Module 3 – Segment Routing Configuration Lab

Objective: All the routers are pre-configured with basic interface and OSPF configuration according to the following topology diagram. As part of the exercise, you will need to enable Segment Routing under OSPF and observe operation with common and different SRGBs. In addition, you will need to configure a traffic-engineered Segment Routing tunnel.

Prerequisites: Knowledge of IGP, EGP, MPLS and Segment Routing is required.

The following will be the common topology and IP address plan used for this lab.

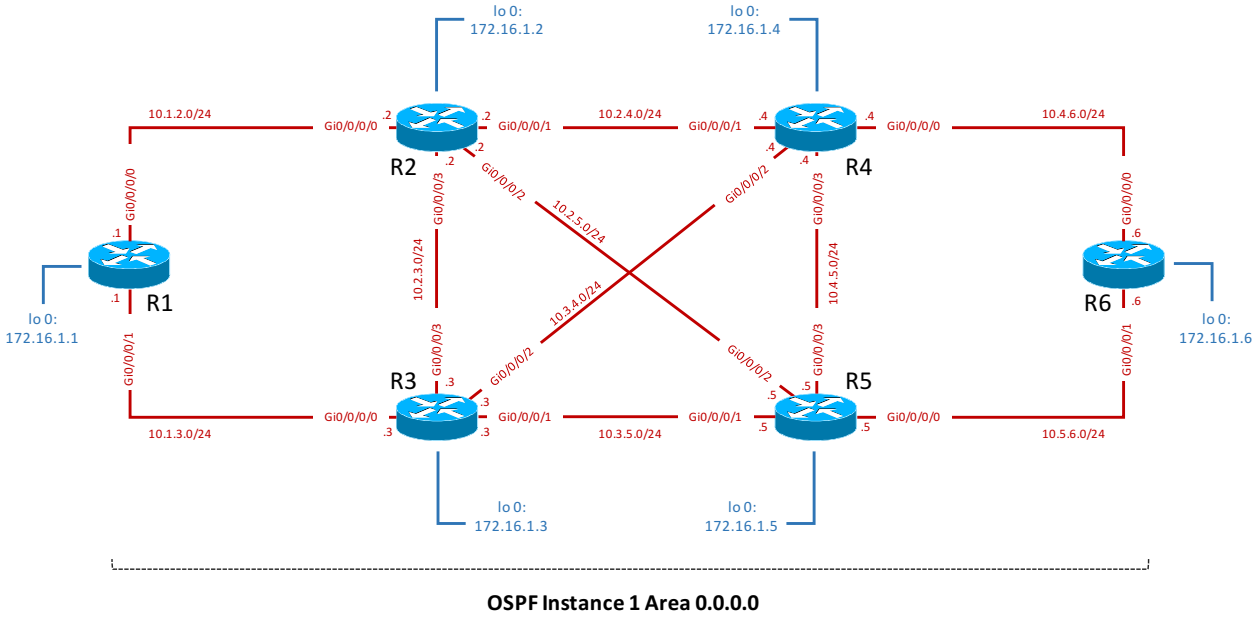


Figure 1 – Segment Routing Lab Base Configuration

Lab Notes

The basic Segment Routing lab topology comprises of 6 routers: R1, R2, R3, R4, R5 and R6. Multiple sets of identical topologies will be used. Workshop attendees will be split up into groups of 6 where each group member will be responsible for the configuration of a specific router.

All routers are running Cisco IOS-XRv 6.1.2 within GNS3. Login credentials are:

