



# Segment Routing Bootcamp Lab



# Prerequisite

Please access and reserve <http://dcloud.cisco.com>  
Cisco WAN Automation Engine 7.1.1.1 - Segment Routing and XTC  
Sandbox v1

Please connect dcloud vpn anyconnect and test Telnet Session to every nodes

Please have python 2.7 installed in the laptop

← → C https://dcloud2-sng.cisco.com/session/282934/details?returnPathTitleKey=view-session&isLoggingIn=true | Paused r

Node-5 - SecureCRT

Cisco AnyConnect Secure Mobility Client

File Edit View Options

Node-1 Node-4

SR/XTC Learn We are All ac this

VPN:  
Connected to dcloud-sng-anyconnect.cisco.com.

dcloud-sng-anyconnect.cisco.com Disconnect

00:03:24 IPv4

Roaming Security:  
You are protected by Umbrella.  
DNS queries are encrypted.

Virtual Center: 4

AnyConnect Credentials

Host dcloud-sng-anyconnect.cisco.com

User v582user1

Password 1f3b75

Command Prompt - python

^C

C:\Users\htjun\python\srv-odn>python

Python 2.7.14 (v2.7.14:84471935ed, Sep 16 2017, 20:19:30) [MSC v.1500 32 bit (Intel)]

Type "help", "copyright", "credits" or "license" for more information.

>>>

>>> -

# Session Details

Virtual Center: 4

## AnyConnect Credentials

Connect up to 16 devices to the session via Cisco AnyConnect.

Host dcloud-sng-anyconnect.cisco.com

User v582user1

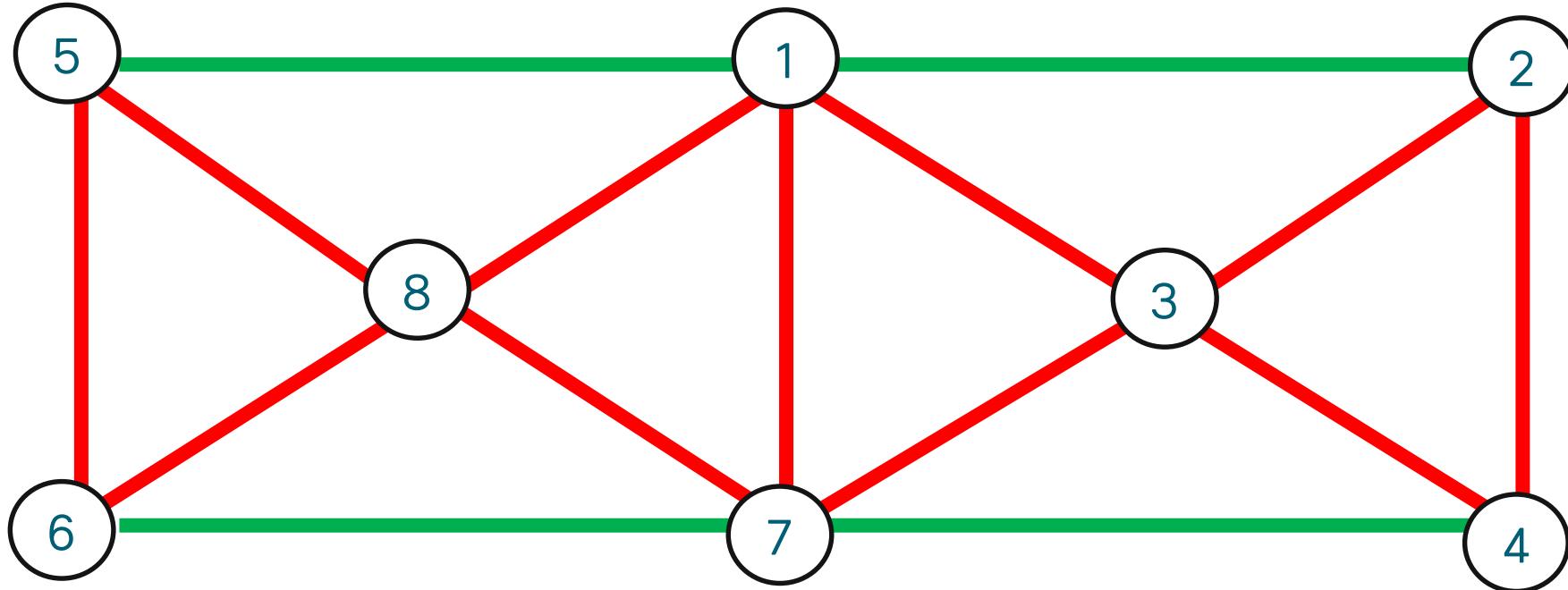
Password 1f3b75



- 0. Understanding SR Lab Topology
- Segment Routing (simplicity)
- Prefix SID
- Adjacency SID
- TI-LFA (auto FRR - protection)
- SR ECMP (auto load balance)



