ node C. The existing RLFA uses LDP TE tunnel for the repair path. When both LDP and SR are enabled, the LDP tunnel is used for RLFA repair path by default unless the segment routing preferred is configured through the **sr-prefer** command.

Topology-Independent LFA

When the local LFA and remote LFA are enabled, there is a good coverage of the prefixes to be protected. However, for some rare topologies that do not have a PQ intersect node, both local and remote LFA will fail to find a release node to protect the failed link. Furthermore, there is no way to prefer a post-convergence path, as the two algorithms have no knowledge of the post-convergence characteristics of the LFA.

To overcome the above limitation, effective Cisco IOS XE Release 3.18S, topology-independent LFA (TI-LFA) is supported on an SR-enabled network.

In Cisco IOS XE Release 3.18S, TI LFA supports the following:

- Link Protection—The LFA provides repair path for failure of the link.
- Local LFA—Whenever a local LFA on the post convergence path is available, it is preferred over TI-LFA because local LFA does not require additional SID for the repair path. That is, the label for the PQ node is not needed for the release node.
- Local LFA for extended P space—For nodes in the extended P space, local LFA is still the most economical method for the repair path. In this case, TI-LFA will not be chosen.
- Tunnel to PQ intersect node—This is similar to remote LFA except that the repair path is guaranteed on the post convergence path using TI-LFA.
- Tunnel to PQ disjoint node—This capability is unique to the TI-LFA in the case when local and remote LFA cannot find a repair path.
- Tunnel to traverse multiple intersect or disjoint PQ nodes, up to the platform's maximum supported labels—TI-LFA provides complete coverage of all prefixes.
- P2P interfaces for the protected link—TI-LFA protects P2P interfaces.
- Asymmetrical links—The ISIS metrics between the neighbors are not the same.
- Multi-homed (anycast) prefix protection—The same prefix may be originated by multiple nodes.
- Protected prefix filtering—The route-map includes or excludes a list of prefixes to be protected and the option to limit the maximum repair distance to the release node.
- Tiebreakers—A subset of existing tiebreakers, applicable to TI-LFA, is supported.

Restrictions for the TI-LFA

- IGP throttles timers that are required for RLFA tunnel are also applicable to SR and SR TI-LFA.
- Scale values supported for TI-LFA
 - Global prefixes: 1500
 - L3VPN: 4000 prefixes
 - L2VPN: 2000 virtual circuits
- SR and TI-LFA are supported on BDI and routed ports.
- Four MPLS label push is supported. TI-LFA tunnel carries a maximum of two labels and the other two labels are for services.
- Cisco ASR900 routers with RSP3 module support a maximum of 2 labels under TI-LFA tunnel.

Tie-breaker

Local and remote LFA use default or user-configured heuristics to break the tie when there is more than one path to protect the prefix. The attributes are used to trim down the number of repair paths at the end of the TI-LFA link protection computation before the load balancing.

Local LFA and remote-LFA support the following tiebreakers:

- linecard-disjoint—Prefers the line card disjoint repair path
- lowest-backup-path-metric—Prefers the repair path with lowest total metric
- node-protecting—Prefers node protecting repair path
- srlg-disjoint—Prefers SRLG disjoint repair path
- load-sharing—Distributes repair paths equally among links and prefixes

For TI-LFA link protection, the following tiebreakers are supported:

- linecard-disjoint—Prefers the line card disjoint repair path.

How it works: When there are two repair paths for a particular prefix, the path that the output port on different line card than that of the primary port is chosen as the repair path.

The following variant of the linecard-disjoint is supported:

- LC disjoint index—If both the repair paths are on the same line card as that of the primary path, then, both paths are considered as candidates. If one of the path is on a different line card, then that path is chosen as the repair path.
- srlg-disjoint—Prefers the SRLG disjoint repair path

The SRLG ID can be configured for each interface. When there are two repair paths for a prefix, the configured SRLG ID for the repair path is compared with that of the primary path SRLG ID. If the SRLG IDs for the secondary path is different than that of the primary, that path is chosen as the repair path.