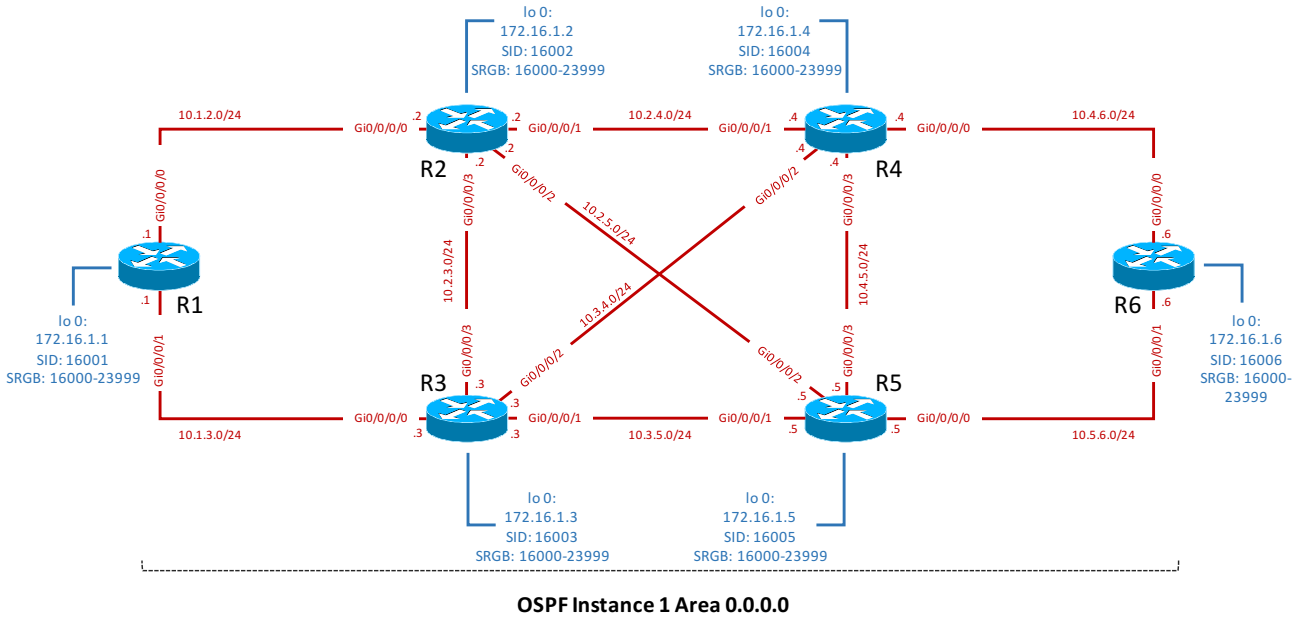
Username: cisco
Password: cisco

Please spend some time to be familiar with the network topology and addressing plan before you start building the configuration on the routers.

In module 3 all required configurations are done in 3 parts.

Part 1. Base Segment Routing configuration.

The following figure reflects the base Segment Routing configuration.

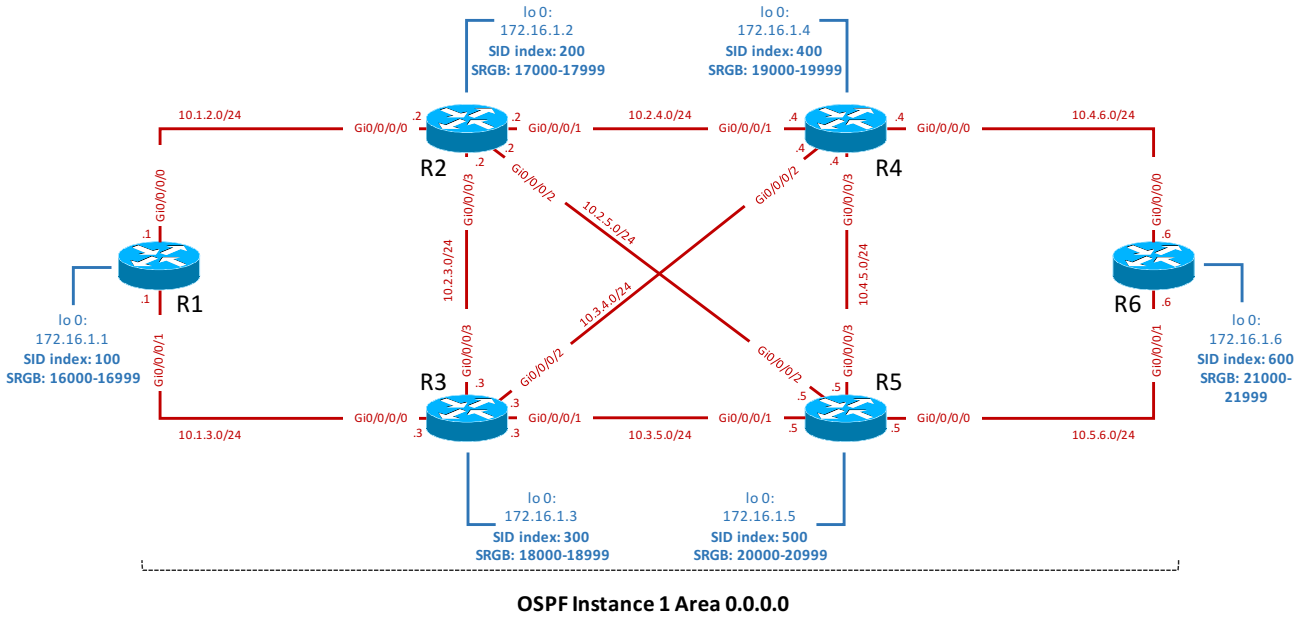


After the base Segment Routing configuration there will be a number of node and adjacency SIDs allocated as per the table below:

Node SID	Adjacency SID
R1=> 16001	R1=>R2
R2=> 16002	R2=>R1
R3=> 16003	R1=>R3
R4=> 16004	R3=>R1
R5=> 16005	R2=>R3
R6=> 16006	R3=>R2
	R2=>R4
	R4=>R2
	R2=>R5
	R5=>R2
	R3=>R4
	R4=>R3
	R3=>R5
	R5=>R3
	R4=>R5
	R5=>R4
	R4=>R6
	R6=>R4
	R5=>R6
	R6=>R5

