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IMAGINE INTUITIVE

Introduction – Segment routing for Policy Aware Network

LABRST-1015

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Learning Objectives

The objective of this session is to provide you hands-on experience in deploying Segment Routing (SR) to build scalable internetworks. You will gain a better understanding of the different components of SR technology (SR Forwarding, XTC Controllers, Traffic Steering and Traffic Engineering), how to configure them, and understand the packet flow in a MPLS-SR environment. During this session, you will have the opportunity to configure SR functions on IOS-XR Cisco operating systems and program the paths using the controllers.The lab consists of multiple modules that cover key functionality and common use-cases of SR. You will be guided to complete the initial module and any subsequent modules/use-cases of interest in the given session time

Prerequisites

General knowledge of IP routing protocol – OSPF, or ISIS and BGP

General understanding of MPLS

Note: This lab is built around ISIS. SR is supported for OSPF as well.

Disclaimer

This lab is not a design guide. The topology and configurations implemented in this lab were constructed to demonstrate specific aspects of MPLS-SR technology; they do not implement the proper redundancy or high availability features for a production network.

This training document is to familiarize with Segment Routing, configuration, and functionality. Although the lab design and configuration examples could be used as a reference, it's not a real design. Not all recommended features are used or enabled optimally. The IP addresses used in these lab scenarios might be combination of both private RFC1918 addresses and public addresses for ease of route differentiations. These addresses are used in a controlled lab environment here for learning purpose only and it may not be used in the production environment. For the design, related questions please contact your representative at Cisco, or a Cisco partner.

Related Sessions at Cisco Live

Segment Routing Demo - CAMDEM 1081

MPLS SR Introduction - LABSPG-1020

Troubleshooting Segment Routing -BRKRST-3009

Segment Routing

Introduction

Segment routing is a method of forwarding packets on the network based on the source routing paradigm. The source chooses a path and encodes it in the packet header as an ordered list of segments. Segments are an identifier for any type of instruction. A segment is encoded as an MPLS label. An ordered list of segments is encoded as a stack of labels. This part of lab focusses on this.

Interior gateway protocol (IGP) distributes two types of segments: prefix segments and adjacency segments. Each router (node) and each link (adjacency) has an associated segment identifier (SID). By combining prefix (node) and adjacency segment IDs in an ordered list, any path within a network can be constructed.

Traffic Steering

Segment Routing (SR) allows a headend node to steer a packet flow along any path. The header of a packet steered in an SR path is augmented with the ordered list of segments. Traffic can be steered onto an SR Policy path either by IGP Best path, SR policy defined locally via CLI, Netconf/Yang, BGP or via external SDN controller.

Traffic Engineering

The Segment Routing Traffic Engineering (SRTE) process installs a Segment Routing Policy (SR Policy) in the forwarding plane (FIB). SRTE process MAY learn multiple candidate paths from different sources: NETCONF with OpenConfig or YANG model, PCEP, BGP or Local configuration. SRTE is an alternate solution to RSVP-TE with much less protocol overheads and intermediate states.

For this lab exercise, you will install SR-Policy via an XTC controller.

Segment Routing Terminology

- **Source Routing**
  - the source chooses a path and encodes it in the packet header as an ordered list of segments
  - the rest of the network executes the encoded instructions
- **Segment: an identifier for any type of instruction**
  - forwarding or service
  - Segment is MPLS
  - Segment list is MPLS Label stacks
- **MPLS**
  - An ordered list of segments is represented as a stack of labels
- **Global Segment**
  - Any node in SR domain understands associated instruction
  - Global label value in Segment Routing Global Block (SRGB)

  - Label used from the default label allocation or customized allocation block
- **Local Segment**
  - Only originating node understands associated instruction
  - Local label value in Segment Routing Local Block (SRLB)
  - Label used from the Dynamics label allocation
- **LSD – Label Switching Database**
  - Local label allocation is managed by Label Switching Database (LSD)
  - Label range [0-15] reserved for special-purposes
  - Label range [16-15,999] reserved for static MPLS labels
  - Label range [16,000-23,999] preserved for SRGB by default
  - Label range [24,000-max] used for dynamic label allocation – LDP,RSVP, SRLB

Network Topology

Physical Network Topology

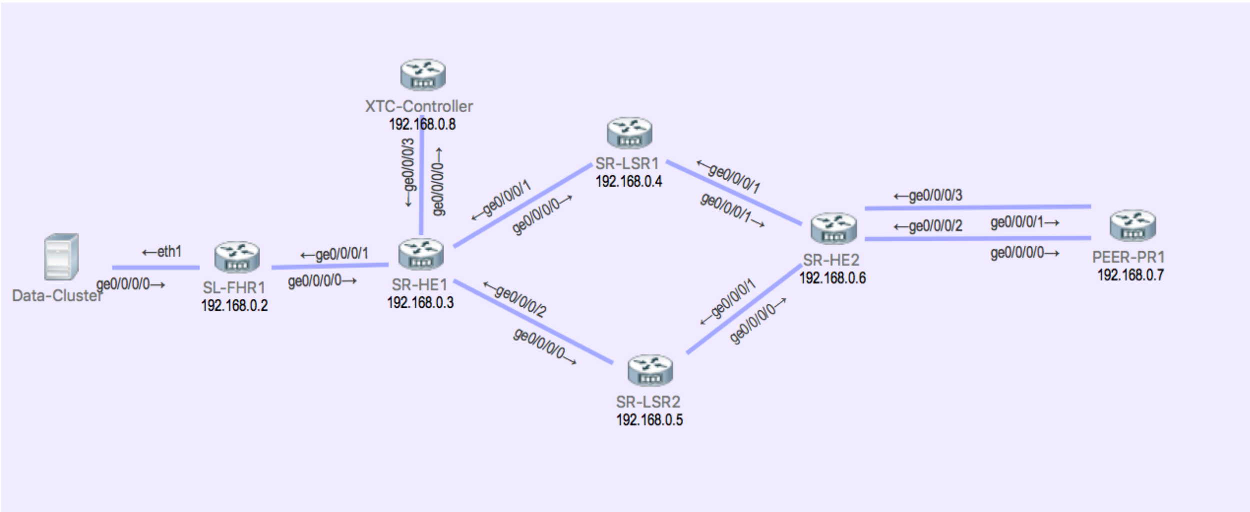


Figure 1 – Topology with flat ISIS Domain

Data-Cluster

Simulates server in cluster environment hosting multiple applications

SL-FHR1

First hop router that imposes BSID (Binding SID) label based on destination address leveraging mpls static

SR-HE1

Headend router that's hosts the applications centric Segment routing policy. SR policies are provisioned either through XTC controller or open source controller Voltron on head end.

SR-LSR1

Label switch router that switches MPLS 2 MPLS or MPLS2IP SWAP

SR-LSR2

Label switch router that switches MPLS 2 MPLS or MPLS2IP SWAP

SR-HE2

Tail-end router where the SR domain ends. SR policies are provisioned either through XTC controller or open source controller Voltron on head end.

XTC-Controller

XR based Transport controller is used for provisioning SR policies.

PEER-P1

External AS peering router simulating an Internet and End host environment.

Other Information

- Network elements username/passwords are **cisco/cisco**
- Information to validate is highlighted in green
- Host names are highlighted in red background.
- CLI command to be typed are highlighted in yellow

Logical Topology

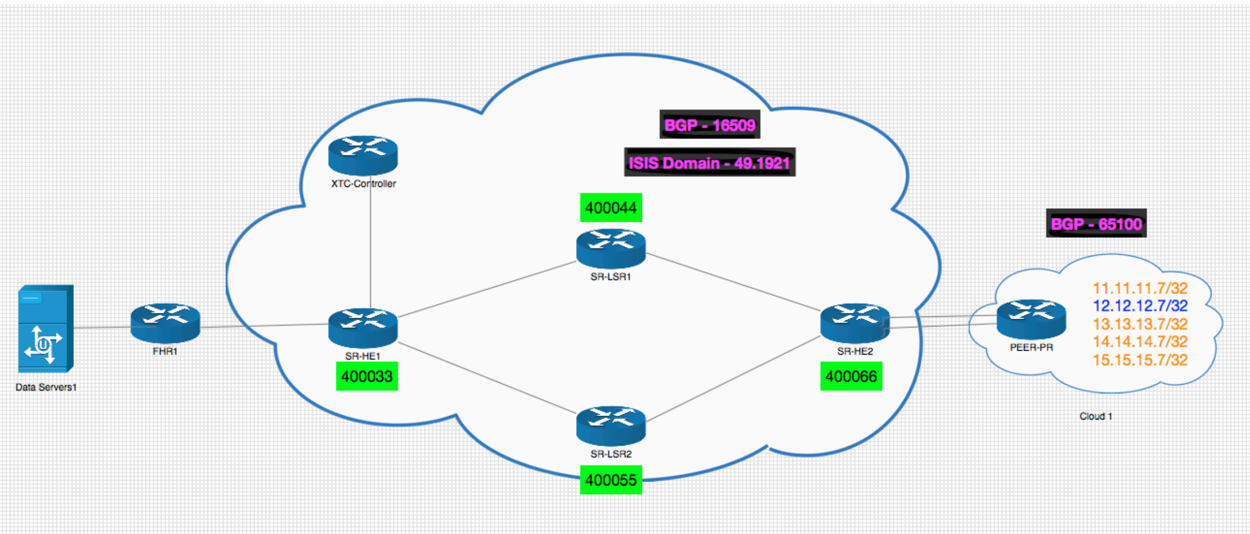


Figure 2 – Network Topology with IGP and Segment Routing enabled

Preloaded IP addressing

Basic IP connectivity with infrastructure routing has already been configured between the devices, and should be verified prior to each lab module. The service provider internet cloud is already built and no need to modify any configuration. All configuration exercise need to be done only SR-HE1 and SR-HE2 routers.

Table 1:

Device Name	Interface	IPv4 Address
Data Cluster	Ethernet1	10.0.0.5/30
FHR1	Loopback 0	192.168.0.2/32
SR-HE1	Loopback 0	192.168.0.3/32
SR-LSR1	Loopback 0	192.168.0.4/32
SR-LSR2	Loopback 0	192.168.0.5/32
SR-HE2	Loopback 0	192.168.0.6/32
PEER-P1	Loopback 0	192.168.0.7/32
XTC-Controller	Loopback 0	192.168.0.8/32

Lab Access

The lab proctor will assign lab access information at the beginning of the session.