Note This policy comes into effect only when the primary path is configured with an SRLG ID.

The following variant of the srlg-disjoint is supported:

- **srlg index**—If both the repair paths have the same SRLG ID as that of the primary path, then, both the paths are considered as candidates. If one of the path has a different srlg id, then path is chosen as the repair path.
- **node-protecting**—For TI-LFA node protection, the protected node is removed when computing the post-convergence shortest path. The repair path must direct traffic around the protected node.

It is possible to configure both node and SRLG protection modes for the same interface or the same protocol instance. In that case, an additional TI-LFA node-SRLG combination protection algorithm is run. The TI-LFA node-SRLG combination algorithm removes the protected node and all members of the interface with the same SRLG group when computing the post-convergence SPT.

For TI-LFA node protection, SRLG protection, and node-SRLG combination protection, it is likely the coverage for the protected prefixes is small. TI-LFA link protection is also run to provide coverage for the prefixes that not yet covered. However, optimization can be achieved when SRLG protection is enabled with no SRLG group on the interface. In that case, SRLG protection produces the same result as link protection and link protection is skipped. Furthermore, if node-protection is also configured in this case, TI-LFA node-SRLG combination protection produces the same result as node-protection and node-protection is skipped.

Interface FRR Tiebreakers

For TI-LFA node and SRLG protection, interface FRR tiebreakers must also be provided. Existing FRR tiebreakers are configured on a per protocol instance. Because FRR tiebreakers are not specific to TI-LFA, interface FRR tiebreakers are available for all FRR types. When both interface and protocol instance FRR tiebreakers are configured, the interface FRR tiebreakers take precedence over the protocol instance. When interface FRR tiebreakers are not configured, the interface inherits the protocol instance FRR tiebreakers. As with the existing tiebreakers, the priority must be unique among the interface and protocol instance for the tiebreakers.

The following interface FRR tiebreaker commands apply only to the particular interface.

```
isis fast-reroute tie-break
[level-1 | level-2] linecard-disjoint
priority
isis fast-reroute tie-break
[level-1 | level-2] lowest-backup-metric
priority
isis fast-reroute tie-break
[level-1 | level-2] node-protecting
priority
isis fast-reroute tie-break
[level-1 | level-2] srlg-disjoint
priority
isis fast-reroute tie-break
[level-1 | level-2] default
```

Tie-breaker default and explicit tie-breaker on the same interface are mutually exclusive.

The following tie-breakers are enabled by default on all LFAs:

- linecard-disjoint
- lowest-backup-metric
- srlg-disjoint

Effective with Cisco IOS XE Release 3.18S, node-protecting tie-breaker is disabled by default.

Limitations on Tie-Breakers

The following tie-breakers are not applicable for these LFA scheme.

TILFA:

- broadcast-interface-disjoint
- downstream
- primary-path
- secondary-path

RLFA:

- broadcast-interface-disjoint
- node-protecting
- downstream
- primary-path
- secondary-path

Configuring T1 LFA

TI-LFA is disabled by default. There are two methods to enable TI-LFA:

1. Using protocol enablement—Enable TI-LFA in router isis mode. This enables TI-LFA for all ISIS interfaces. Optionally, use the interface command to exclude the interfaces on which TI-LFA should be disabled.

For example, to enable TI-LFA for all IS-IS interfaces:

```
router isis 1
fast-reroute per-prefix {level-1 | level-2}
fast-reroute ti-lfa {level-1 | level-2} [maximum-metric value]
```

The **maximum-metric** option specifies the maximum repair distance which a node is still considered eligible as a release node.

To disable TI-LFA on a particular interface:

```
interface interface-name
isis fast-reroute ti-lfa protection level-1 disable
```



Note The **isis fast-reroute protection level-x** command enables local LFA and is required to enable TI-LFA.

2. Using interface enablement—Enable TI-LFA selectively on each interface

```
interface interface-name
isis fast-reroute protection {level-1 | level-2}
isis fast-reroute ti-lfa protection {level-1 | level-2} [maximum-metric value]
```

When both interface and protocol are TI-LFA enabled, the interface configuration takes precedence over the protocol configuration.