Part 2. Using SID index values with different SRGBs on all routers

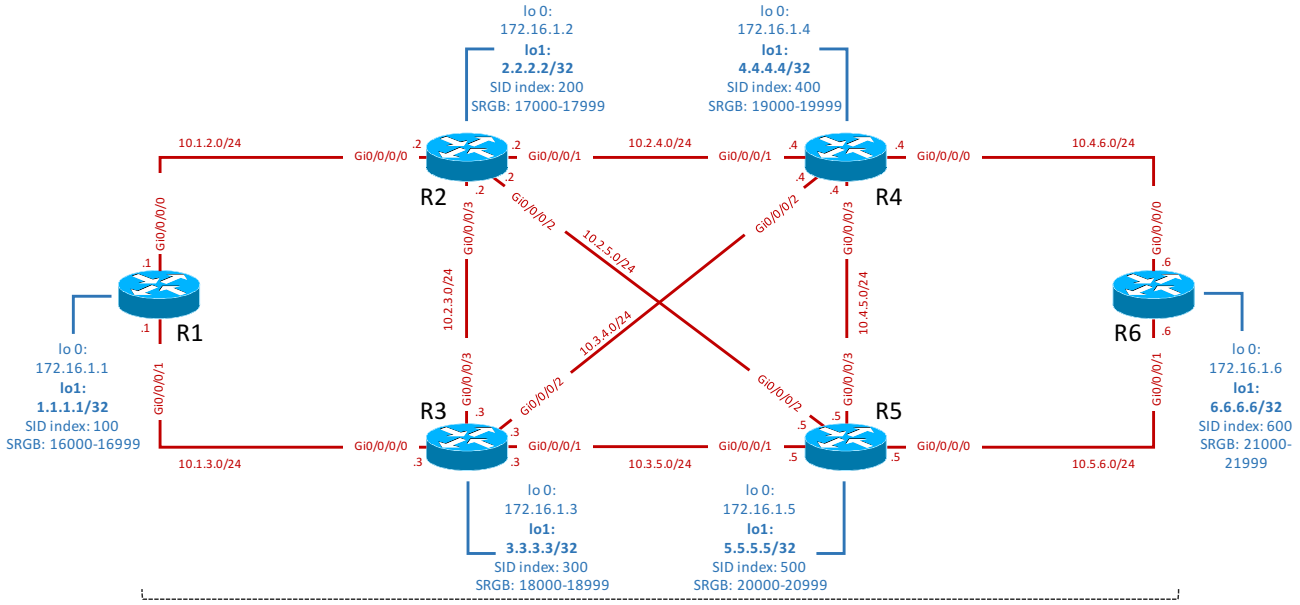
The following reflects the Segment Routing configuration using SID index values and different SRGBs.



In this part, we use indexes instead of absolute SID values. In addition, we configure different SRGBs on each of the routers.

Part 3. Traffic-engineering Segment Routing tunnel

The following figure includes the additional configuration required for this part.



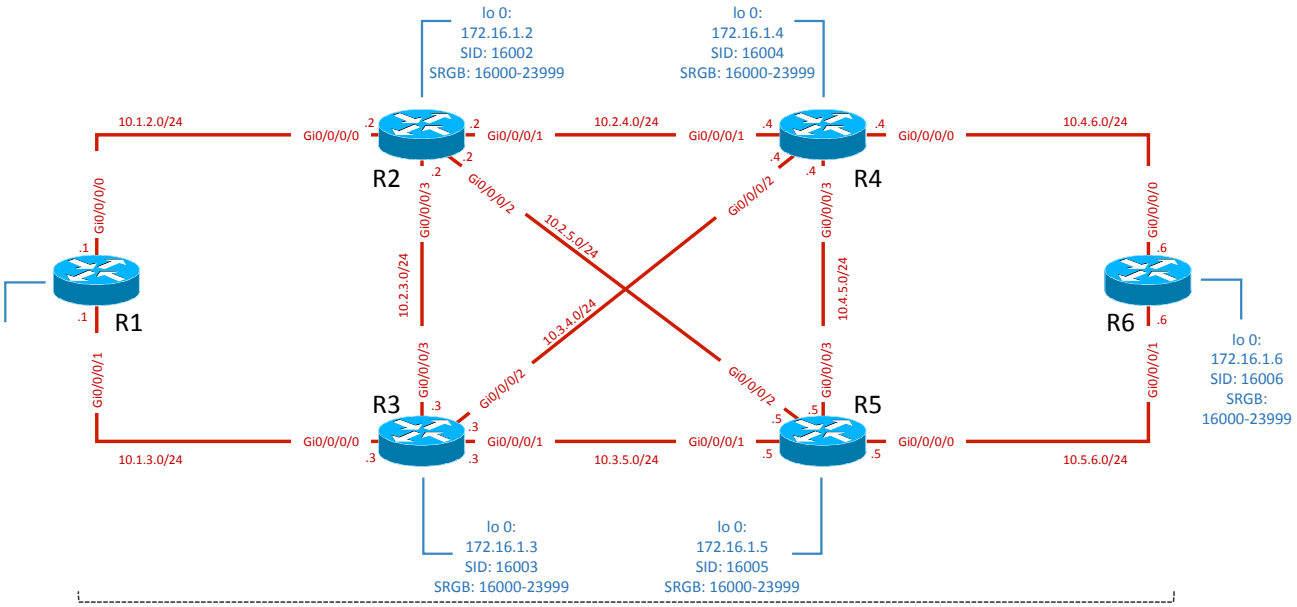
We configure explicitly-routed traffic-engineered paths and resolve them using Segment Routing SIDs. Each router configures a unique path as per the table below.