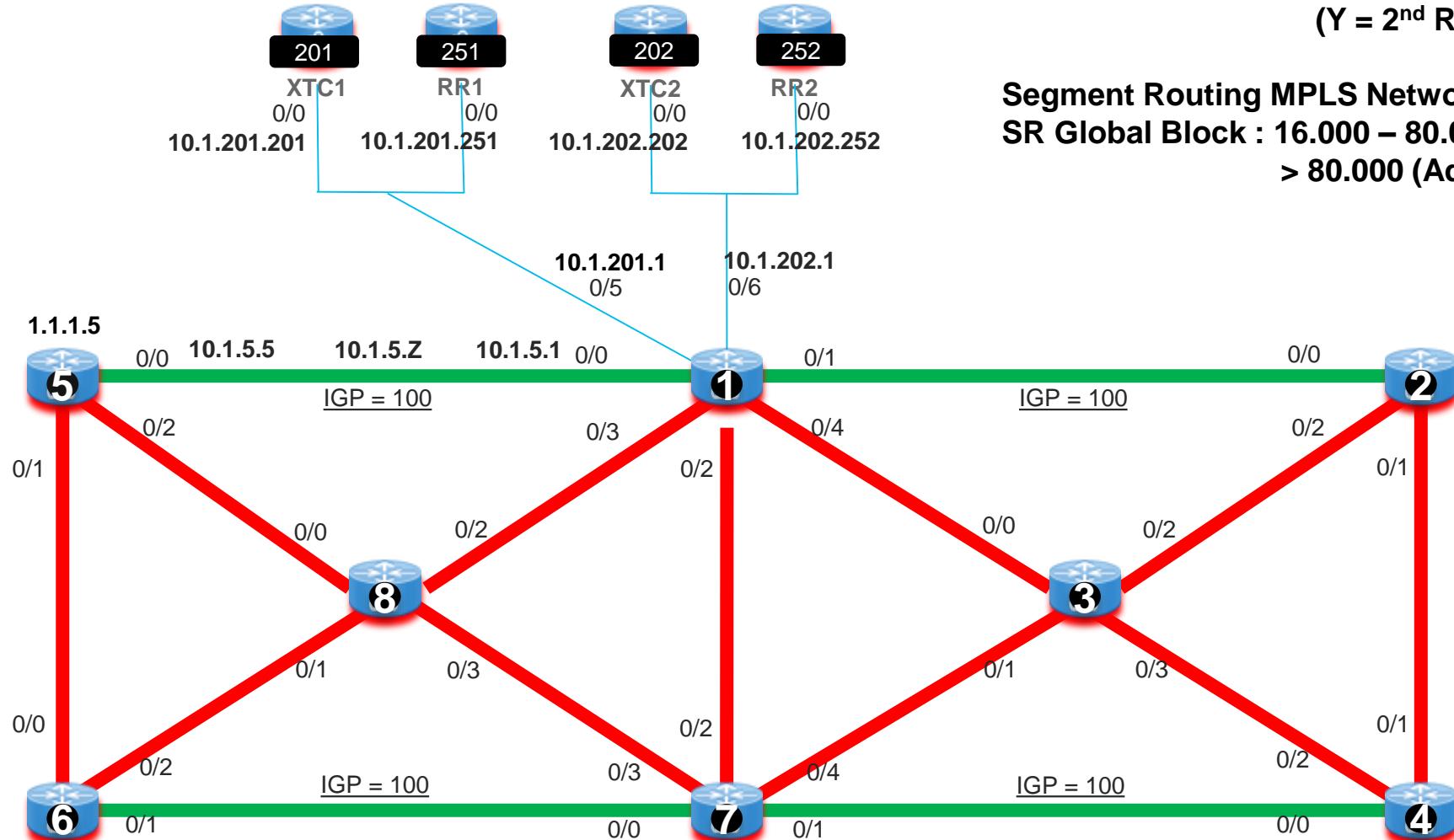
# Lab Topology



# Topology

BGP VPN

ISIS + SR  
IP  
+  
XTC



Lo0 IP = 1.1.1.Z      (Z = Local Router Number )  
Inft IP = 10.X.Y.Z      (X = 1<sup>st</sup> Router Number )  
(Y = 2<sup>nd</sup> Router Number )

Segment Routing MPLS Network  
SR Global Block : 16.000 – 80.000 (Prefix SID)  
> 80.000 (Adj SID)

# Lab Access Credential

Server	IP	Port	Loopback	User Name	Password
Node-1	198.18.1.41	23	1.1.1.1	cisco	cisco
Node-2	198.18.1.42	23	1.1.1.2	cisco	cisco
Node-3	198.18.1.43	23	1.1.1.3	cisco	cisco
Node-4	198.18.1.44	23	1.1.1.4	cisco	cisco
Node-5	198.18.1.45	23	1.1.1.5	cisco	cisco
Node-6	198.18.1.46	23	1.1.1.6	cisco	cisco
Node-7	198.18.1.47	23	1.1.1.7	cisco	cisco
Node-8	198.18.1.48	23	1.1.1.8	cisco	cisco
XTC-1	198.18.1.31	23	1.1.1.201	cisco	cisco
XTC-2	198.18.1.32	23	1.1.1.202	cisco	cisco
RR-1	198.18.1.52	23	1.1.1.251	cisco	cisco
RR-2	198.18.1.53	23	1.1.1.252	cisco	cisco

# SR Predefined Configuration

Show run router isis

Show run router bgp

Show run segment-routing

Show run mpls ldp

Show run mpls traffic-engineering

Show mpls ldp neighbor

Show mpls forwarding

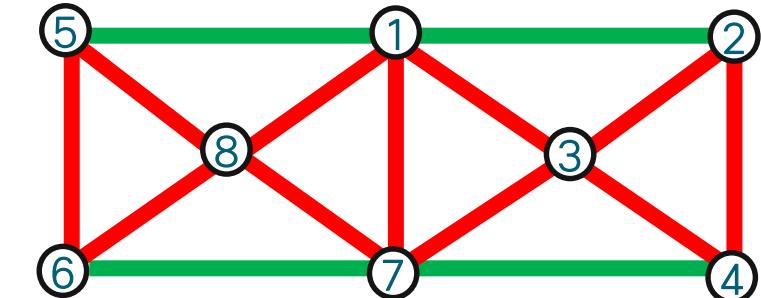
Show isis adjacency detail

Show route

Show route 1.1.1.1 detail

Show cef 1.1.1.1/32 detail

Show mpls forwarding labels 16001 detail

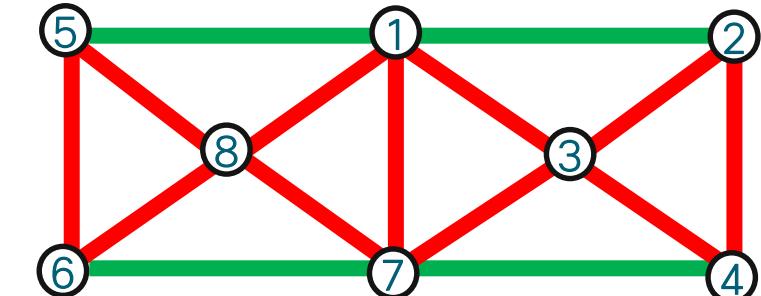


# SR ECMP

```
@Node 5  
Ping 1.1.1.4  
Ping sr-mpls 1.1.1.4/32
```

```
Trace 1.1.1.4  
Trace sr-mpls 1.1.1.4/32  
trace sr-mpls multipath 1.1.1.4/32 verbose
```

Stop Traffic Generator @ dcloud control page  
Stop > disable traffic



```
@Node 8  
Monitor interface g0/0/0/0 g0/0/0/2 g0/0/0/3  
Add 2 telnet Node-8  
Trace 1.1.1.4 source 10.5.8.8  
Trace 1.1.1.4 source 10.6.8.8  
Ping 1.1.1.4 source 10.5.8.8 repeat 100000  
Ping 1.1.1.4 source 10.6.8.8 repeat 100000  
Show Route
```

```
@Node 4  
Trace 10.5.8.8  
Trace 10.6.8.8
```