Configuration Example

Example 1: In the following example, local LFA is configured with linecard-disjoint and srlg-disjoint tie-breakers. linecard-disjoint is given preference with a lower priority value (10) than the srlg-disjoint (11).

```
router isis access
 net 49.0001.2037.0685.b002.00
 metric-style wide
 fast-flood 10
 max-lsp-lifetime 65535
 lsp-refresh-interval 65000
 spf-interval 5 50 200
 prc-interval 5 50 200
 lsp-gen-interval 5 5 200
 log-adjacency-changes
 nsf ietf
 segment-routing mpls
 fast-reroute per-prefix level-1 all - configures the local LFA
 fast-reroute per-prefix level-2 all
 fast-reroute remote-lfa level-1 mpls-ldp - enables rLFA (optional)
 fast-reroute remote-lfa level-2 mpls-ldp
 fast-reroute ti-lfa level-1 - enables TI-LFA
 microloop avoidance rib-update-delay 15000
 bfd all-interfaces
```

Example 2—Enable TI-LFA node-protecting tie-breaker on all ISIS level-2 interfaces with priority 100. All other tie-breakers are disabled.

```
router isis
 fast-reroute per-prefix level-2 all
 fast-reroute ti-lfa level-2
 fast-reroute tie-break level-2 node-protecting 100
```

Example 3—Enable TI-LFA node-protecting tie-breaker with priority 100 and TI-LFA SRLG protection with priority 200 on all IS-IS level-2 interfaces. All other tiebreakers are disabled because the node-protecting tie-breaker is configured.

```
router isis
 fast-reroute per-prefix level-2 all
 fast-reroute ti-lfa level-2
 fast-reroute tie-break level-2 node-protecting 100
 fast-reroute tie-break level-2 srlg-disjoint 200
```

Example 3—Enable TI-LFA node-protecting tie-breaker with priority 100 on all ISIS level-2 interfaces except on Ethernet0/0. For those IS-IS interfaces, all other tiebreakers are disabled. Ethernet0/0 overwrites the inheritance and uses the default set of tiebreakers with linecard-disjoint, lowest-backup-path-metric, srlg-disjoint enabled.

```
router isis
 fast-reroute per-prefix level-2 all
 fast-reroute ti-lfa level-2
 fast-reroute tie-break level-2 node-protecting 100
 !
 interface ethernet0/0
```

```
ip router isis
isis fast-reroute tie-break level-2 default
```

Example 4—Enable TI-LFA using the default tiebreaker on all IS-IS interfaces except on Ethernet0/0. On Ethernet0/0 enable TI-LFA node-protecting with priority 100 and disable all other tiebreakers.

```
router isis
fast-reroute per-prefix level-2 all
fast-reroute ti-lfa level-2
!
interface ethernet0/0
ip router isis
isis fast-reroute tie-break level-2 node-protecting 100
```

Example 5—Enable TI-LFA node-protecting tie-breaker with priority 200 and linecard-disjoint tie-breaker with priority 100 on all ISIS level-2 interfaces. All other tiebreakers are disabled.

```
router isis
fast-reroute per-prefix level-2 all
fast-reroute ti-lfa level-2
fast-reroute tie-break level-2 linecard-disjoint 100
fast-reroute tie-break level-2 node-protecting 200
```

Verifying the Tie-breaker

To view tiebreakers are enabled on the interface:

```
Router# show running-configuration | router isis access
Building configuration...

Current configuration : 702 bytes
!
Configuration of Partition - router isis access
!
router isis access
net 49.0001.2037.0685.b002.00
metric-style wide
fast-flood 10
max-lsp-lifetime 65535
lsp-refresh-interval 65000
spf-interval 5 50 200
prc-interval 5 50 200
lsp-gen-interval 5 5 200
no hello padding point-to-point
log-adjacency-changes
nsf cisco
nsf interval 0
segment-routing mpls
fast-reroute per-prefix level-1 all
fast-reroute per-prefix level-2 all
fast-reroute tie-break level-1 linecard-disjoint 12
fast-reroute remote-lfa level-1 mpls-ldp
fast-reroute remote-lfa level-2 mpls-ldp
fast-reroute ti-lfa level-1
bfd all-interfaces
mpls traffic-eng router-id Loopback0
mpls traffic-eng level-1
!
!
end
```