Router	Destination	Path
R1	R6	R1-R2-R3-R4-R5-R6
R2	R1	R2-R4-R6-R5-R3-R1
R3	R5	R3-R1-R2-R4-R6-R5
R4	R2	R4-R6-R5-R3-R1-R2
R5	R6	R5-R3-R1-R2-R4-R6
R6	R1	R6-R4-R5-R2-R3-R1

Lab Exercise

1. Base Segment Routing configuration:

The following figure reflects the base Segment Routing configuration.



Here is an example configuration for R1

```
config t
mpls traffic-eng
```
! Enables traffic engineering functionality on the node.

```
router ospf 1
segment-routing global-block 16000 23999
```
! Configure the SRGB for this node

```
segment-routing mpls
```
! Enables Segment Routing using the mpls dataplane. Also enables Segment Routing on all areas and interfaces. Is also required to install SIDs received by OSPF into the forwarding table.

```
mpls traffic-eng router-id loopback0
```
! Configures loopback 0 as the traffic-engineering router identifier.

```
area 0.0.0.0
mpls traffic-eng
```
! Enables traffic-engineering functionality for OSPF.

```
interface loopback 0
prefix-sid absolute 16001
```
! Assigns an absolute SID value to loopback 0 (your SID value will depend on your router as per the figure)

```
end
```

Please wait for all routers in your group to be configured before you issue the following verification commands. Please also do not move to the next part until advised to do so by your instructors.

Verify your configuration:

Use the following commands to verify the operation of Segment Routing:

```
show mpls label table detail
```
! Ensure you thoroughly understand each entry.

```
show mpls label range
```

```
show mpls forwarding
show mpls forwarding labels 16006 detail
```
! Select a label value for a router other than your own.

```
show ospf database opaque-area self-originate
```
! Shows contents of the opaque area-scope LSAs originated by the router in detail.

```
show ip cef 172.16.1.6/32
```
! Select a loopback address for a router other than your own.

```
ping mpls nil-fec labels 16006 output interface gigabitEthernet 0/0/0/0 nexthop
10.1.2.2
```
! Ping a loopback prefix SID for a router other than your own. Change output interface and next-hop accordingly.

```
trace mpls nil-fec labels 16006 output interface gigabitEthernet 0/0/0/0
nexthop 10.1.2.2
```
! Trace a loopback prefix SID for a router other than your own. Change output interface and next-hop accordingly.

Segment Routing Debugging

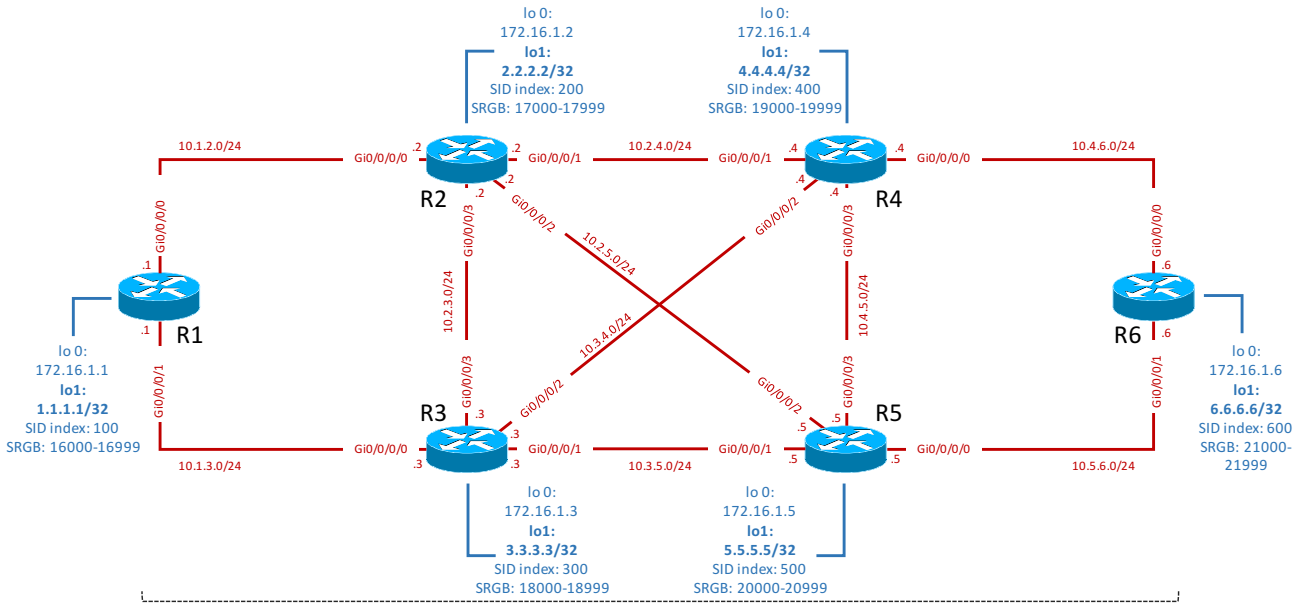
```
debug mpls packet
```

```
show logging
```

```
debug no debug mpls packet
```