Step 1: Identify the user and VPN details you have been assigned.

VPN Login info:

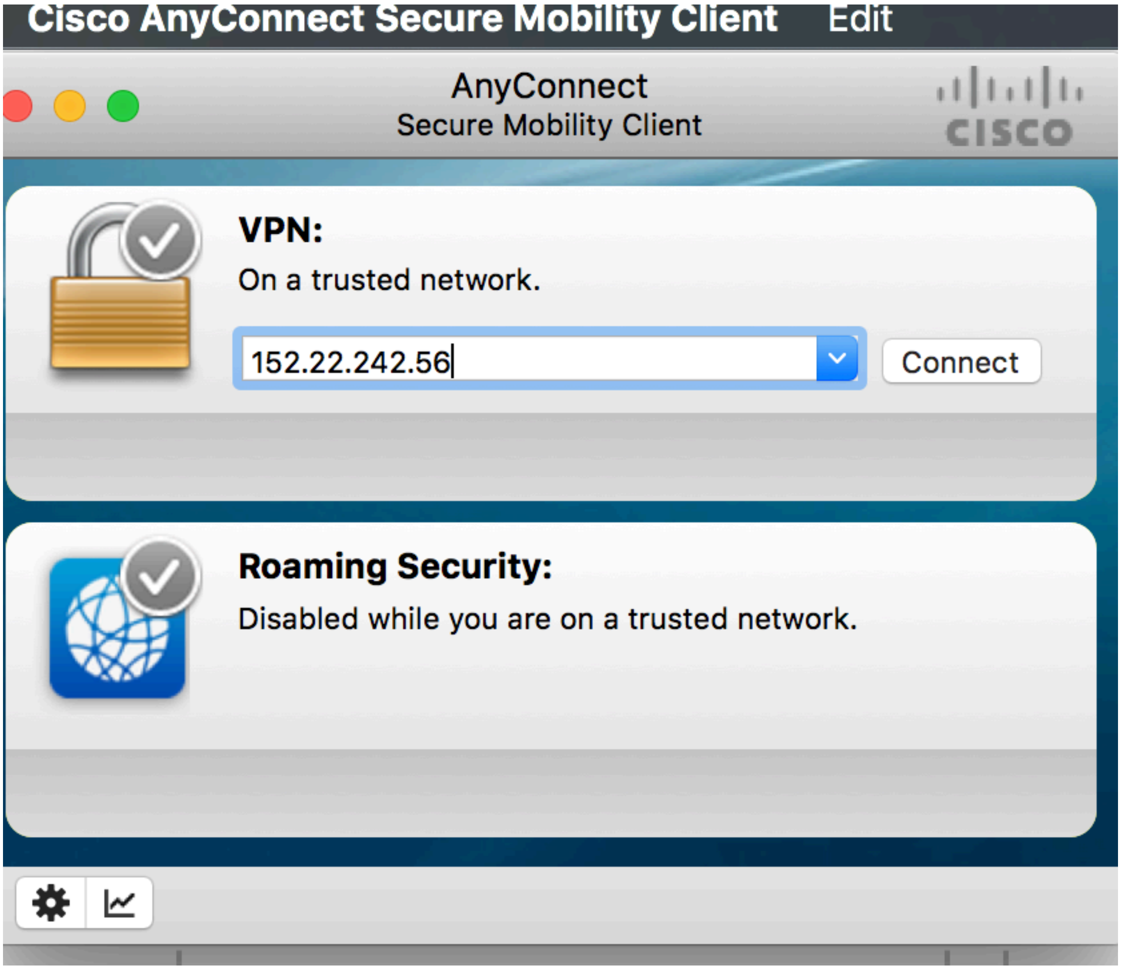
User No:	Any connect VPN	Username	Password
"All Users"	152.22.242.56	clus2018	CLUS2018isFUN!

User-lab Login info:

	Lab1	Lab2	Lab3	Lab4	Lab5
XTC-Controller	172.16.111.73	172.16.111.116	172.16.111.120	172.16.111.93	172.16.111.98
Peer-PR1	172.16.111.67	172.16.111.104	172.16.111.110	172.16.111.81	172.16.111.99
Data-Cluster	172.16.111.74	172.16.111.103	172.16.111.109	172.16.111.94	172.16.111.100
Server-2	172.16.111.75			172.16.111.95	172.16.111.88
SR-HE1	172.16.111.69	172.16.111.106	172.16.111.112	172.16.111.82	172.16.111.89
SR-HE2	172.16.111.70	172.16.111.113	172.16.111.117	172.16.111.83	172.16.111.90
SR-LSR1	172.16.111.71	172.16.111.114	172.16.111.118	172.16.111.91	172.16.111.96
SR-LSR2	172.16.111.72	172.16.111.115	172.16.111.119	172.16.111.92	172.16.111.97
SL-FHR1	172.16.111.68	172.16.111.105	172.16.111.111	172.16.111.88	172.16.111.82

Step 2: Connect to Cisco DMZ zone where the lab is hosted:

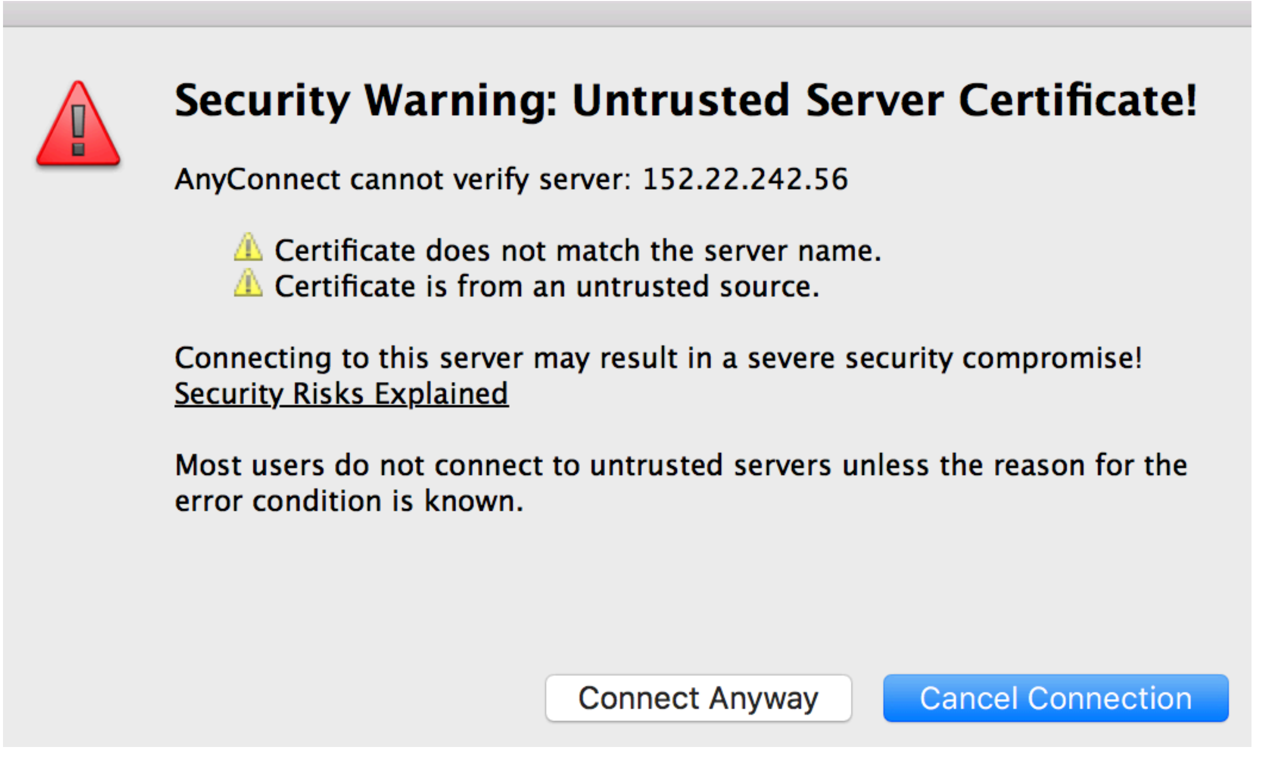
1. Run Any connect client from the terminal



2. Add **152.22.242.56** as the destination IP address for the DMZ. Destination address will vary based on user assignment. Please reach out to proctor if required. **This is critical for landing in correct POD**

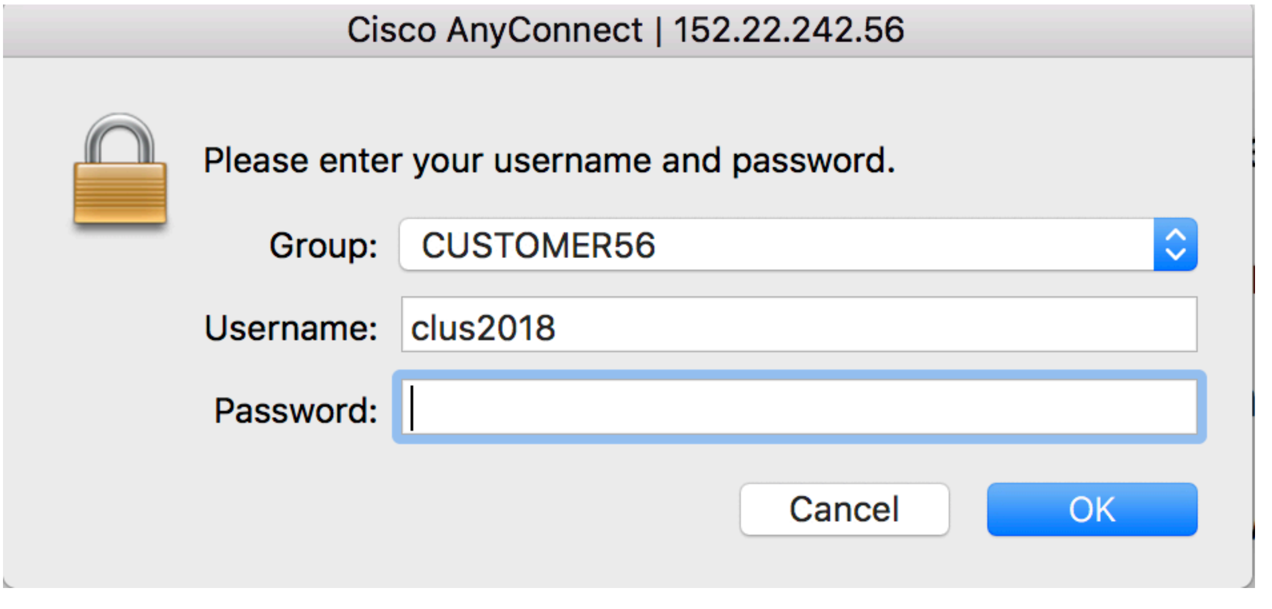
3. Click on connect

4. Select connect anyway on the security warning



5. Enter username/password: **clus2018/ *CLUS2018isFUN!***

✋*: If you are assigned user1 or 2, then your target Any connect VPN address is 152.22.242.56, Username/password is clus2018/CLUS2018isFUN!*



6. On successful connection. You will see a successful icon on the upper bar as follows 
7. If it times out, retry it again
8. If you are unable to select, please reach out to lab proctor

Lab Objectives:

Lab Module 1: In this lab you will review the base “ISIS-SR” segment routing configuration and validate traffic forwarding using labels.