Python node-8-shut-int-g2.py  
Python node-8-no-shut-int-g2.py

198.18.133.1:8000/stop    WAE Lab Overview    Login    WAE    Welcome to dCloud    198.18.133.1:12012/?sim\_i

Not secure | 198.18.133.1:8000/stop

Apps    Remote Control    dCloud Demo Document    NSO    WAE    Terminals    Live Visualization Engine    Eagle Eye

## Launch Progress

Command Groups

1 2 3 4 5 6 7 8 9 10

Start more info

Check more info

Stop more info

disableTraffic  
schedulerStop  
stopEagleEye  
stopNSO  
stopSitMan  
stopVirl

2019-02-10 04:53 Traffic stopped successfully

The Best Of X +

Node-8 - SecureCRT

File Edit View Options Transfer Script Tools Window Help

Node-8 X

Success rate is 99 percent (16023/16025), round-trip RP/0/0/CPU0:Node-8#

Node-8 - SecureCRT

File Edit View Options Transfer Script Tools Window Help

Node-1 Node-2 Node-3 Node-4 Node-5 Node-6 Node-7 Node-8 RR-1 XTC SysUptime

Monitor Time: 00:09:23

Protocol: General

Interface	In(bps)	Out(bps)	InBytes/Delta
Gi0/0/0/0	1000/ 0%	1000/ 0%	10.2G/1514
Gi0/0/0/2	2000/ 0%	2000/ 0%	21.5G/1598
Gi0/0/0/3	5000/ 0%	5000/ 0%	16.1G/84

Quit='q', Clear='c', Freeze='f', Thaw='t',  
 Next set='n', Prev set='p', Bytes='y', Packets='k'  
 (General='g', IPv4 Uni='4u', IPv4 Multi='4m', IPv6 Uni='6u', I

c:\ Command Prompt

Sun Feb 10 05:36:36.138 UTC

Interface	IP-Address	Status	Protocol	Vrf-Name
Loopback0	1.1.1.8	Up	Up	default
MgmtEth0/0/CPU0/0	198.18.1.48	Up	Up	default
GigabitEthernet0/0/0/0	10.5.8.8	Up	Up	default
GigabitEthernet0/0/0/1	10.6.8.8	Up	Up	default
GigabitEthernet0/0/0/2	10.1.8.8	Up	Up	default
GigabitEthernet0/0/0/3	10.7.8.8	Up	Up	default
GigabitEthernet0/0/0/4	10.11.12.8	Up	Up	default
RP/0/0/CPU0:Node-8#exit				

C:\Users\htjun\python\sr-odn>python node-8-no-shut-int-2.py

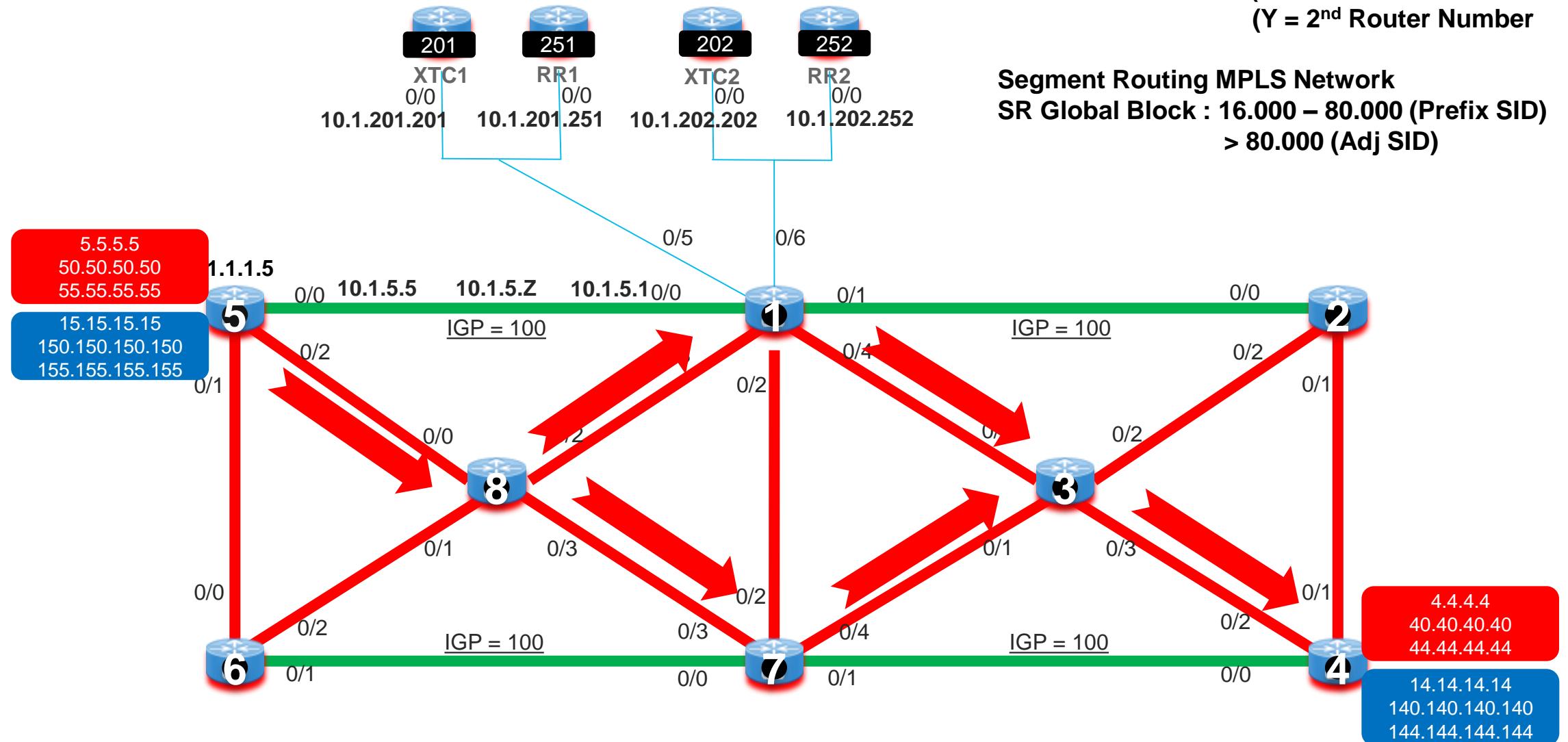
2/10/2019



1. Build VPNV4 on SR Lab  
vrf red  
vrf blue  
SR ECMP



# VPNv4 Topology



# VPNv4 vrf red blue

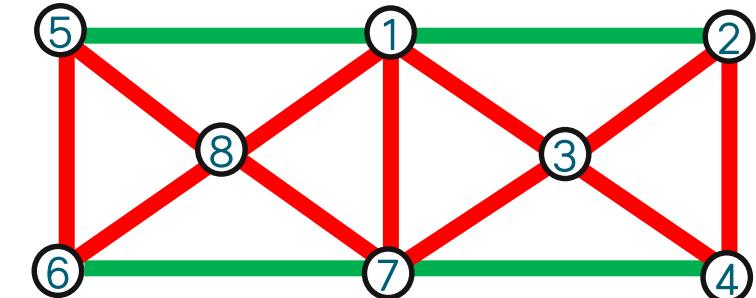
Python node-4-vrf-red-blue.py  
Python node-5-vrf-red-blue.py