2. Using SID index values with different SRGBs on all routers

The following figure includes the additional configuration required for this part.



Here is an example configuration for R1

```
config t

router ospf 1
area 0.0.0.0
interface loopback 0
prefix-sid index 100
```

! Assigns a SID index of 100 to loopback 0 (your index will depend on your router as per the figure)

```
exit
exit
segment-routing global-block 16000 16999
```

! Changes the SRGB of the node to 16000-16999 (your range will depend on your router as per the figure)

```
end
```

Please wait for all routers in your group to be configured before you issue the following verification commands. Please also do not move to the next part until advised to do so by your instructors.

Verify your configuration:

Use the following commands to verify the operation of Segment Routing:

```
show mpls label table detail
```

! Ensure you thoroughly understand each entry.

```
show mpls label range

show mpls forwarding
show mpls forwarding labels 16600 detail
```
! Select a label value for a router other than your own.

```
show ospf database opaque-area self-originate
```
! Shows contents of the opaque area-scope LSAs originated by the router in detail.

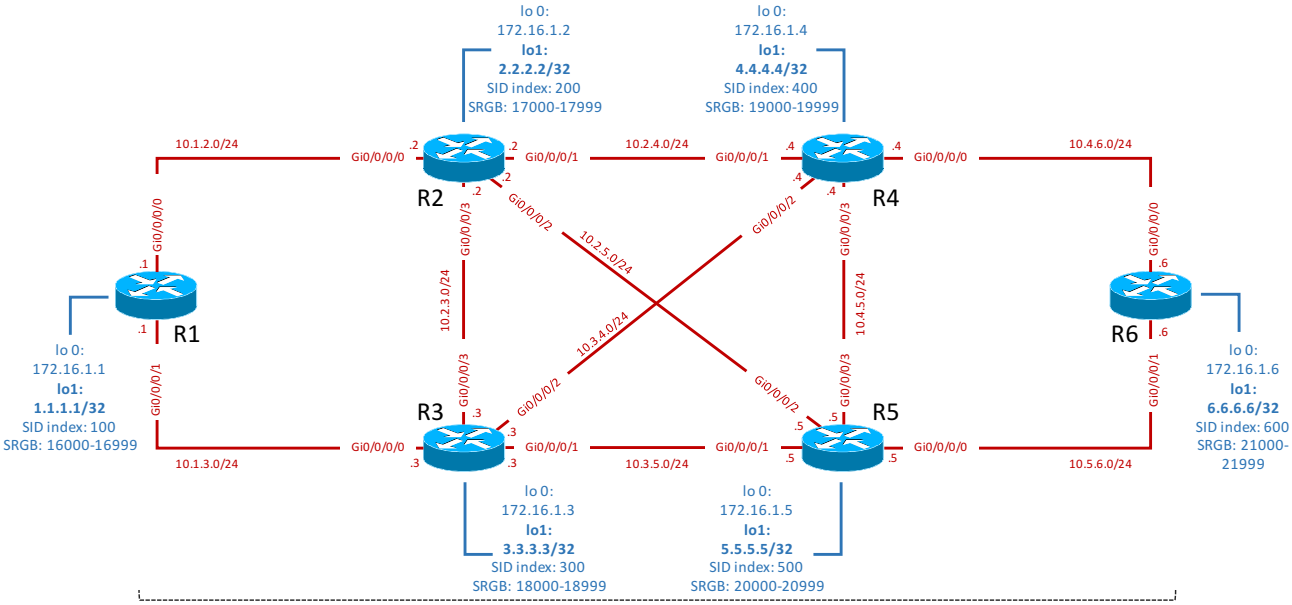
```
show ip cef 172.16.1.6/32
```
! Select a loopback address for a router other than your own.

```
ping mpls nil-fec labels 17600 output interface gigabitEthernet 0/0/0/0 nexthop
10.1.2.2
```
! Ping a loopback prefix SID for a router other than your own. Change output interface and next-hop accordingly.

```
trace mpls nil-fec labels 17600 output interface gigabitEthernet 0/0/0/0
nexthop 10.1.2.2
```
! Trace a loopback prefix SID for a router other than your own. Change output interface and next-hop accordingly.

