IS-IS Link-protection Topology Independent Loop Free Alternate Fast Reroute

This document describes the functionalities and IS-IS implementation of IP Fast Re-Route feature (IPFRR) using Segment Routing (SR) Topology Independent Loop Free Alternative (TI-LFA) link protection.

Feature Information for IS-IS Link-protection Topology Independent Loop Free Alternate Fast Reroute

Table 1: Feature Information for IS-IS Link-protection Topology Independent Loop Free Alternate Fast Reroute

Feature Name	Releases	Feature Information
IS-IS Link-protection Topology Independent Loop Free Alternate Fast Reroute	Cisco IOS XE Amsterdam 17.3.2	The following commands were introduced or modified: **fast-reroute ti-lfa {level-1 | level-2} [maximum-metric value]** , isis fast-reroute ti-lfa protection level-1 disable, **isis fast-reroute ti-lfa protection {level-1 | level-2} [maximum-metric value]**, **show running all | section interface interface-name**, **show running all | section router isis**.

Feature Name	Releases	Feature Information
IPv4 GRE-TP tunnel as protected link support for SR-MPLS TI-LFA with IS-IS	Cisco IOS XE 17.18.2	From Cisco IOS XE 17.18.2 this feature extends IPv4 GRE-TP tunnel as protected link support for SR-MPLS TILFA with ISIS.

Prerequisites for IS-IS Link-protection Topology Independent Loop Free Alternate Fast Reroute

- Enable TI-LFA on all the nodes, before configuring SR-TE for TI-LFA.

```
mpls traffic-eng tunnels
!
segment-routing mpls
 connected-prefix-sid-map
  address-family ipv4
   10.1.1.1/32 index 11 range 1
  exit-address-family
 !
interface Loopback1
 ip address 10.1.1.1 255.255.255.255
 ip router isis 1
!
interface Tunnel1
 ip unnumbered Loopback1
 tunnel mode mpls traffic-eng
 tunnel destination 10.6.6.6
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng path-option 10 explicit name IP_PATH segment-routing
!
interface GigabitEthernet2
 ip address 192.168.1.1 255.255.255.0
 ip router isis 1
 negotiation auto
 mpls traffic-eng tunnels
 isis network point-to-point
!
interface GigabitEthernet3
 ip address 192.168.2.1 255.255.255.0
 ip router isis 1
 negotiation auto
 mpls traffic-eng tunnels
 isis network point-to-point
!
router isis 1
 net 49.0001.0010.0100.1001.00
 is-type level-1
 metric-style wide
 log-adjacency-changes
 segment-routing mpls
 fast-reroute per-prefix level-1 all
 fast-reroute ti-lfa level-1
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng level-1
!
ip explicit-path name IP_PATH enable
 next-address 10.4.4.4
```

```
 next-address 10.5.5.5
 next-address 10.6.6.6
```

- If a microloop gets created between routers in case of primary and secondary path switch over you need to bring down the convergence time. Use the **microloop avoidance rib-update-delay** command to bring down the convergence time:

```
router isis ipfrr
net 49.0001.0120.1201.2012.00
is-type level-2-only
metric-style wide
log-adjacency-changes
segment-routing mpls
segment-routing prefix-sid-map advertise-local
fast-reroute per-prefix level-2 all
fast-reroute ti-lfa level-2
microloop avoidance rib-update-delay 10000
```

- Enable MPLS-TE nonstop routing (NSR) and IS-IS nonstop forwarding (NSF) to reduce or minimize traffic loss after a high availability (HA) switch over. Use the **mpls traffic-eng nsr** command in global exec mode.

```
mpls traffic-eng nsr
```

Use the **nsf** command under IS-IS.

```
router isis
nsf cisco
nsf interval 0
```

Restrictions for IS-IS Link-protection Topology Independent Loop Free Alternate Fast Reroute

- The IGP cannot guarantee loop-free paths when tunnels are used for protection or repair, as it is unaware of the tunnel's underlying physical path.
- Forwarding failures on tunnel interfaces can occur in cases where local link failures do not occur. For this reason, in order to quickly detect forwarding failures on tunnel interfaces it is advisable to use the BFD protocol.