@Node4 & 5  
Show config commit change last 1

@Node5  
Show bgp vpnv4 uni sum  
Show bgp vpnv4 uni  
Show route vrf red

Show mpls forward  
Show cef vrf red 4.4.4.4

Trace vrf red 4.4.4.4 source 5.5.5.5  
Trace vrf red 4.4.4.4 source 50.50.50.50

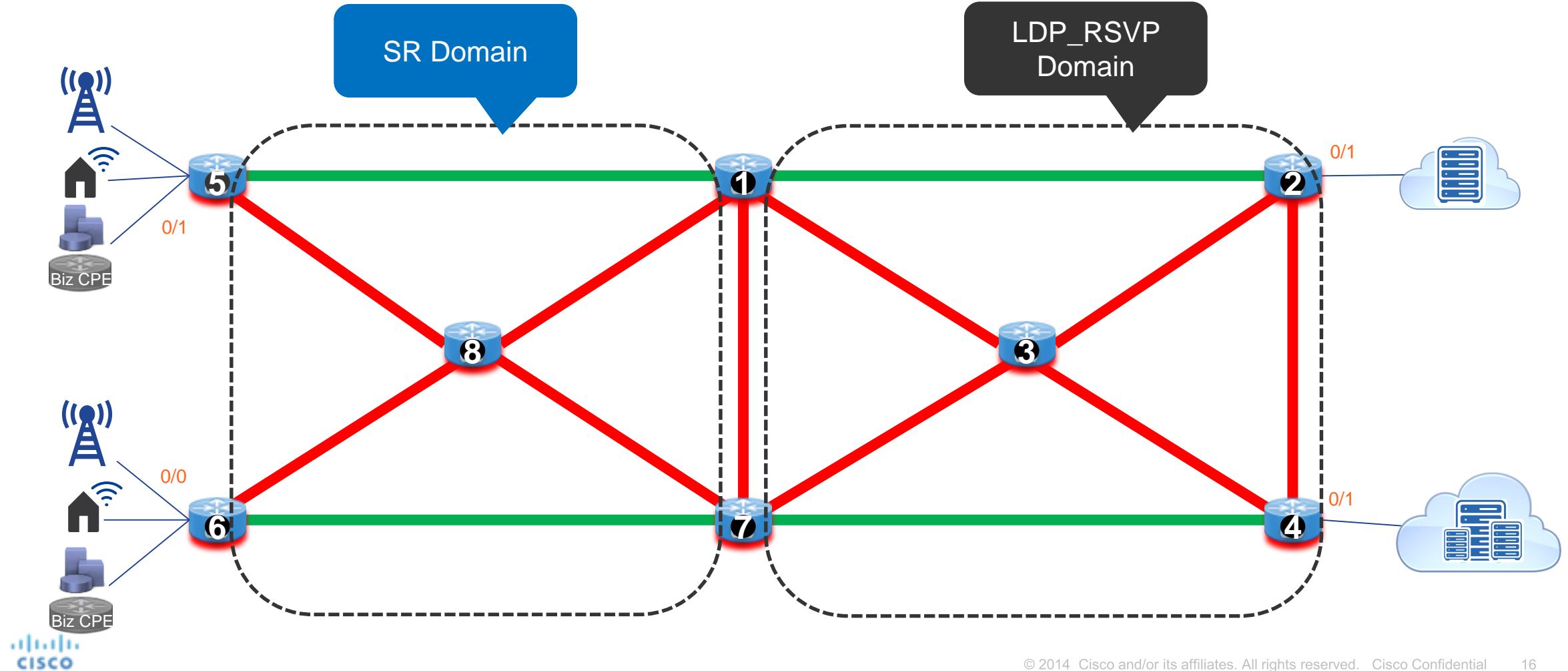




## 2. Build SR Domain + LDP-RSVP Domain Use Case P - PE



# SR + LDP\_RSVP Topology



# Enable LDP\_RSVP @1,2,3,4,7 Disable SR @2,3,4

```
Python node-1 intf-rsvp-ldp  
Python node-2 intf-rsvp-ldp  
Python node-3 intf-rsvp-ldp  
Python node-4 intf-rsvp-ldp  
Python node-7 intf-rsvp-ldp
```

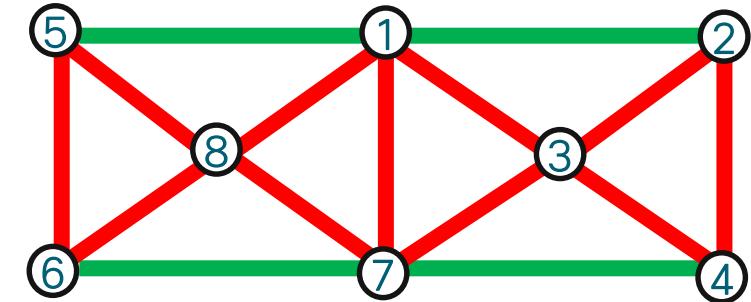
```
Python node-2 no-migrate-to-sr  
Python node-3 no-migrate-to-sr  
Python node-4 no-migrate-to-sr
```

@Node 2,3,4  
Show mpls forwarding (complexity)  
Dependency igp-ldp sync

sh mpls for | util wc lines  
sh route | util wc lines

@Node5  
Show route  
Ping sr-mpls 1.1.1.1/32  
Ping sr-mpls 1.1.1.4/32  
Show mpls forwarding  
Show cef 1.1.1.1/32  
Show cef 1.1.1.4/32  
Ping vrf red 4.4.4.4  
Show cef vrf red 4.4.4.4

@Node4  
Show route  
Ping mpls ipv4 1.1.1.7/32  
Ping mpls ipv4 1.1.1.5/32 fec generic  
Show mpls forwarding  
Show cef 1.1.1.5/32  
Show mpls for | in (label imposed)  
Ping vrf red 5.5.5.5  
Show cef vrf red 5.5.5.5