Lab Module 2: In this lab you will advertise BGP prefixes with color, setup BGP address-family sr-policy between XTC controller and SR-Headend router – SR-HE1.

Lab Module 3: In this lab, you will enable SR policy such that different applications are treated differently within the network. Application is uniquely identified by its BSID. After validating the policy, remove policy. In this lab you can either use curl or Postman.

Lab 4: In this lab, you will enable Egress peer engineering, and push a policy where by as operator you determine which egress interface can be utilized

Lab Module 1 – Configure Segment Routing and validate control and data plane

In this lab module, you will configure segment routing and validate the control and date plane. For convenience, user will enable segment routing for ISIS on SR-HE1 and SR-HE2 node. Nodes SR-LSR1 & SR-LSR2 have been preconfigured with segment routing.

Logical Topology

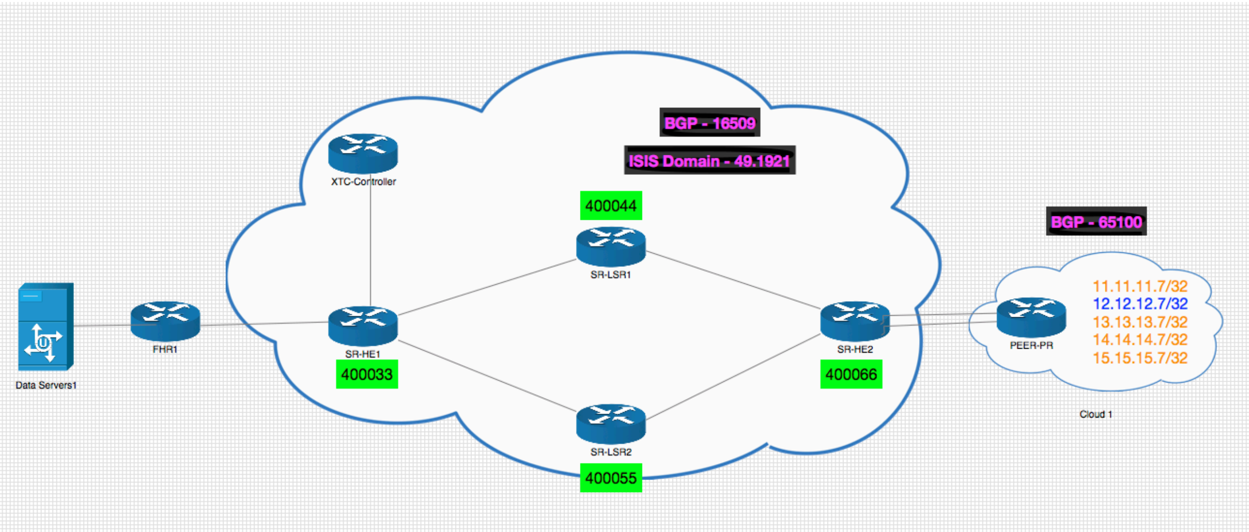


Figure 3 – Network Topology with IGP and Segment Routing enabled

1. Configure SR-HE1 for Segment Routing in ISIS:

Telnet to node SR-HE1 and enable segment routing as follows (username/password: cisco/cisco)

```
CL18-LABRST1015:~ yraghuna$ telnet 172.16.111.69
Trying 172.16.111.69...
Connected to 172.16.111.69.
Escape character is '^]'
...
User Access Verification
Username:
Username: cisco
Password:cisco
RP/0/0/CPU0:SR-HE1#
RP/0/0/CPU0:SR-HE1#conf t
Fri May 25 22:32:48.688 UTC
RP/0/0/CPU0:SR-HE1(config)#config-isis-sr-he1
RP/0/0/CPU0:SR-HE1(config)#router isis 16509
RP/0/0/CPU0:SR-HE1(config)#segment-routing global-block 400000 464000
RP/0/0/CPU0:SR-HE1(config)#address-family ipv4 unicast
RP/0/0/CPU0:SR-HE1(config)#segment-routing mpls
```

```
RP/0/0/CPU0:SR-HE1(config)#interface Loopback0
RP/0/0/CPU0:SR-HE1(config)#address-family ipv4 unicast
RP/0/0/CPU0:SR-HE1(config)#prefix-sid index 33
RP/0/0/CPU0:SR-HE1(config)#commit
Fri May 25 22:33:01.927 UTC
RP/0/0/CPU0:SR-HE1(config)#end
RP/0/0/CPU0:SR-HE1#
```

segment-routing global-block 400000 464000	Specifies the block of segment routing IDs that are allocated for the routers in the network. [Node-SID]
segment-routing mpls	Enables segment routing for IPv4 addresses with MPLS data plane.
prefix-sid index 33	Configures the segment ID (Node-SID) With Index Node SID, SR routing id is derived from [400000+33]

👉: *SR-HE1 has been enabled for Segment routing with MPLS as encapsulation. Prefix SID comes from custom configured block (SRGB+Index) for loopback0.*

2. Configure SR-HE2 for Segment Routing in ISIS:

Telnet to node SR-HE2 and enable segment routing as follows (username/password:cisco/cisco)

```
CL18-LABRST1015:~ yraghuna$ telnet 172.16.111.70
Trying 172.16.111.70...
Connected to 172.16.111.70.
Escape character is '^]'
...
User Access Verification
Username:
Username: cisco
Password:cisco
RP/0/0/CPU0:SR-HE2#conf t
Fri May 25 22:47:50.526 UTC
RP/0/0/CPU0:SR-HE2(config)#config-isis-sr-he2
RP/0/0/CPU0:SR-HE2(config)#router isis 16509
RP/0/0/CPU0:SR-HE2(config)#segment-routing global-block 400000 464000
RP/0/0/CPU0:SR-HE2(config)#address-family ipv4 unicast
RP/0/0/CPU0:SR-HE2(config)#segment-routing mpls
RP/0/0/CPU0:SR-HE2(config)#interface Loopback0
RP/0/0/CPU0:SR-HE2(config)#address-family ipv4 unicast
RP/0/0/CPU0:SR-HE2(config)#prefix-sid index 66
RP/0/0/CPU0:SR-HE2(config)#commit
Fri May 25 22:48:00.796 UTC
RP/0/0/CPU0:SR-HE2(config)#end
RP/0/0/CPU0:SR-HE2#
```

segment-routing global-block 400000 464000	Specifies the block of segment routing IDs that are allocated for the routers in the network. [Node-SID]
segment-routing mpls	Enables segment routing for IPv4 addresses with MPLS data plane.
prefix-sid index 66	Configures the segment ID (Node-SID) With Index Node SID, SR routing id is derived from [400000+66]

👉: *SR-HE2 has been enabled for Segment routing with MPLS as encapsulation. Prefix SID comes from custom configured block (SRGB+Index) for loopback0.*

3. Review Segment routing configuration on SR-LSR1/SR-LSR2 (No configuration required – Optional step to review)

   SR-LSR1/SR-LSR2 has been configured with SR configuration. User can enter the terminal for LSR-PE2 and review the configuration using show run router ISIS (username/password:cisco/cisco)

```
CL18-LABRST1015:~ yraghuna$ telnet 172.16.111.71
Trying 172.16.111.71...
Connected to 172.16.111.71.
Escape character is '^]'
...
User Access Verification

Username:
Username: cisco
Password:

RP/0/0/CPU0:SR-LSR1#show-isis
RP/0/0/CPU0:SR-LSR1#show run router isis
Fri May 25 22:54:17.381 UTC
router isis 16509
 net 49.1921.6800.0004.00
 segment-routing global-block 400000 464000
 address-family ipv4 unicast
  metric-style wide
  segment-routing mpls
 !
 interface Loopback0
  passive
  circuit-type level-2-only
  address-family ipv4 unicast
   prefix-sid index 44
  !
 !
```

```
interface GigabitEthernet0/0/0/0
 circuit-type level-2-only
 point-to-point
 address-family ipv4 unicast
  metric 1
 !
!
interface GigabitEthernet0/0/0/1
 circuit-type level-2-only
 point-to-point
 address-family ipv4 unicast
  metric 1
 !
!
!
```

4. Review routing configuration on XTC-Controller (No configuration required – Optional step to review)

   👉: *XTC-Controller ISIS enabled but has not been enabled for segment routing. XTC-controller needs IP connectivity to one of the routers in the SR-Domain to learns its IGP topology to push the policy*

```
CL18-LABRST1015:~ yraghuna$ telnet 172.16.111.73
Trying 172.16.111.73...
Connected to 172.16.111.73.
Escape character is '^]'
...
User Access Verification

Username:
Username: cisco
Password:

RP/0/0/CPU0:XTC-Controller#
RP/0/0/CPU0:XTC-Controller#show-isis
RP/0/0/CPU0:XTC-Controller#show run router isis
Fri May 25 23:00:25.576 UTC
router isis 16509
 net 49.1921.6800.0008.00
 address-family ipv4 unicast
  metric-style wide
 !
 interface Loopback0
  passive
  circuit-type level-2-only
  address-family ipv4 unicast
  !
 !
 interface GigabitEthernet0/0/0/0
  circuit-type level-2-only
  point-to-point
  address-family ipv4 unicast
```

```
  metric 1
 !
!
!
```