  Note that aggressive BFD timers must be used with care on tunnel interfaces as they can lead to false indication of failures
- Due to limitations on this platform, IGP TI-LFA cannot guarantee 50ms FRR failover.

Information About IS-IS Link-protection Topology Independent Loop Free Alternate Fast Reroute

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 3.18, topology-independent LFA (TI-LFA) is supported on an SR-enabled network.

Topology-Independent Loop Free Alternate

TI-LFA provides supports for 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.

Topology Independent Loop Free Alternate Tie-break

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

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

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

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

Interface Fast Reroute Tiebreakers

Interface fast reroute (FRR) tiebreakers are also needed for TI-LFA node and SRLG protection. When interface and protocol instance FRR tiebreakers both 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.

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 3.18, node-protecting tie-breaker is disabled by default.

How to Configure IS-IS Link-protection Topology Independent Loop Free Alternate Fast Reroute

Perform the following steps to configure Link-protection Topology Independent Loop Free Alternate Fast Reroute.

Configuring Topology Independent Loop Free Alternate Fast Reroute

You can enable TI-LFA using any of the following two methods:

1. **Protocol enablement**—Enables TI-LFA in router isis mode for all IS-IS 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]
   ```

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

2. **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]
   ```

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

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

   To disable TI-LFA on a particular interface, use the following command:

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

Configuring Topology Independent Loop Free Alternate With Mapping Server

Consider the following topology to understand the configuration:

- IXIA-2 injects ISIS prefixes, and IXIA-1 sends one-way traffic to IXIA-2

  .
- In R1 10,000 prefixes are configured in the segment-routing mapping-server.

The configuration on R1 is:

```
configure terminal
segment-routing mpls
global-block 16 20016
!
connected-prefix-sid-map
address-family ipv4
10.11.11.11/32 index 11 range 1
exit-address-family
!
!
mapping-server
!
prefix-sid-map
address-family ipv4
10.0.0.0/24 index 2 range 1 attach
203.0.113.1/24 index 1 range 1 attach
192.168.0.0/24 index 100 range 10000 attach
exit-address-family
!
!
!
!
interface Loopback0
ip address 10.11.11.11 255.255.255.255
ip router isis ipfrr
!
interface GigabitEthernet0/1/0
ip address 10.14.0.1 255.255.255.0
ip router isis ipfrr
negotiation auto
isis network point-to-point
!
interface GigabitEthernet0/1/2
ip address 10.0.0.1 255.255.255.0
ip router isis ipfrr
negotiation auto
isis network point-to-point
!
interface GigabitEthernet0/1/4
ip address 203.0.113.2 255.255.255.0
ip router isis ipfrr
negotiation auto
isis network point-to-point
!
router isis ipfrr
net 49.0001.0110.1101.1011.00
is-type level-2-only
metric-style wide
log-adjacency-changes
nsf cisco
segment-routing mpls
segment-routing prefix-sid-map advertise-local
fast-reroute per-prefix level-2 all
fast-reroute ti-lfa level-2
microloop avoidance rib-update-delay 10000
```

On R2 the configuration is

```
configure terminal
!
!
segment-routing mpls
!
connected-prefix-sid-map
address-family ipv4
10.12.12.12/32 index 12 range 1
exit-address-family
!
!
interface Loopback0
ip address 10.12.12.12 255.255.255.255
ip router isis ipfrr
!
interface GigabitEthernet0/1/0
ip address 10.12.0.1 255.255.255.0
ip router isis ipfrr
negotiation auto
isis network point-to-point
!
interface GigabitEthernet0/1/1
ip address 10.11.0.2 255.255.255.0
ip router isis ipfrr
negotiation auto
isis network point-to-point
!
router isis ipfrr
net 49.0001.0120.1201.2012.00
is-type level-2-only
metric-style wide
log-adjacency-changes
nsf cisco
segment-routing mpls
segment-routing prefix-sid-map advertise-local
fast-reroute per-prefix level-2 all
fast-reroute ti-lfa level-2
microloop avoidance rib-update-delay 10000
!
```