Similarly, to view the tiebreakers enabled for the router mode:

```
Router# show running-configuration | isis neighbor
Tag access:
System Id      Type Interface      IP Address      State Holdtime Circuit Id
920-CE1        L1  Gi0/2/0          10.0.0.1        UP    25      02
9k-1           L1  Gi0/2/3          14.0.0.2        UP    27      00

Router(config-srmppls)# do sh run | sec interface GigabitEthernet0/2/0
interface GigabitEthernet0/2/0
 srlg gid 5
 srlg gid 10
 ip unnumbered Loopback0
 ip router isis access
 ip ospf network point-to-point
 carrier-delay down msec 1
 negotiation auto
 ipv6 address 10:1::2/64
 mpls ip
 mpls traffic-eng tunnels
 bfd template BFD1
 cdp enable
 isis network point-to-point
903-PE1(config-srmppls)#do sh run | sec interface GigabitEthernet0/2/3
interface GigabitEthernet0/2/3
 srlg gid 10
 ip address 14.0.0.1 255.255.255.0
 ip router isis access
 ip ospf network point-to-point
 negotiation auto
 mpls ip
 mpls traffic-eng tunnels
 cdp enable
 isis circuit-type level-1
 isis network point-to-point
```

Verifying the Primary and Repair Paths

In this example, 10.0.0.1 is the protecting neighbor and 4.4.4.4 is the neighbor on the protecting link.

```
Router#
show ip cef 10.0.0.1
10.0.0.1/32
  nexthop 10.0.0.1 GigabitEthernet0/2/0 label [explicit-null|explicit-null]() - slot 2 is
primary interface
  repair: attached-nexthop 24.0.0.2 TenGigabitEthernet0/3/0 - slot 3 is repair interface
  nexthop 24.0.0.2 TenGigabitEthernet0/3/0 label [explicit-null|explicit-null]()
  repair: attached-nexthop 10.0.0.1 GigabitEthernet0/2/0
Router#
show ip cef 4.4.4.4
4.4.4.4/32
  nexthop 4.4.4.4 GigabitEthernet0/2/3 label [explicit-null|16004]() - slot 2 is primary
interface
  repair: attached-nexthop 5.5.5.5 MPLS-SR-Tunnel2
Router# show ip cef 4.4.4.4 int
4.4.4.4/32, epoch 3, RIB[I], refcnt 6, per-destination sharing
sources: RIB, Adj, LTE
feature space:
  IPRM: 0x00028000
  Broker: linked, distributed at 4th priority
  LFD: 4.4.4.4/32 2 local labels
```

```

dflt local label info: global/877 [0x3]
sr local label info: global/16004 [0x1B]
contains path extension list
dflt disposition chain 0x46654200
  label implicit-null
  FRR Primary
  <primary: IP adj out of GigabitEthernet0/2/3, addr 4.4.4.4>
dflt label switch chain 0x46654268
  label implicit-null
  TAG adj out of GigabitEthernet0/2/3, addr 4.4.4.4
sr disposition chain 0x46654880
  label explicit-null
  FRR Primary
  <primary: TAG adj out of GigabitEthernet0/2/3, addr 4.4.4.4>
sr label switch chain 0x46654880
  label explicit-null
  FRR Primary
  <primary: TAG adj out of GigabitEthernet0/2/3, addr 4.4.4.4>
subblocks:
  Adj source: IP adj out of GigabitEthernet0/2/3, addr 4.4.4.4 464C6620
  Dependent covered prefix type adjfib, cover 0.0.0.0/0
ifnums:
  GigabitEthernet0/2/3(11): 4.4.4.4
  MPLS-SR-Tunnel2(1022)
path list 3B1FC930, 15 locks, per-destination, flags 0x4D [shble, hvsh, rif, hwn]
  path 3C04D5E0, share 1/1, type attached nexthop, for IPv4, flags [has-rpr]
  MPLS short path extensions: [rib | lblmrg | srlbl] MOI flags = 0x21 label explicit-null

  nexthop 4.4.4.4 GigabitEthernet0/2/3 label [explicit-null|16004](), IP adj out of
  GigabitEthernet0/2/3, addr 4.4.4.4 464C6620
  repair: attached-nexthop 5.5.5.5 MPLS-SR-Tunnel2 (3C04D6B0)
  path 3C04D6B0, share 1/1, type attached nexthop, for IPv4, flags [rpr, rpr-only]
  MPLS short path extensions: [rib | lblmrg | srlbl] MOI flags = 0x1 label 16004
  nexthop 5.5.5.5 MPLS-SR-Tunnel2 label 16004(), repair, IP midchain out of
MPLS-SR-Tunnel2 46CE2440
output chain:
  label [explicit-null|16004]()
  FRR Primary (0x3B209220)
  <primary: TAG adj out of GigabitEthernet0/2/3, addr 4.4.4.4 464C6480> - primary path
  <repair: TAG midchain out of MPLS-SR-Tunnel2 46CE22A0
  label 16()
  label 16003()
  TAG adj out of TenGigabitEthernet0/3/0, addr 24.0.0.2 46CE25E0> - repair
path

