# Configure Segment Routing for BGP

Border Gateway Protocol (BGP) is an Exterior Gateway Protocol (EGP) that allows you to create loop-free inter-domain routing between autonomous systems. An autonomous system is a set of routers under a single technical administration. Routers in an autonomous system can use multiple Interior Gateway Protocols (IGPs) to exchange routing information inside the autonomous system and an EGP to route packets outside the autonomous system.

This module provides the configuration information used to enable Segment Routing for BGP.

> **Note** For additional information on implementing BGP on your Cisco ASR 9000 Series Router, see the *Implementing BGP* module in the *Cisco ASR 9000 Series Aggregation Services Router Routing Configuration Guide*.

# Segment Routing for BGP

In a traditional BGP-based data center (DC) fabric, packets are forwarded hop-by-hop to each node in the autonomous system. Traffic is directed only along the external BGP (eBGP) multipath ECMP. No traffic engineering is possible.

In an MPLS-based DC fabric, the eBGP sessions between the nodes exchange BGP labeled unicast (BGP-LU) network layer reachability information (NLRI). An MPLS-based DC fabric allows any leaf (top-of-rack or border router) in the fabric to communicate with any other leaf using a single label, which results in higher packet forwarding performance and lower encapsulation overhead than traditional BGP-based DC fabric. However, since each label value might be different for each hop, an MPLS-based DC fabric is more difficult to troubleshoot and more complex to configure.

BGP has been extended to carry segment routing prefix-SID index. BGP-LU helps each node learn BGP prefix SIDs of other leaf nodes and can use ECMP between source and destination. Segment routing for BGP simplifies the configuration, operation, and troubleshooting of the fabric. With segment routing for BGP, you can enable traffic steering capabilities in the data center using a BGP prefix SID.

# Configure BGP Prefix Segment Identifiers

Segments associated with a BGP prefix are known as BGP prefix SIDs. The BGP prefix SID is global within a segment routing or BGP domain. It identifies an instruction to forward the packet over the ECMP-aware best-path computed by BGP to the related prefix. The BGP prefix SID is manually configured from the segment routing global block (SRGB) range of labels.

Each BGP speaker must be configured with an SRGB using the **segment-routing global-block** command. See the About the Segment Routing Global Block section for information about the SRGB.

**Note**
You must enable SR and explicitly configure the SRGB before configuring SR BGP. The SRGB must be explicitly configured, even if you are using the default range (16000 – 23999). BGP uses the SRGB and the index in the BGP prefix-SID attribute of a learned BGP-LU advertisement to allocate a local label for a given destination.

If SR and the SRGB are enabled after configuring BGP, then BGP is not aware of the SRGB, and therefore it allocates BGP-LU local labels from the dynamic label range instead of from the SRGB. In this case, restart the BGP process in order to allocate BGP-LU local labels from the SRGB.

**Note**
Because the values assigned from the range have domain-wide significance, we recommend that all routers within the domain be configured with the same range of values.

To assign a BGP prefix SID, first create a routing policy using the **set label-index** *index* attribute, then associate the index to the node.

**Note**
A routing policy with the **set label-index** attribute can be attached to a network configuration or redistribute configuration. Other routing policy language (RPL) configurations are possible. For more information on routing policies, refer to the "Implementing Routing Policy" chapter in the *Cisco ASR 9000 Series Aggregation Services Router Routing Configuration Guide*.

**Example**

The following example shows how to configure the SRGB, create a BGP route policy using a $SID parameter and **set label-index** attribute, and then associate the prefix-SID index to the node.

```
RP/0/RSP0/CPU0:router(config)# segment-routing global-block 16000 23999

RP/0/RSP0/CPU0:router(config)# route-policy SID($SID)
RP/0/RSP0/CPU0:router(config-rpl)# set label-index $SID
RP/0/RSP0/CPU0:router(config-rpl)# end policy

RP/0/RSP0/CPU0:router(config)# router bgp 1
RP/0/RSP0/CPU0:router(config-bgp)# bgp router-id 10.1.1.1
RP/0/RSP0/CPU0:router(config-bgp)# address-family ipv4 unicast
RP/0/RSP0/CPU0:router(config-bgp-af)# network 10.1.1.3/32 route-policy SID(3)
RP/0/RSP0/CPU0:router(config-bgp-af)# allocate-label all
```

```
RP/0/RSP0/CPU0:router(config-bgp-af)# commit
RP/0/RSP0/CPU0:router(config-bgp-af)# end


RP/0/RSP0/CPU0:router# show bgp 10.1.1.3/32
BGP routing table entry for 10.1.1.3/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 74         74
    Local Label: 16003
Last Modified: Sep 29 19:52:18.155 for 00:07:22
Paths: (1 available, best #1)
  Advertised to update-groups (with more than one peer):
    0.2
  Path #1: Received by speaker 0
  Advertised to update-groups (with more than one peer):
    0.2
  3
    99.3.21.3 from 99.3.21.3 (10.1.1.3)
      Received Label 3
      Origin IGP, metric 0, localpref 100, valid, external, best, group-best
      Received Path ID 0, Local Path ID 1, version 74
      Origin-AS validity: not-found
      Label Index: 3
```

# Segment Routing Egress Peer Engineering

*Table 1: Feature History Table*

| Feature Name | Release Information | Feature Description |
| --- | --- | --- |
| BGP PeerSet SID | Release 7.3.1 | BGP peer SIDs are used to express source-routed interdomain paths and are of two types: Peer Node SIDs and Peer Adjacency SIDs.<br><br>This release supports a new type of BGP peering SID, called BGP Peer Set SID. It is a group or set of BGP peer SIDs, that can provide load balancing over BGP neighbors (nodes) or links (adjacencies). The BGP peer Set SID can be associated with any combination of Peer Node SIDs or Peer Adjacency SIDs. |

Segment routing egress peer engineering (EPE) uses a controller to instruct an ingress provider edge, or a content source (node) within the segment routing domain, to use a specific egress provider edge (node) and a specific external interface to reach a destination. BGP peer SIDs are used to express source-routed inter-domain paths.