3. Traffic-engineering Segment Routing tunnel

The following figure includes the additional configuration required for this part.



Each router needs to be configured with a different explicit tunnel as per the table below.

Router	Destination	Path
R1	R6	R1-R2-R3-R4-R5-R6
R2	R1	R2-R4-R6-R5-R3-R1
R3	R5	R3-R1-R2-R4-R6-R5
R4	R2	R4-R6-R5-R3-R1-R2
R5	R6	R5-R3-R1-R2-R4-R6
R6	R1	R6-R4-R5-R2-R3-R1

Here is an example configuration for R1 based on the above table.

```
conf t
explicit-path name SR-TE-PATH-1
 index 1 next-address strict ipv4 unicast 172.16.1.2
 index 2 next-address strict ipv4 unicast 172.16.1.3
 index 3 next-address strict ipv4 unicast 172.16.1.4
 index 4 next-address strict ipv4 unicast 172.16.1.5
 index 5 next-address strict ipv4 unicast 172.16.1.6
 !
exit
```

! create an explicit path named SR-TE-PATH-1 with an explicitly-specified list of hops

```
interface tunnel-te0
 ipv4 unnumbered Loopback0
 destination 172.16.1.6
 path-option 1 explicit name SR-TE-PATH-1 segment-routing
!
```

! create a tunnel interface with a destination of R6 and link the previously-created explicit path SR-TE-PATH-1 with it

```
int lo1
 ipv4 address 1.1.1.1/32
 exit
```

! create a new loopback address on the router (use the address corresponding to your router as per the diagram)

! create a static route to R6's loopback address (choose a target router based on the destination of the tunnel interface created earlier)

```
router static
address-family ipv4 unicast
6.6.6.6/32 tunnel-te0
exit
```

Please wait for all routers in your group to be configured before you issue the following verification commands.

Verify your configuration:

Use the following commands to verify your configuration:

```
show mpls traffic-eng tunnels 0 detail
```

! Ensure you thoroughly understand the output and, in particular, the resolution of the IP loopback addresses to SID values.

```
ping 6.6.6.6
```
! verify the static route

Workshop templates for reference purpose only:

R1

Base Segment Routing configuration

```
config t
mpls traffic-eng
router ospf 1
segment-routing global-block 16000 23999
segment-routing mpls
mpls traffic-eng router-id loopback0
area 0.0.0.0
mpls traffic-eng
interface loopback 0
prefix-sid absolute 16001
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 16006 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.6/32
ping mpls nil-fec labels 16006 output interface gigabitEthernet 0/0/0/0 nexthop
10.1.2.2
trace mpls nil-fec labels 16006 output interface gigabitEthernet 0/0/0/0
nexthop 10.1.2.2
```

Using SID index values with different SRGBs on all routers

```
config t
router ospf 1
area 0.0.0.0
interface loopback 0
prefix-sid index 100
exit
exit
segment-routing global-block 16000 16999
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 16600 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.6/32
ping mpls nil-fec labels 17600 output interface gigabitEthernet 0/0/0/0 nexthop
10.1.2.2
trace mpls nil-fec labels 17600 output interface gigabitEthernet 0/0/0/0
nexthop 10.1.2.2
```

Traffic-engineering Segment Routing tunnel

```
conf t
explicit-path name SR-TE-PATH-1
index 1 next-address strict ipv4 unicast 172.16.1.2
index 2 next-address strict ipv4 unicast 172.16.1.3
index 3 next-address strict ipv4 unicast 172.16.1.4
index 4 next-address strict ipv4 unicast 172.16.1.5
index 5 next-address strict ipv4 unicast 172.16.1.6
!
exit
interface tunnel-te0
ipv4 unnumbered Loopback0
destination 172.16.1.6
path-option 1 explicit name SR-TE-PATH-1 segment-routing
!
int lo1
ipv4 address 1.1.1.1/32
exit
!
router static
address-family ipv4 unicast
6.6.6.6/32 tunnel-te0
exit
!
end
```

Verification Commands:

```
show mpls traffic-eng tunnels 0 detail
ping 6.6.6.6
```