```

Verifying the IS-IS Segment Routing Configuration

```

Router# show isis segment-routing
ISIS protocol is registered with MFI
ISIS MFI Client ID:0x63
Tag Null - Segment-Routing:
  SR State:SR_ENABLED
  Number of SRGB:1
  SRGB Start:14000, Range:1001, srgb_handle:0xE0934788, srgb_state: created
  Address-family IPv4 unicast SR is configured
  Operational state: Enabled

```

The command with keyword **global-block** displays the SRGB and the range for LSPs.

```

Router# show isis segment-routing global-block
IS-IS Level-1 Segment-routing Global Blocks:

```

System ID	SRGB Base	SRGB Range
nevada	20000	4001
arizona	* 16000	1000
utah	40000	8000

The **show isis segment-routing prefix-sid-map** command with keyword **advertise** displays the prefix-sid maps that the router advertises.

```
Router# show isis segment-routing prefix-sid-map adv
IS-IS Level-1 advertise prefix-sid maps:
Prefix          SID Index  Range      Flags
16.16.16.16/32  101       1          Attached
16.16.16.17/32  102       1          Attached
```

The **show isis segment-routing prefix-sid-map** command with keyword **receive** displays the prefix-sid maps that the router receives.

```
Router #sh isis segment-routing prefix-sid-map receive
IS-IS Level-1 receive prefix-sid maps:
Host           Prefix          SID Index  Range      Flags
utah           16.16.16.16/32  101       1          Attached
               16.16.16.17/32  102       1          Attached
```

To display the connected-SIDs found in the LSPs and passed to the mapping server component, use the **show isis segment-routing connected-sid** command.

```
Router# show isis segment-routing connected-sid
IS-IS Level-1 connected-sids
Host           Prefix          SID Index  Range      Flags
nevada        * 1.1.1.2/32    1002      1          Attached
               2.2.2.2/32     20        1          Attached
               100.1.1.10/32  10        1          Attached
colorado      1.1.1.3/32     33        1          Attached
               1.1.1.6/32     6         1          Attached
IS-IS Level-2 connected-sids
Host           Prefix          SID Index  Range      Flags
```

Verifying the IS-IS TI-LFA Tunnels

```
Router# show isis fast-reroute ti-lfa tunnel
Fast-Reroute TI-LFA Tunnels:
Tunnel  Interface  Next Hop      End Point      Label      End Point Host
MP1     Et1/0     30.1.1.4     1.1.1.2       41002     nevada
MP2     Et0/0     19.1.1.6     1.1.1.6       60006     colorado
               1.1.1.2     16          nevada
MP3     Et0/0     19.1.1.6     1.1.1.6       60006     colorado
               1.1.1.2     16          nevada
               1.1.1.5     70005     wyoming
```