Below are the BGP-EPE peering SID types:

• PeerNode SID—To an eBGP peer. Pops the label and forwards the traffic on any interface to the peer.

- PeerAdjacency SID—To an eBGP peer via interface. Pops the label and forwards the traffic on the related interface.

- PeerSet SID—To a set of eBGP peers. Pops the label and forwards the traffic on any interface to the set of peers. All the peers in a set might not be in the same AS.

  Multiple PeerSet SIDs can be associated with any combination of PeerNode SIDs or PeerAdjacency SIDs.

The controller learns the BGP peer SIDs and the external topology of the egress border router through BGP-LS EPE routes. The controller can program an ingress node to steer traffic to a destination through the egress node and peer node using BGP labeled unicast (BGP-LU).

EPE functionality is only required at the EPE egress border router and the EPE controller.

# Usage Guidelines and Limitations

- When enabling BGP EPE, you must enable MPLS encapsulation on the egress interface connecting to the eBGP peer. This can be done by enabling either BGP labeled unicast (BGP-LU) address family or MPLS static for the eBGP peer.

  For information about BGP-LU, refer to the "Implementing BGP" chapter in the *Routing Configuration Guide for Cisco ASR 9000 Series Routers*.

  For information about MPLS static, refer to the "Implementing MPLS Static Labeling chapter in the *MPLS Configuration Guide for Cisco ASR 9000 Series Routers*.

# Configure Segment Routing Egress Peer Engineering

This task explains how to configure segment routing EPE on the EPE egress node.

### SUMMARY STEPS

1. **router bgp** *as-number*
2. **neighbor** *ip-address*
3. **remote-as** *as-number*
4. **egress-engineering**
5. **exit**
6. **mpls static**
7. **interface** *type interface-path-id*
8. Use the **commit** or **end** command.

### DETAILED STEPS

|        | Command or Action | Purpose |
|--------|-------------------|---------|
| **Step 1** | **router bgp** *as-number*<br><br>**Example:**<br><br>`RP/0/RSP0/CPU0:router(config)#` **`router bgp 1`** | Specifies the BGP AS number and enters the BGP configuration mode, allowing you to configure the BGP routing process. |

| | | **Command or Action** | **Purpose** |
|---|---|---|---|
| **Step 2** | | **neighbor** *ip-address*<br><br>**Example:**<br><br>`RP/0/RSP0/CPU0:router(config-bgp)# neighbor`<br>`192.168.1.3` | Places the router in neighbor configuration mode for BGP routing and configures the neighbor IP address as a BGP peer. |
| **Step 3** | | **remote-as** *as-number*<br><br>**Example:**<br><br>`RP/0/RSP0/CPU0:router(config-bgp-nbr)# remote-as`<br>`3` | Creates a neighbor and assigns a remote autonomous system number to it. |
| **Step 4** | | **egress-engineering**<br><br>**Example:**<br><br>`RP/0/RSP0/CPU0:router(config-bgp-nbr)#`<br>`egress-engineering` | Configures the egress node with EPE for the eBGP peer. |
| **Step 5** | | **exit**<br><br>**Example:**<br><br>`RP/0/RSP0/CPU0:router(config-bgp-nbr)# exit`<br>`RP/0/RSP0/CPU0:router(config-bgp)# exit`<br>`RP/0/RSP0/CPU0:router(config)#` | |
| **Step 6** | | **mpls static**<br><br>**Example:**<br><br>`RP/0/RSP0/CPU0:router(config)# mpls static` | Configure MPLS static on the egress interface connecting to the eBGP peer. |
| **Step 7** | | **interface** *type interface-path-id*<br><br>**Example:**<br><br>`RP/0/RSP0/CPU0:router(config-mpls-static)#`<br>`interface GigabitEthernet0/0/1/2` | Specifies the egress interface connecting to the eBGP peer. |
| **Step 8** | | Use the **commit** or **end** command. | **commit** —Saves the configuration changes and remains within the configuration session.<br><br>**end** —Prompts user to take one of these actions:<br><br>• **Yes** — Saves configuration changes and exits the configuration session.<br><br>• **No** —Exits the configuration session without committing the configuration changes. |

| Command or Action | Purpose |
|---|---|
| | • **Cancel** —Remains in the configuration session, without committing the configuration changes. |

**Example**

**Running Config:**

```
router bgp 1
 neighbor 192.168.1.3
  remote-as 3
  egress-engineering
  !
 !
mpls static
 interface GigabitEthernet0/0/1/2
 !
!
```

# Configuring Manual BGP-EPE Peering SIDs

*Table 2: Feature History Table*

| Feature Name | Release Information | Feature Description |
|---|---|---|
| Manual BGP-EPE Peer SIDs | Release 7.3.1 | BGP Peering SIDs that are allocated dynamically are not persistent and can be reallocated after a reload or a process restart.<br><br>This feature allows you to manually configure BGP Egress Peer Engineering (EPE) Peering SIDs. This functionality provides predictability, consistency, and reliability if there are system reloads or process restarts. |

Configuring manual BGP-EPE Peer SIDs allows for persistent EPE label values. Manual BGP-EPE SIDs are advertised through BGP-LS and are allocated from the Segment Routing Local Block (SRLB). See Configure Segment Routing Global Block and Segment Routing Local Block for information about the SRLB.

Each PeerNode SID, PeerAdjacency SID, and PeerSet SID is configured with an index value. This index serves as an offset from the configured SRLB start value and the resulting MPLS label (SRLB start label + index) is assigned to these SIDs. This label is used by CEF to perform load balancing across the individual BGP PeerSet SIDs, BGP PeerNode SID, or ultimately across each first-hop adjacency associated with that BGP PeerNode SID or BGP PeerSet SID.