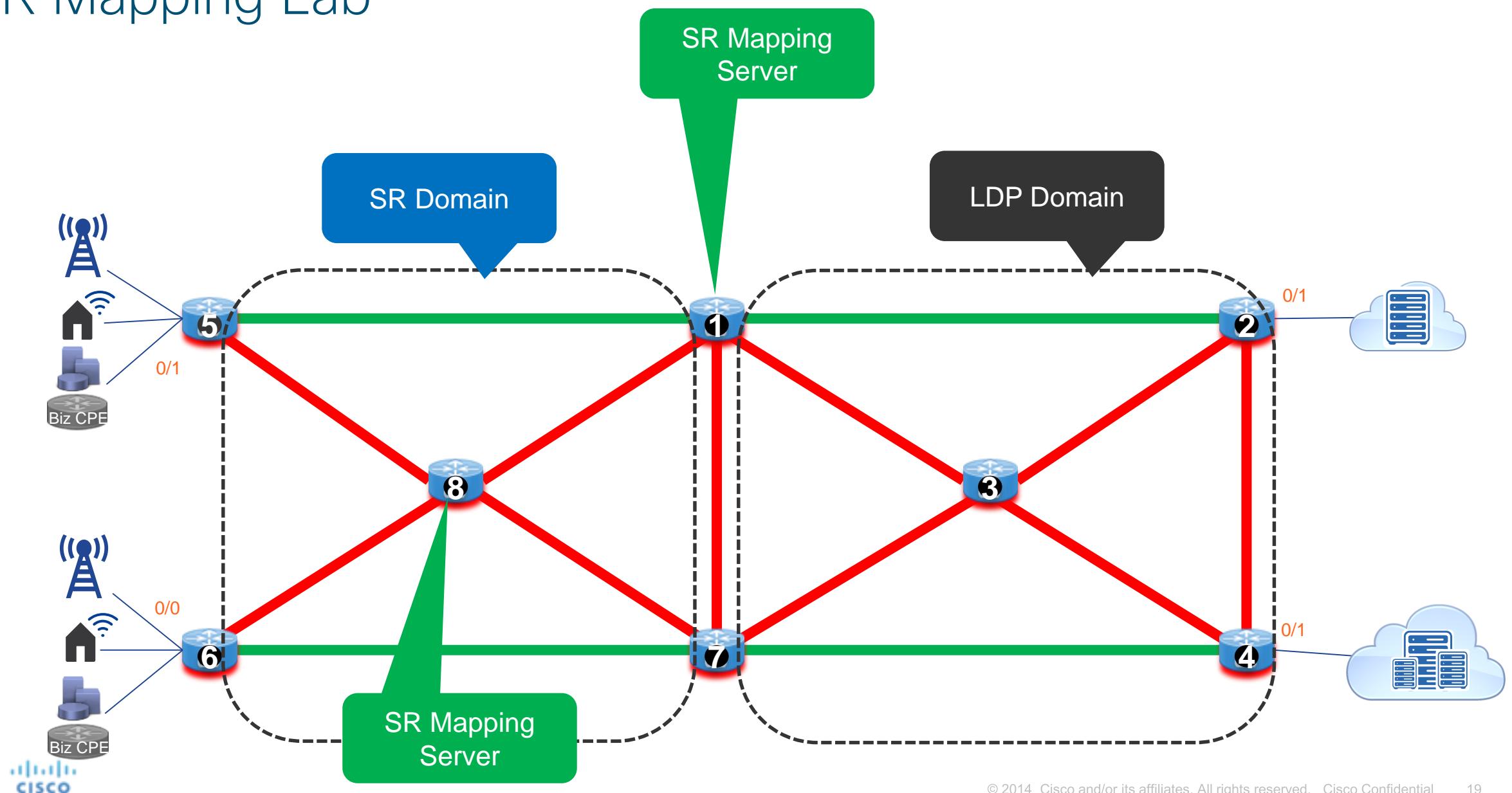




### 3. Build SR Mapping Server Interworking SR + LDP



# SR Mapping Lab



# Enable SR Mapping Server @1,8

```
Python node-1 sr-mapping  
Python node-8 sr-mapping
```

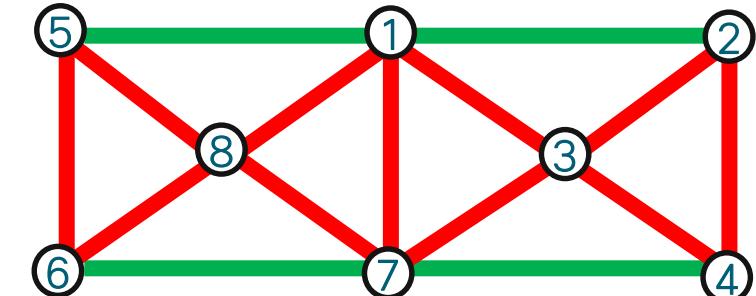
```
@Node5  
Show route  
Ping sr-mpls 1.1.1.1/32  
Ping sr-mpls 1.1.1.4/32  
Show mpls forwarding  
Show cef 1.1.1.4/32
```

```
@Node4  
Show route  
Ping mpls ipv4 1.1.1.7/32  
Ping mpls ipv4 1.1.1.5/32  
Show mpls forwarding  
Show cef 1.1.1.5/32
```

