Egress Peer Engineering with Segment Routing

BGP Prefix SID

In order to support segment routing, BGP requires the ability to advertise a segment identifier (SID) for a BGP prefix. A BGP prefix SID is always global within the segment routing BGP domain and identifies an instruction to forward the packet over the ECMP-aware best path computed by BGP to the related prefix. The BGP prefix SID identifies the BGP prefix segment.

Adjacency SID

The adjacency segment Identifier (SID) is a local label that points to a specific interface and a next hop out of that interface. No specific configuration is required to enable adjacency SIDs. Once segment routing is enabled over BGP for an address family, for any interface that BGP runs over, the address family automatically allocates an adjacency SID toward every neighbor out of that interface.

High Availability for Segment Routing

In-service software upgrades (ISSUs) are minimally supported with BGP graceful restart. All states (including the segment routing state) must be relearned from the BGP router's peers. During the graceful restart period, the previously learned route and label state are retained.

Overview of BGP Egress Peer Engineering With Segment Routing

Cisco Nexus 9000 Series switches are often deployed in massive scale data centers (MSDCs). In such environments, there is a requirement to support BGP Egress Peer Engineering (EPE) with Segment Routing (SR).

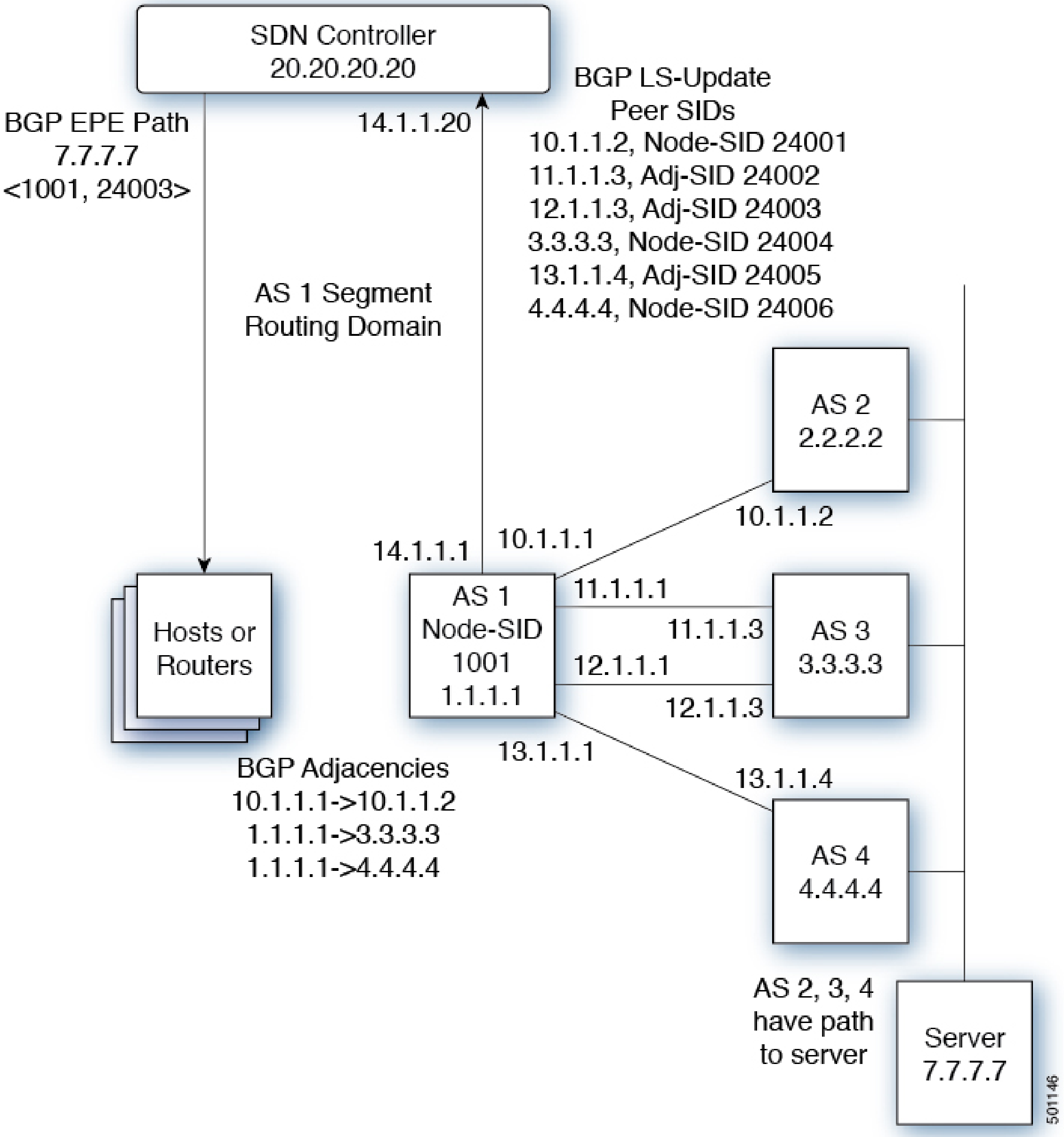
Segment Routing (SR) leverages source routing. A node steers a packet through a controlled set of instructions, known as segments, by prepending the packet with an SR header. A segment can represent any topological or service-based instruction. SR allows steering a flow through any topological path or any service chain while maintaining per-flow state only at the ingress node of the SR domain. For this feature, the Segment Routing architecture is applied directly to the MPLS data plane.