### Configuring Manual PeerNode SID

Each eBGP peer will be associated with a PeerNode SID index that is configuration driven.

```
RP/0/0/CPU0:PE1(config)# router bgp 10
RP/0/0/CPU0:PE1(config-bgp)# neighbor 10.10.10.2
RP/0/0/CPU0:PE1(config-bgp-nbr)# remote-as 20
RP/0/0/CPU0:PE1(config-bgp-nbr)# egress-engineering
RP/0/0/CPU0:PE1(config-bgp-nbr)# peer-node-sid index 600
```

### Configuring Manual PeerAdjacency SID

Any first-hop for which an adjacency SID is configured needs to be in the resolution chain of at least one eBGP peer that is configured for egress-peer engineering. Otherwise such a kind of "orphan" first-hop with regards to BGP has no effect on this feature. This is because BGP only understands next-hops learnt by the BGP protocol itself and in addition only the resolving IGP next-hops for those BGP next-hops.

```
RP/0/0/CPU0:PE1(config)# router bgp 10
RP/0/0/CPU0:PE1(config-bgp)# adjacencies
RP/0/0/CPU0:PE1(config-bgp-adj)# 10.1.1.2
RP/0/0/CPU0:PE1(config-bgp-adj)# adjacency-sid index 500
```
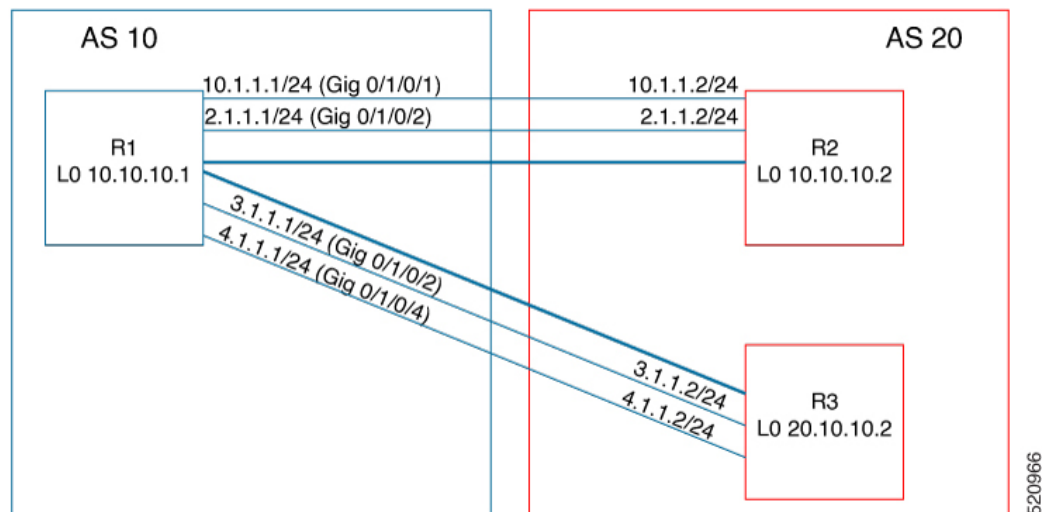
### Configuring Manual PeerSet SID

The PeerSet SID is configured under global Address Family. This configuration results in the creation of a Peer-Set SID EPE object.

```
RP/0/0/CPU0:PE1(config)# router bgp 10
RP/0/0/CPU0:PE1(config-bgp)# address-family ipv4 unicast
RP/0/0/CPU0:PE1(config-bgp-afi)# peer-set-id 1
RP/0/0/CPU0:PE1(config-bgp-peer-set)# peer-set-sid 300
```

### Example

**Topology**

The example in this section uses the following topology.



In this example, BGP-EPE peer SIDs are allocated from the default SRLB label range (15000 – 15999). The BGP-EPE peer SIDs are configured as follows:

- PeerNode SIDs to 10.10.10.2 with index 600 (label 15600), and for 20.10.10.2 with index 700 (label 15700)

- PeerAdj SID to link 10.1.1.2 with index 500 (label 15500)

- PeerSet SID 1 to load balance over BGP neighbors 10.10.10.1 and 20.10.10.2 with SID index 300 (label 15300)

- PeerSet SID 2 to load balance over BGP neighbor 20.10.10.2 and link 10.1.1.2 with SID index 400 (label 15400)

**Configuration on R1**

```
router bgp 10
 address-family ipv4 unicast
  peer-set-id 1
   peer-set-sid index 300
  !
  peer-set-id 2
   peer-set-sid index 400
  !
 !
 adjacencies
  10.1.1.2
   adjacency-sid index 500
   peer-set 2
  !
 !
 neighbor 10.10.10.2
  remote-as 20
  egress-engineering
  peer-node-sid index 600
  peer-set 1
 !
 neighbor 20.10.10.2
  egress-engineering
  peer-node-sid index 700
  peer-set 1
  peer-set 2
 !
```

To further show the load balancing of this example:

