Configure Segment Routing over IPv6 (SRv6) with Full-Length SIDs

Table 1: Feature History Table

Feature Name	Release	Feature Description
SRv6 with Full-Length SIDs	Release 25.1.1	Introduced in this release on: Fixed Systems (8700 [ASIC: K100], 8010 [ASIC: A100]) This feature is now supported on: • 8712-MOD-M • 8011-4G24Y4H-I
SRv6 with Full-Length SIDs	Release 24.4.1	Introduced in this release on: Fixed Systems(8200, 8700);Modular Systems (8800 [LC ASIC: P100]) (select variants only*) *This feature is now supported on: • 8212-32FH-M • 8711-32FH-M • 88-LC1-12TH24FH-E
SRv6 with Full-Length SIDs	Release 7.5.2	This feature extends Segment Routing support with IPv6 data plane. In a Segment Routing over IPv6 (SRv6) network, an IPv6 address serves as the Segment Identifier (SID). The source router encodes the path to destination as an ordered list of segments (list of IPv6 addresses) in the IPv6 packet using a new header for SRv6 called a Segment Routing Header (SRH). In an SRv6 enabled network, the active segment is indicated by the destination address of the packet, and the next segment is indicated by a pointer in the SRH.

Segment Routing for IPv6 (SRv6) is the implementation of Segment Routing over the IPv6 dataplane.

Segment Routing over IPv6 Overview

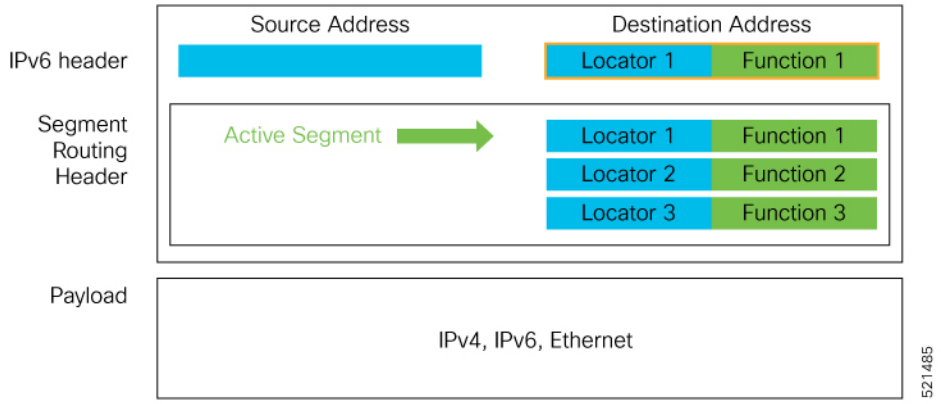
Segment Routing (SR) can be applied on both MPLS and IPv6 data planes. Segment Routing over IPv6 (SRv6) extends Segment Routing support with IPv6 data plane.

In an SR-MPLS enabled network, an MPLS label represents an instruction. The source nodes programs the path to a destination in the packet header as a stack of labels.

SRv6 introduces the Network Programming framework that enables a network operator or an application to specify a packet processing program by encoding a sequence of instructions in the IPv6 packet header. Each instruction is implemented on one or several nodes in the network and identified by an SRv6 Segment Identifier (SID) in the packet. The SRv6 Network Programming framework is defined in IETF RFC 8986 SRv6 Network Programming.

In SRv6, an IPv6 address represents an instruction. SRv6 uses a new type of IPv6 Routing Extension Header, called the Segment Routing Header (SRH), in order to encode an ordered list of instructions. The active segment is indicated by the destination address of the packet, and the next segment is indicated by a pointer in the SRH.

Figure 1: Network Program in the Packet Header



The SRv6 SRH is documented in IETF RFC IPv6 Segment Routing Header (SRH).

The SRH is defined as follows:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Next Header   |  Hdr Ext Len  | Routing Type  | Segments Left |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Last Entry   |     Flags     |              Tag              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|            Segment List[0] (128-bit IPv6 address)             |
|                                                               |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                                                               |
                              ...
|                                                               |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|            Segment List[n] (128-bit IPv6 address)             |
|                                                               |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
//                                                             //
//         Optional Type Length Value objects (variable)       //
//                                                             //
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The following list explains the fields in SRH:

- Next header—Identifies the type of header immediately following the SRH.
- Hdr Ext Len (header extension length)—The length of the SRH in 8-octet units, not including the first 8 octets.
- Segments left—Specifies the number of route segments remaining. That means, the number of explicitly listed intermediate nodes still to be visited before reaching the final destination.

- Last Entry—Contains the index (zero based) of the last element of the segment list.
- Flags— Contains 8 bits of flags.
- Tag—Tag a packet as part of a class or group of packets like packets sharing the same set of properties.
- Segment list—128-bit IPv6 addresses representing the *n*th segment in the segment list. The segment list encoding starts from the last segment of the SR policy (path). That means the first element of the segment list (Segment list [0]) contains the last segment of the SR policy, the second element contains the penultimate segment of the SR policy and so on.

In SRv6, a SID represents a 128-bit value, consisting of the following three parts:

- Locator: This is the first part of the SID with most significant bits and represents an address of a specific SRv6 node.
- Function: This is the portion of the SID that is local to the owner node and designates a specific SRv6 function (network instruction) that is executed locally on a particular node, specified by the locator bits.
- Args: This field is optional and represents optional arguments to the function.

The locator part can be further divided into two parts:

- SID Block: This field is the SRv6 network designator and is a fixed or known address space for an SRv6 domain. This is the most significant bit (MSB) portion of a locator subnet.
- Node Id: This field is the node designator in an SRv6 network and is the least significant bit (LSB) portion of a locator subnet.

SRv6 Node Roles

Each node along the SRv6 packet path has a different functionality:

- Source node—A node that can generate an IPv6 packet with an SRH (an SRv6 packet), or an ingress node that can impose an SRH on an IPv6 packet.
- Transit node—A node along the path of the SRv6 packet (IPv6 packet and SRH). The transit node does not inspect the SRH. The destination address of the IPv6 packet does not correspond to the transit node.
- Endpoint node—A node in the SRv6 domain where the SRv6 segment is terminated. The destination address of the IPv6 packet with an SRH corresponds to the end point node. The segment endpoint node executes the function bound to the SID

SRv6 Head-End Behaviors

The SR Headend with Encapsulation behaviors are documented in the IETF RFC 8986 SRv6 Network Programming.

The SR Headend with Insertion head-end behaviors are documented in the following IETF draft:

https://datatracker.ietf.org/doc/draft-filsfils-spring-srv6-net-pgm-insertion/

SRv6 Endpoint Behaviors

The SRv6 endpoint behaviors are documented in the IETF RFC 8986 SRv6 Network Programming.

The following is a subset of defined SRv6 endpoint behaviors that can be associated with a SID.

- End—Endpoint function. The SRv6 instantiation of a Prefix SID [RFC8402].
- End.X—Endpoint with Layer-3 cross-connect. The SRv6 instantiation of an Adj SID [RFC8402].
- End.DX6—Endpoint with decapsulation and IPv6 cross-connect (IPv6-L3VPN - equivalent to per-CE VPN label).
- End.DX4—Endpoint with decapsulation and IPv4 cross-connect (IPv4-L3VPN - equivalent to per-CE VPN label).
- End.DT6—Endpoint with decapsulation and IPv6 table lookup (IPv6-L3VPN - equivalent to per-VRF VPN label).
- End.DT4—Endpoint with decapsulation and IPv4 table lookup (IPv4-L3VPN - equivalent to per-VRF VPN label).
- End.DX2—Endpoint with decapsulation and L2 cross-connect (L2VPN use-case).
- End.B6.Encaps—Endpoint bound to an SRv6 policy with encapsulation. SRv6 instantiation of a Binding SID.
- End.B6.Encaps.RED—End.B6.Encaps with reduced SRH. SRv6 instantiation of a Binding SID.

SRv6 Endpoint Behavior Variants

Depending on how the SRH is handled, different behavior variants are defined for the End and End.X behaviors. The End and End.X behaviors can support these variants, either individually or in combinations.

- **Penultimate Segment Pop (PSP) of the SRH variant**—An SR Segment Endpoint Nodes receive the IPv6 packet with the Destination Address field of the IPv6 Header equal to its SID address.

  A penultimate SR Segment Endpoint Node is one that, as part of the SID processing, copies the last SID from the SRH into the IPv6 Destination Address and decrements the Segments Left value from one to zero.

  The PSP operation takes place only at a penultimate SR Segment Endpoint Node and does not happen at non-penultimate endpoint nodes. When a SID of PSP-flavor is processed at a non-penultimate SR Segment Endpoint Node, the PSP behavior is not performed since Segments Left would not be zero.

  The SR Segment Endpoint Nodes advertise the SIDs instantiated on them via control plane protocols. A PSP-flavored SID is used by the Source SR Node when it needs to instruct the penultimate SR Segment Endpoint Node listed in the SRH to remove the SRH from the IPv6 header.

- **Ultimate Segment Pop (USP) of the SRH variant**—The SRH processing of the End and End.X behaviors are modified as follows:

  If Segments Left is 0, then:

  1. Update the Next Header field in the preceding header to the Next Header value of the SRH
  2. Decrease the IPv6 header Payload Length by 8*(Hdr Ext Len+1)
  3. Remove the SRH from the IPv6 extension header chain
  4. Proceed to process the next header in the packet

  One of the applications of the USP flavor is when a packet with an SRH is destined to an application on hosts with smartNICs implementing SRv6. The USP flavor is used to remove the consumed SRH from the extension header chain before sending the packet to the host.

- **Ultimate Segment Decapsulation (USD) variant**—The Upper-layer header processing of the End and End.X behaviors are modified as follows:
  - **End** behavior: If the Upper-layer Header type is 41 (IPv6), then:
    1. Remove the outer IPv6 Header with all its extension headers
    2. Submit the packet to the egress IPv6 FIB lookup and transmission to the new destination
    3. Else, if the Upper-layer Header type is 4 (IPv4)
    4. Remove the outer IPv6 Header with all its extension headers
    5. Submit the packet to the egress IPv4 FIB lookup and transmission to the new destination
    6. Else, process as per Section 4.1.1 (Upper-Layer Header) of IETF RFC 8986 SRv6 Network Programming
  - **End.X** behavior: If the Upper-layer Header type is 41 (IPv6) or 4 (IPv4), then:
    1. Remove the outer IPv6 Header with all its extension headers
    2. Forward the exposed IP packet to the L3 adjacency J
    3. Else, process as per Section 4.1.1 (Upper-Layer Header) of IETF RFC 8986 SRv6 Network Programming

  One of the applications of the USD flavor is the case of TI-LFA in P routers with encapsulation with H.Encaps. The USD flavor allows the last Segment Endpoint Node in the repair path list to decapsulate the IPv6 header added at the TI-LFA Point of Local Repair and forward the inner packet.

Usage Guidelines and Limitations

General Guidelines and Limitations

- SRv6 Underlay support includes:
  - IGP redistribution/leaking between levels
  - Prefix Summarization on ABR routers
  - IS-IS TI-LFA
  - Microloop Avoidance
  - Flex-algo

Platform-Specific Guidelines and Limitations

- SRv6 is supported on the following Cisco 8000 series Q200-based line cards and fixed-port routers:
  - Cisco 8800 with 88-LC0-36FH-M, 88-LC0-36FH, 88-LC0-34H14FH line cards
  - Cisco 8201-32FH
  - Cisco 8102-64H, 8101-32-FH
- SRv6 is not supported on Q100-based line cards and fixed-port routers.

- Egress marking on the outer header during SRv6 encapsulation operations (TI-LFA) is not supported.
- OAM: Ping and traceroute are supported.
- This release supports the following SRv6 behaviors and variants:
  - **Endpoint behaviors:**
    - END with PSP/USD
    - END.X with PSP/USD
    - END.DT4
    - END.DT6
  - **Head-end behaviors:**
    - H.Encap.Red

Encapsulation Capabilities and Parameters

- Cisco 8000 series routers are able to add an SRH with one segment. Therefore, a total of two segments are supported (1 SID in the outer DA, and 1 SID in the SRH).
- **Encapsulation Capabilities and Parameters**

  The following describes the Cisco 8000 series router capabilities for setting or propagating certain fields in the outer IPv6 header for SRv6 encapsulated packets:

  - **Source address**: Cisco 8000 series routers support a single source address (SA) for SRv6 encapsulated packets. The SA is derived from the SRv6 global configuration; if not configured, it is derived from the IPv6 Loopback address.
  - **Hop limit**: Cisco 8000 series routers propagate the hop-limit of the inner packet into the outer IPv6 header during encapsulation and decapsulation operations. Propagation of the hop-limit value of locally generated OAM packets into the outer IPv6 header can be enabled via configuration.
    - Overlay encapsulation

      Default: propagate=No

      The **hop-limit propagate** command enables propagation from inner header to outer header.
    - Underlay encapsulation (TI-LFA) behavior is always in propagate mode, regardless of the CLI.

    Manual configuration of the hop-limit value in the outer IPv6 header is not supported.
  - **Traffic-class**: Cisco 8000 series routers propagate the traffic-class of the inner packet into the outer IPv6 header during encapsulation and decapsulation operations. Propagation of the traffic-class value of locally generated OAM packets into the outer IPv6 header can be enabled via configuration.
    - Overlay encapsulation

      Default: propagate=No

      The **traffic-class propagate** command enables propagation from inner header to outer header.
    - Underlay encapsulation (TI-LFA) behavior is always in propagate mode, regardless of the CLI.

Manual configuration of the traffic-class value in the outer IPv6 header is not supported.

- **Flow Label**:
  - Cisco 8000 series routers use the flow-label from the incoming IPv6 header. In case of USD operations, flow-label is used from the inner IPv6 header.
  - During H.Encap.Red operations, if the inner packet has a flow label (non-zero value), the Cisco 8000 series routers propagate it to the outer IPv6 header. If the flow label is not present (zero), it is computed.

- **PE role:**
  - Overlay H-Encaps: 3 sids (1 carrier with 3 sids per carrier)

Configuring SRv6

To enable SRv6 globally, you should first configure a locator with its prefix. The IS-IS protocol announces the locator prefix in IPv6 network and SRv6 applications (like ISIS, BGP) use it to allocate SIDs.

The following usage guidelines and restrictions apply while configuring SRv6.

- All routers in the SRv6 domain should have the same SID block (network designator) in their locator.
- The locator length should be 64-bits long.
  - The SID block portion (MSBs) cannot exceed 40 bits. If this value is less than 40 bits, user should use a pattern of zeros as a filler.
  - The Node Id portion (LSBs) cannot exceed 24 bits.
- You can configure up to 8 locators to support SRv6 Flexible Algorithm. All locators prefix must share the same SID block (first 40-bits).