In order to support Segment Routing, BGP requires the ability to advertise a Segment Identifier (SID) for a BGP prefix. A BGP prefix is always global within the SR or BGP domain and it identifies an instruction to forward the packet over the ECMP-aware best-path that is computed by BGP to the related prefix. The BGP prefix is the identifier of the BGP prefix segment.

The SR-based Egress Peer Engineering (EPE) solution allows a centralized (SDN) controller to program any egress peer policy at ingress border routers or at hosts within the domain.

In the following example, all three routers run iBGP and they advertise NRLI to one another. The routers also advertise their loopback as the next-hop and it is recursively resolved. This provides an ECMP between the routers as displayed in the illustration.

Figure 1: Example of Egress Peer Engineering



The SDN controller receives the Segment IDs from the egress router 1.1.1.1 for each of its peers and adjacencies. It can then intelligently advertise the exit points to the other routers and the hosts within the controller's routing domain. As displayed in the illustration, the BGP Network Layer Reachability Information (NLRI) contains both the Node-SID to Router 1.1.1.1 and the Peer-Adjacency-SID 24003 indicating that the traffic to 7.7.7.7 should egress over the link 12.1.1.1->12.1.1.3.

Guidelines and Limitations for BGP Egress Peer Engineering

BGP Egress Peer Engineering has the following guidelines and limitations:

- BGP Egress Peer Engineering is only supported for IPv4 BGP peers. IPv6 BGP peers are not supported.
- BGP Egress Peer Engineering is only supported in the default VPN Routing and Forwarding (VRF) instance.
- Any number of Egress Peer Engineering (EPE) peers may be added to an EPE peer set. However, the installed resilient per-CE FEC is limited to 32 peers.
- A given BGP neighbor can only be a member of a single peer-set. Peer-sets are configured. Multiple peer-sets are not supported. An optional **peer-set** name may be specified to add neighbor to a peer-set. The corresponding RPC FEC load-balances the traffic across all the peers in the peer-set. The peer-set name is a string that is a maximum length of 63 characters (64 NULL terminated). This length is consistent with the NX-OS policy name lengths. A peer can only be a member of a single peer-set.
- Adjacencies for a given peer are not separately assignable to different peer-sets.
- Beginning with Cisco NX-OS Release 9.3(3), BGP Egress Peer Engineering is supported on Cisco Nexus 9300-GX platform switches.

Configuring Neighbor Egress Peer Engineering Using BGP

With the introduction of RFC 7752 and draft-ietf-idr-bgpls-segment-routing-epe, you can configure Egress Engineering. The feature is valid only for external BGP neighbors and it is not configured by default. Egress Engineering uses RFC 7752 encoding.