5. Review routing configuration on SR-FHR1 (No configuration required – Optional step to review)

```
CL18-LABRST1015:~ yraghuna$ telnet 172.16.111.68
Trying 172.16.111.68...
Connected to 172.16.111.68.
Escape character is '^]'
...
User Access Verification

Username:
Username: cisco
Password:

RP/0/0/CPU0:SR-FHR1#
RP/0/0/CPU0:SR-FHR1#show-isis
RP/0/0/CPU0:SR-FHR1#show run router isis
Fri May 25 23:09:52.624 UTC
% No such configuration item(s)

RP/0/0/CPU0:SR-FHR1#show-static
RP/0/0/CPU0:SR-FHR1#show run router static
Fri May 25 23:09:56.333 UTC
router static
 address-family ipv4 unicast
  192.168.0.0/24 GigabitEthernet0/0/0/1 10.0.0.10
 !
 vrf Mgmt-intf
  address-family ipv4 unicast
   0.0.0.0/0 MgmtEth0/0/CPU0/0 172.16.111.254
  !
 !
!

RP/0/0/CPU0:SR-FHR1#show-mpls-static
RP/0/0/CPU0:SR-FHR1#show run mpls static
Fri May 25 23:09:59.113 UTC
% No such configuration item(s)

RP/0/0/CPU0:SR-FHR1#
```

👉: *SR-FHR1 does not have any dynamic routing or segment routing enabled. The purpose of this node is to push IP2IP or IP2MPLS packets using static mpls. In the base configuration the node should be enabled only for static routing.*

6. Validate the control plane by running through following commands.

1. Check the ISIS neighbor is up and running from SR-HE1 Node.

```
RP/0/0/CPU0:SR-HE1#
RP/0/0/CPU0:SR-HE1#show-isis-nei
RP/0/0/CPU0:SR-HE1#show isis neighbors
Sat May 26 16:52:48.656 UTC

IS-IS 16509 neighbors:
System Id      Interface       SNPA          State Holdtime Type IETF-NSF
XTC-Controller Gi0/0/0/3       *PtoP*        Up    24       L2   Capable
SR-LSR1        Gi0/0/0/1       *PtoP*        Up    25       L2   Capable
SR-MP-LSR2     Gi0/0/0/2       *PtoP*        Up    21       L2   Capable
Total neighbor count: 3
```

2. Identify the LSP ID where the database contents are stored for the ISIS domain

```
RP/0/0/CPU0:SR-HE1#show-isis-db
RP/0/0/CPU0:SR-HE1#show isis database
Sat May 26 16:53:14.985 UTC

IS-IS 16509 (Level-1) Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime/Rcvd  ATT/P/OL
SR-HE1.00-00        * 0x000001c2   0x1bfa        539  /*            0/0/0

 Total Level-1 LSP count: 1     Local Level-1 LSP count: 1

IS-IS 16509 (Level-2) Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime/Rcvd  ATT/P/OL
SR-HE1.00-00        * 0x000001c6   0x97e9        920  /*            0/0/0
SR-LSR1.00-00         0x000001c3   0xa328        494  /1199         0/0/0
SR-MP-LSR2.00-00      0x000001c4   0xd301        575  /1199         0/0/0
SR-HE2.00-00          0x000001ca   0x1188        564  /1199         0/0/0
XTC-Controller.00-00  0x000001c2   0xa68b        1068 /1199         0/0/0

 Total Level-2 LSP count: 5     Local Level-2 LSP count: 1
RP/0/0/CPU0:SR-HE1#

RP/0/0/CPU0:SR-HE1#show-isis-db verbose SR-HE1.00-00 detail
RP/0/0/CPU0:SR-HE1#show isis database verbose SR-HE1.00-00 detail
Sat May 26 16:53:57.402 UTC

IS-IS 16509 (Level-1) Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime/Rcvd  ATT/P/OL
SR-HE1.00-00        * 0x000001c2   0x1bfa        496  /*            0/0/0
  Area Address:   49
```

```
  NLPID:         0xcc
  IP Address:     192.168.0.3
  Hostname:       SR-HE1
  Router Cap:     192.168.0.3, D:0, S:0
    Segment Routing: I:1 V:0, SRGB Base: 400000
Range: 64001
    SR Local Block: Base: 15000 Range: 1000
    SR Algorithm:
      Algorithm: 0
      Algorithm: 1
    Node Maximum SID Depth:
      Subtype: 1, Value: 10

IS-IS 16509 (Level-2) Link
State Database
```

I - IPv4 Address Family
V - IPv6 Address Family
SRGB Block 400,000 -464000
- Custom defined in config

0 – Shortest Path First – Permits any node to overwrite the SPF Path

1 – Strict Shortest Path First – Permits All nodes need to honor the path, cannot overwrite the SPF 1 Path

```
LSPID             LSP Seq Num  LSP Checksum  LSP Holdtime/Rcvd  ATT/P/OL
SR-HE1.00-00       * 0x000001c6   0x97e9       878  /*          0/0/0
  Area Address:   49
  NLPID:         0xcc
  IP Address:     192.168.0.3
  Metric: 1         IP-Extended 10.0.0.8/30
    Prefix Attribute Flags: X:0 R:0 N:0
  Metric: 1         IP-Extended 10.0.0.12/30
    Prefix Attribute Flags: X:0 R:0 N:0
  Metric: 1         IP-Extended 10.0.0.16/30
    Prefix Attribute Flags: X:0 R:0 N:0
  Metric: 1         IP-Extended 10.0.0.20/30
    Prefix Attribute Flags: X:0 R:0 N:0
  Metric: 0         IP-Extended 192.168.0.3/32
    Prefix-SID Index: 33, Algorithm:0, R:0 N:1 P:0 E:0 V:0 L:0
    Prefix Attribute Flags: X:0 R:0 N:1
  Hostname:       SR-HE1
  Router Cap:     192.168.0.3, D:0, S:0
    Segment Routing: I:1 V:0, SRGB Base: 400000 Range: 64001
    SR Local Block: Base: 15000 Range: 1000
    SR Algorithm:
      Algorithm: 0
      Algorithm: 1
    Node Maximum SID Depth:
      Subtype: 1, Value: 10
  Metric: 1         IS-Extended SR-
LSR1.00
    Interface IP Address: 10.0.0.13
    Neighbor IP Address: 10.0.0.14
    Link Maximum SID Depth:
      Subtype: 1, Value: 10
    ADJ-SID: F:0 B:0 V:1 L:1 S:0 P:0 weight:0 Adjacency-sid:24001
  Metric: 1         IS-Extended SR-MP-LSR2.00
    Interface IP Address: 10.0.0.17
    Neighbor IP Address: 10.0.0.18
    Link Maximum SID Depth:
      Subtype: 1, Value: 10
    ADJ-SID: F:0 B:0 V:1 L:1 S:0 P:0 weight:0 Adjacency-sid:24003
```

IPv4 adjacency SID
F:0, Address-family IPv4
B:0, unprotected
V:1, label value
L:1, local segment
S:0, not a set of adjacencies
Adjacency SID - comes from dynamic range

```
  Metric: 1          IS-Extended XTC-Controller.00
    Interface IP Address: 10.0.0.21
    Neighbor IP Address: 10.0.0.22
    Link Maximum SID Depth:
      Subtype: 1, Value: 10
    ADJ-SID: F:0 B:0 V:1 L:1 S:0 P:0 weight:0 Adjacency-sid:24005
RP/0/0/CPU0:SR-HE1#
```

3. Check for the isis Adjacency information

```
RP/0/0/CPU0:SR-HE1#show-isis-adj
RP/0/0/CPU0:SR-HE1#show isis adjacency detail
Sat May 26 16:52:59.196 UTC

IS-IS 16509 Level-1 adjacencies:
System Id      Interface        SNPA           State Hold Changed  NSF IPv4 IPv6
                                                              BFD  BFD

IS-IS 16509 Level-2 adjacencies:
System Id      Interface        SNPA           State Hold Changed  NSF IPv4 IPv6
                                                              BFD  BFD
XTC-Controller Gi0/0/0/3        *PtoP*         Up    29   4d01h    Yes None None
  Area Address:           49
  Neighbor IPv4 Address:  10.0.0.22*
  Adjacency SID:          24004
  Non-FRR Adjacency SID:  24005
  Topology:               IPv4 Unicast
SR-LSR1        Gi0/0/0/1        *PtoP*         Up    22   4d01h    Yes None None
  Area Address:           49
  Neighbor IPv4 Address:  10.0.0.14*
  Adjacency SID:          24000
  Non-FRR Adjacency SID:  24001
  Topology:               IPv4 Unicast
SR-MP-LSR2     Gi0/0/0/2        *PtoP*         Up    29   4d01h    Yes None None
  Area Address:           49
  Neighbor IPv4 Address:  10.0.0.18*
  Adjacency SID:          24002
  Non-FRR Adjacency SID:  24003
  Topology:               IPv4 Unicast

Total adjacency count: 3
RP/0/0/CPU0:SR-HE1#
```

4. Validate the segment routing labels allocated per node

```
RP/0/0/CPU0:SR-HE1#show-mpls-isis
RP/0/0/CPU0:SR-HE1#show mpls label table application isis
Sat May 26 17:09:00.960 UTC
Table Label   Owner                            State  Rewrite
----- ------- ------------------------------ ------ -------
```

```
0    24000  ISIS(A):16509              InUse  Yes
0    24001  ISIS(A):16509              InUse  Yes
0    24002  ISIS(A):16509              InUse  Yes
0    24003  ISIS(A):16509              InUse  Yes
0    24004  ISIS(A):16509              InUse  Yes
0    24005  ISIS(A):16509              InUse  Yes
0    400000  ISIS(A):16509             InUse  No
RP/0/0/CPU0:SR-HE1#
RP/0/0/CPU0:SR-HE1#
RP/0/0/CPU0:SR-HE1#show-mpls-table
RP/0/0/CPU0:SR-HE1#show mpls label table
Sat May 26 17:12:25.626 UTC
Table Label   Owner                         State  Rewrite
----- ------- ------------------------------- ------ -------
0    0      LSD(A)                    InUse  Yes
0    1      LSD(A)                    InUse  Yes
0    2      LSD(A)                    InUse  Yes
0    13      LSD(A)                   InUse  Yes
0    15000  LSD(A)                     InUse  No
0    24000  ISIS(A):16509              InUse  Yes
0    24001  ISIS(A):16509              InUse  Yes
0    24002  ISIS(A):16509              InUse  Yes
0    24003  ISIS(A):16509              InUse  Yes
0    24004  ISIS(A):16509              InUse  Yes
0    24005  ISIS(A):16509              InUse  Yes
0    400000  ISIS(A):16509             InUse  No
RP/0/0/CPU0:SR-HE1#
```