- 15600 is load balanced over {10.1.1.1 and 2.1.1.1}

- 15700 is load balanced over {3.1.1.1 and 4.1.1.1}

- 15500 is load balanced over {10.1.1.1}

- 15300 is load balanced over {10.1.1.1, 2.1.1.1, 3.1.1.1 and 4.1.1.1}

- 15400 is load balanced over {10.1.1.1, 3.1.1.1 and 4.1.1.1}
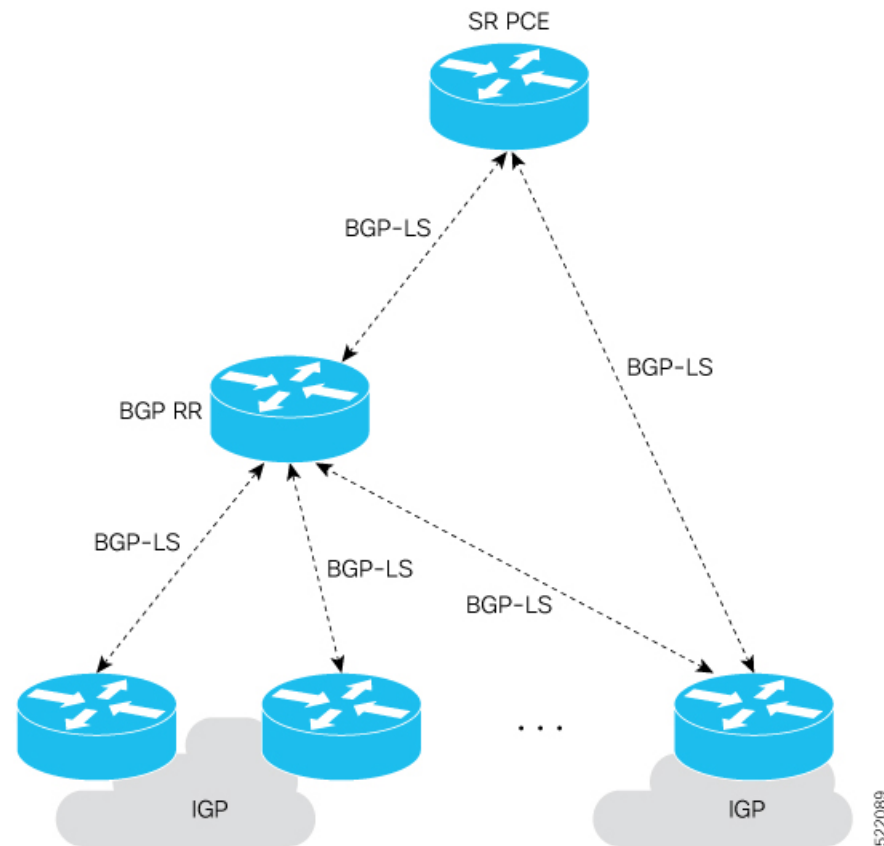
# Configure BGP Link-State

BGP Link-State (LS) is an Address Family Identifier (AFI) and Sub-address Family Identifier (SAFI) originally defined to carry interior gateway protocol (IGP) link-state information through BGP. The BGP Network Layer Reachability Information (NLRI) encoding format for BGP-LS and a new BGP Path Attribute called the

BGP-LS attribute are defined in RFC7752. The identifying key of each Link-State object, namely a node, link, or prefix, is encoded in the NLRI and the properties of the object are encoded in the BGP-LS attribute.

The BGP-LS Extensions for Segment Routing are documented in RFC9085.

BGP-LS applications like an SR Path Computation Engine (SR-PCE) can learn the SR capabilities of the nodes in the topology and the mapping of SR segments to those nodes. This can enable the SR-PCE to perform path computations based on SR-TE and to steer traffic on paths different from the underlying IGP-based distributed best-path computation.

The following figure shows a typical deployment scenario. In each IGP area, one or more nodes (BGP speakers) are configured with BGP-LS. These BGP speakers form an iBGP mesh by connecting to one or more route-reflectors. This way, all BGP speakers (specifically the route-reflectors) obtain Link-State information from all IGP areas (and from other ASes from eBGP peers).



### Usage Guidelines and Limitations

- BGP-LS supports IS-IS and OSPFv2.

- The identifier field of BGP-LS (referred to as the Instance-ID) identifies the IGP routing domain where the NLRI belongs. The NLRIs representing link-state objects (nodes, links, or prefixes) from the same IGP routing instance must use the same Instance-ID value.

- When there is only a single protocol instance in the network where BGP-LS is operational, we recommend configuring the Instance-ID value to **0**.

- Assign consistent BGP-LS Instance-ID values on all BGP-LS Producers within a given IGP domain.

- NLRIs with different Instance-ID values are considered to be from different IGP routing instances.

- Unique Instance-ID values must be assigned to routing protocol instances operating in different IGP domains. This allows the BGP-LS Consumer (for example, SR-PCE) to build an accurate segregated multi-domain topology based on the Instance-ID values, even when the topology is advertised via BGP-LS by multiple BGP-LS Producers in the network.

- If the BGP-LS Instance-ID configuration guidelines are not followed, a BGP-LS Consumer may see duplicate link-state objects for the same node, link, or prefix when there are multiple BGP-LS Producers deployed. This may also result in the BGP-LS Consumers getting an inaccurate network-wide topology.

- The following table defines the supported extensions to the BGP-LS address family for carrying IGP topology information (including SR information) via BGP. For more information on the BGP-LS TLVs, refer to Border Gateway Protocol - Link State (BGP-LS) Parameters.

**Table 3: IOS XR Supported BGP-LS Node Descriptor, Link Descriptor, Prefix Descriptor, and Attribute TLVs**

| TLV Code Point | Description | Produced by IS-IS | Produced by OSPFv2 | Produced by BGP |
|---|---|---|---|---|
| 256 | Local Node Descriptors | X | X | — |
| 257 | Remote Node Descriptors | X | X | — |
| 258 | Link Local/Remote Identifiers | X | X | — |
| 259 | IPv4 interface address | X | X | — |
| 260 | IPv4 neighbor address | X | | |
| 261 | IPv6 interface address | X | — | — |
| 262 | IPv6 neighbor address | X | — | — |
| 263 | Multi-Topology ID | X | — | — |
| 264 | OSPF Route Type | — | X | — |
| 265 | IP Reachability Information | X | X | — |
| 266 | Node MSD TLV | X | X | — |
| 267 | Link MSD TLV | X | X | — |
| 512 | Autonomous System | — | — | X |
| 513 | BGP-LS Identifier | — | — | X |
| 514 | OSPF Area-ID | — | X | — |
| 515 | IGP Router-ID | X | X | — |
| 516 | BGP Router-ID TLV | — | — | X |
| 517 | BGP Confederation Member TLV | — | — | X |
| 1024 | Node Flag Bits | X | X | — |
| 1026 | Node Name | X | X | — |
| 1027 | IS-IS Area Identifier | X | — | — |