Before you begin

- You must enable BGP.
- After an upgrade from Release 7.0(3)I3(1) or Release 7.0(3)I4(1), configure the TCAM region before configuring Egress Peer Engineering (EPE) on Cisco Nexus 9000 Series switches using the following commands:

  1. switch# **hardware access-list tcam region vpc-convergence 0**
  2. switch# **hardware access-list tcam region racl 0**
  3. switch# **hardware access-list tcam region mpls 256 double-wide**

- Save the configuration and reload the switch.

For more information, see the Using Templates to Configure ACL TCAM Region Sizes and Configuring ACL TCAM Region Sizes sections in the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide*.

Procedure

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**router bgp** <*bgp autonomous number*>	Specifies the autonomous router BGP number.
Step 3	**neighbor** <*IP address*>	Configures the IP address for the neighbor.

Step 4	[**no**|**default**] **egress-engineering** [**peer-set** *peer-set-name*]
	Example:
	`switch(config)# router bgp 1`
	`switch(config-router)# neighbor 4.4.4.4`
	`switch(config-router)# egress-engineering peer-set NewPeer`
		Specifies whether a Peer-Node-SID is allocated for the neighbor and it is advertised in an instance of a BGP Link-State (BGP-LS) address family Link NLRI. If the neighbor is a multi-hop neighbor, a BGP-LS Link NLRI instance is also advertised for each Equal-Cost-MultiPath (ECMP) path to the neighbor and it includes a unique Peer-Adj-SID.
		Optionally, you can add the neighbor to a peer-set. The Peer-Set-SID is also advertised in the BGP-LS Link NLRI in the same instance as the Peer-Node-SID. BGP Link-State NLRI is advertised to all neighbors with the link-state address family configured.
		See RFC 7752 and draft-ietf-idr-bgpls-segment-routing-epe-05 for more information on EPE.

Configuration Example for Egress Peer Engineering

See the Egress Peer Engineering sample configuration for the BGP speaker 1.1.1.1. Note that the neighbor 20.20.20.20 is the SDN controller.

```
 hostname epe-as-1
install feature-set mpls
feature-set mpls

feature telnet
feature bash-shell
feature scp-server
feature bgp
feature mpls segment-routing

segment-routing mpls
vlan 1

vrf context management
  ip route 0.0.0.0/0 10.30.97.1
  ip route 0.0.0.0/0 10.30.108.1
```

```
interface Ethernet1/1
  no switchport
  ip address 10.1.1.1/24
  no shutdown

interface Ethernet1/2
  no switchport
  ip address 11.1.1.1/24
  no shutdown

interface Ethernet1/3
  no switchport
  ip address 12.1.1.1/24
  no shutdown

interface Ethernet1/4
  no switchport
  ip address 13.1.1.1/24
  no shutdown

interface Ethernet1/5
  no switchport
  ip address 14.1.1.1/24
  no shutdown

interface mgmt0
  ip address dhcp
  vrf member management


interface loopback1
  ip address 1.1.1.1/32
line console

line vty
ip route 2.2.2.2/32 10.1.1.2
ip route 3.3.3.3/32 11.1.1.3
ip route 3.3.3.3/32  12.1.1.3
ip route 4.4.4.4/32  13.1.1.4
ip route 20.20.20.20/32 14.1.1.20

router bgp 1
  address-family ipv4 unicast
  address-family link-state
 neighbor 10.1.1.2
    remote-as 2
    address-family ipv4
    egress-engineering
 neighbor 3.3.3.3
   remote-as 3
   address-family ipv4
   update-source loopback1
   ebgp-multihop 2
   egress-engineering
 neighbor 4.4.4.4
   remote-as 4
   address-family ipv4
   update-source loopback1
   ebgp-multihop 2
   egress-engineering
neighbor 20.20.20.20
   remote-as 1
   address-family link-state
   update-source loopback1
   ebgp-multihop 2
neighbor 124.11.50.5
    bfs
    remote-as 6
    update-source port-channel50.11
    egress-engineering peer-set pset2 <<<<<<<
    address-family ipv4 unicast
neighbor 124.11.101.2
    bfd
    remote-as 6
    update-source Vlan2401
    egress-engineering
    address-family ipv4 unicast
```