On R3 the configuration is

```
configure terminal
!
mpls traffic-eng tunnels
!
segment-routing mpls
!
connected-prefix-sid-map
address-family ipv4
10.13.13.13/32 index 13 range 1
exit-address-family
!
!
interface Loopback0
ip address 10.13.13.13 255.255.255.255
ip router isis ipfrr
!
interface GigabitEthernet0/0/4
ip address 10.13.0.1 255.255.255.0
ip router isis ipfrr
```

```
load-interval 30
speed 1000
no negotiation auto
isis network point-to-point
!
interface GigabitEthernet0/0/5
ip address 10.12.0.2 255.255.255.0
ip router isis ipfrr
negotiation auto
isis network point-to-point
!
router isis ipfrr
net 49.0001.0130.1301.3013.00
is-type level-2-only
metric-style wide
log-adjacency-changes
nsf cisco
segment-routing mpls
segment-routing prefix-sid-map advertise-local
fast-reroute per-prefix level-2 all
fast-reroute ti-lfa level-2
microloop avoidance rib-update-delay 10000
!
```

On R4 the configuration is:

```
configure terminal
!
mpls traffic-eng tunnels
!
segment-routing mpls
!
connected-prefix-sid-map
address-family ipv4
10.14.14.14/32 index 14 range 1
exit-address-family
!
!
interface Loopback0
ip address 10.14.14.14 255.255.255.255
ip router isis ipfrr
!
interface GigabitEthernet0/0/0
ip address 10.14.0.2 255.255.255.0
ip router isis ipfrr
negotiation auto
isis network point-to-point
!
interface GigabitEthernet0/0/3
ip address 10.13.0.2 255.255.255.0
ip router isis ipfrr
speed 1000
no negotiation auto
isis network point-to-point
!
interface GigabitEthernet0/0/5
ip address 10.120.0.1 255.255.255.0
ip router isis ipfrr
speed 1000
no negotiation auto
isis network point-to-point
!
router isis ipfrr
net 49.0001.0140.1401.4014.00
```

```
is-type level-2-only
metric-style wide
log-adjacency-changes
nsf cisco
segment-routing mpls
segment-routing prefix-sid-map advertise-local
fast-reroute per-prefix level-2 all
fast-reroute ti-lfa level-2
microloop avoidance rib-update-delay 10000
!
```

Examples: Configuring IS-IS Link-protection Topology Independent Loop Free Alternate Fast Reroute

Example 1: In the following example, local LFA is configured with linecard-disjoint and srlg-disjoint tiebreakers. 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 10000
 bfd all-interfaces
```

Example 2—Enable TI-LFA node-protecting tie-breaker on all ISIS level-2 interfaces with priority 100. 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 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 4—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 5—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 6—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 Tiebreaker

To view tiebreakers enabled on the interface, use the following command:

show running all | section interface *interface-name*

To view tiebreakers enabled on the router mode, use the following command:

show running all | section router isis

Verifying the Primary and Repair Paths

In this example, 10.1.1.1 is the protecting neighbor and 10.4.4.4 is the neighbor on the protecting link.

```
Router#
show ip cef 10.1.1.1
10.1.1.1/32
  nexthop 10.1.1.1 GigabitEthernet0/2/0 label [explicit-null|explicit-null]() - slot 2 is
primary interface
    repair: attached-nexthop 10.24.0.2 TenGigabitEthernet0/3/0 - slot 3 is repair interface

  nexthop 10.24.0.2 TenGigabitEthernet0/3/0 label [explicit-null|explicit-null]()
    repair: attached-nexthop 10.1.1.1 GigabitEthernet0/2/0
Router#
show ip cef 10.4.4.4
10.4.4.4/32
```