| TLV Code Point | Description | Produced by IS-IS | Produced by OSPFv2 | Produced by BGP |
|---|---|---|---|---|
| 1028 | IPv4 Router-ID of Local Node | X | X | — |
| 1029 | IPv6 Router-ID of Local Node | X | — | — |
| 1030 | IPv4 Router-ID of Remote Node | X | X | — |
| 1031 | IPv6 Router-ID of Remote Node | X | — | — |
| 1034 | SR Capabilities TLV | X | X | — |
| 1035 | SR Algorithm TLV | X | X | — |
| 1036 | SR Local Block TLV | X | X | — |
| 1039 | Flex Algo Definition (FAD) TLV | X | X | — |
| 1044 | Flex Algorithm Prefix Metric (FAPM) TLV | X | X | — |
| 1088 | Administrative group (color) | X | X | — |
| 1089 | Maximum link bandwidth | X | X | — |
| 1090 | Max. reservable link bandwidth | X | X | — |
| 1091 | Unreserved bandwidth | X | X | — |
| 1092 | TE Default Metric | X | X | — |
| 1093 | Link Protection Type | X | X | — |
| 1094 | MPLS Protocol Mask | X | X | — |
| 1095 | IGP Metric | X | X | — |
| 1096 | Shared Risk Link Group | X | X | — |
| 1099 | Adjacency SID TLV | X | X | — |
| 1100 | LAN Adjacency SID TLV | X | X | — |
| 1101 | PeerNode SID TLV | — | — | X |
| 1102 | PeerAdj SID TLV | — | — | X |
| 1103 | PeerSet SID TLV | — | — | X |
| 1114 | Unidirectional Link Delay TLV | X | X | — |
| 1115 | Min/Max Unidirectional Link Delay TLV | X | X | — |
| 1116 | Unidirectional Delay Variation TLV | X | X | — |
| 1117 | Unidirectional Link Loss | X | X | — |
| 1118 | Unidirectional Residual Bandwidth | X | X | — |
| 1119 | Unidirectional Available Bandwidth | X | X | — |
| 1120 | Unidirectional Utilized Bandwidth | X | X | — |
| 1122 | Application-Specific Link Attribute TLV | X | X | — |

| TLV Code Point | Description | Produced by IS-IS | Produced by OSPFv2 | Produced by BGP |
|---|---|---|---|---|
| 1152 | IGP Flags | X | X | — |
| 1153 | IGP Route Tag | X | X | — |
| 1154 | IGP Extended Route Tag | X | — | — |
| 1155 | Prefix Metric | X | X | — |
| 1156 | OSPF Forwarding Address | — | X | — |
| 1158 | Prefix-SID | X | X | — |
| 1159 | Range | X | X | — |
| 1161 | SID/Label TLV | X | X | — |
| 1170 | Prefix Attribute Flags | X | X | — |
| 1171 | Source Router Identifier | X | — | — |
| 1172 | L2 Bundle Member Attributes TLV | X | — | — |
| 1173 | Extended Administrative Group | X | X | — |

### Exchange Link State Information with BGP Neighbor

The following example shows how to exchange link-state information with a BGP neighbor:

```
Router# configure
Router(config)# router bgp 1
Router(config-bgp)# neighbor 10.0.0.2
Router(config-bgp-nbr)# remote-as 1
Router(config-bgp-nbr)# address-family link-state link-state
Router(config-bgp-nbr-af)# exit
```

### IGP Link-State Database Distribution

A given BGP node may have connections to multiple, independent routing domains. IGP link-state database distribution into BGP-LS is supported for both OSPF and IS-IS protocols in order to distribute this information on to controllers or applications that desire to build paths spanning or including these multiple domains.

To distribute IS-IS link-state data using BGP-LS, use the **distribute link-state** command in router configuration mode.

```
Router# configure
Router(config)# router isis isp
Router(config-isis)# distribute link-state instance-id 32
```
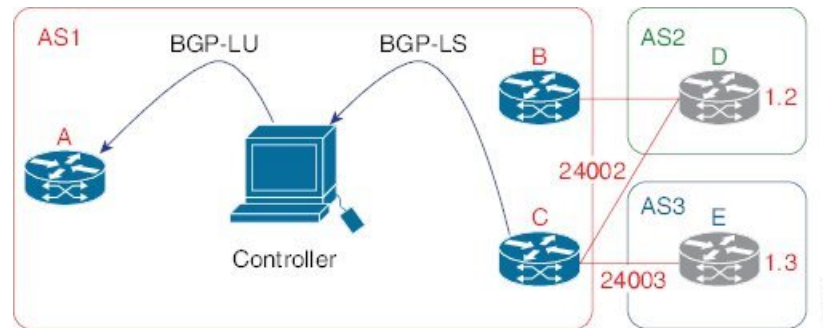
To distribute OSPFv2 link-state data using BGP-LS, use the **distribute link-state** command in router configuration mode.

```
Router# configure
Router(config)# router ospf 100
Router(config-ospf)# distribute link-state instance-id 32
```

# Use Case: Configuring SR-EPE and BGP-LS

In the following figure, segment routing is enabled on autonomous system AS1 with ingress node A and egress nodes B and C. In this example, we configure EPE on egress node C.

**Figure 1: Topology**



**Step 1** Configure node C with EPE for eBGP peers D and E.

**Example:**

```
RP/0/RSP0/CPU0:router_C(config)# router bgp 1
RP/0/RSP0/CPU0:router_C(config-bgp)# neighbor 192.168.1.3
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# remote-as 3
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# description to E
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# egress-engineering
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# address-family ipv4 unicast
RP/0/RSP0/CPU0:router_C(config-bgp-nbr-af)# route-policy bgp_in in
RP/0/RSP0/CPU0:router_C(config-bgp-nbr-af)# route-policy bgp_out out
RP/0/RSP0/CPU0:router_C(config-bgp-nbr-af)# exit
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# exit
RP/0/RSP0/CPU0:router_C(config-bgp)# neighbor 192.168.1.2
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# remote-as 2
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# description to D
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# egress-engineering
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# address-family ipv4 unicast
RP/0/RSP0/CPU0:router_C(config-bgp-nbr-af)# route-policy bgp_in in
RP/0/RSP0/CPU0:router_C(config-bgp-nbr-af)# route-policy bgp_out out
RP/0/RSP0/CPU0:router_C(config-bgp-nbr-af)# exit
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# exit
```