This example shows sample output for the **show bgp internal epe** command.

```
switch# show bgp internal epe
BGP Egress Peer Engineering (EPE) Information:
Link-State Server: Inactive
Link-State Client: Active
Configured EPE Peers: 26
Active EPE Peers: 3
EPE SID State:
RPC SID Peer or Set Assigned
ID Type Set Name ID Label Adj-Info, iod
1 Node 124.1.50.5 1 1600
2 Set pset1 2 1601
3 Node 6.6.6.6 3 1602
4 Node 124.11.50.5 4 1603
5 Set pset2 5 1604
6 Adj 6.6.6.6 6 1605 124.11.50.4->124.11.50.5/0x1600b031, 80
7 Adj 6.6.6.6 7 1606 124.1.50.4->124.1.50.5/0x16000031, 78
EPE Peer-Sets:
IPv4 Peer-Set: pset1, RPC-Set 2, Count 7, SID 1601
Peers: 124.11.116.2 124.11.111.2 124.11.106.2 124.11.101.2
124.11.49.5 124.1.50.5 124.1.49.5
IPv4 Peer-Set: pset2, RPC-Set 5, Count 5, SID 1604
Peers: 124.11.117.2 124.11.112.2 124.11.107.2 124.11.102.2
124.11.50.5
IPv4 Peer-Set: pset3, RPC-Set 0, Count 4, SID unspecified
Peers: 124.11.118.2 124.11.113.2 124.11.108.2 124.11.103.2
IPv4 Peer-Set: pset4, RPC-Set 0, Count 4, SID unspecified
Peers: 124.11.119.2 124.11.114.2 124.11.109.2 124.11.104.2
IPv4 Peer-Set: pset5, RPC-Set 0, Count 4, SID unspecified
Peers: 124.11.120.2 124.11.115.2 124.11.110.2 124.11.105.2
switch#
```

Configuring the BGP Link State Address Family

You can configure the BGP link state address family for a neighbor session with a controller to advertise the corresponding SIDs. You can configure this feature in global configuration mode and neighbor address family configuration mode.

Before you begin

You must enable BGP.

Procedure

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**router bgp** <*bgp autonomous number*>	Specifies the autonomous router BGP number.

Step 3	[**no**] **address-family link-state**
	Example:
	`switch(config)# router bgp 64497`
	`switch (config-router af)# address-family link-state`
		Enters address-family interface configuration mode.
		Note This command can also be configured in neighbor address-family configuration mode.