Enabling SRv6 with Locator

This example shows how to globally enable SRv6 and configure locator.

```
Router(config)# segment-routing srv6
Router(config-srv6)# locators
Router(config-srv6-locators)# locator myLoc1
Router(config-srv6-locator)# prefix 2001:db8:0:a2::/64
```

Optional: Enabling Syslog Logging for Locator Status Changes

This example shows how to enable the logging of locator status.

```
Router(config)# segment-routing srv6
Router(config-srv6)# logging locator status
```

Verifying SRv6 Manager

This example shows how to verify the overall SRv6 state from SRv6 Manager point of view. The output displays parameters in use, summary information, and platform specific capabilities.

```
Router# SF-D#sh segment-routing srv6 manager
Parameters:
```

```
  SRv6 Enabled: No
  SRv6 Operational Mode: None
  Encapsulation:
    Source Address:
      Configured: ::
      Default: 77::77
    Hop-Limit: Default
    Traffic-class: Default
    SID Formats:
      f3216 <32B/16NFA> (2)
    uSID LIB Range:
    LIB Start : 0xe000
    ELIB Start : 0xfe00
    uSID WLIB Range:
    EWLIB Start : 0xfff7
Summary:
  Number of Locators: 0 (0 operational)
  Number of SIDs: 0 (0 stale)
  Max SID resources: 24000
  Number of free SID resources: 24000
  OOR:
    Thresholds (resources): Green 1200, Warning 720
    Status: Resource Available
      History: (0 cleared, 0 warnings, 0 full)
Platform Capabilities:
  SRv6: Yes
  TILFA: Yes
  Microloop-Avoidance: Yes
  Endpoint behaviors:
    End.DT6
    End.DT4
    End.DT46
    End (PSP/USD)
    End.X (PSP/USD)
    uN (PSP/USD)
    uA (PSP/USD)
    uDT6
    uDT4
    uDT46
Headend behaviors:
  T
  H.Encaps.Red
Security rules:
  SEC-1
  SEC-2
  SEC-3
Counters:
  None
Signaled parameters:
  Max-SL : 3
  Max-End-Pop-SRH : 3
  Max-H-Insert : 0 sids
  Max-H-Encap : 2 sids
  Max-End-D : 5
Configurable parameters (under srv6):
  Ranges:
   LIB : Yes
   WLIB : Yes
  Encapsulation:
    Source Address: Yes
    Hop-Limit : value=No, propagate=Yes
    Traffic-class : value=No, propagate=Yes
    Default parameters (under srv6):
  Encapsulation:
```

```
    Hop-Limit : value=128, propagate=No
    Traffic-class : value=0, propagate=No
    Max Locators: 16
    Max SIDs: 24000
    SID Holdtime: 3 mins
Router# :SF-D#
```

Verifying SRv6 Locator

This example shows how to verify the locator configuration and its operational status.

```
Router# show segment-routing srv6 locator myLoc1 detail
Name                 ID      Prefix                   Status
-------------------- ------- ------------------------ -------
myLoc1*              5       2001:db8:0:a2::/64       Up
  (*): is-default
  Interface:
    Name: srv6-myLoc1
    IFH : 0x00000170
    IPv6 address: 2001:db8:0:a2::/64
  Chkpt Obj ID: 0x2fc8
  Created: Apr 25 06:21:57.077 (00:03:37 ago)
```

Verifying SRv6 local SIDs

This example shows how to verify the allocation of SRv6 local SIDs off locator(s).

```
Router# show segment-routing srv6 locator myLoc1 sid

SID                         Function     Context                          Owner
     State  RW
--------------------------  -----------  -------------------------------  ------------------
  -----  --
2001:db8:0:a2:1::           End (PSP)    'default':1                      sidmgr
     InUse  Y
2001:db8:0:a2:40::          End.DT4      'VRF1'                           bgp-100
     InUse  Y
2001:db8:0:a2:41::          End.X (PSP)  [Hu0/1/0/1, Link-Local]          isis-srv6
     InUse  Y
```

The following example shows how to display detail information about an allocated SRv6 local SID:

```
Router# show segment-routing srv6 locator myLoc1 sid 2001:db8:0:a2:40:: detail

SID                         Function     Context                          Owner
     State  RW
--------------------------  -----------  -------------------------------  ------------------
  -----  --
2001:db8:0:a2:40::          End.DT4      'VRF1'                           bgp-100
     InUse  Y
  SID context: { table-id=0xe0000011 ('VRF1':IPv4/Unicast) }
  Locator: myLoc1'
  Allocation type: Dynamic
  Created: Feb  1 14:04:02.901 (3d00h ago)
```

show Commands

You can use the following **show** commands to verify the SRv6 global and locator configuration:

Command	Description
show segment-routing srv6 manager	Displays the summary information from SRv6 manager, including platform capabilities.
show segment-routing srv6 locator *locator-name* [**detail**]	Displays the SRv6 locator information on the router.
show segment-routing srv6 locator *locator-name* **sid** [[*sid-ipv6-address* [**detail**]	Displays the information regarding SRv6 local SID(s) allocated from a given locator.
show segment-routing srv6 sid [*sid-ipv6-address* | **all** | **stale**] [**detail**]	Displays SID information across locators. By default, only "active" (i.e. non-stale) SIDs are displayed.
show route ipv6 local-srv6	Displays all SRv6 local-SID prefixes in IPv6 RIB.

Configuring SRv6 under IS-IS

Intermediate System-to-Intermediate System (IS-IS) protocol already supports segment routing with MPLS dataplane (SR-MPLS). This feature enables extensions in IS-IS to support Segment Routing with IPv6 data plane (SRv6). The extensions include advertising the SRv6 capabilities of nodes and node and adjacency segments as SRv6 SIDs.

SRv6 IS-IS performs the following functionalities:

1. Interacts with SID Manager to learn local locator prefixes and announces the locator prefixes in the IGP domain.
2. Learns remote locator prefixes from other ISIS neighbor routers and installs the learned remote locator IPv6 prefix in RIB or FIB.
3. Allocate or learn prefix SID and adjacency SIDs, create local SID entries, and advertise them in the IGP domain.

Usage Guidelines and Restrictions

The following usage guidelines and restrictions apply for SRv6 IS-IS:

- An IS-IS address-family can support either SR-MPLS or SRv6, but both at the same time is not supported.

Configuring SRv6 IS-IS

To configure SRv6 IS-IS, use the **router isis** command. Enable SRv6 under the IS-IS IPv6 address-family and assign SRv6 locator(s) to it. Use the **level** {**1** | **2**} keywords to advertise the locator only in the specified IS-IS level.

Note If no level is specified, local locators will be advertised into all configured ISIS levels. Ensure that locators are included in the redistribution or propagation policy to prevent potential loops when redistributing between multiple instances or propagating between Level 2 and Level 1.

The following example shows how to configure SRv6 IS-IS.

```
Router(config)# router isis core
Router(config-isis)# address-family ipv6 unicast
Router(config-isis-af)# segment-routing srv6
Router(config-isis-srv6)# locator myLoc1
Router(config-isis-srv6-loc)# exit
```

Configuring SRv6 IS-IS TI-LFA

This feature introduces support for implementing TI-LFA using IS-IS SRv6.

Topology-Independent Loop-Free Alternate (TI-LFA) provides link protection in topologies where other fast reroute techniques cannot provide protection. The goal of TI-LFA is to reduce the packet loss that results while routers converge after a topology change due to a link failure. TI-LFA leverages the post-convergence path which is planned to carry the traffic and ensures link and node protection with in 50 milliseconds. TI-LFA with IS-IS SR-MPLS is already supported.

TI-LFA provides link, node, and Shared Risk Link Groups (SRLG) protection in any topology.

For more information, see Configure Topology-Independent Loop-Free Alternate (TI-LFA).

Usage Guidelines and Limitations

The following usage guidelines and limitations apply:

- TI-LFA provides link protection by default. Additional tiebreaker configuration is required to enable node or SRLG protection.
- Usage guidelines for node and SRLG protection:
  - TI-LFA node protection functionality provides protection from node failures. The neighbor node is excluded during the post convergence backup path calculation.
  - Shared Risk Link Groups (SRLG) refer to situations in which links in a network share a common fiber (or a common physical attribute). These links have a shared risk: when one link fails, other links in the group might also fail. TI-LFA SRLG protection attempts to find the post-convergence backup path that excludes the SRLG of the protected link. All local links that share any SRLG with the protecting link are excluded.
  - When you enable link protection, you can also enable node protection, SRLG protection, or both, and specify a tiebreaker priority in case there are multiple LFAs.
  - Valid priority values are from 1 to 255. The lower the priority value, the higher the priority of the rule. Link protection always has a lower priority than node or SRLG protection.

- Cisco 8000 Series Routers support the insertion of up to two SIDs. If the computed backup path requires more than two SIDs, the backup path will not be installed in the RIB and the path will not be protected.

Configuring SRv6 IS-IS TI-LFA

The following example shows how to configure SRv6 IS-IS TI-LFA.

Note Complete the Configuring SRv6, on page 8 before performing these steps.

```
Router(config)# router isis core
Router(config-isis)# address-family ipv6 unicast
Router(config-isis-af)# segment-routing srv6
Router(config-isis-srv6)# locator locator1
Router(config-isis-srv6-loc)# exit
Router(config-isis)# interface loopback 0
Router(config-isis-if)# passive
Router(config-isis-if)# address-family ipv6 unicast
Router(config-isis-if-af)# exit
Router(config-isis)# interface bundle-ether 1201
Router(config-isis-if)# address-family ipv6 unicast
Router(config-isis-if-af)# fast-reroute per-prefix
Router(config-isis-if-af)# fast-reroute per-prefix ti-lfa
Router(config-isis-if-af)# exit
Router(config-isis)# interface bundle-ether 1301
Router(config-isis-if)# address-family ipv6 unicast
Router(config-isis-if-af)# fast-reroute per-prefix
Router(config-isis-if-af)# fast-reroute per-prefix ti-lfa
Router(config-isis-if-af)# fast-reroute per-prefix tiebreaker node-protecting index 100
Router(config-isis-if-af)# fast-reroute per-prefix tiebreaker srlg-disjoint index 200
Router(config-isis-if-af)# exit
```

Verification

This example shows how to verify the SRv6 IS-IS TI-LFA configuration using the **show isis ipv6 fast-reroute** *ipv6-prefix* **detail** command.

```
Router# show isis ipv6 fast-reroute cafe:0:0:66::/64 detail
Thu Nov 22 16:12:51.983 EST

L1 cafe:0:0:66::/64 [11/115] low priority
     via fe80::2, TenGigE0/0/0/6, SRv6-HUB6, Weight: 0
      Backup path: TI-LFA (link), via fe80::1, Bundle-Ether1201 SRv6-LF1, Weight: 0, Metric:
 51
         P node: SRv6-TP8.00 [8::8], SRv6 SID: cafe:0:0:88:1:: End (PSP)
         Backup-src: SRv6-HUB6.00
       P: No, TM: 51, LC: No, NP: No, D: No, SRLG: Yes
     src SRv6-HUB6.00-00, 6::6
```

This example shows how to verify the SRv6 IS-IS TI-LFA configuration using the **show route ipv6** *ipv6-prefix* **detail** command.

```
Router# show route ipv6 cafe:0:0:66::/64 detail
Thu Nov 22 16:14:07.385 EST
```

```
Routing entry for cafe:0:0:66::/64
  Known via "isis srv6", distance 115, metric 11, type level-1
  Installed Nov 22 09:24:05.160 for 06:50:02
  Routing Descriptor Blocks
    fe80::2, from 6::6, via TenGigE0/0/0/6, Protected
      Route metric is 11
      Label: None
      Tunnel ID: None
      Binding Label: None
      Extended communities count: 0
      Path id:1       Path ref count:0
      NHID:0x2000a(Ref:11)
      NHID eid:0xffffffffffffffff
      Backup path id:65
    fe80::1, from 6::6, via Bundle-Ether1201, Backup (TI-LFA)
      Repair Node(s): 8::8
      Route metric is 51
      Label: None
      Tunnel ID: None
      Binding Label: None
      Extended communities count: 0
      Path id:65              Path ref count:1
      NHID:0x2000d(Ref:11)
      NHID eid:0xffffffffffffffff
      SRv6 Headend: H.Encaps.Red
      SRv6 SID-list { cafe:0:0:88:1:: }
      MPLS eid:0x1380800000001
```

This example shows how to verify the SRv6 IS-IS TI-LFA configuration using the **show cef ipv6** *ipv6-prefix* **detail location** *location* command.

```
Router# show cef  ipv6 cafe:0:0:66::/64 detail location 0/0/cpu0
Thu Nov 22 17:01:58.536 EST
cafe:0:0:66::/64, version 1356, SRv6 Transit, internal 0x1000001 0x2 (ptr 0x8a4a45cc) [1],
 0x0 (0x8a46ae20), 0x0 (0x8c8f31b0)
 Updated Nov 22 09:24:05.166
 local adjacency fe80::2
 Prefix Len 64, traffic index 0, precedence n/a, priority 2
  gateway array (0x8a2dfaf0) reference count 4, flags 0x500000, source rib (7), 0 backups
                [5 type 3 flags 0x8401 (0x8a395d58) ext 0x0 (0x0)]
  LW-LDI[type=3, refc=1, ptr=0x8a46ae20, sh-ldi=0x8a395d58]
  gateway array update type-time 1 Nov 22 09:24:05.163
 LDI Update time Nov 22 09:24:05.163
 LW-LDI-TS Nov 22 09:24:05.166
   via fe80::2/128, TenGigE0/0/0/6, 8 dependencies, weight 0, class 0, protected [flags
0x400]
    path-idx 0 bkup-idx 1 NHID 0x2000a [0x8a2c2fd0 0x0]
    next hop fe80::2/128
   via fe80::1/128, Bundle-Ether1201, 8 dependencies, weight 0, class 0, backup (TI-LFA)
[flags 0xb00]
    path-idx 1 NHID 0x2000d [0x8c2670b0 0x0]
    next hop fe80::1/128, Repair Node(s): 8::8
    local adjacency
     SRv6 H.Encaps.Red SID-list {cafe:0:0:88:1::}


    Load distribution: 0 (refcount 5)

    Hash  OK  Interface                 Address
    0     Y   TenGigE0/0/0/6            fe80::2
```

This example shows how to verify the SRv6 IS-IS TI-LFA configuration using the **show cef ipv6 fast-reroute-db** command.

```
Router# show cef ipv6 fast-reroute-db
Sun Dec  9 20:23:08.111 EST

 PROTECT-FRR: per-prefix [1, 0x0, 0x0, 0x98c83270]
 protect-interface: Te0/0/0/6 (0x208)
 protect-next-hop:  fe80::2/128
 ipv6 nhinfo [0x977397d0]
 Update Time Dec  9 17:29:42.427

     BACKUP-FRR: per-prefix [5, 0x0, 0x2, 0x98c83350]
     backup-interface: BE1201 (0x800002c)
     backup-next-hop:  fe80::1/128
     ipv6 nhinfo [0x977396a0 protect-frr: 0x98c83270]
 Update Time Dec  9 17:29:42.428

 PROTECT-FRR: per-prefix [1, 0x0, 0x0, 0x98c830b0]
 protect-interface: BE1201 (0x800002c)
 protect-next-hop:  fe80::1/128
 ipv6 nhinfo [0x977396a0]
 Update Time Dec  9 17:29:42.429

     BACKUP-FRR: per-prefix [5, 0x0, 0x1, 0x98c83190]
     backup-interface: Te0/0/0/6 (0x208)
     backup-next-hop:  fe80::2/128
     ipv6 nhinfo [0x977397d0 protect-frr: 0x98c830b0]
 Update Time Dec  9 17:29:42.429
```

Configuring SRv6 IS-IS Microloop Avoidance

This feature introduces support for implementing microloop avoidance using IS-IS SRv6.

Restrictions and Usage Guidelines

The following restrictions and usage guidelines apply:

- The Routing Information Base (RIB) update delay value specifies the amount of time the node uses the microloop avoidance policy before updating its forwarding table. The *delay-time* range is from 1 to 60000 milliseconds; the default value is 5000.

Configuring SRv6 IS-IS Microloop Avoidance

The following example shows how to configure SRv6 IS-IS Microloop Avoidance and set the Routing Information Base (RIB) update delay value.

Note Complete the Configuring SRv6, on page 8 before performing these steps.

```
Router(config)# router isis test-igp
Router(config-isis)# address-family ipv6 unicast
Router(config-isis-af)# microloop avoidance segment-routing
```

```
Router(config-isis-af)# commit
```

Configuring SRv6 IS-IS Flexible Algorithm

This feature introduces support for implementing Flexible Algorithm using IS-IS SRv6.

SRv6 Flexible Algorithm allows operators to customize IGP shortest path computation according to their own needs. An operator can assign custom SR prefix-SIDs to realize forwarding beyond link-cost-based SPF. As a result, Flexible Algorithm provides a traffic engineered path automatically computed by the IGP to any destination reachable by the IGP.

Restrictions and Usage Guidelines

The following restrictions and usage guidelines apply:

- You can configure up to 8 locators to support SRv6 Flexible Algorithm:
  - All locators prefix must share the same SID block (first 40-bits).
  - The Locator Algorithm value range is 128 to 255.

Configuring SRv6 IS-IS Flexible Algorithm

The following example shows how to configure SRv6 IS-IS Flexible Algorithm.

Note Complete the Configuring SRv6, on page 8 before performing these steps.