**Step 2** Configure node C to advertise peer node SIDs to the controller using BGP-LS.

**Example:**

```
RP/0/RSP0/CPU0:router_C(config-bgp)# neighbor 172.29.50.71
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# remote-as 1
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# description to EPE_controller
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# address-family link-state link-state
RP/0/RSP0/CPU0:router_C(config-bgp-nbr)# exit
RP/0/RSP0/CPU0:router_C(config-bgp)# exit
```

**Step 3** Configure MPLS static on the egress interfaces connecting to the eBGP peer.

**Example:**

```
RP/0/RSP0/CPU0:router_C(config)# mpls static
RP/0/RSP0/CPU0:router_C(config-mpls-static)# interface TenGigE 0/3/0/0
RP/0/RSP0/CPU0:router_C(config-mpls-static)# interface TenGigE 0/1/0/0
RP/0/RSP0/CPU0:router_C(config-mpls-static)# exit
```

**Step 4** Commit the configuration.

**Example:**

```
RP/0/RSP0/CPU0:router_C(config)# commit
```

**Step 5** Verify the configuration.

**Example:**

```
RP/0/RSP0/CPU0:router_C# show bgp egress-engineering

 Egress Engineering Peer Set: 192.168.1.2/32 (10b87210)
     Nexthop: 192.168.1.2
     Version: 2, rn_version: 2
       Flags: 0x00000002
   Local ASN: 1
  Remote ASN: 2
   Local RID: 10.1.1.3
  Remote RID: 10.1.1.4
   First Hop: 192.168.1.2
        NHID: 3
       Label: 24002, Refcount: 3
     rpc_set: 10b9d408

 Egress Engineering Peer Set: 192.168.1.3/32 (10be61d4)
     Nexthop: 192.168.1.3
     Version: 3, rn_version: 3
       Flags: 0x00000002
   Local ASN: 1
  Remote ASN: 3
   Local RID: 10.1.1.3
  Remote RID: 10.1.1.5
   First Hop: 192.168.1.3
        NHID: 4
       Label: 24003, Refcount: 3
     rpc_set: 10be6250
```

The output shows that node C has allocated peer SIDs for each eBGP peer.

**Example:**

```
RP/0/RSP0/CPU0:router_C# show mpls forwarding labels 24002 24003
Local  Outgoing    Prefix            Outgoing    Next Hop        Bytes
Label  Label       or ID             Interface                   Switched
------ ----------- ----------------- ----------- --------------- ------------
24002  Pop         No ID             Te0/3/0/0   192.168.1.2     0
24003  Pop         No ID             Te0/1/0/0   192.168.1.3     0
```

The output shows that node C installed peer node SIDs in the Forwarding Information Base (FIB).

# Configure BGP Proxy Prefix SID

To support segment routing, Border Gateway Protocol (BGP) requires the ability to advertise a segment identifier (SID) for a BGP prefix. A BGP-Prefix-SID is the segment identifier of the BGP prefix segment in a segment routing network. BGP prefix SID attribute is a BGP extension to signal BGP prefix-SIDs. However, there may be routers which do not support BGP extension for segment routing. Hence, those routers also do not support BGP prefix SID attribute and an alternate approach is required.

BGP proxy prefix SID feature allows you to attach BGP prefix SID attributes for remote prefixes learnt from BGP labeled unicast (LU) neighbours which are not SR-capable and propagate them as SR prefixes. This allows an LSP towards non SR endpoints to use segment routing global block in a SR domain. Since BGP proxy prefix SID uses global label values it minimizes the use of limited resources such as ECMP-FEC and provides more scalability for the networks.

BGP proxy prefix SID feature is implemented using the segment routing mapping server (SRMS). SRMS allows the user to configure SID mapping entries to specify the prefix-SIDs for the prefixes. The mapping server advertises the local SID-mapping policy to the mapping clients. BGP acts as a client of the SRMS and uses the mapping policy to calculate the prefix-SIDs.

### Configuration Example:

This example shows how to configure the BGP proxy prefix SID feature for the segment routing mapping server.

```
RP/0/RSP0/CPU0:router(config)# segment-routing
RP/0/RSP0/CPU0:router(config-sr)# mapping-server
RP/0/RSP0/CPU0:router(config-sr-ms)# prefix-sid-map
RP/0/RSP0/CPU0:router(config-sr-ms-map)# address-family ipv4
RP/0/RSP0/CPU0:router(config-sr-ms-map-af)# 10.1.1.1/32 10 range 200
RP/0/RSP0/CPU0:router(config-sr-ms-map-af)# 192.168.64.1/32 400 range 300
```

This example shows how to configure the BGP proxy prefix SID feature for the segment-routing mapping client.

```
RP/0/RSP0/CPU0:router(config)# router bgp 1
RP/0/RSP0/CPU0:router(config-bgp)# address-family ip4 unicast
RP/0/RSP0/CPU0:router(config-bgp-af)# segment-routing prefix-sid-map
```