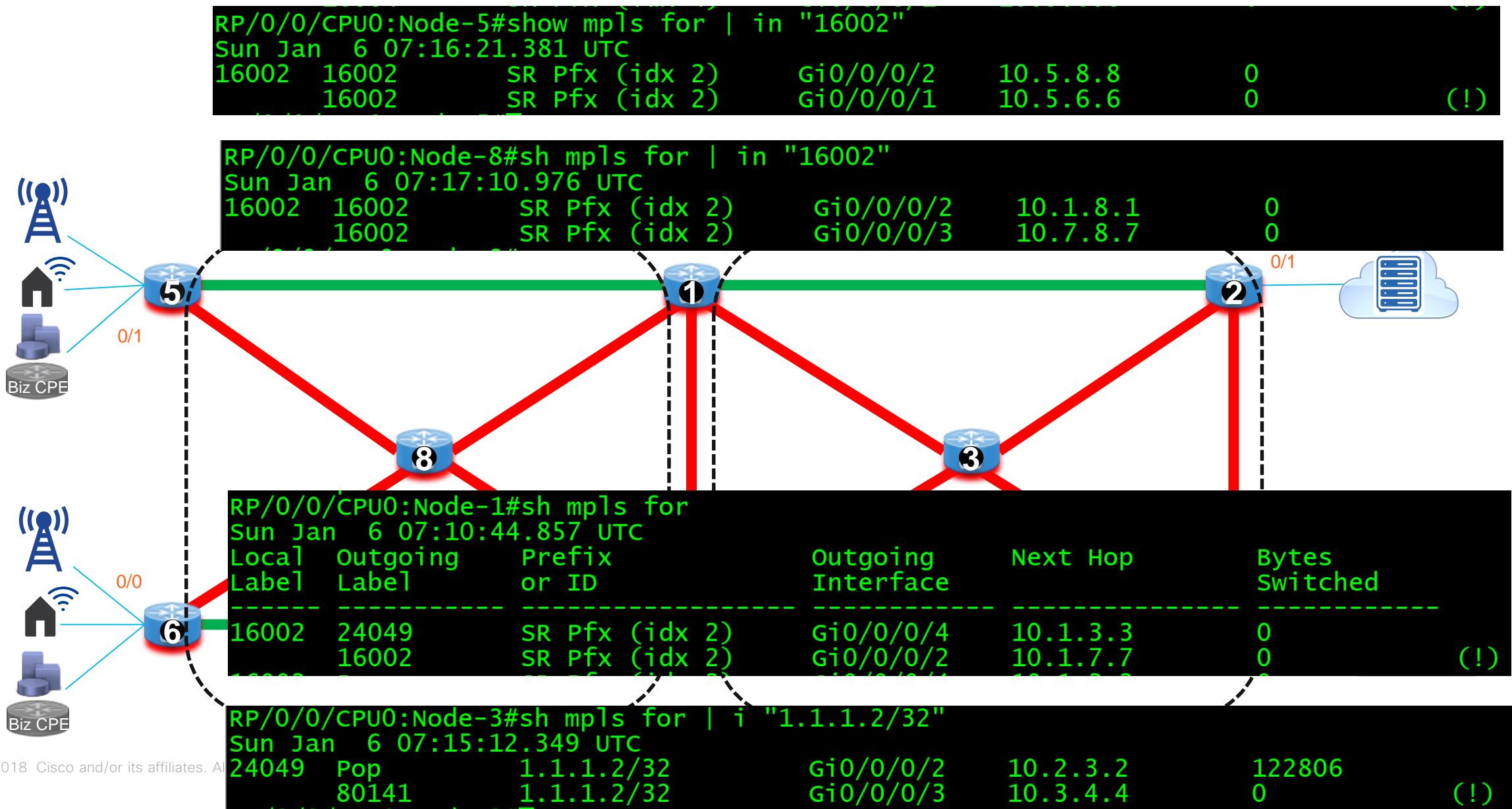
```
@Node1, 8  
Show segment mapping prefix ipv4  
Show segment mapping prefix ipv4 detail
```

```
@Node NON-SR  
Show isis/ospf segment prefix active-policy detail  
Show isis/ospf segment prefix backup-policy detail
```

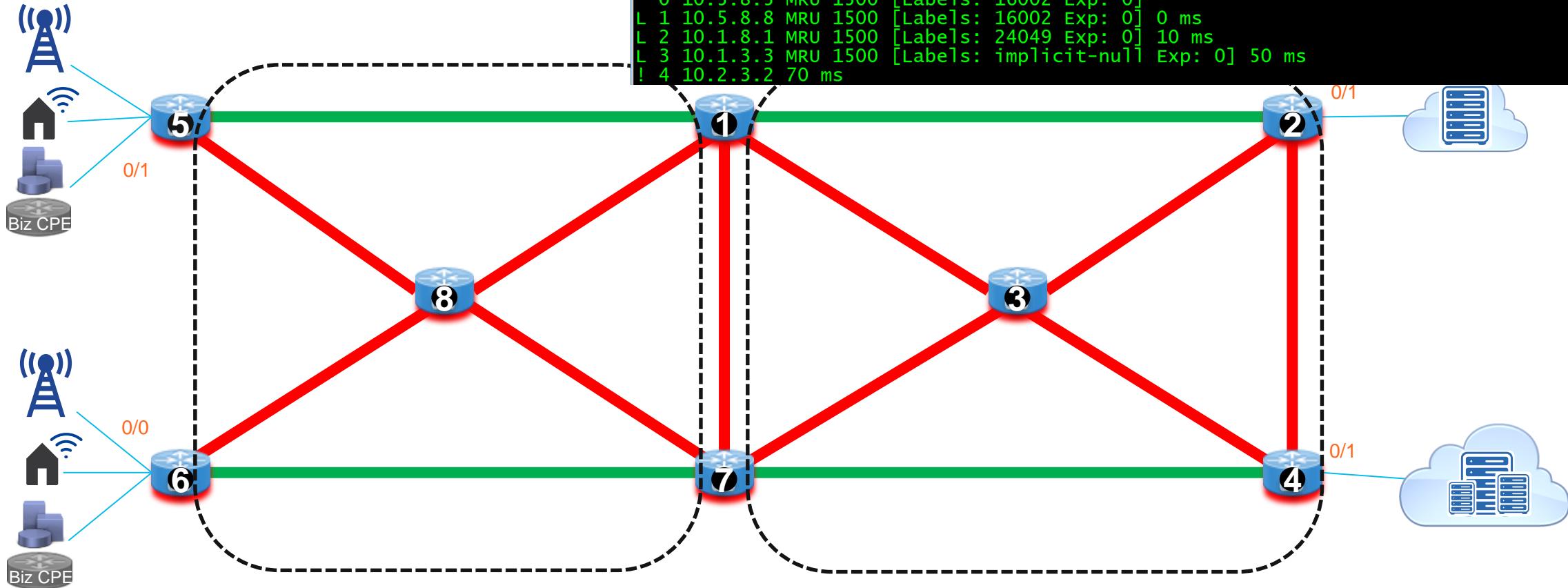
```
@Node5 – SR ECMP + LDP + SR Mapping Server  
trace vrf red 4.4.4.4 source 5.5.5.5  
Trace vrf red 4.4.4.4 source 50.50.50.50
```