Note For Cisco NCS5500 Series Routers, you must first use the **hw-module profile segment-routing srv6** command to enable SRv6 functionality. Then, reload the line card after enabling this command.

```
Router(config)# segment-routing srv6
Router(config-srv6)# locators
Router(config-srv6-locators)# locator Loc1-BE // best-effort
Router(config-srv6-locator)# prefix 2001:db8:0:a2::/64
Router(config-srv6-locator)# exit
Router(config-srv6-locators)# locator Loc1-LL // low latency
Router(config-srv6-locator)# prefix 2001:db8:1:a2::/64
Router(config-srv6-locator)# algorithm 128
Router(config-srv6-locator)# exit
Router(config-srv6)# exit
```

Configuring SRv6 IS-IS

The following example shows how to configure SRv6 IS-IS.

```
Router(config)# router isis test-igp
Router(config-isis)# address-family ipv6 unicast
Router(config-isis-af)# segment-routing srv6
```

```
Router(config-isis-srv6)# locator Loc1-BE
Router(config-isis-srv6-loc)# exit
Router(config-isis-srv6)# locator Loc1-LL
Router(config-isis-srv6-loc)# exit
```

Enable Flexible Algorithm for Low Latency

The following example shows how to enable Flexible Algorithm for low-latency:

- IS-IS: Configure Flexible Algorithm definition with **delay** objective
- Performance-measurement: Configure static delay per interface

```
Router(config)# router isis test-igp
Router(config-isis)# flex-algo 128
Router(config-isis-flex-algo)# metric-type delay
Router(config-isis-flex-algo)# exit
Router(config-isis)# interface GigabitEthernet0/0/0/0
Router(config-isis-if)# address-family ipv6 unicast
Router(config-isis-if-af)# root

Router(config)# performance-measurement
Router(config-perf-meas)# interface GigabitEthernet0/0/0/0
Router(config-pm-intf)# delay-measurement
Router(config-pm-intf-dm)# advertise-delay 100
Router(config-pm-intf-dm)# commit
```

Verification

```
Router# show segment-routing srv6 locator
Mon Aug 12 20:54:15.414 EDT
Name                  ID       Algo  Prefix                    Status
--------------------  -------  ----  ------------------------  -------
Loc1-BE               17       0     2001:db8:0:a2::/64        Up
Loc1-LL               18       128   2001:db8:1:a2::/64        Up


Router# show isis flex-algo 128
Mon Aug 12 21:00:54.282 EDT

IS-IS 200 Flex-Algo Database

Flex-Algo 128:

Level-2:
        Definition Priority: 128
        Definition Source: SRv6-LF1.00, (Local)
        Definition Equal to Local: Yes
        Disabled: No


Level-1:
        Definition Priority: 128
        Definition Source: SRv6-LF1.00, (Local)
        Definition Equal to Local: Yes
        Disabled: No


    Local Priority: 128
```

```
FRR Disabled: No
Microloop Avoidance Disabled: No
```

SRv6 Services: IPv4 L3VPN

Table 2: Feature History Table

Feature Name	Release Information	Feature Description
SRv6-based IPv4 L3VPN	Release 25.1.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]) This feature is now supported on: • 8011-4G24Y4H-I
SRv6-based IPv4 L3VPN	Release 24.4.1	Introduced in this release on: Fixed Systems(8700)(select variants only*) You can deploy IPv4 L3VPN over an SRv6 data plane with the SRv6-based IPv4 L3VPN feature. This feature uses SRv6 Segment IDs (SIDs) for service segments. It allows for the interconnection of multiple sites, creating a private network service over public infrastructure. SRv6-based IPv4 L3VPN functionality is now extended to the Cisco 8712-MOD-M routers.

The SRv6-based IPv4 L3VPN feature enables deployment of IPv4 L3VPN over a SRv6 data plane. Traditionally, it was done over an MPLS-based system. SRv6-based L3VPN uses SRv6 Segment IDs (SIDs) for service segments instead of labels. SRv6-based L3VPN functionality interconnects multiple sites to resemble a private network service over public infrastructure. To use this feature, you must configure SRv6-base.

For this feature, BGP allocates an SRv6 SID from the locator space, configured under SRv6-base and VPNv4 address family. For more information on this, refer to Segment Routing over IPv6 Overview, on page 2. The BGP SID can be allocated in the following ways:

- Per-VRF mode that provides End.DT4 support. End.DT4 represents the Endpoint with decapsulation and IPv4 table lookup.

BGP encodes the SRv6 SID in the prefix-SID attribute of the IPv4 L3VPN Network Layer Reachability Information (NLRI) and advertises it to IPv6 peering over an SRv6 network. The Ingress PE (provider edge) router encapsulates the VRF IPv4 traffic with the SRv6 VPN SID and sends it over the SRv6 network.

Restrictions and Usage Guidelines

- MPLS based L3VPN inter-operability is not supported on a router that is configured for SRv6-based L3VPN.
- Only IPv4 L3VPN is supported, and IPv6 L3VPN is not supported.
- Equal-Cost Multi-path (ECMP) and Unequal Cost Multipath (UCMP) are supported.
- BGP, OSPF, Static are supported as PE-CE protocol.

Configuring SRv6 based IPv4 L3VPN

To enable SRv6-based L3VPN, you need to configure SRv6 under BGP and SID allocation mode. The following example shows how to configure SRv6-based L3VPN:

```
/*Configure SRv6 locator name under BGP Global*/
RP/0/0/CPU0:Router(config)# router bgp 100
RP/0/0/CPU0:Router(config-bgp)# bgp router-id 10.6.6.6
RP/0/0/CPU0:Router(config-bgp)# segment-routing srv6
RP/0/0/CPU0:Router(config-bgp-srv6)# locator my-locator
RP/0/0/CPU0:Router(config-bgp-srv6)# exit


/*Configure SRv6 locator under VRF All under VPNv4 AFI*/
RP/0/0/CPU0:Router(config)# router bgp 100
RP/0/0/CPU0:Router(config-bgp)# bgp router-id 10.6.6.6
RP/0/0/CPU0:Router(config-bgp)# address-family vpnv4 unicast
RP/0/0/CPU0:Router(config-bgp-af)# verf all
RP/0/0/CPU0:Router(config-bgp-af-vrfall)# segment-routing srv6
RP/0/0/CPU0:Router(config-bgp-af-vrfall-srv6)# locator my-locator
RP/0/0/CPU0:Router(config-bgp-af-vrfall-srv6)# exit


/*Configure a VRF with per-vrf label allocation mode*/
RP/0/0/CPU0:Router(config-bgp-af)# vrf vrf1
RP/0/0/CPU0:Router(config-bgp-vrf)# rd 106:1
RP/0/0/CPU0:Router(config-bgp-vrf)# address-family ipv4 unicast
RP/0/0/CPU0:Router(config-bgp-vrf-af)# segment-routing srv6
RP/0/0/CPU0:Router(config-bgp-vrf-af-srv6)# alloc mode per-vrf
RP/0/0/CPU0:Router(config-bgp-vrf-af-srv6)# exit
RP/0/0/CPU0:Router(config-bgp-vrf-af)# exit
RP/0/0/CPU0:Router(config-bgp-vrf)# neighbor 10.1.2.2
RP/0/0/CPU0:Router(config-bgp-vrf-nbr)# remote-as 100
RP/0/0/CPU0:Router(config-bgp-vrf-nbr)# address-family ipv4 unicast

/*Configure a VRF with per-ce label allocation mode*/
RP/0/0/CPU0:Router(config-bgp-af)# vrf vrf2
RP/0/0/CPU0:Router(config-bgp-vrf)# rd 106:2
RP/0/0/CPU0:Router(config-bgp-vrf)# address-family ipv4 unicast
RP/0/0/CPU0:Router(config-bgp-vrf-af)# segment-routing srv6
RP/0/0/CPU0:Router(config-bgp-vrf-af-srv6)# alloc mode per-ce
RP/0/0/CPU0:Router(config-bgp-vrf-af-srv6)# exit
RP/0/0/CPU0:Router(config-bgp-vrf-af)# exit
RP/0/0/CPU0:Router(config-bgp-vrf)# neighbor 10.1.2.2
RP/0/0/CPU0:Router(config-bgp-vrf-nbr)# remote-as 100
RP/0/0/CPU0:Router(config-bgp-vrf-nbr)# address-family ipv4 unicast
```

Verification

The following example shows how to verify the SRv6 based L3VPN configuration using the **show segment-routing srv6 sid** command.

In this example, End.X represents Endpoint function with Layer-3 cross-connect, End.DT4 represents Endpoint with decapsulation and IPv4 table lookup represents Endpoint with decapsulation and IPv4 cross-connect.

```
 RP/0/0/CPU0:Router# show segment-routing srv6 sid
*** Locator: 'my_locator' ***
SID                         Function     Context                           Owner
     State  RW
--------------------------  -----------  ------------------------------    ------------------
  -----  --
cafe:0:0:66:1::             End (PSP)    'my_locator':1                    sidmgr
     InUse  Y
cafe:0:0:66:40::            End.X (PSP)  [Te0/0/0/2, Link-Local]           isis-srv6
     InUse  Y
cafe:0:0:66:41::            End.X (PSP)  [BE6801, Link-Local]              isis-srv6
     InUse  Y
cafe:0:0:66:42::            End.X (PSP)  [BE5601, Link-Local]              isis-srv6
     InUse  Y
cafe:0:0:66:43::            End.X (PSP)  [BE5602, Link-Local]              isis-srv6
     InUse  Y
cafe:0:0:66:44::            End.DT4      'VRF1'                            bgp-100
     InUse  Y
cafe:0:0:66:45::            End.DT4      'VRF2'                            bgp-100
     InUse  Y
```

The following example shows how to verify the SRv6 based L3VPN configuration using the **show segment-routing srv6** *SID-prefix* **detail** command.

```
RP/0/RP0/CPU0:Router#sh segment-routing srv6 sid cafe:0:0:66:43:: detail
Sun Dec  9 16:52:54.015 EST
*** Locator: 'my_locator' ***
SID                         Function     Context                           Owner
     State  RW
--------------------------  -----------  ------------------------------    ------------------
  -----  --
cafe:0:0:66:44::            End.DT4      'VRF1'                            bgp-100
     InUse  Y
  SID context: { table-id=0xe0000001 ('VRF1':IPv4/Unicast) }
  Locator: 'my_locator'
  Allocation type: Dynamic
  Created: Dec  8 16:34:32.506 (1d00h ago)
RP/0/RP0/CPU0:SRv6-HUB6#sh segment-routing srv6 sid cafe:0:0:66:47:: detail
Sun Dec  9 16:54:26.073 EST
*** Locator: 'my_locator' ***
```

The following example shows how to verify the SRv6 based L3VPN configuration using the **show bgp vpnv4 un rd** *route-distinguisher prefix* command on Egress PE.

```
RP/0/RP0/CPU0:SRv6-Hub6#sh bgp vpnv4 un rd 106:1 10.15.0.0/30
Wed Nov 21 16:08:44.765 EST
BGP routing table entry for 10.15.0.0/30, Route Distinguisher: 106:1
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker            2282449     2282449
    SRv6-VPN SID: cafe:0:0:66:44::/128
Last Modified: Nov 21 15:50:34.235 for 00:18:10
Paths: (2 available, best #1)
  Advertised to peers (in unique update groups):
```

```
    2::2
  Path #1: Received by speaker 0
  Advertised to peers (in unique update groups):
    2::2
  200
    10.1.2.2 from 10.1.2.2  (10.7.0.1)
      Origin IGP, localpref 200, valid, internal, best, group-best, import-candidate
      Received Path ID 0, Local Path ID 1, version 2276228
      Extended community: RT:201:1
  Path #2: Received by speaker 0
  Not advertised to any peer
  200
    10.2.2.2 from 10.2.2.2 (10.20.1.2)
      Origin IGP, localpref 100, valid, internal
      Received Path ID 0, Local Path ID 0, version 0
      Extended community: RT:201:1
```

The following example shows how to verify the SRv6 based L3VPN configuration using the **show bgp vpnv4 un rd** *route-distinguisher prefix* command on Ingress PE.

```
RP/0/RP0/CPU0:SRv6-LF1#sh bgp vpnv4 un rd 106:1 10.15.0.0/30
Wed Nov 21 16:11:45.538 EST
BGP routing table entry for 10.15.0.0/30, Route Distinguisher: 106:1
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker            2286222     2286222
Last Modified: Nov 21 15:47:26.288 for 00:24:19
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  200, (received & used)
    6::6 (metric 24) from 2::2 (6.6.6.6)
      Received Label 3
      Origin IGP, localpref 200, valid, internal, best, group-best, import-candidate,
not-in-vrf
      Received Path ID 1, Local Path ID 1, version 2286222
      Extended community: RT:201:1
      Originator: 6.6.6.6, Cluster list: 2.2.2.2
      SRv6-VPN-SID: T1-cafe:0:0:66:44:: [total 1]
```

The following example shows how to verify the SRv6 based L3VPN configuration using the **show route vrf** *vrf-name prefix* **detail** command.

```
RP/0/RP0/CPU0:Router#sh route vrf VRF1 10.15.0.0/30detail
Wed Nov 21 16:35:17.775 EST
Routing entry for 10.15.0.0/30
  Known via "bgp 100", distance 200, metric 0
  Tag 200, type internal
  Installed Nov 21 16:35:14.107 for 00:00:03
  Routing Descriptor Blocks
    6::6, from 2::2
      Nexthop in Vrf: "default", Table: "default", IPv6 Unicast, Table Id: 0xe0800000
      Route metric is 0
      Label: None
      Tunnel ID: None
      Binding Label: None
      Extended communities count: 0
      Source RD attributes: 0x0000:106:1
      NHID:0x0(Ref:0)
      SRv6 Headend: H.Encaps.Red [base]
      SRv6 SID-list { cafe:0:0:66:44:: }
      MPLS eid:0x1380600000001
```

```
  Route version is 0xd (13)
  No local label
  IP Precedence: Not Set
  QoS Group ID: Not Set
  Flow-tag: Not Set
  Fwd-class: Not Set
  Route Priority: RIB_PRIORITY_RECURSIVE (12) SVD Type RIB_SVD_TYPE_REMOTE
  Download Priority 3, Download Version 3038384
  No advertising protos.
```

The following example shows how to verify the SRv6 based L3VPN configuration for per-ce allocation mode using the **show bgp vrf** *vrf* **nexthop-set** command.

```
RP/0/RP0/CPU0:Router#show bgp vrf VRF2 nexthop-set
Wed Nov 21 15:52:17.464 EST
 Resilient per-CE nexthop set, ID 3
 Number of nexthops 1, Label 0, Flags 0x2200
 SRv6-VPN SID: cafe:0:0:66:46::/128
 Nexthops:
10.1.2.2
 Reference count 1,
 Resilient per-CE nexthop set, ID 4
 Number of nexthops 2, Label 0, Flags 0x2100
 SRv6-VPN SID: cafe:0:0:66:47::/128
 Nexthops:
 10.1.2.2
 10.2.2.2
Reference count 2,
```

The following example shows how to verify the SRv6 based L3VPN configuration using the **show cef vrf** *vrf-name prefix* **detail location** *line-card* command.

```
RP/0/RP0/CPU0:Router#sh cef vrf VRF1 10.15.0.0/30 detail location 0/0/cpu0
Wed Nov 21 16:37:06.894 EST
151.1.0.0/30, version 3038384, SRv6 Transit, internal 0x5000001 0x0 (ptr 0x9ae6474c) [1],
0x0 (0x0), 0x0 (0x8c11b238)
 Updated Nov 21 16:35:14.109
 Prefix Len 30, traffic index 0, precedence n/a, priority 3
  gateway array (0x8cd85190) reference count 1014, flags 0x2010, source rib (7), 0 backups
                [1 type 3 flags 0x40441 (0x8a529798) ext 0x0 (0x0)]
  LW-LDI[type=0, refc=0, ptr=0x0, sh-ldi=0x0]
  gateway array update type-time 1 Nov 21 14:47:26.816
 LDI Update time Nov 21 14:52:53.073
  Level 1 - Load distribution: 0
  [0] via cafe:0:0:66::/128, recursive
   via cafe:0:0:66::/128, 7 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x8acb53cc 0x0]
    next hop VRF - 'default', table - 0xe0800000
    next hop cafe:0:0:66::/128 via cafe:0:0:66::/64
     SRv6 H.Encaps.Red SID-list {cafe:0:0:66:44::}
    Load distribution: 0 (refcount 1)
    Hash  OK  Interface                 Address
    0     Y   Bundle-Ether1201          fe80::2
```

SRv6 Services: IPv6 L3VPN

Table 3: Feature History Table

Feature Name	Release Information	Feature Description
SRv6 Services: IPv6 L3VPN	Release 25.1.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]) This feature is now supported on: • 8011-4G24Y4H-I
SRv6 Services: IPv6 L3VPN	Release 24.4.1	Introduced in this release on: Fixed Systems(8700)(select variants only*) * SRv6 Services: IPv6 L3VPN is now supported on the Cisco 8712-MOD-M routers.
SRv6 Services: IPv6 L3VPN	Release 7.8.1	With this feature, the egress PE can signal an SRv6 Service SID with the BGP overlay service route. The ingress PE encapsulates the IPv4/IPv6 payload in an outer IPv6 header where the destination address is the SRv6 Service SID provided by the egress PE. BGP messages between PEs carry SRv6 Service SIDs as a means to interconnect PEs and form VPNs.