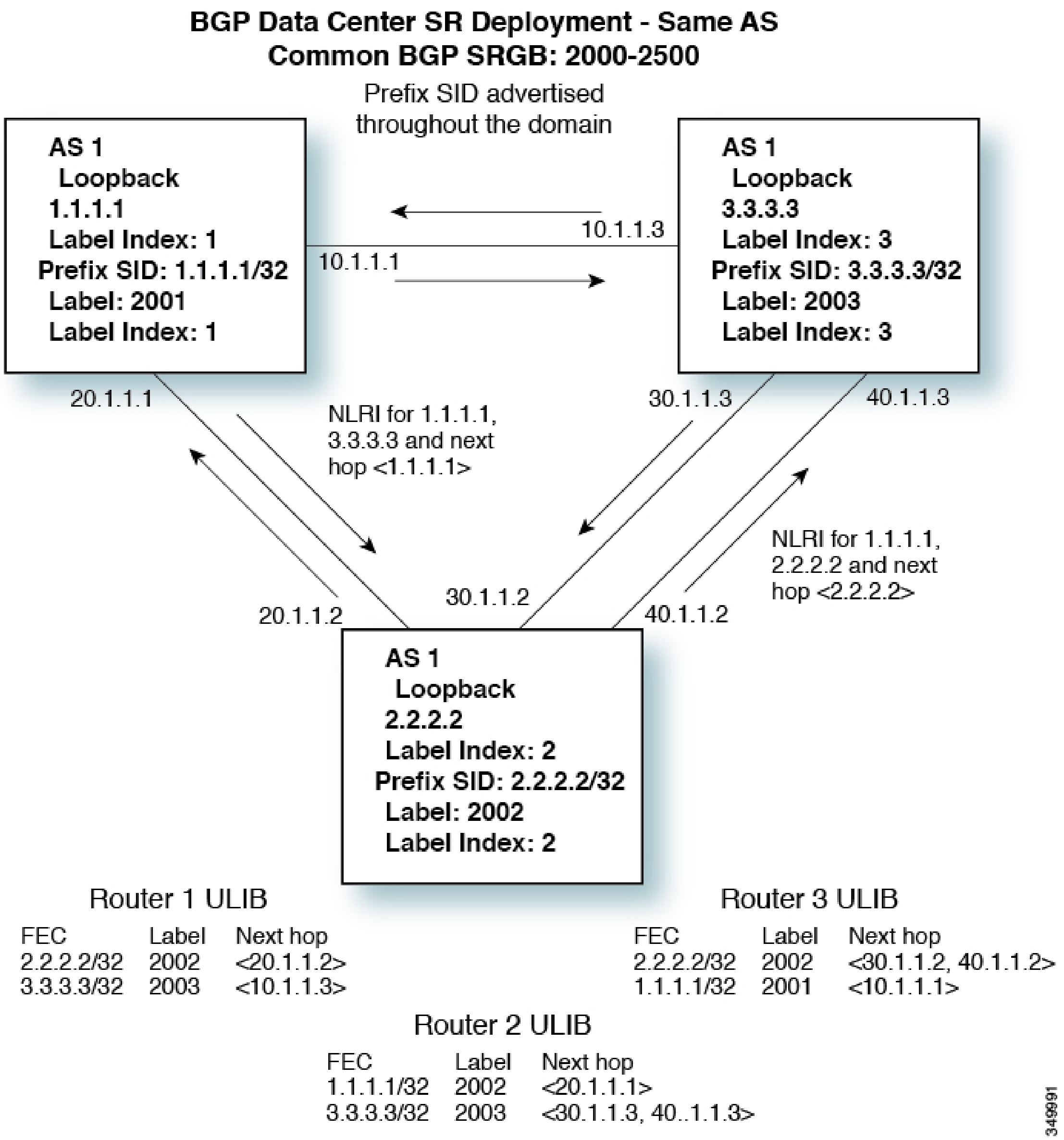
Step 4	**neighbor** <*IP address*>	Configures the IP address for the neighbor.

Step 5	[**no**] **address-family link-state**
	Example:
	`switch(config)#router bgp 1`
	`switch(config-router)#address-family link-state`
	`switch(config-router)#neighbor 20.20.20.20`
	`switch(config-router)#address-family link-state`
		Enters address-family interface configuration mode.
		Note This command can also be configured in neighbor address-family configuration mode.

BGP Prefix SID Deployment Example

In the simple example below, all three routers are running iBGP and advertising Network Layer Reachability Information (NRLI) to one another. The routers are also advertising their loopback interface as the next hop, which provides the ECMP between routers 2.2.2.2 and 3.3.3.3.

Figure 2: BGP Prefix SID Simple Example



Router 1 ULIB

FEC	Label	Next hop
2.2.2.2/32	2002	<20.1.1.2>
3.3.3.3/32	2003	<10.1.1.3>

Router 3 ULIB

FEC	Label	Next hop
2.2.2.2/32	2002	<30.1.1.2, 40.1.1.2>
1.1.1.1/32	2001	<10.1.1.1>

Router 2 ULIB

FEC	Label	Next hop
1.1.1.1/32	2002	<20.1.1.1>
3.3.3.3/32	2003	<30.1.1.3, 40..1.1.3>