# Label Swap from Node 5 to Node 2



# Traceroute Label Swap from Node 5 to Node 2

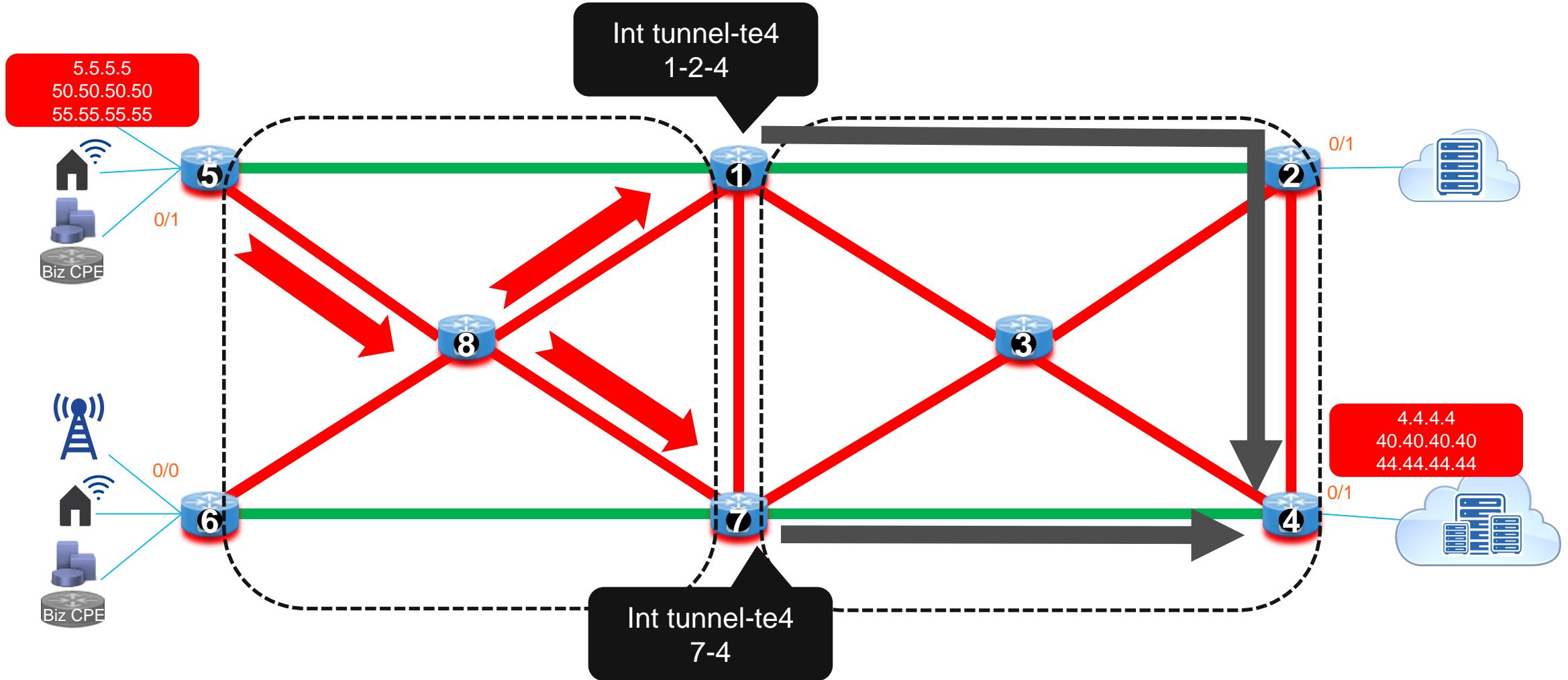




## 4. Interworking SR + RSVP\_TE Interworking SRTE + RSVP\_TE



# SR ECMP + RSVP\_TE Lab



# Setup SR ECMP + RSVP\_TE

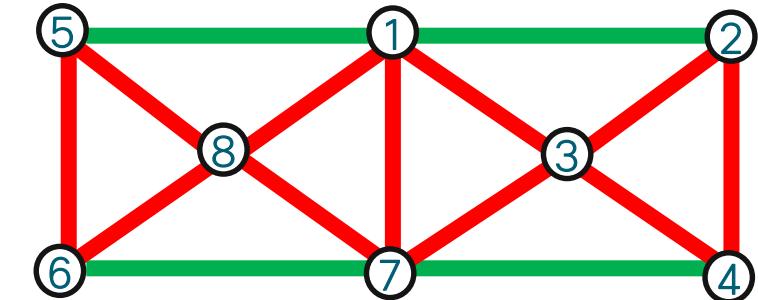
```
Python node-1 rsvp-te-4  
Python node-7 rsvp-te-4
```

@Node5  
Trace vrf red 4.4.4.4 source 5.5.5.5 (before)  
Trace vrf red 4.4.4.4 source 5.5.5.5 (after)

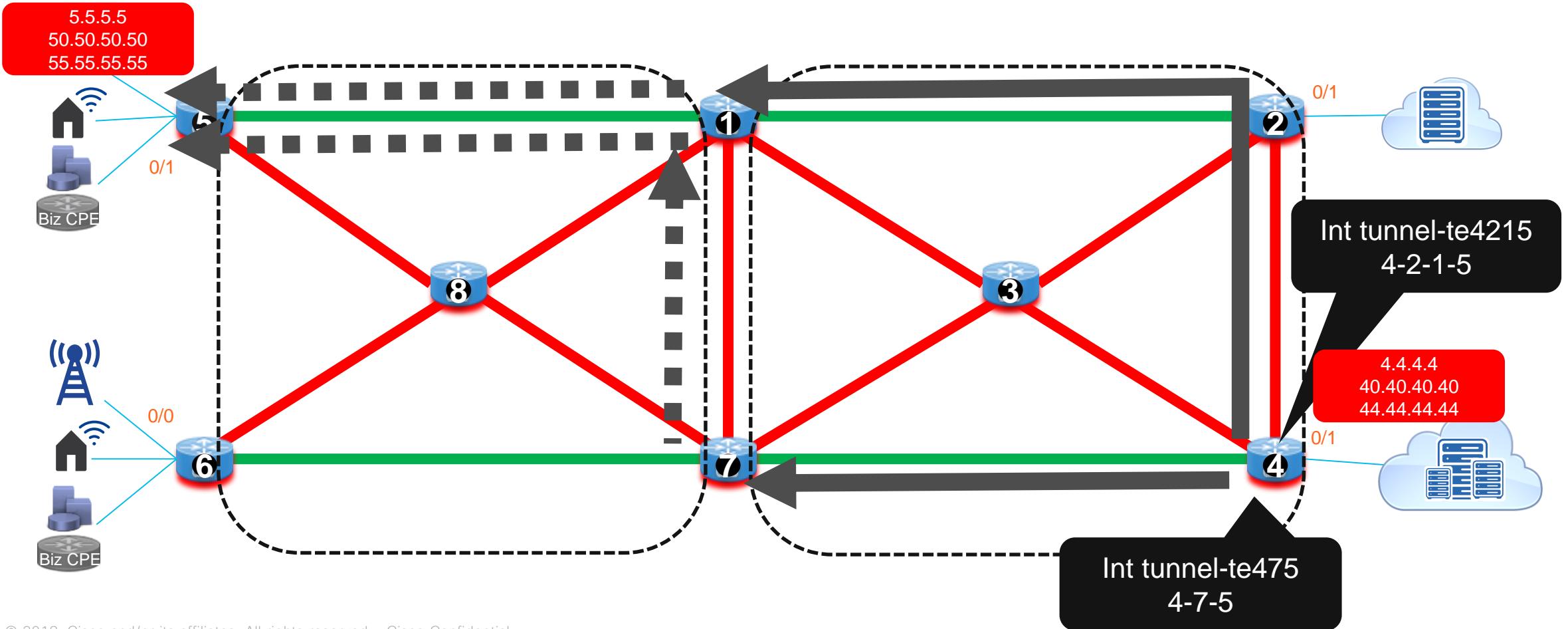
@Node1  
Show ip int brief  
Show mpls traffic tunnel