Building on the messages and procedures defined in IETF draft "BGP/MPLS IP Virtual Private Networks (VPNs)", this feature provides IPv6 L3VPNs (VPNv6) over an SRv6 network.

In SRv6-based L3VPNs, the egress PE signals an SRv6 Service SID with the BGP overlay service route. The ingress PE encapsulates the IPv4/IPv6 payload in an outer IPv6 header where the destination address is the SRv6 Service SID provided by the egress PE. BGP messages between PEs carry SRv6 Service SIDs as a means to interconnect PEs and form VPNs.

SRv6 Service SID refers to a segment identifier associated with one of the SRv6 service-specific behaviors on the advertising VPNv6 PE router, such as END.DT6 (Endpoint with decapsulation and IPv6 table lookup) behaviors.

Based on the messages and procedures defined in IETF draft "SRv6 BGP based Overlay services", BGP encodes the SRv6 Service SID in the prefix-SID attribute of the IPv6 L3VPN Network Layer Reachability Information (NLRI) and advertises it to its IPv6 BGP peers.

BGP allocates an SRv6 Service SID from the locator space, configured under SRv6 and VPNv6 address family. For more information on this, see Segment Routing over IPv6 Overview. The SRv6 Service SID can be allocated in the following ways:

- Per-VRF mode that provides End.DT6 support. End.DT6 represents the Endpoint with decapsulation and IPv6 table lookup.

Usage Guidelines and Restrictions

- SRv6 locator can be assigned globally, for all VRFs, for an individual VRF, or per-prefix.
- Equal-Cost Multi-path (ECMP) and Unequal Cost Multipath (UCMP) are supported.
- BGP, OSPF, Static are supported as PE-CE protocol.
- Dual-Stack L3VPN Services (IPv4, IPv6) are supported.
- MPLS L3VPN and SRv6 L3VPN interworking gateway is supported.

Configuring SRv6-based IPv6 L3VPN

To enable SRv6-based L3VPN, you need to configure SRv6 under BGP and configure the SID allocation mode.

The following examples show how to configure SRv6-based L3VPN.

Configure SRv6 Locator Under BGP Global

This example shows how to configure the SRv6 locator name under BGP Global:

```
RP/0/0/CPU0:Node1(config)# router bgp 100
RP/0/0/CPU0:Node1(config-bgp)# segment-routing srv6
RP/0/0/CPU0:Node1(config-bgp-gbl-srv6)# locator Node1-locator
RP/0/0/CPU0:Node1(config-bgp-gbl-srv6)# exit
RP/0/0/CPU0:Node1(config-bgp)# address-family vpnv6 unicast
RP/0/0/CPU0:Node1(config-bgp-af)# exit
RP/0/0/CPU0:Node1(config-bgp)# neighbor 3001::1:1:1:4
RP/0/0/CPU0:Node1(config-bgp-nbr)# remote-as 100
RP/0/0/CPU0:Node1(config-bgp-nbr)# address-family vpnv6 unicast
RP/0/0/CPU0:Node1(config-bgp-nbr-af)# exit
RP/0/0/CPU0:Node1(config-bgp-nbr)# exit
RP/0/0/CPU0:Node1(config-bgp)# vrf vrf_cust6
RP/0/0/CPU0:Node1(config-bgp-vrf)# rd 100:6
RP/0/0/CPU0:Node1(config-bgp-vrf)# address-family ipv6 unicast
RP/0/0/CPU0:Node1(config-bgp-vrf-af)# commit
```

Running Configuration

```
router bgp 100
 segment-routing srv6
  locator Node1-locator
 !
 address-family vpnv6 unicast
 !
 neighbor 3001::1:1:1:4
  remote-as 100
  address-family vpnv6 unicast
  !
 !
 vrf vrf_cust6
  rd 100:6
  address-family ipv6 unicast
  !
 !
```

```
!
end
```

Configure SRv6 Locator For All VRF Under VPNv6 AFI

This example shows how to configure the SRv6 locator for all VRFs under VPNv6 address family, with per-VRF label allocation mode:

```
RP/0/0/CPU0:Node1(config)# router bgp 100
RP/0/0/CPU0:Node1(config-bgp)# address-family vpnv6 unicast
RP/0/0/CPU0:Node1(config-bgp-af)# vrf all
RP/0/0/CPU0:Node1(config-bgp-af-vrfall)# segment-routing srv6
RP/0/0/CPU0:Node1(config-bgp-af-vrfall-srv6)# locator Node1-locator
RP/0/0/CPU0:Node1(config-bgp-af-vrfall-srv6)# alloc mode per-vrf
RP/0/0/CPU0:Node1(config-bgp-af-vrfall-srv6)# exit
RP/0/0/CPU0:Node1(config-bgp-af-vrfall)# exit
RP/0/0/CPU0:Node1(config-bgp-af)# exit
RP/0/0/CPU0:Node1(config-bgp)# neighbor 3001::1:1:1:4
RP/0/0/CPU0:Node1(config-bgp-nbr)# remote-as 100
RP/0/0/CPU0:Node1(config-bgp-nbr)# address-family vpnv6 unicast
RP/0/0/CPU0:Node1(config-bgp-nbr-af)# exit
RP/0/0/CPU0:Node1(config-bgp-nbr)# exit
RP/0/0/CPU0:Node1(config-bgp)# vrf vrf_cust6
RP/0/0/CPU0:Node1(config-bgp-vrf)# rd 100:6
RP/0/0/CPU0:Node1(config-bgp-vrf)# address-family ipv6 unicast
RP/0/0/CPU0:Node1(config-bgp-vrf-af)# commit
```

Running Configuration

```
router bgp 100
 address-family vpnv6 unicast
  vrf all
   segment-routing srv6
    locator Node1-locator
    alloc mode per-vrf
   !
  !
 !
 neighbor 3001::1:1:1:4
  remote-as 100
  address-family vpnv6 unicast
  !
 !
 vrf vrf_cust6
  rd 100:6
  address-family ipv6 unicast
  !
 !
!
end
```

Configure an Individual VRF with Per-VRF Label Allocation Mode

This example shows how to configure the SRv6 locator for an individual VRF, with per-VRF label allocation mode:

```
RP/0/0/CPU0:Node1(config)# router bgp 100
RP/0/0/CPU0:Node1(config-bgp)# address-family vpnv6 unicast
RP/0/0/CPU0:Node1(config-bgp-af)# exit
RP/0/0/CPU0:Node1(config-bgp)# neighbor 3001::1:1:1:4
RP/0/0/CPU0:Node1(config-bgp-nbr)# remote-as 100
RP/0/0/CPU0:Node1(config-bgp-nbr)# address-family vpnv6 unicast
```

```
RP/0/0/CPU0:Node1(config-bgp-nbr-af)# exit
RP/0/0/CPU0:Node1(config-bgp-nbr)# exit
RP/0/0/CPU0:Node1(config-bgp)# vrf vrf_cust6
RP/0/0/CPU0:Node1(config-bgp-vrf)# rd 100:6
RP/0/0/CPU0:Node1(config-bgp-vrf)# address-family ipv6 unicast
RP/0/0/CPU0:Node1(config-bgp-vrf-af)# segment-routing srv6
RP/0/0/CPU0:Node1(config-bgp-vrf-af-srv6)# locator Node1-locator
RP/0/0/CPU0:Node1(config-bgp-vrf-af-srv6)# alloc mode per-vrf
RP/0/0/CPU0:Node1(config-bgp-vrf-af-srv6)# commit
```

Running Configuration

```
router bgp 100
 address-family vpnv6 unicast
 !
 neighbor 3001::1:1:1:4
  remote-as 100
  address-family vpnv6 unicast
  !
 !
 vrf vrf_cust6
  rd 100:6
  address-family ipv6 unicast
   segment-routing srv6
    locator Node1-locator
    alloc mode per-vrf
   !
  !
 !
!
end
```

Verification

The following examples shows how to verify the SRv6 based L3VPN configurations for an Individual VRF with per VRF label allocation mode.

In this example, End.X represents Endpoint function with Layer-3 cross-connect, and End.DT6 represents Endpoint with decapsulation and IPv6 table lookup.

```
RP/0/RSP0/CPU0:Node1# show segment-routing srv6 sid
Fri Jan 15 18:58:04.911 UTC

*** Locator: 'Node1-locator' ***

SID                         Behavior          Context                          Owner
          State  RW
--------------------------  ----------------  -------------------------------
------------------  -----  --
cafe:0:0:1:1::              End (PSP)         'default':1                      sidmgr
          InUse  Y
cafe:0:0:1:40::             End.X (PSP)       [Hu0/0/0/0, Link-Local]          isis-1
          InUse  Y
cafe:0:0:1:41::             End.X (PSP)       [Hu0/0/0/1, Link-Local]          isis-1
          InUse  Y
cafe:0:0:1:47::             End.X (PSP)       [Hu0/0/0/0, Link-Local]:P        isis-1
          InUse  Y
cafe:0:0:1:48::             End.X (PSP)       [Hu0/0/0/1, Link-Local]:P        isis-1
          InUse  Y
cafe:0:0:1:49::             End.DT6           'default'                        bgp-100
          InUse  Y
cafe:0:0:1:4a::             End.DT6           'vrf_cust6'                      bgp-100
```

```
          InUse  Y
```

The following examples show how to verify the SRv6 based L3VPN configuration using the **show bgp vpnv6 unicast** commands on the Ingress PE.

```
RP/0/RSP0/CPU0:Node1# show bgp vpnv6 unicast summary
Fri Jan 15 18:37:04.791 UTC
BGP router identifier 10.1.1.1, local AS number 100
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0x0   RD version: 0
BGP main routing table version 21
BGP NSR Initial initsync version 4 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

BGP is operating in STANDALONE mode.


Process       RcvTblVer   bRIB/RIB   LabelVer  ImportVer  SendTblVer  StandbyVer
Speaker              21         21         21         21          21           0

Neighbor        Spk    AS MsgRcvd MsgSent   TblVer  InQ OutQ  Up/Down  St/PfxRcd
3001::1:1:1:4     0   100    1352    1352       21    0    0 01:46:26          1
3001::1:1:1:5     0   100    1351    1351       21    0    0 01:44:47          1

RP/0/RSP0/CPU0:Node1# show bgp vpnv6 unicast rd 100:6
Fri Jan 15 18:38:02.919 UTC
BGP router identifier 10.1.1.1, local AS number 100
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0x0   RD version: 0
BGP main routing table version 21
BGP NSR Initial initsync version 4 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 100:6 (default for vrf vrf_cust6)
*> 3001::12:1:1:1/128 ::                        0         32768 ?
*>i3001::12:1:1:4/128 3001::1:1:1:4             0    100      0 ?
*>i3001::12:1:1:5/128 3001::1:1:1:5             0    100      0 ?

Processed 3 prefixes, 3 paths

RP/0/RSP0/CPU0:Node1# show bgp vpnv6 unicast rd 100:6 3001::12:1:1:4/128
Fri Jan 15 18:38:26.492 UTC
BGP routing table entry for 3001::12:1:1:4/128, Route Distinguisher: 100:6
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 17          17
Last Modified: Jan 15 16:50:44.032 for 01:47:43
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  Local, (received & used)
    3001::1:1:1:4 (metric 30) from 3001::1:1:1:4 (10.1.1.4)
```

```
      Received Label 0x4900
      Origin incomplete, metric 0, localpref 100, valid, internal, best, group-best,
import-candidate, imported
      Received Path ID 0, Local Path ID 1, version 17
      Extended community: RT:100:6
      PSID-Type:L3, SubTLV Count:1
       SubTLV:
        T:1(Sid information), Sid:cafe:0:0:4::, Behavior:18, SS-TLV Count:1
         SubSubTLV:
          T:1(Sid structure):
      Source AFI: VPNv6 Unicast, Source VRF: vrf_cust6, Source Route Distinguisher: 100:6
```

The following examples show how to verify the BGP prefix information for VRF instances:

```
RP/0/RSP0/CPU0:Node1# show bgp vrf vrf_cust6 ipv6 unicast
Fri Jan 15 18:38:49.705 UTC
BGP VRF vrf_cust6, state: Active
BGP Route Distinguisher: 100:6
VRF ID: 0x60000008
BGP router identifier 10.1.1.1, local AS number 100
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0800017   RD version: 21
BGP main routing table version 21
BGP NSR Initial initsync version 4 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0

Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 100:6 (default for vrf vrf_cust6)
*> 3001::12:1:1:1/128 ::                        0         32768 ?
*>i3001::12:1:1:4/128 3001::1:1:1:4             0    100      0 ?
*>i3001::12:1:1:5/128 3001::1:1:1:5             0    100      0 ?

Processed 3 prefixes, 3 paths

RP/0/RSP0/CPU0:Node1# show bgp vrf vrf_cust6 ipv6 unicast 3001::12:1:1:4/128
Fri Jan 15 18:39:05.115 UTC
BGP routing table entry for 3001::12:1:1:4/128, Route Distinguisher: 100:6
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 17          17
Last Modified: Jan 15 16:50:44.032 for 01:48:21
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  Local, (received & used)
    3001::1:1:1:4 (metric 30) from 3001::1:1:1:4 (10.1.1.4)
      Received Label 0x4900
      Origin incomplete, metric 0, localpref 100, valid, internal, best, group-best,
import-candidate, imported
      Received Path ID 0, Local Path ID 1, version 17
      Extended community: RT:100:6
      PSID-Type:L3, SubTLV Count:1
       SubTLV:
        T:1(Sid information), Sid:cafe:0:0:4::, Behavior:18, SS-TLV Count:1
         SubSubTLV:
          T:1(Sid structure):
      Source AFI: VPNv6 Unicast, Source VRF: vrf_cust6, Source Route Distinguisher: 100:6
```

The following examples show how to verify the current routes in the Routing Information Base (RIB):

```
RP/0/RSP0/CPU0:Node1# show route vrf vrf_cust6 ipv6 unicast
Fri Jan 15 18:39:20.619 UTC

Codes: C - connected, S - static, R - RIP, B - BGP, (>) - Diversion path
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - ISIS, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, su - IS-IS summary null, * - candidate default
       U - per-user static route, o - ODR, L - local, G  - DAGR, l - LISP
       A - access/subscriber, a - Application route
       M - mobile route, r - RPL, t - Traffic Engineering, (!) - FRR Backup path

Gateway of last resort is not set

L    3001::12:1:1:1/128 is directly connected,
      21:14:10, Loopback105
B    3001::12:1:1:4/128
      [200/0] via 3001::1:1:1:4 (nexthop in vrf default), 01:48:36
B    3001::12:1:1:5/128
      [200/0] via 3001::1:1:1:5 (nexthop in vrf default), 01:46:56

RP/0/RSP0/CPU0:Node1# show route vrf vrf_cust6 ipv6 unicast 3001::12:1:1:4/128
Fri Jan 15 18:39:39.689 UTC

Routing entry for 3001::12:1:1:4/128
  Known via "bgp 100", distance 200, metric 0, type internal
  Installed Jan 15 16:50:44.381 for 01:48:55
  Routing Descriptor Blocks
    3001::1:1:1:4, from 3001::1:1:1:4
      Nexthop in Vrf: "default", Table: "default", IPv6 Unicast, Table Id: 0xe0800000
      Route metric is 0
  No advertising protos.

RP/0/RSP0/CPU0:Node1# show route vrf vrf_cust6 ipv6 unicast 3001::12:1:1:4/128 detail
Fri Jan 15 18:39:51.573 UTC

Routing entry for 3001::12:1:1:4/128
  Known via "bgp 100", distance 200, metric 0, type internal
  Installed Jan 15 16:50:44.381 for 01:49:07
  Routing Descriptor Blocks
    3001::1:1:1:4, from 3001::1:1:1:4
      Nexthop in Vrf: "default", Table: "default", IPv6 Unicast, Table Id: 0xe0800000
      Route metric is 0
      Label: None
      Tunnel ID: None
      Binding Label: None
      Extended communities count: 0
      Source RD attributes: 0x0000:100:6
      NHID:0x0(Ref:0)
      SRv6 Headend: H.Encaps.Red [base], SID-list {cafe:0:0:4:49::}
  Route version is 0x1 (1)
  No local label
  IP Precedence: Not Set
  QoS Group ID: Not Set
  Flow-tag: Not Set
  Fwd-class: Not Set
  Route Priority: RIB_PRIORITY_RECURSIVE (12) SVD Type RIB_SVD_TYPE_REMOTE
  Download Priority 3, Download Version 3
  No advertising protos.
```