7. Validate the data plane by enabling end to end pings from the Datacenter server connected to FHR1 to target SR-HE2 – node [192.168.0.6]

    1. Enable ping from the Server1 targeted towards SR-HE2 – node [192.168.0.6]

```
CL18-LABRST1015:$ ssh cisco@172.16.111.74
cisco@172.16.111.74's password:
Welcome to Ubuntu 14.04.5 LTS (GNU/Linux 3.13.0-119-generic x86_64)

 * Documentation:  https://help.ubuntu.com/

  System information as of Wed May 23 00:32:58 UTC 2018

  System load:  0.4               Processes:           112
  Usage of /:   81.0% of 2.13GB   Users logged in:     1
  Memory usage: 30%               IP address for eth0: 172.16.111.74
  Swap usage:   0%                IP address for eth1: 10.0.0.6

  Graph this data and manage this system at:
    https://landscape.canonical.com/

```

```
 Get cloud support with Ubuntu Advantage Cloud Guest:
   http://www.ubuntu.com/business/services/cloud

New release '16.04.4 LTS' available.
Run 'do-release-upgrade' to upgrade to it.


Last login: Wed May 23 00:32:58 2018 from 172.31.56.96
cisco@server-1:~$
cisco@server-1:~$ cisco@server-1:~$ ping 192.168.0.6
PING 192.168.0.8 (192.168.0.8) 56(84) bytes of data.
64 bytes from 192.168.0.8: icmp_seq=1 ttl=253 time=3.61 ms
64 bytes from 192.168.0.8: icmp_seq=2 ttl=253 time=3.27 ms
....
```

2. Validate intermediate data plane counters within SR Domain

   As identified with host name, please execute the commands on the right host.

```
RP/0/0/CPU0:SR-HE1#show-route 192.168.0.6
RP/0/0/CPU0:SR-HE1#show route 192.168.0.6
Fri May 25 23:19:36.155 UTC

Routing entry for 192.168.0.6/32
  Known via "isis 16509", distance 115, metric 2, labeled SR, type level-2
  Installed May 25 22:22:33.000 for 00:57:03
  Routing Descriptor Blocks
    10.0.0.14, from 192.168.0.6, via GigabitEthernet0/0/0/1
      Route metric is 2
    10.0.0.18, from 192.168.0.6, via GigabitEthernet0/0/0/2
      Route metric is 2
  No advertising protos.
RP/0/0/CPU0:SR-HE1# show-cef 192.168.0.6
RP/0/0/CPU0:SR-HE1#show cef 192.168.0.6
Fri May 25 23:19:40.345 UTC
192.168.0.6/32, version 123, labeled SR, internal 0x1000001 0x81 (ptr 0xa14d9174) [1], 0x0 (0xa14be9e0), 0xa28 (0xa1956050)
 Updated May 25 22:22:36.079
 local adjacency 10.0.0.14
 Prefix Len 32, traffic index 0, precedence n/a, priority 1
   via 10.0.0.14/32, GigabitEthernet0/0/0/1, 9 dependencies, weight 0, class 0 [flags 0x0]
    path-idx 0 NHID 0x0 [0xa1824250 0x0]
    next hop 10.0.0.14/32
    local adjacency
     local label 400066      labels imposed {400066}
   via 10.0.0.18/32, GigabitEthernet0/0/0/2, 9 dependencies, weight 0, class 0 [flags 0x0]
    path-idx 1 NHID 0x0 [0xa18243f4 0x0]
    next hop 10.0.0.18/32
    local adjacency
```

```
     local label 400066      labels imposed {400066}
RP/0/0/CPU0:SR-HE1#

RP/0/0/CPU0:SR-HE1#show-forward 400066
RP/0/0/CPU0:SR-HE1#show mpls forwarding labels 400066
Fri May 25 23:18:55.698 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
400066 400066      SR Pfx (idx 66)    Gi0/0/0/1    10.0.0.14       6047
       400066      SR Pfx (idx 66)    Gi0/0/0/2    10.0.0.18       0
RP/0/0/CPU0:SR-HE1#
RP/0/0/CPU0:SR-HE1#show-forward 400066
RP/0/0/CPU0:SR-HE1#show mpls forwarding labels 400066
Fri May 25 23:18:57.038 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
400066 400066      SR Pfx (idx 66)    Gi0/0/0/1    10.0.0.14       6223
       400066      SR Pfx (idx 66)    Gi0/0/0/2    10.0.0.18       0
RP/0/0/CPU0:SR-HE1#
```

```
RP/0/0/CPU0:SR-LSR1#
RP/0/0/CPU0:SR-LSR1#show-route 192.168.0.6
RP/0/0/CPU0:SR-LSR1#show route 192.168.0.6
Fri May 25 23:24:01.698 UTC

Routing entry for 192.168.0.6/32
  Known via "isis 16509", distance 115, metric 1, labeled SR, type level-2
  Installed May 25 22:22:33.321 for 01:01:28
  Routing Descriptor Blocks
    10.0.0.26, from 192.168.0.6, via GigabitEthernet0/0/0/1
      Route metric is 1
  No advertising protos.
RP/0/0/CPU0:SR-LSR1#
RP/0/0/CPU0:SR-LSR1#show-cef 192.168.0.6
RP/0/0/CPU0:SR-LSR1#show cef 192.168.0.6
Fri May 25 23:24:06.508 UTC
192.168.0.6/32, version 56, labeled SR, internal 0x1000001 0x81 (ptr 0xa14d8ecc) [1], 0x0
(0xa14be5f0), 0xa20 (0xa1678190)
 Updated May 25 22:22:33.341
 local adjacency 10.0.0.26
 Prefix Len 32, traffic index 0, precedence n/a, priority 1
   via 10.0.0.26/32, GigabitEthernet0/0/0/1, 9 dependencies, weight 0, class 0 [flags 0x0]
    path-idx 0 NHID 0x0 [0xa18022a4 0xa18022f8]
    next hop 10.0.0.26/32
    local adjacency
     local label 400066      labels imposed {ImplNull}
RP/0/0/CPU0:SR-LSR1#
RP/0/0/CPU0:SR-LSR1#show-forward 400066
```

```
RP/0/0/CPU0:SR-LSR1#show mpls forwarding labels 400066
Fri May 25 23:24:11.318 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
400066 Pop         SR Pfx (idx 66)    Gi0/0/0/1    10.0.0.26       48212
RP/0/0/CPU0:SR-LSR1#
RP/0/0/CPU0:SR-LSR1#show-forward-400066
RP/0/0/CPU0:SR-LSR1#show mpls forwarding labels 400066
Fri May 25 23:24:13.338 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
400066 Pop         SR Pfx (idx 66)    Gi0/0/0/1    10.0.0.26       48380
RP/0/0/CPU0:SR-LSR1#
```

Key Learning from LAB Module 1:

- Each SR node assigns an unique node identifier that is drivered by combing the SRGB Global block and Prefix Index.
- Node SID's are exchanged within ISIS using new TLV's there by eliminating the requirement for any label distribution protocol
- With SR based on IGP forward, labels are imposed based on IGP best path.

Lab Module 2: Enable BGP Control plane for pushing SR Policies from XTC Controller

Logical Topology

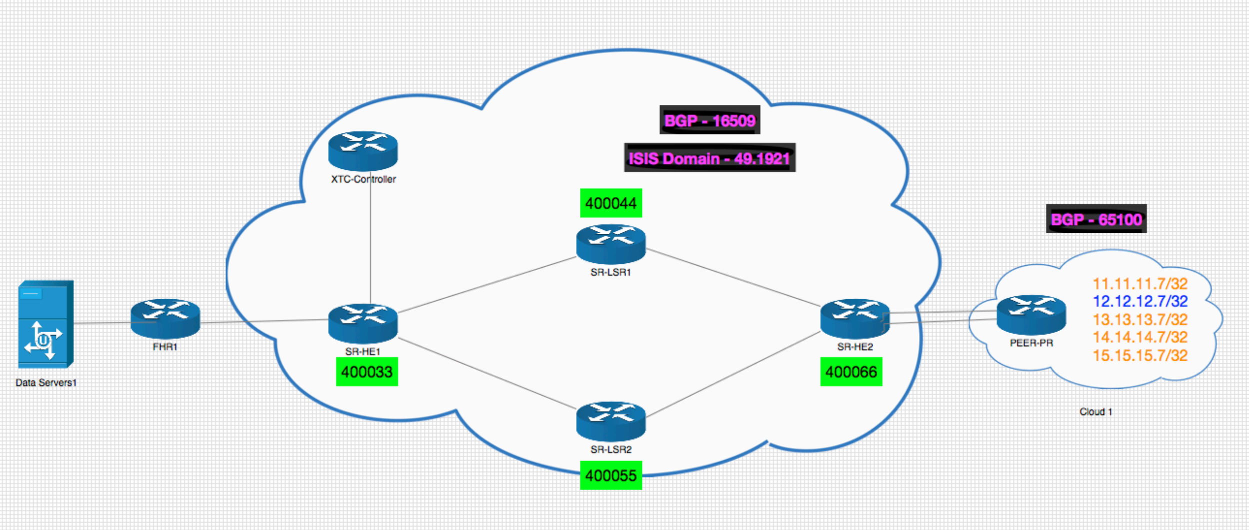


Figure 4 – Network Topology with IGP and Segment Routing enabled

In this lab, You will configure Internet prefixes simulated through (x.x.x.x.7/32) subnets to be colored and enable necessary control plane configuration between XTC-Controller and SR-TE1.