```
  nexthop 10.4.4.4 GigabitEthernet0/2/3 label [explicit-null|16004]() - slot 2 is primary
interface
    repair: attached-nexthop 10.5.5.5 MPLS-SR-Tunnel2
Router# show ip cef 10.4.4.4 int
10.4.4.4/32, epoch 3, RIB[I], refcnt 6, per-destination sharing
  sources: RIB, Adj, LTE
  feature space:
    IPRM: 0x00028000
    Broker: linked, distributed at 4th priority
    LFD: 10.4.4.4/32 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 10.4.4.4>
        dflt label switch chain 0x46654268
          label implicit-null
          TAG adj out of GigabitEthernet0/2/3, addr 10.4.4.4
        sr disposition chain 0x46654880
          label explicit-null
          FRR Primary
            <primary: TAG adj out of GigabitEthernet0/2/3, addr 10.4.4.4>
        sr label switch chain 0x46654880
          label explicit-null
          FRR Primary
            <primary: TAG adj out of GigabitEthernet0/2/3, addr 10.4.4.4>
  subblocks:
    Adj source: IP adj out of GigabitEthernet0/2/3, addr 10.4.4.4 464C6620
      Dependent covered prefix type adjfib, cover 10.0.0.0/0
  ifnums:
    GigabitEthernet0/2/3(11): 10.4.4.4
    MPLS-SR-Tunnel2(1022)
  path list 3B1FC930, 15 locks, per-destination, flags 0x4D [shble, hvsh, rif, hwcn]
    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 10.4.4.4 GigabitEthernet0/2/3 label [explicit-null|16004](), IP adj out of
GigabitEthernet0/2/3, addr 10.4.4.4 464C6620
        repair: attached-nexthop 10.5.5.5 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 10.5.5.5 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 10.4.4.4 464C6480> - primary path

      <repair:  TAG midchain out of MPLS-SR-Tunnel2 46CE22A0
                label 16()
                label 16003()
                TAG adj out of TenGigabitEthernet0/3/0, addr 10.24.0.2 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.

```
Roouter# show isis segment-routing prefix-sid-map adv
IS-IS Level-1 advertise prefix-sid maps:
Prefix               SID Index    Range        Flags
10.16.16.16/32       101          1
10.16.16.17/32       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                 10.16.16.16/32       101          1
                     10.16.16.17/32       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              * 10.1.1.2/32          1002         1
                      10.2.2.2/32          20           1
                      10.1.1.10/32         10           1
colorado              10.1.1.3/32          33           1
                      10.1.1.6/32          6            1
IS-IS Level-2 connected-sids
Host                 Prefix               SID Index    Range        Flags
```

Verifying the IS-IS Topology Independent Loop Free Alternate 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      10.30.1.4        10.1.1.2          41002     nevada
MP2     Et0/0      10.19.1.6        10.1.1.6          60006     colorado
                                    10.1.1.2          16        nevada
MP3     Et0/0      10.19.1.6        10.1.1.6          60006     colorado
                                    10.1.1.2          16        nevada
                                    10.1.1.5          70005     wyoming
```

Verifying the Segment Routing Traffic Engineering With Topology Independent Loop Free Alternate Configuration

```
Router# show mpls traffic-eng tunnels tunnel1
Name: PE1                              (Tunnel1) Destination: 10.6.6.6
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 10, (SEGMENT-ROUTING) type explicit IP_PATH (Basis for Setup)
  Config Parameters:
    Bandwidth: 0        kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    Path Selection:
     Protection: any (default)
    Path-invalidation timeout: 45000 msec (default), Action: Tear
    AutoRoute: enabled  LockDown: disabled Loadshare: 0 [0] bw-based
    auto-bw: disabled
    Fault-OAM: disabled, Wrap-Protection: disabled, Wrap-Capable: No
  Active Path Option Parameters:
    State: explicit path option 10 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled
  History:
    Tunnel:
      Time since created: 4 hours, 25 minutes
      Time since path change: 4 hours, 21 minutes
      Number of LSP IDs (Tun_Instances) used: 37
    Current LSP: [ID: 37]
      Uptime: 4 hours, 21 minutes
  Tun_Instance: 37
  Segment-Routing Path Info (isis  level-1)
    Segment0[Node]: 10.4.4.4, Label: 16014
    Segment1[Node]: 10.5.5.5, Label: 16015
    Segment2[Node]: 10.6.6.6, Label: 16016
Router# show isis fast-reroute ti-lfa tunnel