R2

Base Segment Routing configuration

```
config t
mpls traffic-eng
router ospf 1
segment-routing global-block 16000 23999
segment-routing mpls
mpls traffic-eng router-id loopback0
area 0.0.0.0
mpls traffic-eng
interface loopback 0
prefix-sid absolute 16002
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 16006 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.6/32
ping mpls nil-fec labels 16006 output interface gigabitEthernet 0/0/0/1 nexthop
10.2.4.4
trace mpls nil-fec labels 16006 output interface gigabitEthernet 0/0/0/1
nexthop 10.2.4.4
```

Using SID index values with different SRGBs on all routers

```
config t
router ospf 1
area 0.0.0.0
interface loopback 0
prefix-sid index 200
exit
exit
segment-routing global-block 17000 17999
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 17600 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.6/32
ping mpls nil-fec labels 19600 output interface gigabitEthernet 0/0/0/1 nexthop
10.2.4.4
trace mpls nil-fec labels 19600 output interface gigabitEthernet 0/0/0/1
nexthop 10.2.4.4
```

Traffic-engineering Segment Routing tunnel

```
conf t
explicit-path name SR-TE-PATH-1
index 1 next-address strict ipv4 unicast 172.16.1.4
index 2 next-address strict ipv4 unicast 172.16.1.6
index 3 next-address strict ipv4 unicast 172.16.1.5
index 4 next-address strict ipv4 unicast 172.16.1.3
index 5 next-address strict ipv4 unicast 172.16.1.1
!
exit
interface tunnel-te0
ipv4 unnumbered Loopback0
destination 172.16.1.1
path-option 1 explicit name SR-TE-PATH-1 segment-routing
!
int lo1
ipv4 address 2.2.2.2/32
exit
!
router static
address-family ipv4 unicast
1.1.1.1/32 tunnel-te0
exit
!
end
```

Verification Commands:

```
show mpls traffic-eng tunnels 0 detail
ping 1.1.1.1
```

R3

Base Segment Routing configuration

```
config t
mpls traffic-eng
router ospf 1
segment-routing global-block 16000 23999
segment-routing mpls
mpls traffic-eng router-id loopback0
area 0.0.0.0
mpls traffic-eng
interface loopback 0
prefix-sid absolute 16003
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 16006 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.6/32
ping mpls nil-fec labels 16006 output interface gigabitEthernet 0/0/0/1 nexthop
10.3.5.5
trace mpls nil-fec labels 16006 output interface gigabitEthernet 0/0/0/1
nexthop 10.3.5.5
```

Using SID index values with different SRGBs on all routers

```
config t
router ospf 1
area 0.0.0.0
interface loopback 0
prefix-sid index 300
exit
exit
segment-routing global-block 18000 18999
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 18600 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.6/32
ping mpls nil-fec labels 20600 output interface gigabitEthernet 0/0/0/1 nexthop
10.3.5.5
trace mpls nil-fec labels 20600 output interface gigabitEthernet 0/0/0/1
nexthop 10.3.5.5
```

Traffic-engineering Segment Routing tunnel

```
conf t
explicit-path name SR-TE-PATH-1
index 1 next-address strict ipv4 unicast 172.16.1.1
index 2 next-address strict ipv4 unicast 172.16.1.2
index 3 next-address strict ipv4 unicast 172.16.1.4
index 4 next-address strict ipv4 unicast 172.16.1.6
index 5 next-address strict ipv4 unicast 172.16.1.5
!
exit
interface tunnel-te0
ipv4 unnumbered Loopback0
destination 172.16.1.5
path-option 1 explicit name SR-TE-PATH-1 segment-routing
!
int lo1
ipv4 address 3.3.3.3/32
exit
!
router static
address-family ipv4 unicast
5.5.5.5/32 tunnel-te0
exit
!
end
```

Verification Commands:

```
show mpls traffic-eng tunnels 0 detail
ping 5.5.5.5
```

R4

Base Segment Routing configuration

```
config t
mpls traffic-eng
router ospf 1
segment-routing global-block 16000 23999
segment-routing mpls
mpls traffic-eng router-id loopback0
area 0.0.0.0
mpls traffic-eng
interface loopback 0
prefix-sid absolute 16004
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 16006 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.1/32
ping mpls nil-fec labels 16001 output interface gigabitEthernet 0/0/0/1 nexthop
10.2.4.2
trace mpls nil-fec labels 16001 output interface gigabitEthernet 0/0/0/1
nexthop 10.2.4.2
```

Using SID index values with different SRGBs on all routers

```
config t
router ospf 1
area 0.0.0.0
interface loopback 0
prefix-sid index 400
exit
exit
segment-routing global-block 19000 19999
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 19100 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.1/32
ping mpls nil-fec labels 17100 output interface gigabitEthernet 0/0/0/1 nexthop
10.2.4.2
trace mpls nil-fec labels 17100 output interface gigabitEthernet 0/0/0/1
nexthop 10.2.4.2
```