The following examples show how to verify the current IPv6 Cisco Express Forwarding (CEF) table:

```
RP/0/RSP0/CPU0:Node1# show cef vrf vrf_cust6 ipv6
Fri Jan 15 18:40:15.833 UTC

::/0
  drop       default handler
3001::12:1:1:1/128
  receive    Loopback105
3001::12:1:1:4/128
  recursive    cafe:0:0:4::/128
3001::12:1:1:5/128
  recursive    cafe:0:0:5::/128
fe80::/10
  receive
ff02::/16
  receive
ff02::2/128
  receive
ff02::1:ff00:0/104
  receive
ff05::/16
  receive
ff12::/16
  receive

RP/0/RSP0/CPU0:Node1# show cef vrf vrf_cust6 ipv6 3001::12:1:1:4/128
Fri Jan 15 18:40:28.853 UTC
3001::12:1:1:4/128, version 3, SRv6 Headend, internal 0x5000001 0x30 (ptr 0x78f2e0e0) [1],
 0x0 (0x0), 0x0 (0x8886b768)
 Updated Jan 15 16:50:44.385
 Prefix Len 128, traffic index 0, precedence n/a, priority 3
   via cafe:0:0:4::/128, 9 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x78a0f504 0x0]
    next hop VRF - 'default', table - 0xe0800000
    next hop cafe:0:0:4::/128 via cafe:0:0:4::/64
    SRv6 H.Encaps.Red SID-list {cafe:0:0:4:49::}

RP/0/RSP0/CPU0:Node1# show cef vrf vrf_cust6 ipv6 3001::12:1:1:4/128 detail
Fri Jan 15 18:40:55.327 UTC
3001::12:1:1:4/128, version 3, SRv6 Headend, internal 0x5000001 0x30 (ptr 0x78f2e0e0) [1],
 0x0 (0x0), 0x0 (0x8886b768)
 Updated Jan 15 16:50:44.385
 Prefix Len 128, traffic index 0, precedence n/a, priority 3
  gateway array (0x7883b320) reference count 1, flags 0x2010, source rib (7), 0 backups
               [1 type 3 flags 0x48441 (0x788e6ad8) ext 0x0 (0x0)]
  LW-LDI[type=0, refc=0, ptr=0x0, sh-ldi=0x0]
  gateway array update type-time 1 Jan 15 16:50:44.385
 LDI Update time Jan 15 16:50:44.385

  Level 1 - Load distribution: 0
  [0] via cafe:0:0:4::/128, recursive

   via cafe:0:0:4::/128, 9 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x78a0f504 0x0]
    next hop VRF - 'default', table - 0xe0800000
    next hop cafe:0:0:4::/128 via cafe:0:0:4::/64
    SRv6 H.Encaps.Red SID-list {cafe:0:0:4:49::}

    Load distribution: 0 1 (refcount 1)

    Hash  OK  Interface                 Address
    0     Y   HundredGigE0/0/0/0        remote
```

```
1      Y    HundredGigE0/0/0/1         remote
```

SRv6 Services: L3VPN VPNv4 Active-Standby Redundancy using Port-Active Mode

Table 4: Feature History Table

Feature Name	Release Information	Feature Description
SRv6 L3VPN VPNv4 Active-Standby Redundancy using Port-Active Mode	Release 25.1.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]) This feature is now supported on: • 8011-4G24Y4H-I
SRv6 L3VPN VPNv4 Active-Standby Redundancy using Port-Active Mode	Release 24.4.1	Introduced in this release on: Fixed Systems(8700)(select variants only*) This feature enables interface-based traffic forwarding, ensuring efficient load-balancing and faster convergence for multihoming. In active-standby scenarios, the active PE router is identified through a designated forwarder (DF) election using byte 10 of the Ethernet Segment Identifier (ESI), and the standby PE router interface is then brought down. * The SRv6 L3VPN VPNv4 Active-Standby Redundancy using Port-Active Mode functionality is now extended to the Cisco 8712-MOD-M routers.

The Segment Routing IPv6 (SRv6) Services: L3VPN VPNv4 Active-Standby Redundancy using Port-Active Mode feature provides all-active per-port load balancing for multihoming. The forwarding of traffic is determined based on a specific interface rather than per-flow across multiple Provider Edge routers. This feature enables efficient load-balancing and provides faster convergence. In an active-standby scenario, the active PE router is detected using designated forwarder (DF) election by modulo calculation and the interface of the standby PE router brought down. For Modulo calculation, byte 10 of the Ethernet Segment Identifier (ESI) is used.

Restrictions

- This feature can only be configured for bundle interfaces.

- When an EVPN Ethernet Segment (ES) is configured with port-active load-balancing mode, you cannot configure ACs of that bundle on bridge-domains with a configured EVPN instance (EVI). EVPN Layer 2 bridging service is not compatible with port-active load-balancing.

SRv6 Services for L3VPN Active-Standby Redundancy using Port-Active Mode: Operation

Under port-active operational mode, EVPN Ethernet Segment (ES) routes are exchanged across BGP for the routers servicing the multihomed ES. Each PE router then builds an ordered list of the IP addresses of all PEs connected to the ES, including itself, and assigns itself an ordinal for its position in the list. The ordinals are used with the modulo calculation to determine which PE will be the Designated Forwarder (DF) for a given ES. All non-DF PEs will take the respective bundles out of service.

In the case of link or port failure, the active DF PE withdraws its ES route. This re-triggers DF election for all PEs that service the ES and a new PE is elected as DF.

Configure SRv6 Services L3VPN Active-Standby Redundancy using Port-Active Mode

This section describes how you can configure SRv6 services L3VPN active-standby redundancy using port-active mode under an Ethernet Segment (ES).

Configuration Example

```
/* Configure Ethernet Link Bundles */
Router# configure
Router(config)# interface Bundle-Ether10
Router(config-if)# ipv4 address 10.0.0.2 255.255.255.0
Router(config-if)# ipv6 address 2001:DB8::1
Router(config-if)# lacp period short
Router(config-if)# mac-address 1.2.3
Router(config-if)# bundle wait-while 0
Router(config-if)# exit
Router(config)# interface GigabitEthernet 0/2/0/5
Router(config-if)# bundle id 14 mode active
Router(config-if)# commit

/* Configure load balancing. */
Router# configure
Router(config)# evpn
Router(config-evpn)# interface Bundle-Ether10
Router(config-evpn-ac)# ethernet-segment
Router(config-evpn-ac-es)# identifier type 0 11.11.11.11.11.11.11.11.14
Router(config-evpn-ac-es)# load-balancing-mode port-active
Router(config-evpn-ac-es)# commit
!
/* Configure address family session in BGP. */
Router# configure
Router(config)# router bgp 100
Router(config-bgp)# bgp router-id 192.168.0.2
Router(config-bgp)# address-family l2vpn evpn
Router(config-bgp)# neighbor 192.168.0.3
Router(config-bgp-nbr)# remote-as 200
```

```
Router(config-bgp-nbr)# update-source Loopback 0
Router(config-bgp-nbr)# address-family l2vpn evpn
Router(config-bgp-nbr)# commit
```

Running Configuration

```
interface Bundle-Ether14
 ipv4 address 14.0.0.2 255.255.255.0
 ipv6 address 14::2/64
 lacp period short
 mac-address 1.2.3
 bundle wait-while 0
!
interface GigabitEthernet0/2/0/5
 bundle id 14 mode active
!
evpn
 interface Bundle-Ether14
  ethernet-segment
   identifier type 0 11.11.11.11.11.11.11.11.14
   load-balancing-mode port-active
  !
 !
!
router bgp 100
 bgp router-id 192.168.0.2
 address-family l2vpn evpn
 !
 neighbor 192.168.0.3
  remote-as 100
  update-source Loopback0
  address-family l2vpn evpn
  !
 !
!
```

Verification

Verify the SRv6 services L3VPN active-standby redundancy using port-active mode configuration.

```
/* Verify ethernet-segment details on active DF router */
Router# show evpn ethernet-segment interface Bundle-Ether14 detail
Ethernet Segment Id      Interface                         Nexthops
------------------------ --------------------------------- --------------------
0011.1111.1111.1111.1114 BE14                              192.168.0.2
                                                           192.168.0.3
    ES to BGP Gates   : Ready
  ES to L2FIB Gates : Ready
  Main port         :
     Interface name : Bundle-Ether14
     Interface MAC  : 0001.0002.0003
     IfHandle       : 0x000041d0
     State          : Up
     Redundancy     : Not Defined
  ESI type          : 0
     Value          : 11.1111.1111.1111.1114
  ES Import RT      : 1111.1111.1111 (from ESI)
  Source MAC        : 0000.0000.0000 (N/A)
  Topology          :
     Operational    : MH
     Configured     : Port-Active
```

```
  Service Carving   : Auto-selection
     Multicast      : Disabled
  Peering Details   :
     192.168.0.2 [MOD:P:00]
     192.168.0.3 [MOD:P:00]

  Service Carving Results:
     Forwarders     : 0
     Permanent      : 0
     Elected        : 0
     Not Elected    : 0
  MAC Flushing mode : STP-TCN
  Peering timer     : 3 sec [not running]
  Recovery timer    : 30 sec [not running]
  Carving timer     : 0 sec [not running]
  Local SHG label   : None
  Remote SHG labels : 0


/* Verify bundle Ethernet configuration on active DF router */
Router# show bundle bundle-ether 14
Bundle-Ether14
  Status:                                  Up
  Local links <active/standby/configured>:   1 / 0 / 1
  Local bandwidth <effective/available>:     1000000 (1000000) kbps
  MAC address (source):                    0001.0002.0003 (Configured)
  Inter-chassis link:                      No
  Minimum active links / bandwidth:        1 / 1 kbps
  Maximum active links:                    64
  Wait while timer:                        Off
  Load balancing:
    Link order signaling:                  Not configured
    Hash type:                             Default
    Locality threshold:                    None
  LACP:                                    Operational
    Flap suppression timer:                Off
    Cisco extensions:                      Disabled
    Non-revertive:                         Disabled
  mLACP:                                   Not configured
  IPv4 BFD:                                Not configured
  IPv6 BFD:                                Not configured

  Port                  Device           State        Port ID         B/W, kbps
  --------------------  ---------------  -----------  --------------  ----------
  Gi0/2/0/5             Local            Active       0x8000, 0x0003     1000000
      Link is Active



/*  Verify ethernet-segment details on standby DF router */
Router# show evpn ethernet-segment interface bundle-ether 10 detail

Router# show evpn ethernet-segment interface Bundle-Ether24 detail
Ethernet Segment Id      Interface                         Nexthops
------------------------ --------------------------------- --------------------
0011.1111.1111.1111.1114 BE24                              192.168.0.2
                                                           192.168.0.3
  ES to BGP Gates   : Ready
  ES to L2FIB Gates : Ready
  Main port         :
     Interface name : Bundle-Ether24
     Interface MAC  : 0001.0002.0003
     IfHandle       : 0x000041b0
     State          : Standby
```

```
     Redundancy     : Not Defined
  ESI type          : 0
     Value          : 11.1111.1111.1111.1114
  ES Import RT      : 1111.1111.1111 (from ESI)
  Source MAC        : 0000.0000.0000 (N/A)
  Topology          :
     Operational    : MH
     Configured     : Port-Active
  Service Carving   : Auto-selection
     Multicast      : Disabled
  Peering Details   :
     192.168.0.2 [MOD:P:00]
     192.168.0.3 [MOD:P:00]

  Service Carving Results:
     Forwarders     : 0
     Permanent      : 0
     Elected        : 0
     Not Elected    : 0
  MAC Flushing mode : STP-TCN
  Peering timer     : 3 sec [not running]
  Recovery timer    : 30 sec [not running]
  Carving timer     : 0 sec [not running]
  Local SHG label   : None
  Remote SHG labels : 0

/* Verify bundle configuration on standby DF router */
Router# show bundle bundle-ether 24

Bundle-Ether24
  Status:                                  LACP OOS (out of service)
  Local links <active/standby/configured>:   0 / 1 / 1
  Local bandwidth <effective/available>:     0 (0) kbps
  MAC address (source):                    0001.0002.0003 (Configured)
  Inter-chassis link:                      No
  Minimum active links / bandwidth:        1 / 1 kbps
  Maximum active links:                    64
  Wait while timer:                        Off
  Load balancing:
    Link order signaling:                  Not configured
    Hash type:                             Default
    Locality threshold:                    None
  LACP:                                    Operational
    Flap suppression timer:                Off
    Cisco extensions:                      Disabled
    Non-revertive:                         Disabled
  mLACP:                                   Not configured
  IPv4 BFD:                                Not configured
  IPv6 BFD:                                Not configured

  Port                  Device           State        Port ID         B/W, kbps
  --------------------  ---------------  -----------  --------------  ----------
  Gi0/0/0/4             Local            Standby      0x8000, 0x0002     1000000
      Link is in standby due to bundle out of service state
```

SRv6 Services: L3VPN VPNv4 Active-Active Redundancy

Table 5: Feature History Table

Feature Name	Release Information	Feature Description
SRv6 L3VPN VPNv4 Active-Active Redundancy	Release 25.1.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]) This feature is now supported on: • 8011-4G24Y4H-I
SRv6 L3VPN VPNv4 Active-Active Redundancy	Release 24.4.1	Introduced in this release on: Fixed Systems(8700)(select variants only*) You can now provide active-active connectivity to a CE device in an L3VPN deployment. The CE device connects to redundant PEs over a single LACP LAG port. Depending on the bundle hashing, ARP or IPv6 ND packets can be sent to any redundant router. Layer-3 local route learning is enhanced with remote route-synchronization to ensure minimal service interruption, using EVPN route-types 2, 7/8, and 5 for synchronization. * The SRv6 L3VPN VPNv4 Active-Active Redundancy functionality is now extended to the Cisco 8712-MOD-M routers.

This feature provides active-active connectivity to a CE device in a L3VPN deployment. The CE device can be Layer-2 or Layer-3 device connecting to the redundant PEs over a single LACP LAG port.

Depending on the bundle hashing, an ARP or IPv6 Network Discovery (ND) packet can be sent to any of the redundant routers. As a result, not all entries will exist on a given PE. In order to provide complete awareness, Layer-3 local route learning is augmented with remote route-synchronization programming.

Route synchronization between service PEs is required in order to provide minimum interruption to unicast and multicast services after failure on a redundant service PE. The following EVPN route-types are used for Layer-3 route synchronization:

- EVPN route-type 2 for synchronizing ARP tables
- EVPN route-type 7/8 for synchronizing IGMP JOINS/LEAVES

In a Layer-3 CE scenario, the router that connects to the redundant PEs may establish an IGP adjacency on the bundle port. In this case, the adjacency will be formed to one of the redundant PEs, and IGP customer routes will only be present on that PE. To synchronize Layer-3 customer subnet routes (IP Prefixes), the EVPN route-type 5 is used to carry the ESI and ETAG as well as the gateway address (prefix next-hop address).

Note Gratuitous ARP (GARP) or IPv6 Network Advertisement (NA) replay is not needed for CEs connected to the redundant PEs over a single LAG port.

The below configuration enables Layer-3 route synchronization for routes learned on the Ethernet-segment sub-interfaces.

```
evpn
 route-sync vrf default
!
vrf RED
 evi route-sync 10
!
vrf BLUE
 evi route-sync 20
!
```

Note EVPN does not support untagged interfaces.

SRv6 Services: BGP Global IPv6

Table 6: Feature History Table

Feature Name	Release Information	Feature Description
SRv6 Services: BGP Global IPv6	Release 25.1.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]) This feature is now supported on: • 8011-4G24Y4H-I

Feature Name	Release Information	Feature Description
SRv6 Services: BGP Global IPv6	Release 24.4.1	Introduced in this release on: Fixed Systems(8700)(select variants only*) This feature extends support of SRv6-based BGP services to include Internet (IPv6) services by implementing End.DT6 SRv6 functions at the PE node, as defined in IETF draft "SRv6 BGP based Overlay services". * SRv6 Services: BGP Global IPv6 functionality is now extended to the Cisco 8712-MOD-M routers.

This feature extends support of SRv6-based BGP services to include Internet (IPv6) services by implementing End.DT6 SRv6 functions at the PE node, as defined in IETF draft "SRv6 BGP based Overlay services".

Usage Guidelines and Limitations

- SRv6 locator can be assigned globally or under IPv4 unicast address family
- Equal-Cost Multi-path (ECMP) and Unequal Cost Multipath (UCMP) are supported.
- BGP, OSPF, Static are supported as PE-CE protocol.

BGP Global IPv6 Over SRv6 with Per-VRF SID Allocation Mode (End.DT6)

To configure BGP global IPv6 over SRv6, use the following commands:

- **router bgp** *as-number* **address-family ipv6 unicast segment-routing srv6**: Enable SRv6
- **router bgp** *as-number* **address-family ipv6 unicast segment-routing srv6 alloc mode per-vrf**: Specify the SID behavior (allocation mode).