1. Peering is preconfigured between SR-TE2 and Peer-PR and subnets with x.x.x.7/32 advertised. Validate that BGP Internet prefixes are received on SR-HE1 router.

```
RP/0/0/CPU0:SR-HE1#show-bgp
RP/0/0/CPU0:SR-HE1#show bgp
Sat May 26 18:00:38.638 UTC
BGP router identifier 192.168.0.3, local AS number 16509
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000   RD version: 76
BGP main routing table version 76
BGP NSR Initial initsync version 2 (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
*>i11.11.11.7/32      192.168.0.6              0    100      0 65100 i
*>i12.12.12.7/32      192.168.0.6              0    100      0 65100 i
*>i13.13.13.7/32      192.168.0.6              0    100      0 65100 i
*>i14.14.14.7/32      192.168.0.6              0    100      0 65100 i
*>i15.15.15.7/32      192.168.0.6              0    100      0 65100 i
```

```
*> 192.168.0.3/32     0.0.0.0                 0          32768 i
*>i192.168.0.6/32     192.168.0.6               0     100       0 i
*>i192.168.0.7/32     192.168.0.6               0     100       0 65100 i
*>i192.168.0.8/32     192.168.0.8               0     100       0 i

Processed 9 prefixes, 9 paths
RP/0/0/CPU0:SR-HE1#
```

2. Enable the BGP color configuration so prefixes are appropriately colored as per design. XTC Segment routing Policy will route traffic based on color and end point. For the lab purpose, we will color internet prefixes with color 1 & 2.
    1. Ext-community-set with color mapping is preconfigured on SR-HE1 router

```
RP/0/0/CPU0:SR-HE1#show run extcommunity-set opaque color1
Sun May 27 01:11:52.595 UTC
extcommunity-set opaque color1
  1
end-set
!

RP/0/0/CPU0:SR-HE1#show run extcommunity-set opaque color2
Sun May 27 01:11:54.365 UTC
extcommunity-set opaque color2
  2
end-set
!
```

    2. Prefixes-set has been preconfigured for internet prefixes with x.x.x.x/32

```
RP/0/0/CPU0:SR-HE1#show run prefix-set epe-prefixes
epe-prefixes  epe-prefixes-12
RP/0/0/CPU0:SR-HE1#show run prefix-set epe-prefixes-12
Sun May 27 01:14:05.096 UTC
prefix-set epe-prefixes-12
  12.12.12.7/32
end-set
```

    3. Ext-community-set with color mapping is preconfigured on SR-HE1 router

```
!
RP/0/0/CPU0:SR-HE1#sho run route-policy color-policy
Sun May 27 01:12:23.893 UTC
route-policy color-policy
  if destination in epe-prefixes-12 then
    set extcommunity color color2
  else
    set extcommunity color color1
  endif
```

```
end-policy
!
```

4. Configure route-policy such that prefix 12.12.12.7/32 has been set with color 2, and remaining BGP internet prefixes from AS 65000 are set with Color one.

```
RP/0/0/CPU0:SR-HE1#conf t
Sun May 27 01:26:11.676 UTC
RP/0/0/CPU0:SR-HE1(config)#
RP/0/0/CPU0:SR-HE1(config)#config-bgp-color
RP/0/0/CPU0:SR-HE1(config)#router bgp 16509
RP/0/0/CPU0:SR-HE1(config)#neighbor 192.168.0.8
RP/0/0/CPU0:SR-HE1(config)#address-family ipv4 unicast
RP/0/0/CPU0:SR-HE1(config)#route-policy color-policy in
RP/0/0/CPU0:SR-HE1(config)#commit
Sun May 27 01:32:42.690 UTC
RP/0/0/CPU0:SR-HE1(config)#end
RP/0/0/CPU0:SR-HE1#
```

3. Validate the simulated BGP prefixes are colored as designed.

```
RP/0/0/CPU0:SR-HE1#show-bgp 11.11.11.7
RP/0/0/CPU0:SR-HE1#show bgp 11.11.11.7
Sun May 27 01:47:49.257 UTC
BGP routing table entry for 11.11.11.7/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 70          70
Last Modified: May 26 17:59:09.756 for 07:48:39
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  65100
    192.168.0.6 (metric 2) from 192.168.0.8 (192.168.0.6)
      Origin IGP, metric 0, localpref 100, valid, internal, best, group-best
      Received Path ID 0, Local Path ID 1, version 70
      Extended community: Color:1
      Originator: 192.168.0.6, Cluster list: 192.168.0.8
RP/0/0/CPU0:SR-HE1#.
RP/0/0/CPU0:SR-HE1#show-bgp 12.12.12.7
RP/0/0/CPU0:SR-HE1#show bgp 12.12.12.7
Sun May 27 01:47:58.587 UTC
BGP routing table entry for 12.12.12.7/32
Versions:
  Process           bRIB/RIB  SendTblVer
  Speaker                 71          71
Last Modified: May 26 17:59:09.756 for 07:48:48
Paths: (1 available, best #1)
  Not advertised to any peer
```

```
 Path #1: Received by speaker 0
 Not advertised to any peer
 65100
   192.168.0.6 (metric 2) from 192.168.0.8 (192.168.0.6)
     Origin IGP, metric 0, localpref 100, valid, internal, best, group-best
     Received Path ID 0, Local Path ID 1, version 71
     Extended community: Color:2
     Originator: 192.168.0.6, Cluster list: 192.168.0.8
RP/0/0/CPU0:SR-HE1#
```

4. Configure and SR Address-family between XTC-Controller and SR-HE1. XTC has been preconfigured.

```
Config t

RP/0/0/CPU0:SR-HE1(config)#config-bgp-srpolicy
RP/0/0/CPU0:SR-HE1(config)#router bgp 16509
RP/0/0/CPU0:SR-HE1(config)#address-family ipv4 sr-policy
RP/0/0/CPU0:SR-HE1(config)#neighbor 192.168.0.8
RP/0/0/CPU0:SR-HE1(config)#address-family ipv4 sr-policy
RP/0/0/CPU0:SR-HE1(config)#commit
Sun May 27 02:05:42.614 UTC
RP/0/0/CPU0:SR-HE1(config)#end
```

5. Review the BGP configuration on XTC-Controller

```
RP/0/0/CPU0:XTC-Controller#show-bgp
RP/0/0/CPU0:XTC-Controller#show run router bgp
Sun May 27 02:09:14.451 UTC
router bgp 16509
 bgp router-id 192.168.0.8
 address-family ipv4 unicast
  network 192.168.0.8/32
 !
 address-family link-state link-state
 !
 address-family ipv4 sr-policy
 !
 neighbor 192.168.0.3
  remote-as 16509
  description iBGP peer SR-HE-LER1
  update-source Loopback0
  address-family ipv4 unicast
   route-reflector-client
  !
  address-family ipv4 sr-policy
  !
 !
 neighbor 192.168.0.6
```

```
 remote-as 16509
 description iBGP peer SR-HE-LER2
 update-source Loopback0
 address-family ipv4 unicast
  route-reflector-client
 !
```

6. Validate that neighbours are up and running.

IPv4 address family and SR-Policy address family is up and running. XTC will utilize the SR-Policy address family to push the policy to the headend

```
RP/0/0/CPU0:SR-HE1#show-bgp-sum-filter
RP/0/0/CPU0:SR-HE1#show bgp all all summary | inc "Address|192.168.0.8"
Sun May 27 02:12:53.584 UTC
Address Family: IPv4 Unicast
192.168.0.8       0 16509    6444    6427      108    0    0 00:06:45         8
Address Family: IPv4 SR-policy
192.168.0.8       0 16509    6444    6427        2    0    0 00:06:45         0
RP/0/0/CPU0:SR-HE1#
```

Key Learning from LAB Module 2:

- Apply route-policy on BGP In-bound coming from route reflector.
- Leverage Color community to each of the external prefixes to be policy routed.

Lab Module 3: Provision an SR-Policy via XTC Controller

Network Topology:

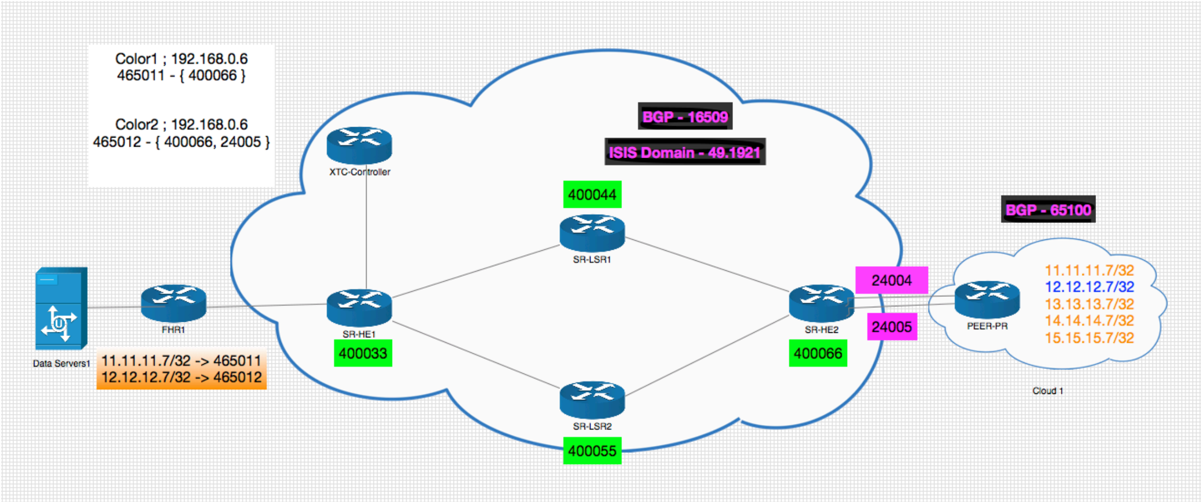


Figure 5 – Network Topology with SR Policy Provisioned.

In this lab module, you will enable SR policy such that different applications are treated differently within the network. Application is uniquely identified by its BSID (Binding SID). After validating the policy, remove policy.

SR-Policy can be provisioned statically or through Controller. For this exercise, we will push the policy using either curl or Postman.