Traffic-engineering Segment Routing tunnel

```
conf t
explicit-path name SR-TE-PATH-1
index 1 next-address strict ipv4 unicast 172.16.1.6
index 2 next-address strict ipv4 unicast 172.16.1.5
index 3 next-address strict ipv4 unicast 172.16.1.3
index 4 next-address strict ipv4 unicast 172.16.1.1
index 5 next-address strict ipv4 unicast 172.16.1.2
!
exit
interface tunnel-te0
ipv4 unnumbered Loopback0
destination 172.16.1.2
path-option 1 explicit name SR-TE-PATH-1 segment-routing
!
int lo1
ipv4 address 4.4.4.4/32
exit
!
router static
address-family ipv4 unicast
2.2.2.2/32 tunnel-te0
exit
!
end
```

Verification Commands:

```
show mpls traffic-eng tunnels 0 detail
ping 2.2.2.2
```

R5

Base Segment Routing configuration

```
config t
mpls traffic-eng
router ospf 1
segment-routing global-block 16000 23999
segment-routing mpls
mpls traffic-eng router-id loopback0
area 0.0.0.0
mpls traffic-eng
interface loopback 0
prefix-sid absolute 16005
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 16001 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.1/32
ping mpls nil-fec labels 16001 output interface gigabitEthernet 0/0/0/1 nexthop
10.3.5.3
trace mpls nil-fec labels 16001 output interface gigabitEthernet 0/0/0/1
nexthop 10.3.5.3
```

Using SID index values with different SRGBs on all routers

```
config t
router ospf 1
area 0.0.0.0
interface loopback 0
prefix-sid index 500
exit
exit
segment-routing global-block 20000 20999
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 20100 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.1/32
ping mpls nil-fec labels 18100 output interface gigabitEthernet 0/0/0/1 nexthop
10.3.5.3
trace mpls nil-fec labels 18100 output interface gigabitEthernet 0/0/0/1
nexthop 10.3.5.3
```

Traffic-engineering Segment Routing tunnel

```
conf t
explicit-path name SR-TE-PATH-1
index 1 next-address strict ipv4 unicast 172.16.1.3
index 2 next-address strict ipv4 unicast 172.16.1.1
index 3 next-address strict ipv4 unicast 172.16.1.2
index 4 next-address strict ipv4 unicast 172.16.1.4
index 5 next-address strict ipv4 unicast 172.16.1.6
!
exit
interface tunnel-te0
ipv4 unnumbered Loopback0
destination 172.16.1.6
path-option 1 explicit name SR-TE-PATH-1 segment-routing
!
int lo1
ipv4 address 5.5.5.5/32
exit
!
router static
address-family ipv4 unicast
6.6.6.6/32 tunnel-te0
exit
!
end
```

Verification Commands:

```
show mpls traffic-eng tunnels 0 detail
ping 6.6.6.6
```

R6

Base Segment Routing configuration

```
config t
mpls traffic-eng
router ospf 1
segment-routing global-block 16000 23999
segment-routing mpls
mpls traffic-eng router-id loopback0
area 0.0.0.0
mpls traffic-eng
interface loopback 0
prefix-sid absolute 16006
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 16001 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.1/32
ping mpls nil-fec labels 16001 output interface gigabitEthernet 0/0/0/1 nexthop
10.5.6.5
trace mpls nil-fec labels 16001 output interface gigabitEthernet 0/0/0/1
nexthop 10.5.6.5
```

Using SID index values with different SRGBs on all routers

```
config t
router ospf 1
area 0.0.0.0
interface loopback 0
prefix-sid index 600
exit
exit
segment-routing global-block 21000 21999
end
```

Verification Commands:

```
show mpls label table detail
show mpls label range
show mpls forwarding
show mpls forwarding labels 21100 detail
show ospf database opaque-area self-originate
show ip cef 172.16.1.1/32
ping mpls nil-fec labels 20100 output interface gigabitEthernet 0/0/0/1 nexthop
10.5.6.5
trace mpls nil-fec labels 20100 output interface gigabitEthernet 0/0/0/1
nexthop 10.5.6.5
```

Traffic-engineering Segment Routing tunnel

```
conf t
explicit-path name SR-TE-PATH-1
index 1 next-address strict ipv4 unicast 172.16.1.4
index 2 next-address strict ipv4 unicast 172.16.1.5
index 3 next-address strict ipv4 unicast 172.16.1.2
index 4 next-address strict ipv4 unicast 172.16.1.3
index 5 next-address strict ipv4 unicast 172.16.1.1
!
exit
interface tunnel-te0
ipv4 unnumbered Loopback0
destination 172.16.1.1
path-option 1 explicit name SR-TE-PATH-1 segment-routing
!
int lo1
ipv4 address 6.6.6.6/32
exit
!
router static
address-family ipv4 unicast
1.1.1.1/32 tunnel-te0
exit
!
end
```

Verification Commands:

```
show mpls traffic-eng tunnels 0 detail
ping 1.1.1.1
```