### Verification

These examples show how to verify the BGP proxy prefix SID feature.

```
RP/0/RSP0/CPU0:router# show segment-routing mapping-server prefix-sid-map ipv4 detail
Prefix
10.1.1.1/32
    SID Index:     10
    Range:         200
    Last Prefix:   10.1.1.200/32
    Last SID Index: 209
    Flags:
Number of mapping entries: 1


RP/0/RSP0/CPU0:router# show bgp ipv4 labeled-unicast 192.168.64.1/32

BGP routing table entry for 192.168.64.1/32
```

```
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker              117        117
  Local Label: 16400
Last Modified: Oct 25 01:02:28.562 for 00:11:45Paths: (2 available, best #1)
 Advertised to peers (in unique update groups):
   201.1.1.1
 Path #1: Received by speaker 0  Advertised to peers (in unique update groups):
    201.1.1.1
  Local
   20.0.101.1 from 20.0.101.1 (20.0.101.1)      Received Label 61
   Origin IGP, localpref 100, valid, internal, best, group-best, multipath, labeled-unicast

   Received Path ID 0, Local Path ID 0, version 117
  Prefix SID Attribute Size: 7
  Label Index: 1

 RP/0/RSP0/CPU0:router# show route ipv4 unicast 192.68.64.1/32 detail

Routing entry for 192.168.64.1/32
  Known via "bgp 65000", distance 200, metric 0, [ei]-bgp, labeled SR, type internal
  Installed Oct 25 01:02:28.583 for 00:20:09
  Routing Descriptor Blocks
    20.0.101.1, from 20.0.101.1, BGP multi path
      Route metric is 0
      Label: 0x3d (61)
      Tunnel ID: None
      Binding Label: None
      Extended communities count: 0
      NHID:0x0(Ref:0)
   Route version is 0x6 (6)
  Local Label: 0x3e81 (16400)
  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 242
  No advertising protos.


 RP/0/RSP0/CPU0:router# show cef ipv4 192.168.64.1/32 detail
192.168.64.1/32, version 476, labeled SR, drop adjacency, internal 0x5000001 0x80 (ptr
0x71c42b40) [1], 0x0 (0x71c11590), 0x808 (0x722b91e0)
 Updated Oct 31 23:23:48.733
 Prefix Len 32, traffic index 0, precedence n/a, priority 4
 Extensions: context-label:16400
  gateway array (0x71ae7e78) reference count 3, flags 0x7a, source rib (7), 0 backups
                [2 type 5 flags 0x88401 (0x722eb450) ext 0x0 (0x0)]
  LW-LDI[type=5, refc=3, ptr=0x71c11590, sh-ldi=0x722eb450]
  gateway array update type-time 3 Oct 31 23:49:11.720
 LDI Update time Oct 31 23:23:48.733
 LW-LDI-TS Oct 31 23:23:48.733
   via 20.0.101.1/32, 0 dependencies, recursive, bgp-ext [flags 0x6020]
    path-idx 0 NHID 0x0 [0x7129a294 0x0]
    recursion-via-/32
    unresolved
     local label 16400
     labels imposed {ExpNullv6}



 RP/0/RSP0/CPU0:router# show bgp labels
BGP router identifier 2.1.1.1, local AS number 65000
BGP generic scan interval 60 secs
```

```
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000   RD version: 245
BGP main routing table version 245
BGP NSR Initial initsync version 16 (Reached)
BGP NSR/ISSU Sync-Group versions 245/0
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        Rcvd Label      Local Label
*>i10.1.1.1/32        10.1.1.1        3               16010
*> 2.1.1.1/32         0.0.0.0         nolabel         3
*> 192.68.64.1/32     20.0.101.1      2               16400
*> 192.68.64.2/32     20.0.101.1      2               16401
```

# BGP-LU Inter-AS Option-C Interworking with LDP and IGP SR-MPLS using Proxy BGP-SR

*Table 4: Feature History Table*

| Feature Name | Release | Description |
|---|---|---|
| BGP-LU Inter-AS Option-C Interworking with LDP and IGP SR-MPLS using Proxy BGP-SR | Release 7.3.2 | This feature extends the current Proxy BGP-SR functionality by allowing the BGP-LU ASBR router with Proxy BGP-SR configured to also interconnect attached LDP domains. The Proxy BGP-SR feature allows interconnection of IGP SR-MPLS domains and legacy domains via BGP-LU Inter-AS option-C. It provides a prefix-to-SID mapping for BGP-LU prefixes that are learned without a Prefix-SID. |

The Proxy BGP-SR feature allows interconnection of IGP SR-MPLS domains and legacy domains via BGP-LU Inter-AS option-C. It provides a prefix-to-SID mapping for BGP-LU prefixes that are learned without a Prefix-SID. This new feature extends the current functionality by allowing the BGP-LU ASBR router (configured with Proxy BGP-SR) to also interconnect attached LDP domains.
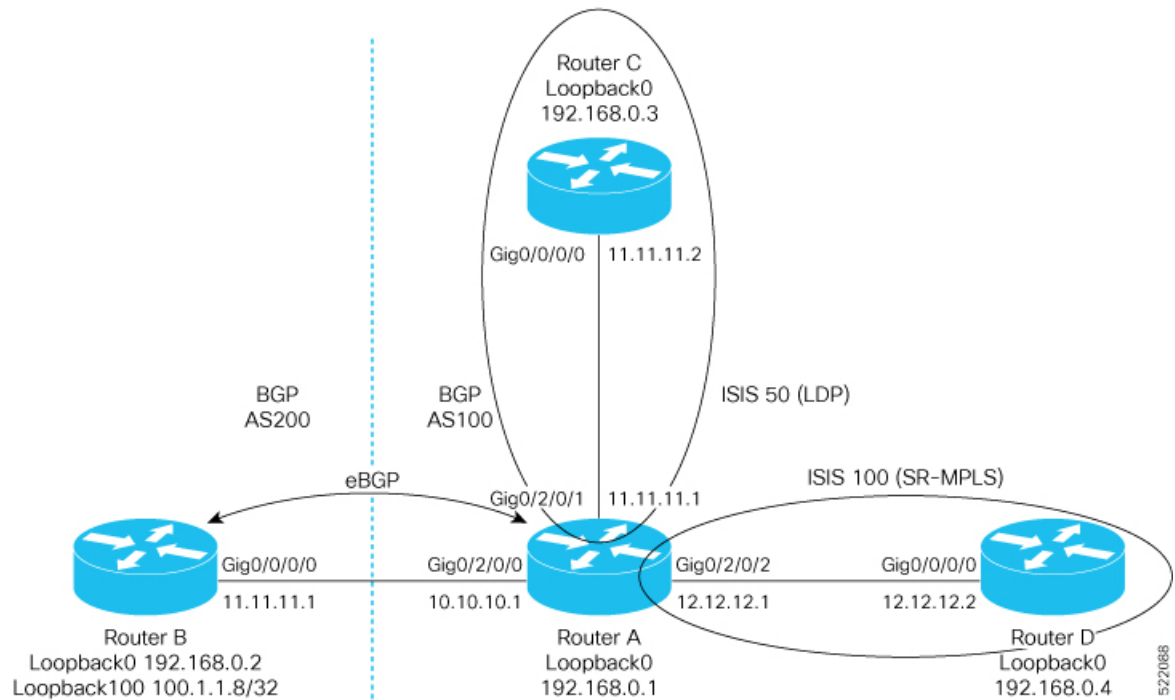
With this enhancement, when performing redistribution from BGP into IGP, LDP would use the same local label assigned by BGP for a prefix learned by BGP-LU. The local label value is based on the SR mapping server configuration (Proxy-BGP SR feature). This behavior allows incoming LDP traffic destined to a redistributed prefix to be switched over to the BGP-LU Inter-AS LSP.