1. Push the following policy from the Server-1 device using Curl command. Server-1 configures the policy on XTC and it advertises through the BGP neighbour.

```
cisco@server-1:~$ curl --request POST --url http://192.168.0.8:8080/srpolicy-install --
header 'cache-control: no-cache' --header 'content-type: application/json' --data '{"source" :
"192.168.0.3", "end-point" : "192.168.0.6", "binding-sid" : 465011, "color" : 1, "preference" :
100, "route-distinguisher" : 2, "path-list" : [{"label-stack" : [400066], "weight" : 1}]}'
```

2. On successful provision, you will receive a success message. For false response, please reach out to proctor. There is a problem in the syntax

```
{"success": true}cisco@server-1:~$
```

3. Validate the policy being provisioned on XTC-Controller

```
RP/0/0/CPU0:XTC-Controller#show-xtc-policy
RP/0/0/CPU0:XTC-Controller#show segment-routing traffic-eng controller policy-$
Sun May 27 02:28:24.022 UTC

Policy request database:
----------------------
```

```
Color: 1 End-Point: 192.168.0.6
  Source: 192.168.0.3
  Binding SID: 465011
  Preference: 100
  Route distinguisher: 2
  Creation Time: Sun May 27 02:23:30 UTC 2018
  Paths:
    Preference 100:
      Explicit: segment-list  (active)
        Weight: 1, Metric Type: Unknown
          400066
```

4. Validate the policy being provisioned on SR-HE1

```
RP/0/0/CPU0:SR-HE1#show-xtc-policy
RP/0/0/CPU0:SR-HE1#show segment-routing traffic-eng policy
Sun May 27 02:35:22.862 UTC

SR-TE policy database
---------------------

Name: bgp_AP_5 (Color: 1, End-point: 192.168.0.6)
   Status:
     Admin: up  Operational: up for 00:11:52 (since May 27 02:23:30.061)
   Candidate-paths:
     Preference 100:
       Explicit: segment-list Autolist_5_1* (active)
         Weight: 1, Metric Type: IGP
           400066
   Attributes:
     Binding SID: 465011
       Allocation mode: explicit
       State: Programmed
       Policy selected: yes
     Forward Class: 0
     Steering BGP disabled: no
     IPv6 caps enable: yes
     Distinguisher: 2
   Auto-policy info:
     Creator: BGP

RP/0/0/CPU0:SR-HE1#
```

5. Check the BGP to validate proper color has been set for BGP Prefixes

```
RP/0/0/CPU0:SR-HE1#show-bgp
RP/0/0/CPU0:SR-HE1#show bgp
Sun May 27 02:31:50.806 UTC
....
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
*>i11.11.11.7/32    192.168.0.6 C:1        0    100      0 65100 i
*>i12.12.12.7/32    192.168.0.6            0    100      0 65100 i
*>i13.13.13.7/32    192.168.0.6 C:1        0    100      0 65100 i
*>i14.14.14.7/32    192.168.0.6 C:1        0    100      0 65100 i
*>i15.15.15.7/32    192.168.0.6 C:1        0    100      0 65100 i
*> 192.168.0.3/32    0.0.0.0               0         32768 i
*>i192.168.0.6/32    192.168.0.6 C:1        0    100      0 i
*>i192.168.0.7/32    192.168.0.6 C:1        0    100      0 65100 i
*>i192.168.0.8/32    192.168.0.8            0    100      0 i

Processed 9 prefixes, 9 paths
RP/0/0/CPU0:SR-HE1#
```

6. Validate the SR-Policy has been programmed on forwarding plane

```
RP/0/0/CPU0:SR-HE1#show-mpls-labels 465011
RP/0/0/CPU0:SR-HE1#show mpls forwarding labels  465011
Sun May 27 02:46:26.786 UTC
Local  Outgoing    Prefix           Outgoing     Next Hop        Bytes
Label  Label       or ID            Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
465011 Pop         No ID            bgp_AP_5     point2point     0
RP/0/0/CPU0:SR-HE1#
RP/0/0/CPU0:SR-HE1#show-sr-tunnel bgp_AP_5
RP/0/0/CPU0:SR-HE1#show mpls forwarding tunnels sr-policy name bgp_AP_5
Sun May 27 02:46:33.476 UTC
Tunnel        Outgoing    Outgoing     Next Hop        Bytes
Name          Label       Interface                    Switched
------------- ----------- ------------ --------------- ------------
bgp_AP_5      (SR) 400066      Gi0/0/0/1    10.0.0.14       0
              400066      Gi0/0/0/2    10.0.0.18       0
RP/0/0/CPU0:SR-HE1#
```

7. Configure FHR1 to push the BSID for the traffic originating from the host application. The purpose of the step is to simulate application coming from server sending with BSID Label

```
RP/0/0/CPU0:SR-FHR1(config)#
RP/0/0/CPU0:SR-FHR1(config)#config-mpls-static
RP/0/0/CPU0:SR-FHR1(config)#mpls static
RP/0/0/CPU0:SR-FHR1(config)#interface GigabitEthernet0/0/0/1
RP/0/0/CPU0:SR-FHR1(config)#address-family ipv4 unicast
RP/0/0/CPU0:SR-FHR1(config)#local-label 465011 allocate per-prefix 11.11.11.7/32
RP/0/0/CPU0:SR-FHR1(config)#forward
RP/0/0/CPU0:SR-FHR1(config)#path 1 nexthop GigabitEthernet0/0/0/1 10.0.0.10 out-label
465011
RP/0/0/CPU0:SR-FHR1(config)#local-label 465012 allocate per-prefix 12.12.12.7/32
```

```
RP/0/0/CPU0:SR-FHR1(config)#forward
RP/0/0/CPU0:SR-FHR1(config)#path 1 nexthop GigabitEthernet0/0/0/1 10.0.0.10 out-label
465012
RP/0/0/CPU0:SR-FHR1(config)#commit
Sun May 27 02:52:56.188 UTC
RP/0/0/CPU0:SR-FHR1(config)#end
```

8. Validate the data plane traffic is going through the SR Policy
    1. Enable end to end ping to a prefix with color mapping of 1. For the purpose of the test we will send traffic to 11.11.11.7

```
cisco@server-1:~$ ping 11.11.11.7
PING 11.11.11.7 (11.11.11.7) 56(84) bytes of data.
64 bytes from 11.11.11.7: icmp_seq=1 ttl=251 time=35.7 ms
64 bytes from 11.11.11.7: icmp_seq=2 ttl=251 time=32.1 ms
64 bytes from 11.11.11.7: icmp_seq=3 ttl=251 time=34.5 ms
```

    2. Validate the forwarding counters on SR-HE1 increments. We can see traffic coming from server with BSID of 465011 are forwarded via SR-Policy.

```
RP/0/0/CPU0:SR-HE1#show mpls forwarding tunnels sr-policy name bgp_AP_5
Sun May 27 02:56:57.953 UTC
Tunnel        Outgoing    Outgoing     Next Hop        Bytes
Name          Label       Interface                    Switched
------------- ----------- ------------ --------------- ------------
bgp_AP_5    (SR) 400066      Gi0/0/0/1     10.0.0.14       8536
                400066      Gi0/0/0/2     10.0.0.18       0
RP/0/0/CPU0:SR-HE1#
```

9. Remove the SR-policy for baseline the config for next lab setup

```
cisco@server-1:~$ curl --request DELETE --url http://192.168.0.8:8080/srpolicy-install --
header 'cache-control: no-cache' --header 'content-type: application/json' --data '{"source" :
"192.168.0.3", "end-point" : "192.168.0.6", "binding-sid" : 465011, "color" : 1, "preference" :
100, "route-distinguisher" : 2, "path-list" : [{"label-stack" : [400066], "weight" : 1}]}'
```

```
{"success": true}cisco@server-1:~$
```

10. Validate the policy has been removed from the SR-HE1.

```
RP/0/0/CPU0:SR-HE1#show-xtc-policy
RP/0/0/CPU0:SR-HE1#show segment-routing traffic-eng policy
Sun May 27 03:08:26.696 UTC
RP/0/0/CPU0:SR-HE1#
```

Key learning from Module 3:

- XTC Controller can be accessed via Curl or Postman.
- SR Policy is provisioned through XTC controller on to head-end device
- By sending the application with appropriate BDID, it can be policy routed across the network

Module Lab 4: Egress Peer Engineering

Network Topology:

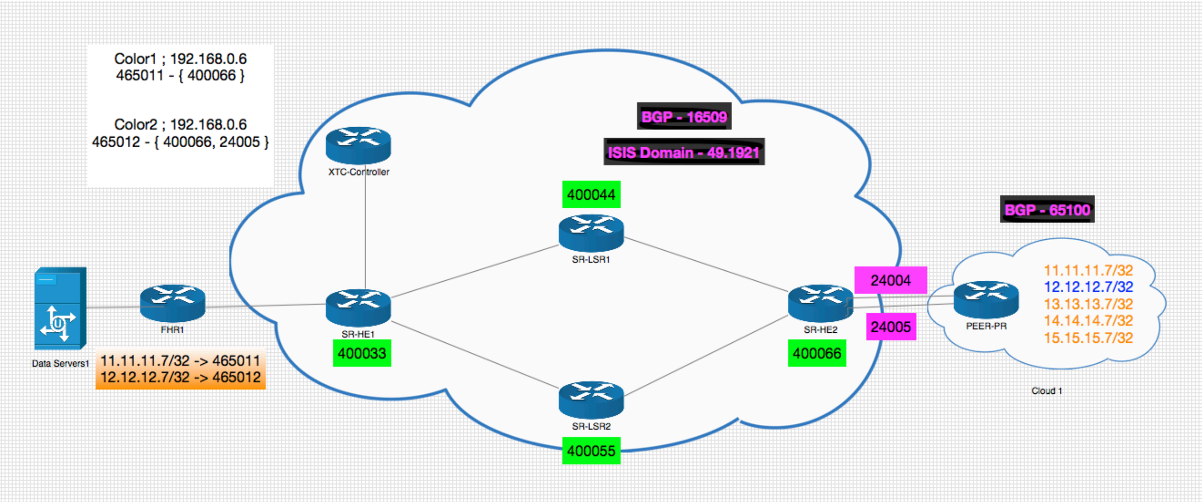


Figure 6 – Network Topology with SR Policy Provisioned with EPE

In this lab, you will enable Egress peer engineering, and push a policy where by as operator you determine which egress interface can be utilized

1. Configure EPE peer engineering on SR-HE2

```
RP/0/0/CPU0:SR-HE2(config)#configure-epe
RP/0/0/CPU0:SR-HE2(config)#router bgp 16509
RP/0/0/CPU0:SR-HE2(config)#neighbor 10.0.0.34
RP/0/0/CPU0:SR-HE2(config)#egress-engineering
RP/0/0/CPU0:SR-HE2(config)#neighbor 10.0.0.38
RP/0/0/CPU0:SR-HE2(config)#egress-engineering
RP/0/0/CPU0:SR-HE2(config)#commit
Sun May 27 19:10:17.033 UTC
RP/0/0/CPU0:SR-HE2(config)#end
```