  The **per-vrf** keyword specifies that the same label is be used for all the routes advertised from a unique VRF.
- **router bgp** *as-number* **address-family ipv6 unicast segment-routing srv6 alloc mode** {**per-vrf** | **route-policy** *policy_name*}: Specify the SID behavior (allocation mode).
  - **per-vrf**: Specifies that the same label is be used for all the routes advertised from a unique VRF.
  - **route-policy** *policy_name*: Uses a route policy to determine the SID allocation mode and locator (if provided) for given prefix.
- **router bgp** *as-number* **address-family ipv6 unicast segment-routing srv6 locator** *WORD*: Specify the locator
- **router bgp** *as-number* {**af-group** *WORD*| **neighbor-group** *WORD* | **neighbor** *ipv6-addr*} **address-family ipv6 unicast encapsulation-type srv6**: Specify the encapuslation type for SRv6.

- Use **af-group** *WORD* to apply the SRv6 encapsulation type to the address family group for BGP neighbors.
- Use **neighbor-group** *WORD*to apply the SRv6 encapsulation type to the neighbor group for Border Gateway Protocol (BGP) neighbors.
- Use **neighbor** *ipv6-addr* to apply the SRv6 encapsulation type to the specific BGP neighbor.

Use Case 1: BGP Global IPv6 over SRv6 with Per-AFI SID Allocation

The following example shows how to configure BGP global IPv6 over SRv6 with per-VRF SID allocation.

```
Node1(config)# router bgp 100
Node1(config-bgp)# bgp router-id 10.1.1.1
Node1(config-bgp)# segment-routing srv6
Node1(config-bgp-gbl-srv6)# locator Node1
Node1(config-bgp-gbl-srv6)# exit
Node1(config-bgp)# address-family ipv6 unicast
Node1(config-bgp-af)# segment-routing srv6
Node1(config-bgp-af-srv6)# locator Node1
Node1(config-bgp-af-srv6)# alloc mode per-vrf
Node1(config-bgp-af-srv6)# exit
Node1(config-bgp-af)# exit
Node1(config-bgp)# neighbor 3001::1:1:1:4
Node1(config-bgp-nbr)# address-family ipv6 unicast
Node1(config-bgp-nbr-af)# encapsulation-type srv6
Node1(config-bgp-nbr-af)# exit
Node1(config-bgp-nbr)# exit
Node1(config-bgp)# neighbor 3001::1:1:1:5
Node1(config-bgp-nbr)# address-family ipv6 unicast
Node1(config-bgp-nbr-af)# encapsulation-type srv6
Node1(config-bgp-nbr-af)# commit
```

Running Configuration

```
router bgp 100
 bgp router-id 10.1.1.1
 segment-routing srv6
  locator Node1
 !
 address-family ipv6 unicast
  segment-routing srv6
   locator Node1
   alloc mode per-vrf
  !
 !
 neighbor 3001::1:1:1:4
  address-family ipv6 unicast
   encapsulation-type srv6
  !
 !
 neighbor 3001::1:1:1:5
  address-family ipv6 unicast
   encapsulation-type srv6
```

Use Case 2: BGP Global IPv6 over SRv6 with Per-Prefix SID Allocation

This use case provides the ability to assign a specific SRv6 locator for a given prefix or a set of prefixes. The egress PE advertises the prefix with the specified locator. This allows for per-prefix steering into desired transport behaviors, such as Flex Algo.

To assign an SRv6 locator for a specific prefix, configure a route policy to specify the SID allocation mode based on match criteria. Examples of match criteria are destination-based match or community-based match.

- Supported SID allocation modes are per-VRF and per-CE.
- For per-VRF allocation mode, you can also specify the SRv6 locator.
  - If an SRv6 locator is specified in the route policy, BGP will use that to allocate per-VRF SID. If the specified locator is invalid, the SID will not be allocated.
  - If an SRv6 locator is not specified in the route policy, the default locator is used to allocate the SID. If the default locator is not configured in BGP, then the SID will not be allocated.
- Per-CE allocation mode always uses the default locator to allocate the SID.

For more information on configuring routing policies, refer to the "Implementing Routing Policy" chapter in the *Routing Configuration Guide for Cisco 8000 Series Routers*.

The following example shows a route policy specifying the SID allocation mode with destination-based match:

```
Node1(config)# route-policy set_per_prefix_locator_rpl
Node1(config-rpl)# if destination in (3001::1:1:1:1/128) then
Node1(config-rpl-if)# set srv6-alloc-mode per-vrf locator locator1
Node1(config-rpl-if)# elseif destination in (3001::2:2:2:2/128) then
Node1(config-rpl-elseif)# set srv6-alloc-mode per-vrf locator locator2
Node1(config-rpl-elseif)# elseif destination in (3001::3:3:3:3/128) then
Node1(config-rpl-elseif)# set srv6-alloc-mode per-vrf
Node1(config-rpl-elseif)# elseif destination in (3001::4:4:4:4/128) then
Node1(config-rpl-elseif)# set srv6-alloc-mode per-ce
Node1(config-rpl-elseif)# else
Node1(config-rpl-else)# drop
Node1(config-rpl-else)# endif
Node1(config-rpl)# end-policy
```

The following example shows how to configure BGP global IPv6 over SRv6 with a route policy to determine the SID allocation mode for given prefix.

```
Node1(config)# router bgp 100
Node1(config-bgp)# address-family ipv4 unicast
Node1(config-bgp-af)# segment-routing srv6
Node1(config-bgp-af-srv6)# alloc mode route-policy set_per_prefix_locator_rpl
```

Running Configuration

```
route-policy set_per_prefix_locator_rpl
  if destination in (3001::1:1:1:1/128) then
    set srv6-alloc-mode per-vrf locator locator1
  elseif destination in (3001::2:2:2:2/128) then
    set srv6-alloc-mode per-vrf locator locator2
  elseif destination in (3001::3:3:3:3/128) then
    set srv6-alloc-mode per-vrf
  elseif destination in (3001::4:4:4:4/128) then
    set srv6-alloc-mode per-ce
  else
    drop
  endif
end-policy
!
router bgp 100
 address-family ipv6 unicast
```

```
  segment-routing srv6
   alloc mode route-policy set_per_prefix_locator_rpl
  !
 !
```

Verify that the local and received SIDs have been correctly allocated under BGP IPv6 address family:

```
Node1# show bgp ipv6 unicast local-sids
…
Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Local Sid                                Alloc mode   Locator
*> 3001::1:1:1:1/128  fc00:0:0:1:41::                          per-vrf      locator1
*> 3001::2:2:2:2/128  fc00:0:8:1:41::                          per-vrf      locator2
*> 3001::3:3:3:3/128  fc00:0:9:1:42::                          per-vrf      locator4
*> 3001::4:4:4:4/128  fc00:0:9:1:43::                          per-ce       locator4
*> 3001::5:5:5:5/128  NO SRv6 Sid                              -            -
* i3008::8:8:8:8/128  NO SRv6 Sid                              -            -


Node1# show bgp ipv6 unicast received-sids
…
Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop                            Received Sid
*> 3001::1:1:1:1/128  66.2.2.2                            NO SRv6 Sid
*> 3001::2:2:2:2/128  66.2.2.2                            NO SRv6 Sid
*> 3001::3:3:3:3/128  66.2.2.2                            NO SRv6 Sid
*> 3001::4:4:4:4/128  66.2.2.2                            NO SRv6 Sid
*> 3001::5:5:5:5/128  66.2.2.2                            NO SRv6 Sid
* i3008::8:8:8:8/128  77.1.1.2                            fc00:0:0:2:41::
```

Verification

The following examples show how to verify the BGP global IPv6 configuration using the **show bgp ipv6 unicast** commands.

```
RP/0/RSP0/CPU0:Node1# show bgp ipv6 unicast summary
Fri Jan 15 21:07:04.681 UTC
BGP router identifier 10.1.1.1, local AS number 100
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0800000   RD version: 4
BGP main routing table version 4
BGP NSR Initial initsync version 1 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

BGP is operating in STANDALONE mode.


Process       RcvTblVer   bRIB/RIB   LabelVer  ImportVer  SendTblVer  StandbyVer
Speaker               4          4          4          4           4           0

Neighbor        Spk    AS MsgRcvd MsgSent   TblVer  InQ OutQ  Up/Down  St/PfxRcd
3001::1:1:1:4     0   100    1502    1502        4    0    0 04:16:26          1
3001::1:1:1:5     0   100    1501    1501        4    0    0 04:14:47          1

RP/0/RSP0/CPU0:Node1# show bgp ipv6 unicast
```

```
Fri Jan 15 21:07:26.818 UTC
BGP router identifier 10.1.1.1, local AS number 100
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0800000   RD version: 4
BGP main routing table version 4
BGP NSR Initial initsync version 1 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf Weight Path
*> 3001::13:1:1:1/128 ::                       0         32768 i
*>i3001::13:1:1:4/128 3001::1:1:1:4            0    100      0 i
*>i3001::13:1:1:5/128 3001::1:1:1:5            0    100      0 i

Processed 3 prefixes, 3 paths

RP/0/RSP0/CPU0:Node1# show bgp ipv6 unicast 3001::13:1:1:4/128
Fri Jan 15 21:07:50.309 UTC
BGP routing table entry for 3001::13:1:1:4/128
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 4           4
Last Modified: Jan 15 17:13:50.032 for 03:54:01
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  Local
    3001::1:1:1:4 (metric 30) from 3001::1:1:1:4 (10.1.1.4)
      Origin IGP, metric 0, localpref 100, valid, internal, best, group-best
      Received Path ID 0, Local Path ID 1, version 4
      PSID-Type:L3, SubTLV Count:1
       SubTLV:
        T:1(Sid information), Sid:cafe:0:0:4:4b::, Behavior:18, SS-TLV Count:1
         SubSubTLV:
          T:1(Sid structure):
```

The following examples show how to verify the current routes in the Routing Information Base (RIB):

```
RP/0/RSP0/CPU0:Node1# show route ipv6 3001::13:1:1:4/128
Fri Jan 15 21:08:05.499 UTC

Routing entry for 3001::13:1:1:4/128
  Known via "bgp 100", distance 200, metric 0, type internal
  Installed Jan 15 17:13:50.431 for 03:54:15
  Routing Descriptor Blocks
    3001::1:1:1:4, from 3001::1:1:1:4
      Route metric is 0
  No advertising protos.

RP/0/RSP0/CPU0:Node1# show route ipv6 3001::13:1:1:4/128 detail
Fri Jan 15 21:08:22.628 UTC

Routing entry for 3001::13:1:1:4/128
  Known via "bgp 100", distance 200, metric 0, type internal
  Installed Jan 15 17:13:50.431 for 03:54:32
  Routing Descriptor Blocks
    3001::1:1:1:4, from 3001::1:1:1:4
      Route metric is 0
```

```
      Label: None
      Tunnel ID: None
      Binding Label: None
      Extended communities count: 0
      NHID:0x0(Ref:0)
      SRv6 Headend: H.Encaps.Red [base], SID-list {cafe:0:0:4:4b::}
  Route version is 0x1 (1)
  No local label
  IP Precedence: Not Set
  QoS Group ID: Not Set
  Flow-tag: Not Set
  Fwd-class: Not Set
  Route Priority: RIB_PRIORITY_RECURSIVE (12) SVD Type RIB_SVD_TYPE_LOCAL
  Download Priority 4, Download Version 93
  No advertising protos.
```

The following examples show how to verify the current IPv6 Cisco Express Forwarding (CEF) table:

```
RP/0/RSP0/CPU0:Node1# show cef ipv6 3001::13:1:1:4/128
Fri Jan 15 21:08:41.483 UTC
3001::13:1:1:4/128, version 93, SRv6 Headend, internal 0x5000001 0x40 (ptr 0x78a100d4) [1],
 0x0 (0x0), 0x0 (0x8886b840)
 Updated Jan 15 17:13:50.433
 Prefix Len 128, traffic index 0, precedence n/a, priority 4
   via cafe:0:0:4::/128, 9 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x78a0f504 0x0]
    next hop cafe:0:0:4::/128 via cafe:0:0:4::/64
    SRv6 H.Encaps.Red SID-list {cafe:0:0:4:4b::}

RP/0/RSP0/CPU0:Node1# show cef ipv6 3001::13:1:1:4/128 detail
Fri Jan 15 21:08:59.789 UTC
3001::13:1:1:4/128, version 93, SRv6 Headend, internal 0x5000001 0x40 (ptr 0x78a100d4) [1],
 0x0 (0x0), 0x0 (0x8886b840)
 Updated Jan 15 17:13:50.433
 Prefix Len 128, traffic index 0, precedence n/a, priority 4
  gateway array (0x7883b5d8) reference count 1, flags 0x2010, source rib (7), 0 backups
                [1 type 3 flags 0x48441 (0x788e6c40) ext 0x0 (0x0)]
  LW-LDI[type=0, refc=0, ptr=0x0, sh-ldi=0x0]
  gateway array update type-time 1 Jan 15 17:13:50.433
 LDI Update time Jan 15 17:13:50.433

  Level 1 - Load distribution: 0
  [0] via cafe:0:0:4::/128, recursive

   via cafe:0:0:4::/128, 9 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x78a0f504 0x0]
    next hop cafe:0:0:4::/128 via cafe:0:0:4::/64
    SRv6 H.Encaps.Red SID-list {cafe:0:0:4:4b::}

    Load distribution: 0 1 (refcount 1)

    Hash  OK  Interface                 Address
    0     Y   HundredGigE0/0/0/0        remote
    1     Y   HundredGigE0/0/0/1        remote
```

SRv6 Services: BGP Global IPv6

Table 7: Feature History Table

Feature Name	Release Information	Feature Description
SRv6 Services: BGP Global IPv6	Release 25.1.1	Introduced in this release on: Fixed Systems (8010 [ASIC: A100]) This feature is now supported on: • 8011-4G24Y4H-I
SRv6 Services: BGP Global IPv6	Release 24.4.1	Introduced in this release on: Fixed Systems(8700)(select variants only*) This feature extends support of SRv6-based BGP services to include Internet (IPv6) services by implementing End.DT6 SRv6 functions at the PE node, as defined in IETF draft "SRv6 BGP based Overlay services". * SRv6 Services: BGP Global IPv6 functionality is now extended to the Cisco 8712-MOD-M routers.

This feature extends support of SRv6-based BGP services to include Internet (IPv6) services by implementing End.DT6 SRv6 functions at the PE node, as defined in IETF draft "SRv6 BGP based Overlay services".

Usage Guidelines and Limitations

- SRv6 locator can be assigned globally or under IPv4 unicast address family
- Equal-Cost Multi-path (ECMP) and Unequal Cost Multipath (UCMP) are supported.
- BGP, OSPF, Static are supported as PE-CE protocol.

BGP Global IPv6 Over SRv6 with Per-VRF SID Allocation Mode (End.DT6)

To configure BGP global IPv6 over SRv6, use the following commands:

- **router bgp** *as-number* **address-family ipv6 unicast segment-routing srv6**: Enable SRv6
- **router bgp** *as-number* **address-family ipv6 unicast segment-routing srv6 alloc mode per-vrf**: Specify the SID behavior (allocation mode).

  The **per-vrf** keyword specifies that the same label is be used for all the routes advertised from a unique VRF.
- **router bgp** *as-number* **address-family ipv6 unicast segment-routing srv6 alloc mode** {**per-vrf** | **route-policy** *policy_name*}: Specify the SID behavior (allocation mode).

- **per-vrf**: Specifies that the same label is be used for all the routes advertised from a unique VRF.
- **route-policy** *policy_name*: Uses a route policy to determine the SID allocation mode and locator (if provided) for given prefix.

- **router bgp** *as-number* **address-family ipv6 unicast segment-routing srv6 locator** *WORD*: Specify the locator
- **router bgp** *as-number* {**af-group** *WORD*| **neighbor-group** *WORD* | **neighbor** *ipv6-addr*} **address-family ipv6 unicast encapsulation-type srv6**: Specify the encapuslation type for SRv6.
  - Use **af-group** *WORD* to apply the SRv6 encapsulation type to the address family group for BGP neighbors.
  - Use **neighbor-group** *WORD*to apply the SRv6 encapsulation type to the neighbor group for Border Gateway Protocol (BGP) neighbors.
  - Use **neighbor** *ipv6-addr* to apply the SRv6 encapsulation type to the specific BGP neighbor.