### Use Case

In the following figure, Router A does the following:

- Is an ASBR for BGP AS 100 running BGP-LU with BGP AS 200

- Interconnects two IS-IS processes: one running LDP and another running Segment Routing

- Redistributes prefixes learned by BGP-LU from AS 200 into both IS-IS instances

- Runs SR Mapping Server (SRMS) in order to assign mappings to prefixes learned by BGP LU from AS 200 without a prefix SID (proxy BGP-SR) and prefixes learned from the LDP domain



**Configuration on Router A - ASBR for AS100**

```
prefix-set pfxset-bgplu
  100.1.1.8/32  // The Prefix under test
end-set
!
prefix-set LOOPBACKS
  192.168.0.1,
  192.168.0.2,
  192.168.0.3,
  192.168.0.4,
  192.168.0.8
end-set
!
route-policy Pass
  pass
end-policy
!
route-policy rpl-bgplu
  if destination in pfxset-bgplu then
    pass
  else
    drop
  endif
end-policy
!
route-policy MATCH_LOOPBACKS
```

```
          if destination in LOOPBACKS then
            pass
          else
            drop
          endif
      end-policy
      !
      router static
       address-family ipv4 unicast
        10.10.10.2/32 GigabitEthernet0/2/0/0
       !
      !
      router isis 50
       is-type level-2-only
       net 49.0001.0000.0000.0001.00
       address-family ipv4 unicast
        metric-style wide
        redistribute bgp 100 route-policy rpl-bgplu  // Redistribute prefixes learned by BGP-LU
      into IS-IS LDP domain
       !
       interface Loopback0
        passive
        address-family ipv4 unicast
        !
       !
       interface GigabitEthernet0/2/0/1
        address-family ipv4 unicast
        !
       !
      !
      router isis 100
       is-type level-2-only
       net 49.0001.0000.0000.0011.00
       distribute link-state
       address-family ipv4 unicast
        metric-style wide
        mpls traffic-eng level-2-only
        mpls traffic-eng router-id Loopback0
        redistribute bgp 100 route-policy rpl-bgplu  // Redistribute prefixes learned by BGP-LU
      into IS-IS SR domain
        segment-routing mpls
        segment-routing prefix-sid-map advertise-local
       !
       interface Loopback0
        passive
        address-family ipv4 unicast
         prefix-sid index 1
        !
       !
       interface GigabitEthernet0/2/0/2
        address-family ipv4 unicast
        !
       !
      !
      router bgp 100
       bgp router-id 192.168.0.1
       address-family ipv4 unicast
        segment-routing prefix-sid-map  // SR Proxy SID Configuration
        network 192.168.0.1/32
        redistribute isis 50 route-policy MATCH_LOOPBACKS
        redistribute isis 100 route-policy MATCH_LOOPBACKS
        allocate-label all
       !
       neighbor 10.10.10.2
```

```
   remote-as 200
   address-family ipv4 labeled-unicast
    route-policy Pass in
    route-policy Pass out
   !
  !
 !
mpls ldp
 router-id 192.168.0.1
 interface GigabitEthernet0/2/0/1
 !
!
segment-routing
 global-block 16000 23999
 mapping-server
  prefix-sid-map  // SRMS configuration
   address-family ipv4
    100.1.1.8/32 108 range 1  // SRMS mapping - LU prefix 100.1.1.8/32 assigned prefix index
 108
     192.168.0.3/32 3 range 1  // SRMS mapping - LDP prefix Router C assigned prefix index
3
   !
  !
 !
!
```

### Configuration on Router B - ASBR for AS200

```
route-policy Pass
  pass
end-policy
!
router static
 address-family ipv4 unicast
  10.10.10.1/32 GigabitEthernet0/0/0/0
 !
!
router bgp 200
 bgp router-id 192.168.0.2
 address-family ipv4 unicast
  network 100.1.1.8/32  // Import/Inject route into BGP
  network 192.168.0.2/32
  allocate-label all
 !
 neighbor 10.10.10.1
  remote-as 100
  address-family ipv4 labeled-unicast
   route-policy Pass in
   route-policy Pass out
  !
 !
!
```

### Configuration on Router C in the LDP Domain

```
router isis 50
 is-type level-2-only
 net 49.0001.0000.0000.0003.00
 address-family ipv4 unicast
  metric-style wide
 !
 interface Loopback0
  passive
```

```
    address-family ipv4 unicast
    !
  !
  interface GigabitEthernet0/0/0/0
   address-family ipv4 unicast
    !
  !
 !
mpls ldp
 router-id 192.168.0.3
 interface GigabitEthernet0/0/0/0
 !
!
```

### Configuration on Router D in the SR IS-IS Domain

```
router isis 100
 is-type level-2-only
 net 49.0001.0000.0000.0004.00
 address-family ipv4 unicast
  metric-style wide
  mpls traffic-eng level-2-only
  mpls traffic-eng router-id Loopback0
  segment-routing mpls
 !
 interface Loopback0
  passive
  address-family ipv4 unicast
   prefix-sid index 4
  !
 !
 interface GigabitEthernet0/0/0/0
  address-family ipv4 unicast
   !
 !
!
segment-routing
!
```