2. Validate the EPE, and identify the labels being assigned to interface peer.

```
RP/0/0/CPU0:SR-HE2#show bgp egress-engineering
Sun May 27 19:15:46.930 UTC

 Egress Engineering Peer Set: 10.0.0.34/32 (14637008)
        Nexthop: 10.0.0.34
        Version: 2, rn_version: 2
          Flags: 0x00000006
      Local ASN: 16509
     Remote ASN: 65100
      Local RID: 192.168.0.6
     Remote RID: 192.168.0.7
  Local Address: 10.0.0.33
```

```
    First Hop: 10.0.0.34
        NHID: 2
         IFH: 0x80
       Label: 24004, Refcount: 3
     rpc_set: 14d0a378, ID: 1

 Egress Engineering Peer Set: 10.0.0.38/32 (14636f64)
     Nexthop: 10.0.0.38
     Version: 3, rn_version: 3
       Flags: 0x00000006
   Local ASN: 16509
  Remote ASN: 65100
   Local RID: 192.168.0.6
  Remote RID: 192.168.0.7
  Local Address: 10.0.0.37
    First Hop: 10.0.0.38
        NHID: 3
         IFH: 0xa0
       Label: 24005, Refcount: 3
     rpc_set: 14d0a3f0, ID: 2
```

3. Identify the best path and the next hop. EPE-HE2 through BGP best practice choose by default on 10.0.0.34.

```
RP/0/0/CPU0:SR-HE2#show bgp
Sun May 27 19:24:57.263 UTC
BGP router identifier 192.168.0.6, local AS number 16509
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000   RD version: 34
BGP main routing table version 34
BGP NSR Initial initsync version 2 (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
*>i0.0.0.0/0          192.168.0.3                   100      0 i
*> 11.11.11.7/32      10.0.0.34                0             0 65100 i
*                     10.0.0.38                0             0 65100 i
*> 12.12.12.7/32      10.0.0.34                0             0 65100 i
*                     10.0.0.38                0             0 65100 i
*> 13.13.13.7/32      10.0.0.34                0             0 65100 i
*                     10.0.0.38                0             0 65100 i
*> 14.14.14.7/32      10.0.0.34                0             0 65100 i
*                     10.0.0.38                0             0 65100 i
*> 15.15.15.7/32      10.0.0.34                0             0 65100 i
*                     10.0.0.38                0             0 65100 i
*>i192.168.0.3/32     192.168.0.3              0    100      0 i
*> 192.168.0.6/32     0.0.0.0                  0         32768 i
```

```
*> 192.168.0.7/32      10.0.0.34              0            0 65100 i
*                      10.0.0.38              0            0 65100 i
*>i192.168.0.8/32      192.168.0.8            0    100     0 i

Processed 10 prefixes, 16 paths
RP/0/0/CPU0:SR-HE2#
```

4. Provision 2 policy on the XTC such that, traffic destined to node 11.11.11.7/32 is preferred over BGP Next hop; traffic destined to node 12.12.12.7/32 is preferred over BGP Next hop;
    1. Push Policy 1 – BSID 465011 for { 1, 192.168.0.6 } forwarded with Label of {400066}

```
cisco@server-1:~$ curl --request POST --url http://192.168.0.8:8080/srpolicy-install --header 'cache-control: no-cache' --header 'content-type: application/json' --data '{"source" : "192.168.0.3", "end-point" : "192.168.0.6", "binding-sid" : 465011, "color" : 1, "preference" : 100, "route-distinguisher" : 2, "path-list" : [{"label-stack" : [400066], "weight" : 1}]}'
{"success": true}cisco@server-1:~$
```

    2. Push Policy 2 – BSID 465012 for { 2, 192.168.0.6 } forwarded with Label of {400066, 24005}. Note Prefix 12.12.12.7 is tagged with Color or 2.

```
cisco@server-1:~$ curl --request POST --url http://192.168.0.8:8080/srpolicy-install --header 'cache-control: no-cache' --header 'content-type: application/json' --data '{"source" : "192.168.0.3", "end-point" : "192.168.0.6", "binding-sid" : 465012, "color" : 2, "preference" : 100, "route-distinguisher" : 2, "path-list" : [{"label-stack" : [400066, 24005], "weight" : 1}]}'
{"success": true}cisco@server-1:~$
```

5. Validate on SR-HE1, the policy has been provisioned.

```
RP/0/0/CPU0:SR-HE1#show segment-routing traffic-eng policy
Sun May 27 20:13:21.563 UTC

SR-TE policy database
---------------------

Name: bgp_AP_6 (Color: 1, End-point: 192.168.0.6)
  Status:
    Admin: up  Operational: up for 00:07:43 (since May 27 20:05:38.325)
  Candidate-paths:
    Preference 100:
      Explicit: segment-list Autolist_6_1* (active)
        Weight: 1, Metric Type: IGP
          400066
  Attributes:
    Binding SID: 465011
```

```
      Allocation mode: explicit
      State: Programmed
      Policy selected: yes
    Forward Class: 0
    Steering BGP disabled: no
    IPv6 caps enable: yes
    Distinguisher: 2
  Auto-policy info:
    Creator: BGP

Name: bgp_AP_7 (Color: 2, End-point: 192.168.0.6)
  Status:
    Admin: up  Operational: up for 00:06:09 (since May 27 20:07:12.659)
  Candidate-paths:
    Preference 100:
      Explicit: segment-list Autolist_7_1* (active)
        Weight: 1, Metric Type: IGP
          400066
          24005
  Attributes:
    Binding SID: 465012
      Allocation mode: explicit
      State: Programmed
      Policy selected: yes
    Forward Class: 0
    Steering BGP disabled: no
    IPv6 caps enable: yes
    Distinguisher: 2
  Auto-policy info:
    Creator: BGP
```

6. Originate traffic from Server destined towards 11.11.11.7, and validate the traffic goes over the BGP preferred next hop interface.

```
cisco@server-1:~$ ping 11.11.11.7
PING 11.11.11.7 (11.11.11.7) 56(84) bytes of data.
64 bytes from 11.11.11.7: icmp_seq=1 ttl=251 time=34.7 ms
64 bytes from 11.11.11.7: icmp_seq=2 ttl=251 time=59.5 ms
64 bytes from 11.11.11.7: icmp_seq=3 ttl=251 time=33.0 ms
64 bytes from 11.11.11.7: icmp_seq=4 ttl=251 time=29.9 ms
64 bytes from 11.11.11.7: icmp_seq=5 ttl=251 time=37.5 ms
```

```
RP/0/0/CPU0:SR-HE1#show mpls forwarding tunnels sr-policy name bgp_AP_6
Sun May 27 20:18:30.792 UTC
Tunnel        Outgoing    Outgoing     Next Hop        Bytes
Name          Label       Interface                    Switched
------------- ----------- ------------ --------------- ------------
bgp_AP_6      (SR) 400066      Gi0/0/0/1    10.0.0.14       8976
                 400066      Gi0/0/0/2    10.0.0.18       0
```

```
RP/0/0/CPU0:SR-HE1#show mpls forwarding tunnels sr-policy name bgp_AP_6
Sun May 27 20:18:32.572 UTC
Tunnel        Outgoing    Outgoing     Next Hop        Bytes
Name          Label       Interface                    Switched
------------- ----------- ------------ --------------- ------------
bgp_AP_6      (SR) 400066     Gi0/0/0/1    10.0.0.14       9064
              400066      Gi0/0/0/2    10.0.0.18       0
```

RP/0/0/CPU0:SR-HE1#

7. Originate traffic from Server destined towards 12.12.12.7, and validate the traffic goes over the Policy routed interface

```
RP/0/0/CPU0:SR-HE1#show mpls forwarding tunnels sr-policy name bgp_AP_7
Sun May 27 20:23:21.362 UTC
Tunnel        Outgoing    Outgoing     Next Hop        Bytes
Name          Label       Interface                    Switched
------------- ----------- ------------ --------------- ------------
bgp_AP_7      (SR) 400066     Gi0/0/0/1    10.0.0.14       792
              400066      Gi0/0/0/2    10.0.0.18       0
RP/0/0/CPU0:SR-HE1#
RP/0/0/CPU0:SR-HE1#show mpls forwarding tunnels sr-policy name bgp_AP_7
Sun May 27 20:23:23.532 UTC
Tunnel        Outgoing    Outgoing     Next Hop        Bytes
Name          Label       Interface                    Switched
------------- ----------- ------------ --------------- ------------
bgp_AP_7      (SR) 400066     Gi0/0/0/1    10.0.0.14       968
              400066      Gi0/0/0/2    10.0.0.18       0
RP/0/0/CPU0:SR-HE1#
```

```
RP/0/0/CPU0:SR-HE2#show mpls forwarding labels 24005
Sun May 27 20:23:46.211 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
24005  Pop         No ID              Gi0/0/0/3    10.0.0.38       2772
RP/0/0/CPU0:SR-HE2#show mpls forwarding labels 24005
Sun May 27 20:23:50.841 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
24005  Pop         No ID              Gi0/0/0/3    10.0.0.38       3108
RP/0/0/CPU0:SR-HE2#show mpls forwarding labels 24005
Sun May 27 20:23:52.821 UTC
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
24005  Pop         No ID              Gi0/0/0/3    10.0.0.38       3276
RP/0/0/CPU0:SR-HE2#
```

8. Delete the 2 policies from the servers.
    1. Delete Policy 1 – BSID 465011 for { 1, 192.168.0.6 } forwarded with Label of {400066}

```
cisco@server-1:~$ curl --request DELETE --url http://192.168.0.8:8080/srpolicy-install --header 'cache-control: no-cache' --header 'content-type: application/json' --data '{"source" : "192.168.0.3", "end-point" : "192.168.0.6", "binding-sid" : 465011, "color" : 1, "preference" : 100, "route-distinguisher" : 2, "path-list" : [{"label-stack" : [400066], "weight" : 1}]}'
{"success": true}cisco@server-1:~$
```

    2. Delete Policy 2 – BSID 465012 for { 2, 192.168.0.6 } forwarded with Label of {400066, 24005}. Note Prefix 12.12.12.7 is tagged with Color or 2.

```
cisco@server-1:~$ curl --request Delete --url http://192.168.0.8:8080/srpolicy-install --header 'cache-control: no-cache' --header 'content-type: application/json' --data '{"source" : "192.168.0.3", "end-point" : "192.168.0.6", "binding-sid" : 465012, "color" : 2, "preference" : 100, "route-distinguisher" : 2, "path-list" : [{"label-stack" : [400066, 24005], "weight" : 1}]}'
{"success": true}cisco@server-1:~$
```

Key learning from lab module 4:

- Based on business decision, by leveraging controller, end user can choose a file based on explicit path different from BGP best path.