Use Case 1: BGP Global IPv6 over SRv6 with Per-AFI SID Allocation

The following example shows how to configure BGP global IPv6 over SRv6 with per-VRF SID allocation.

```
Node1(config)# router bgp 100
Node1(config-bgp)# bgp router-id 10.1.1.1
Node1(config-bgp)# segment-routing srv6
Node1(config-bgp-gbl-srv6)# locator Node1
Node1(config-bgp-gbl-srv6)# exit
Node1(config-bgp)# address-family ipv6 unicast
Node1(config-bgp-af)# segment-routing srv6
Node1(config-bgp-af-srv6)# locator Node1
Node1(config-bgp-af-srv6)# alloc mode per-vrf
Node1(config-bgp-af-srv6)# exit
Node1(config-bgp-af)# exit
Node1(config-bgp)# neighbor 3001::1:1:1:4
Node1(config-bgp-nbr)# address-family ipv6 unicast
Node1(config-bgp-nbr-af)# encapsulation-type srv6
Node1(config-bgp-nbr-af)# exit
Node1(config-bgp-nbr)# exit
Node1(config-bgp)# neighbor 3001::1:1:1:5
Node1(config-bgp-nbr)# address-family ipv6 unicast
Node1(config-bgp-nbr-af)# encapsulation-type srv6
Node1(config-bgp-nbr-af)# commit
```

Running Configuration

```
router bgp 100
 bgp router-id 10.1.1.1
 segment-routing srv6
  locator Node1
 !
 address-family ipv6 unicast
  segment-routing srv6
   locator Node1
   alloc mode per-vrf
  !
 !
 neighbor 3001::1:1:1:4
  address-family ipv6 unicast
   encapsulation-type srv6
```

```
 !
!
neighbor 3001::1:1:1:5
 address-family ipv6 unicast
  encapsulation-type srv6
```

Use Case 2: BGP Global IPv6 over SRv6 with Per-Prefix SID Allocation

This use case provides the ability to assign a specific SRv6 locator for a given prefix or a set of prefixes. The egress PE advertises the prefix with the specified locator. This allows for per-prefix steering into desired transport behaviors, such as Flex Algo.

To assign an SRv6 locator for a specific prefix, configure a route policy to specify the SID allocation mode based on match criteria. Examples of match criteria are destination-based match or community-based match.

- Supported SID allocation modes are per-VRF and per-CE.
- For per-VRF allocation mode, you can also specify the SRv6 locator.
  - If an SRv6 locator is specified in the route policy, BGP will use that to allocate per-VRF SID. If the specified locator is invalid, the SID will not be allocated.
  - If an SRv6 locator is not specified in the route policy, the default locator is used to allocate the SID. If the default locator is not configured in BGP, then the SID will not be allocated.
- Per-CE allocation mode always uses the default locator to allocate the SID.

For more information on configuring routing policies, refer to the "Implementing Routing Policy" chapter in the *Routing Configuration Guide for Cisco 8000 Series Routers*.

The following example shows a route policy specifying the SID allocation mode with destination-based match:

```
Node1(config)# route-policy set_per_prefix_locator_rpl
Node1(config-rpl)# if destination in (3001::1:1:1:1/128) then
Node1(config-rpl-if)# set srv6-alloc-mode per-vrf locator locator1
Node1(config-rpl-if)# elseif destination in (3001::2:2:2:2/128) then
Node1(config-rpl-elseif)# set srv6-alloc-mode per-vrf locator locator2
Node1(config-rpl-elseif)# elseif destination in (3001::3:3:3:3/128) then
Node1(config-rpl-elseif)# set srv6-alloc-mode per-vrf
Node1(config-rpl-elseif)# elseif destination in (3001::4:4:4:4/128) then
Node1(config-rpl-elseif)# set srv6-alloc-mode per-ce
Node1(config-rpl-elseif)# else
Node1(config-rpl-else)# drop
Node1(config-rpl-else)# endif
Node1(config-rpl)# end-policy
```

The following example shows how to configure BGP global IPv6 over SRv6 with a route policy to determine the SID allocation mode for given prefix.

```
Node1(config)# router bgp 100
Node1(config-bgp)# address-family ipv4 unicast
Node1(config-bgp-af)# segment-routing srv6
Node1(config-bgp-af-srv6)# alloc mode route-policy set_per_prefix_locator_rpl
```

Running Configuration

```
route-policy set_per_prefix_locator_rpl
  if destination in (3001::1:1:1:1/128) then
    set srv6-alloc-mode per-vrf locator locator1
  elseif destination in (3001::2:2:2:2/128) then
```

```
    set srv6-alloc-mode per-vrf locator locator2
  elseif destination in (3001::3:3:3:3/128) then
    set srv6-alloc-mode per-vrf
  elseif destination in (3001::4:4:4:4/128) then
    set srv6-alloc-mode per-ce
  else
    drop
  endif
end-policy
!
router bgp 100
 address-family ipv6 unicast
  segment-routing srv6
   alloc mode route-policy set_per_prefix_locator_rpl
  !
 !
```

Verify that the local and received SIDs have been correctly allocated under BGP IPv6 address family:

```
Node1# show bgp ipv6 unicast local-sids
…
Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Local Sid                                Alloc mode   Locator
*> 3001::1:1:1:1/128  fc00:0:0:1:41::                          per-vrf      locator1
*> 3001::2:2:2:2/128  fc00:0:8:1:41::                          per-vrf      locator2
*> 3001::3:3:3:3/128  fc00:0:9:1:42::                          per-vrf      locator4
*> 3001::4:4:4:4/128  fc00:0:9:1:43::                          per-ce       locator4
*> 3001::5:5:5:5/128  NO SRv6 Sid                              -            -
* i3008::8:8:8:8/128  NO SRv6 Sid                              -            -


Node1# show bgp ipv6 unicast received-sids
…
Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop                            Received Sid
*> 3001::1:1:1:1/128  66.2.2.2                            NO SRv6 Sid
*> 3001::2:2:2:2/128  66.2.2.2                            NO SRv6 Sid
*> 3001::3:3:3:3/128  66.2.2.2                            NO SRv6 Sid
*> 3001::4:4:4:4/128  66.2.2.2                            NO SRv6 Sid
*> 3001::5:5:5:5/128  66.2.2.2                            NO SRv6 Sid
* i3008::8:8:8:8/128  77.1.1.2                            fc00:0:0:2:41::
```

Verification

The following examples show how to verify the BGP global IPv6 configuration using the **show bgp ipv6 unicast** commands.

```
RP/0/RSP0/CPU0:Node1# show bgp ipv6 unicast summary
Fri Jan 15 21:07:04.681 UTC
BGP router identifier 10.1.1.1, local AS number 100
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0800000   RD version: 4
BGP main routing table version 4
BGP NSR Initial initsync version 1 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs
```

```
BGP is operating in STANDALONE mode.


Process       RcvTblVer   bRIB/RIB   LabelVer  ImportVer  SendTblVer  StandbyVer
Speaker               4          4          4          4           4           0

Neighbor        Spk    AS MsgRcvd MsgSent   TblVer  InQ OutQ  Up/Down  St/PfxRcd
3001::1:1:1:4     0   100    1502    1502        4    0    0 04:16:26          1
3001::1:1:1:5     0   100    1501    1501        4    0    0 04:14:47          1

RP/0/RSP0/CPU0:Node1# show bgp ipv6 unicast
Fri Jan 15 21:07:26.818 UTC
BGP router identifier 10.1.1.1, local AS number 100
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0800000   RD version: 4
BGP main routing table version 4
BGP NSR Initial initsync version 1 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network            Next Hop            Metric LocPrf Weight Path
*> 3001::13:1:1:1/128 ::                       0         32768 i
*>i3001::13:1:1:4/128 3001::1:1:1:4            0    100      0 i
*>i3001::13:1:1:5/128 3001::1:1:1:5            0    100      0 i

Processed 3 prefixes, 3 paths

RP/0/RSP0/CPU0:Node1# show bgp ipv6 unicast 3001::13:1:1:4/128
Fri Jan 15 21:07:50.309 UTC
BGP routing table entry for 3001::13:1:1:4/128
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                  4           4
Last Modified: Jan 15 17:13:50.032 for 03:54:01
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  Local
    3001::1:1:1:4 (metric 30) from 3001::1:1:1:4 (10.1.1.4)
      Origin IGP, metric 0, localpref 100, valid, internal, best, group-best
      Received Path ID 0, Local Path ID 1, version 4
      PSID-Type:L3, SubTLV Count:1
       SubTLV:
        T:1(Sid information), Sid:cafe:0:0:4:4b::, Behavior:18, SS-TLV Count:1
         SubSubTLV:
          T:1(Sid structure):
```

The following examples show how to verify the current routes in the Routing Information Base (RIB):

```
RP/0/RSP0/CPU0:Node1# show route ipv6 3001::13:1:1:4/128
Fri Jan 15 21:08:05.499 UTC

Routing entry for 3001::13:1:1:4/128
  Known via "bgp 100", distance 200, metric 0, type internal
  Installed Jan 15 17:13:50.431 for 03:54:15
  Routing Descriptor Blocks
    3001::1:1:1:4, from 3001::1:1:1:4
```

```
      Route metric is 0
  No advertising protos.

RP/0/RSP0/CPU0:Node1# show route ipv6 3001::13:1:1:4/128 detail
Fri Jan 15 21:08:22.628 UTC

Routing entry for 3001::13:1:1:4/128
  Known via "bgp 100", distance 200, metric 0, type internal
  Installed Jan 15 17:13:50.431 for 03:54:32
  Routing Descriptor Blocks
    3001::1:1:1:4, from 3001::1:1:1:4
      Route metric is 0
      Label: None
      Tunnel ID: None
      Binding Label: None
      Extended communities count: 0
      NHID:0x0(Ref:0)
      SRv6 Headend: H.Encaps.Red [base], SID-list {cafe:0:0:4:4b::}
  Route version is 0x1 (1)
  No local label
  IP Precedence: Not Set
  QoS Group ID: Not Set
  Flow-tag: Not Set
  Fwd-class: Not Set
  Route Priority: RIB_PRIORITY_RECURSIVE (12) SVD Type RIB_SVD_TYPE_LOCAL
  Download Priority 4, Download Version 93
  No advertising protos.
```

The following examples show how to verify the current IPv6 Cisco Express Forwarding (CEF) table:

```
RP/0/RSP0/CPU0:Node1# show cef ipv6 3001::13:1:1:4/128
Fri Jan 15 21:08:41.483 UTC
3001::13:1:1:4/128, version 93, SRv6 Headend, internal 0x5000001 0x40 (ptr 0x78a100d4) [1],
 0x0 (0x0), 0x0 (0x8886b840)
 Updated Jan 15 17:13:50.433
 Prefix Len 128, traffic index 0, precedence n/a, priority 4
   via cafe:0:0:4::/128, 9 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x78a0f504 0x0]
    next hop cafe:0:0:4::/128 via cafe:0:0:4::/64
    SRv6 H.Encaps.Red SID-list {cafe:0:0:4:4b::}

RP/0/RSP0/CPU0:Node1# show cef ipv6 3001::13:1:1:4/128 detail
Fri Jan 15 21:08:59.789 UTC
3001::13:1:1:4/128, version 93, SRv6 Headend, internal 0x5000001 0x40 (ptr 0x78a100d4) [1],
 0x0 (0x0), 0x0 (0x8886b840)
 Updated Jan 15 17:13:50.433
 Prefix Len 128, traffic index 0, precedence n/a, priority 4
  gateway array (0x7883b5d8) reference count 1, flags 0x2010, source rib (7), 0 backups
                [1 type 3 flags 0x48441 (0x788e6c40) ext 0x0 (0x0)]
  LW-LDI[type=0, refc=0, ptr=0x0, sh-ldi=0x0]
  gateway array update type-time 1 Jan 15 17:13:50.433
 LDI Update time Jan 15 17:13:50.433

  Level 1 - Load distribution: 0
  [0] via cafe:0:0:4::/128, recursive

   via cafe:0:0:4::/128, 9 dependencies, recursive [flags 0x6000]
    path-idx 0 NHID 0x0 [0x78a0f504 0x0]
    next hop cafe:0:0:4::/128 via cafe:0:0:4::/64
    SRv6 H.Encaps.Red SID-list {cafe:0:0:4:4b::}

    Load distribution: 0 1 (refcount 1)

    Hash  OK  Interface                 Address
```

```
0      Y    HundredGigE0/0/0/0         remote
1      Y    HundredGigE0/0/0/1         remote
```

SRv6 services on EVPN E-Line

Table 8: Feature History Table

Feature Name	Release Information	Feature Description
SRv6 services on EVPN E-Line	Release 25.1.1	Introduced in this release on: Fixed Systems (8700 [ASIC: K100]) (select variants only*) * This feature is supported on Cisco 8712-MOD-M routers.
SRv6 services on EVPN E-Line	Release 24.4.1	Introduced in this release on: Fixed Systems (8200 [ASIC: Q200] (select variants only*); Centralized Systems (8600 [ASIC: Q200]) SRv6 services on EVPN E-Line offers a modern approach to simplify and enhance network operations. * This feature is supported on: • 8201-32FH • 8101-32FH
SRv6 services on EVPN E-Line	Release 24.3.1	Introduced in this release on: Fixed Systems (8200 [ASIC: P100], 8700 [ASIC: P100]); Modular Systems (8800 [LC ASIC: P100]) Segment Routing over IPv6 (SRv6) services on Ethernet Virtual Private Network (EVPN) E-Line offers a modern approach to simplify and enhance network operations. SRv6 utilizes IPv6 addresses to encode segment routing information, seamlessly integrating with EVPN E-Line services to provide efficient, scalable, and flexible network solutions.

SRv6 services over EVPN E-LINE

You can now configure Segment Routing over IPv6 (SRv6) services on an EVPN E-Line network. SRv6 leverages the Segment Routing Header in IPv6 packets to define paths and services. SRv6 services on EVPN E-Line provide point-to-point (P2P) Ethernet services over an SRv6 network. This setup leverages the benefits of both EVPN E-Line and SRv6 technologies to deliver efficient, scalable, and flexible network services.

For more information on EVPN E-Line, see the *EVPN Configuration Guide for Cisco 8000 Series Routers*.

Components and functions of SRv6 locators

SRv6 locators define the IPv6 address space used for segment routing. They represent the first part of a Segment Identifier (SID) and are used to identify a specific SRv6 node within a network. The locator is can be divided into two parts:

- **SID Block**: This is the SRv6 network designator, representing a fixed or known address space for an SRv6 domain.
- **Node ID**: This designates a specific node within the SRv6 network.

Priority levels for SRv6 locator configuration in EVPN E-Line

For EVPN E-Line services, the SRv6 locators can be configured at different levels. When configuring the locators at different levels simultaneously, the priority is as follows:

- **Individual EVI Service Locator**: This locator applies to an individual EVI service and has the highest priority.
- **Specific EVI Locator**: This locator applies to all EVPN E-Line services for a specific EVI.
- **Global locator**: This is the default locator for all EVPN E-Line services, with the lowest priority.

Benefits of SRv6 Services on EVPN E-line

- **Load Balancing**: Distributes traffic across multiple PEs, enhancing network efficiency and performance.
- **Redundancy**: Provides failover capabilities, ensuring continuous service availability.
- **Scalability**: Easily scales to accommodate large networks with numerous nodes.
- **Simplified Operations**: Reduces complexity by eliminating the need for traditional protocols like LDP and RSVP.
- **Enhanced Automation**: Supports comprehensive automation strategies for network management and optimization.

Restrictions for SRv6 services on EVPN E-Line

The SRv6 services are supported on:

- EVPN E-Line single-homing and multi-homing port-active mode on the following routers:
  - Fixed Systems (8201-32FH, 8101-32FH)
  - Centralized Systems (8600)

- EVPN E-Line single-homing and multi-homing modes on the following routers:
  - Fixed Systems (8212-48FH-M, 8711-32FH-M)
  - Modular Systems (8800 [LC ASIC: P100])
- Both the format1 and Micro-SID with f3216. These formats are used to encode multiple segments within an IPv6 header. For more information on the formats, see Configure Segment Routing over IPv6 (SRv6) with Micro-SIDs.

Configure SRv6 services on EVPN E-Line

To configure SRv6 Services on EVPN E-Line:

- Configure address family session in BGP.
- Configure Segment Routing and SRv6 locator on EVPN.
- Configure EVPN E-Line and associate the SRv6 locator with the EVPN E-Line instance.

The following example shows configuration of global locator.