Tag 1:
Fast-Reroute TI-LFA Tunnels:
Tunnel  Interface  Next Hop         End Point        Label     End Point Host
MP1     Gi2        192.168.1.2      10.6.6.6         16016     SR_R6
MP2     Gi3        192.168.2.2      10.6.6.6         16016     SR_R6
Router# show frr-manager client client-name ISIS interfaces detail
TunnelI/F : MP1
  Type : SR
  Next-hop : 192.168.1.2
  End-point : 10.6.6.6
  OutI/F : Gi2
  Adjacency State : 1
  Prefix0 : 10.6.6.6(Label : 16016)
TunnelI/F : MP2
  Type : SR
  Next-hop : 192.168.2.2
  End-point : 10.6.6.6
  OutI/F : Gi3
  Adjacency State : 1
  Prefix0 : 10.6.6.6(Label : 16016)
Router# show ip cef 10.6.6.6 internal

10.6.6.6/32, epoch 2, RIB[I], refcnt 6, per-destination sharing
  sources: RIB, LTE
  feature space:
    IPRM: 0x00028000
    Broker: linked, distributed at 1st priority
```

```
    LFD: 10.6.6.6/32 1 local label
    sr local label info: global/16016 [0x1A]
        contains path extension list
        sr disposition chain 0x7FC6B0BF2AF0
          label implicit-null
          IP midchain out of Tunnel1
          label 16016
          FRR Primary
            <primary: label 16015
                      TAG adj out of GigabitEthernet3, addr 192.168.2.2>
        sr label switch chain 0x7FC6B0BF2B88
          label implicit-null
          TAG midchain out of Tunnel1
          label 16016
          FRR Primary
            <primary: label 16015
                      TAG adj out of GigabitEthernet3, addr 192.168.2.2>
  ifnums:
    Tunnel1(13)
  path list 7FC6B0BBDDE0, 3 locks, per-destination, flags 0x49 [shble, rif, hwcn]
    path 7FC7144D4300, share 1/1, type attached nexthop, for IPv4
      MPLS short path extensions: [rib | prfmfi | lblmrg | srlbl] MOI flags = 0x3 label
implicit-null
      nexthop 10.6.6.6 Tunnel1, IP midchain out of Tunnel1 7FC6B0BBB440
  output chain:
    IP midchain out of Tunnel1 7FC6B0BBB440
    label [16016|16016]
    FRR Primary (0x7FC714515460)
      <primary: label 16015
                TAG adj out of GigabitEthernet3, addr 192.168.2.2 7FC6B0BBB630>
      <repair:  label 16015
                label 16014
                TAG midchain out of MPLS-SR-Tunnel1 7FC6B0BBAA90
                label 16016
                TAG adj out of GigabitEthernet2, addr 192.168.1.2 7FC6B0BBBA10>
```

Note To ensure a less than 50 msec traffic protection with TI-LFA, SR-TE with dynamic path option must use the backup adjacency SID.

To create an SR-TE with dynamic path option, use the following configuration on every router in the topology:

```
router isis 1
fast-reroute per-prefix level-1 all
```

At the tunnel head-end router:

```
interface Tunnel1
ip unnumbered Loopback1
tunnel mode mpls traffic-eng
tunnel destination 10.6.6.6
tunnel mpls traffic-eng autoroute announce
tunnel mpls traffic-eng path-option 1 dynamic segment-routing
tunnel mpls traffic-eng path-selection segment-routing adjacency protected
```