Procedure

Step 1 Configure address family session in BGP.

```
Router(config)#router bgp 100
Router(config-bgp)#bgp router-id 172.16.0.1
Router(config-bgp)#address-family l2vpn evpn
Router(config-bgp-af)#exit
Router(config-bgp)#neighbor 2001:db8:1::1
Router(config-bgp-nbr)#remote-as 100
Router(config-bgp-nbr)#update-source loopback0
Router(config-bgp-nbr)#address-family l2vpn evpn
Router(config-bgp-nbr-af)#root
```

Step 2 Configure Segment Routing and SRv6 locator on EVPN.

```
Router(config)#evpn
Router(config-evpn)#interface tengigE 0/0/0/0
Router(config-evpn-ac)#exit
Router(config-evpn)#segment-routing srv6
Router(config-evpn-srv6)#locator POD0
Router(config-evpn-srv6-locator)#root
```

Step 3 Configure EVPN E-Line and associate the SRv6 locator with the EVPN E-Line instance.

```
Router(config)#l2vpn
Router(config-l2vpn)#xconnect group 2
Router(config-l2vpn-xc)#p2p 2
Router(config-l2vpn-xc-p2p)#interface tengigE 0/0/0/0.2
Router(config-l2vpn-xc-p2p)#neighbor evpn evi 2 service 2 segment-routing srv6
```

Step 4 Run the **show running** command to view the running configuration.

```
Router# show running configuration
router bgp 100
```

```
  bgp router-id 172.16.0.1
  address-family l2vpn evpn
  !
  neighbor 2001:db8:1::1
   remote-as 100
   update-source Loopback0
  address-family l2vpn evpn

  evpn
 interface TenGigE0/0/0/0
 !
 segment-routing srv6
  locator POD0
 !
!
l2vpn
 xconnect group 2
  p2p 2
   interface TenGigE0/0/0/0.2
   neighbor evpn evi 11001 service 2002 segment-routing srv6
```

Step 5 Verify the SRv6 configuration using the following show commands. The outputs show the status of the global locator, which is the default locator.

```
Router#show segment-routing srv6 locator POD0 sid
SID                         Behavior     Context                          Owner               State
  RW
--------------------------  -----------  -------------------------------  ------------------  -----
  --
2001:db8:1::1               End.DX2      'default':1                      sidmgr              InUse
  Y
```

```
Router#show evpn segment-routing srv6 detail
Configured default locator: POD0
EVIs with unknown locator config: 0
VPWS with unknown locator config: 0

Locator name       Prefix                    OOR      Service count    SID count
------------       ------                    ---      -------------    ---------
POD0              2001:db8:1::/48            False    1                1
   Default locator
```

Step 6 Run the **show l2vpn** command to view a detailed information about a specific L2VPN P2P service for a VPWS instance.

Example:

```
Router#show l2vpn xconnect group xg2001 xc-name vpws-20010001 detail
Thu Aug 22 18:27:14.344 UTC

Group xg2001, XC vpws-20010001, state is up; Interworking none
  AC: Bundle-Ether201.20010001, state is up
    Type VLAN; Num Ranges: 1
    Outer Tag: 2001
    Rewrite Tags: []
    VLAN ranges: [1, 1]
    MTU 9194; XC ID 0xa00003e9; interworking none
    Statistics:
      packets: received 14089, sent 11603
      bytes: received 1803392, sent 1461978
      drops: illegal VLAN 0, illegal length 0
  EVPN: neighbor ::ffff:10.0.0.5, PW ID: evi 2001, ac-id 1, state is up ( established )
    XC ID 0xc00003e9
    Encapsulation SRv6
    Encap type Ethernet
    Ignore MTU mismatch: Enabled
```

```
Transmit MTU zero: Enabled
Reachability: Up
Nexthop type: Internal ID ::ffff:10.0.0.5

  SRv6              Local                        Remote
  ----------------  ---------------------------- --------------------------
  uDX2              fccc:cc00:1:e001::           fccc:cc00:2:e001::
  AC ID             1                            1
  MTU               9208                         0
  Locator           locator0                     N/A
  Locator Resolved  Yes                          N/A
  SRv6 Headend      H.Encaps.L2.Red              N/A
Statistics:
  packets: received 11603, sent 14089
  bytes: received 1461978, sent 1803392
```

Step 7 Run the **show evpn internal-id** command to view the internal ID mappings for the EVPN instance.

Example:

```
Router#show evpn internal-id
Mon Aug 12 16:56:18.218 UTC


VPN-ID     Encap  Ethernet Segment Id         EtherTag     Internal ID
---------- ------ --------------------------- ----------   -----------

2001       SRv6   2::1                        1            ::ffff:10.0.0.5
   Summary pathlist (ID 0x0000000000000201):
 0x05000007 (P) 2::1                                      fccc:cc00:2:e001::
```

SRv6 SID Information in BGP-LS Reporting

BGP Link-State (LS) is used to report the topology of the domain using nodes, links, and prefixes. This feature adds the capability to report SRv6 Segment Identifier (SID) Network Layer Reachability Information (NLRI).

The following NLRI has been added to the BGP-LS protocol to support SRv6:

- Node NLRI: SRv6 Capabilities, SRv6 MSD types
- Link NLRI: End.X, LAN End.X, and SRv6 MSD types
- Prefix NLRI: SRv6 Locator
- SRv6 SID NLRI (for SIDs associated with the node): Endpoint Function, BGP-EPE Peer Node/Set and Opaque

This example shows how to distribute IS-IS SRv6 link-state data using BGP-LS:

```
Router(config)# router isis 200
Router(config-isis)# distribute link-state instance-id 200
```

Note It is still possible to ping or trace a SID:

- **ping** B:k:F::
- **traceroute** B:k:F::

It is possible to use a list of packed carriers to ping or trace a SID, to ping or trace route, use <destination SID> via srv6-carriers <list of packed carriers>

SRv6 OAM — SID Verification

Table 9: Feature History Table

Feature Name	Release	Description
SRv6 OAM — SID Verification	Release 24.4.1	Introduced in this release on: Fixed Systems (8700 [ASIC: P100]) (select variants only*) This feature provides enhanced Operations, Administration, and Maintenance (OAM) in Segment Routing Networks with IPv6 Data plane (SRv6). * This feature is supported on Cisco 8712-MOD-M routers.
SRv6 OAM — SID Verification	Release 7.5.2	This feature provides enhanced Operations, Administration, and Maintenance (OAM) in Segment Routing Networks with IPv6 Data plane (SRv6). Existing OAM mechanisms to ping and trace a remote IPv6 prefix, along the shortest path, continue to work without any modification in an SRv6 network. However, classic IPv6 OAM cannot be used to ping or trace a remote SRv6 SID function. This feature augments ping and traceroute operations to target remote SRv6 SIDs. An SRv6-enabled router now allocates a new SRv6 OAM SID known as END.OP (OAM Endpoint with Punt).

This feature provides enhanced Operations, Administration, and Maintenance (OAM) in Segment Routing Networks with IPv6 Data plane (SRv6).

Existing OAM mechanisms to ping and trace a remote IPv6 prefix, along the shortest path, continue to work without any modification in an SRv6 network.

However, classic IPv6 OAM cannot be used to ping or trace a remote SRv6 SID function. This feature augments ping and traceroute operations to target remote SRv6 SIDs. An SRv6-enabled router now allocates a new SRv6 OAM SID known as END.OP (OAM Endpoint with Punt).

Use the following commands to performs SRv6 ping and traceroute:

ping *B*:*k*:*F*:: [**use-srv6-op-sid** [*end.op-sid-value*]]

traceroute *B*:*k*:*F*:: [**use-srv6-op-sid** [*end.op-sid-value*]]

Where *B*:*k*:*F*:: is the target SID at node *k* with locator block *B* and function *F*.

Ping/Traceroute to SID Without OAM SID

The user can issue ping or traceroute to an SRv6 SID using the classic CLI. A ping or traceroute to an SRv6 SID does not require the user to enter the “use-end-op” keyword when pinging or tracing a SID function. In this case, and as usual, the packet is pre-routed as an ICMP echo request or UDP packet.

Ping/Traceroute to SID With OAM SID

When ping or traceroute operations include the **use-srv6-op-sid** keyword, the packet is pre-routed with END.OP SID as Destination Address (DA) and the target SID in the SRH.

Note The END.OP SID value is an optional 128 bit value in IPv6 address format. See **END.OP SID Derivation** below for details on this value.

At the target node, the END.OP SID forces the punt of the packet to the OAM process, which verifies that the next SID is local and valid. If the next SID received by the target node is a local valid address that is not a SID, the target node still replies to indicate ping success. The ping reply contains a subtype to indicate the target was a SID or a local address.

A target remote SID include the following:

- END
- END.DT4/END.DX4 (used by L3 Services over SRv6)
- END.DX2 (used by L2 Services over SRv6)

END.OP SID Derivation

The ingress node can automatically derive the END.OP SID associated with a specified target SID by leveraging the IGP topology database in that node. The database will contain END.OP SIDs from remote nodes.

An END.OP SID associated with a locator will be advertised by IS-IS within an IGP domain in an area/level, which is added to the topology database. However, END.OP SIDs are not redistributed by IS-IS across IGP domains or across different area/level within an IGP domain. In this case, the topology database in a node contains END.OP SIDs only from the nodes within the same IGP domain in an area/level. An END.OP SID cannot be determine automatically if the specified target SID is external to the domain. For target SIDs across

IGP domains or across different area/level within an IGP domain, the *end.op-sid-value* must be explicitly provided.

If *end.op-sid-value* is not provided and the END.OP SID cannot be automatically derived, an error is displayed prompting the user to provide the *end.op-sid-value*.

Configuration Examples

The following example shows using ping to a SID without OAM SID.

```
Router# ping cafe:0:0:a3:40::
Wed Jul 24 19:24:50.812 UTC
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to cafe:0:0:a3:40::, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

The following example shows using ping to a SID with an OAM SID. Note that the output shows "S" to indicate that this is a response from a SID target.

```
Router# ping cafe:0:0:a3:40:: use-srv6-op-sid
Wed Jul 24 19:24:50.812 UTC
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to cafe:0:0:a3:40::, timeout is 2 seconds:
SSSSS
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

The following example shows using ping to a SID with an explicit OAM SID. Note that the output shows "S" to indicate that this is a response from a SID target.

```
Router# ping cafe:0:0:a3:40:: use-srv6-op-sid cafe:0:0:a3:11::
Wed Jul 24 19:24:50.812 UTC
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to cafe:0:0:a3:40::, timeout is 2 seconds:
SSSSS
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

The following example shows using traceroute to a SID without OAM SID.

```
Router# traceroute cafe:0:0:a3:1::
Wed Jul 24 19:40:19.192 UTC

Type escape sequence to abort.
Tracing the route to cafe:0:0:a3:1::

 1  2001::1:1:1:1 2 msec 2 msec 2 msec
 2  2001:10:10:13::2 2 msec 2 msec 2 msec
```

The following example shows using traceroute to a SID with OAM SID.

```
Router# traceroute cafe:0:0:a3:40:: use-srv6-op-sid

Type escape sequence to abort.
Tracing the route to cafe:0:0:a3:40::

 1  2001::1:1:1:1
       [IP tunnel: DA=cafe:0:0:a3:11:: SRH Stack 0 =(cafe:0:0:a3:40::   ,SL=1)       ] 2
msec
 2  2001::33:33:33:33
       [IP tunnel: DA=cafe:0:0:a3:11:: SRH Stack 0 =(cafe:0:0:a3:40::   ,SL=1)       ] 3
```

```
msec
```

The following example shows using traceroute to a SID with an explicit OAM SID.

```
Router# traceroute cafe:0:0:a3:40:: use-srv6-op-sid cafe:0:0:a3:11::

Type escape sequence to abort.
Tracing the route to cafe:0:0:a3:40::

 1  2001::1:1:1:1
       [IP tunnel: DA=cafe:0:0:a3:11:: SRH Stack 0 =(cafe:0:0:a3:40::   ,SL=1)       ] 2
msec
 2  2001::33:33:33:33
       [IP tunnel: DA=cafe:0:0:a3:11:: SRH Stack 0 =(cafe:0:0:a3:40::   ,SL=1)       ] 3
msec
```

Dual-Stack with SRv6 Unicast and IPv4 Multicast Core

Table 10: Feature History Table

Feature Name	Release Information	Feature Description
Dual-Stack Support with SRv6 Unicast and IPv4 Multicast Core	Release 25.2.1	Fixed Systems (8700 [ASIC: K100]; Centralized Systems (8400 [ASIC: K100]) The feature introduces dual-stack support with SRv6 for unicast traffic and IPv4 for multicast communication. The dual-stack simplifies the routing process by combining the advantages of both IPv4 and SRv6 protocols, and facilitates smoother interoperability between the two protocols. The dual-stack enables efficient unicast communication through SRv6 by allowing precise control over the path that a packet takes through a network and streamlines the network routing, while using the deployment support of IPv4 for multicast traffic.

Support Multiple IP Versions with Dual-Stack

Dual-stack is a feature that enables a device to simultaneously support multiple Internet Protocol (IP) versions within a network stack. The most commonly supported protocols are IPv4 and IPv6. Dual-stacking allows devices to support both IPv4 and IPv6 unicast addresses simultaneously, facilitating the transition to IPv6 while maintaining compatibility with existing IPv4 networks and applications.

Dual-stack support for SRv6 and IPv4 for Unicast and Multicast traffic

In the dual-stack support with SRv6 and IPv4 configuration, SRv6 is utilized for unicast traffic, where packets are sent from a single sender to a single receiver. On the other hand, IPv4 is used for multicast communication, which involves sending packets from one sender to multiple receivers.

Benefits of dual-stack with SRv6 Unicast and IPv4 Multicast

The key benefits of the feature are:

- The dual-stack combines the benefits of both IPv4 and SRv6 protocols, by providing a streamlined and optimized network experience for both unicast and multicast communication.
- It facilitates seamless interoperability between IPv4 and IPv6 protocols.
- Based on the availability and performance of the IPv4 and IPv6 services, dual-stack enables devices to use the optimal protocol for a specific network scenario.
- It provides a simple solution for data transfer from IPv4 to SRv6 without requiring complex tunneling or translation mechanisms.
- It preserves the end-to-end connectivity and security of IPv6 while ensuring compatibility with the existing IPv4 infrastructure and applications.

Usage Guidelines and Limitations for Dual-Stack with SRv6 and IPv4

The following usage guidelines and limitations apply:

- The dual-stack support is available on MVPN GRE-based profiles such as profile 0 and profile 11.
- The dual-stack supports only SRv6 micro-segments (uSIDs).
- The dual-stack uses Customer Edge (CE) label allocation for SRv6.

Enable Dual-Stack with SRv6 Unicast and IPv4 Multicast Core

This section includes only the BGP configuration required to enable dual-stack with SRv6 unicast and an IPv4 multicast core. For more information about SRv6 configuration, see *Configure Segment Routing over IPv6 (SRv6) with Micro-SIDs* chapter in the *Segment Routing Configuration Guide*.

For more information about profile-based multicast and IPv4 multicast configurations, see the *Multicast Configuration Guide*.

Procedure

Step 1 Enable SRv6 globally under the BGP routing process using the **router bgp** *as-number* **segment-routing srv6** command.

The *as-number* range is 1–65535.

Example:

```
Router(config)#router bgp 101
Router(config-bgp)#nsr
Router(config-bgp)#mvpn
```

```
Router(config-bgp)#bgp router-id 10.10.10.1
Router(config-bgp)#bgp graceful-restart
Router(config-bgp)#segment-routing srv6
```

Step 2 Configure IPv4 for multicast communication under the BGP routing process.

Example:

```
Router(config-bgp)#address-family ipv4 multicast
Router(config-bgp-af)#redistribute connected
```

Step 3 Configure SRv6 for unicast communication under the BGP routing process. The **address-family ipv6 unicast** and **segment-routing srv6** configurations indicate that SRv6 is used for unicast communication.

Example:

```
Router(config-bgp)#address-family ipv6 unicast
Router(config-bgp-af)#segment-routing srv6
Router(config-bgp-af)#redistribute connected
Router(config-bgp)#address-family ipv6 mvpn
Router(config-bgp)#address-family ipv4 mvpn
```

Step 4 Verify the running configuration using the **show running-config** command.

Example:

```
router bgp 101
 nsr
 mvpn
 bgp router-id 10.10.10.1
 bgp graceful-restart
 segment-routing srv6
 !
 address-family ipv4 multicast
  redistribute connected
 !
 address-family ipv6 unicast
  segment-routing srv6
  !
  redistribute connected
 !
 address-family ipv4 mvpn
 !
 address-family ipv6 mvpn
 !
!
```