@Node5  
Trace vrf red 4.4.4.4 source 50.50.50.50 (before)  
Trace vrf red 4.4.4.4 source 50.50.50.50 (after)

@Node7  
Show ip int brief  
Show mpls traffic tunnel



# RSVP\_TE + SR ECMP Lab



# Setup RSVP\_TE + SR ECMP

Python node-4 rsvppte-4215

Python node-4 rsvppte-475

@Node4

Trace vrf red 5.5.5.5 source 4.4.4.4 (before)

Trace vrf red 5.5.5.5 source 4.4.4.4 (after)

@Node1

Show ip int brief

Show mpls traffic tunnel

@Node4

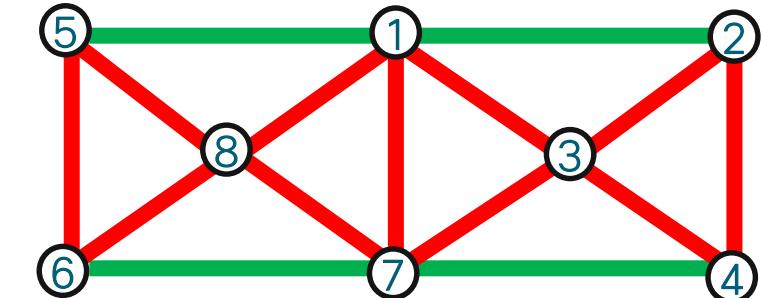
Trace vrf red 50.50.50.50 source 4.4.4.4 (before)

Trace vrf red 50.50.50.50 source 4.4.4.4 (after)

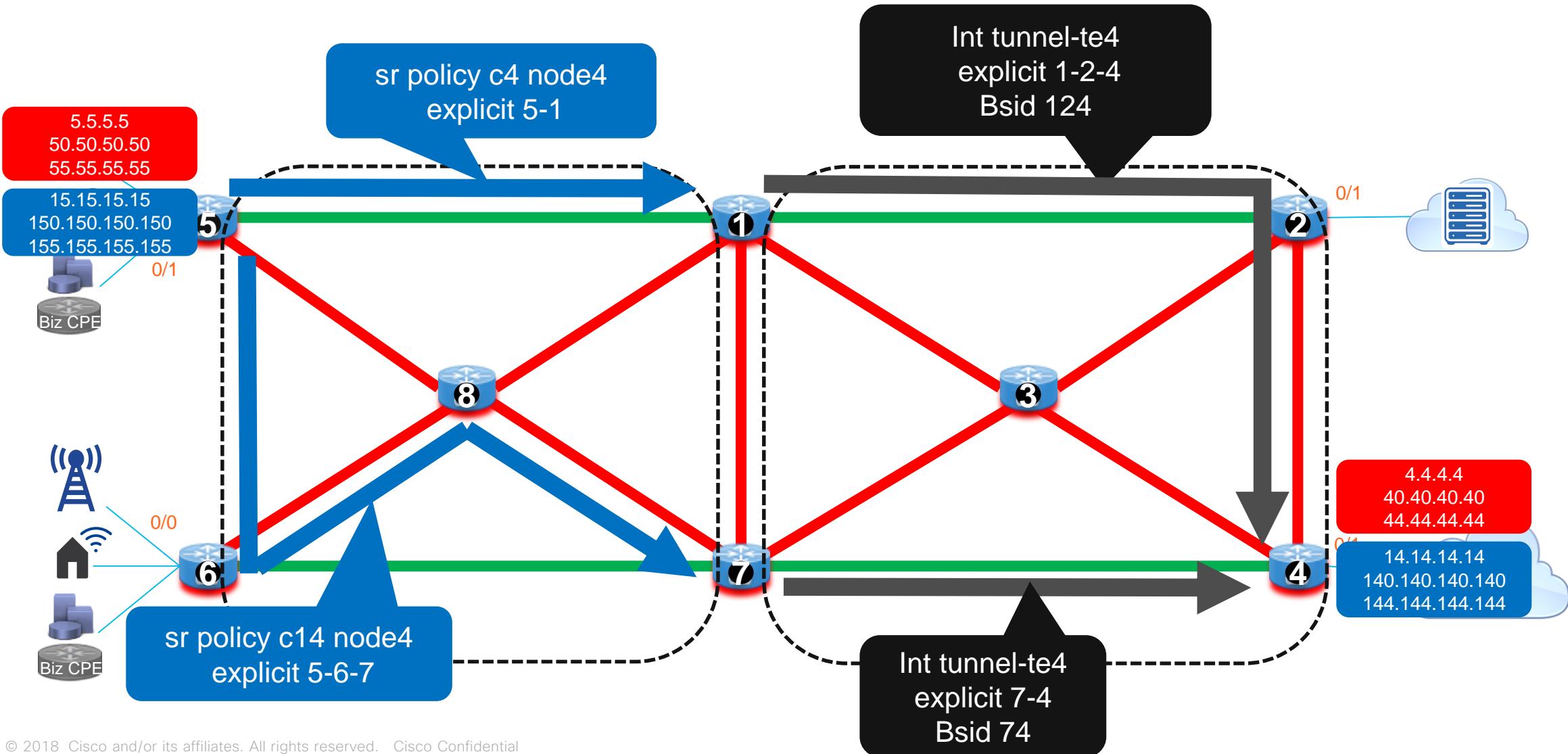
@Node7

Show ip int brief

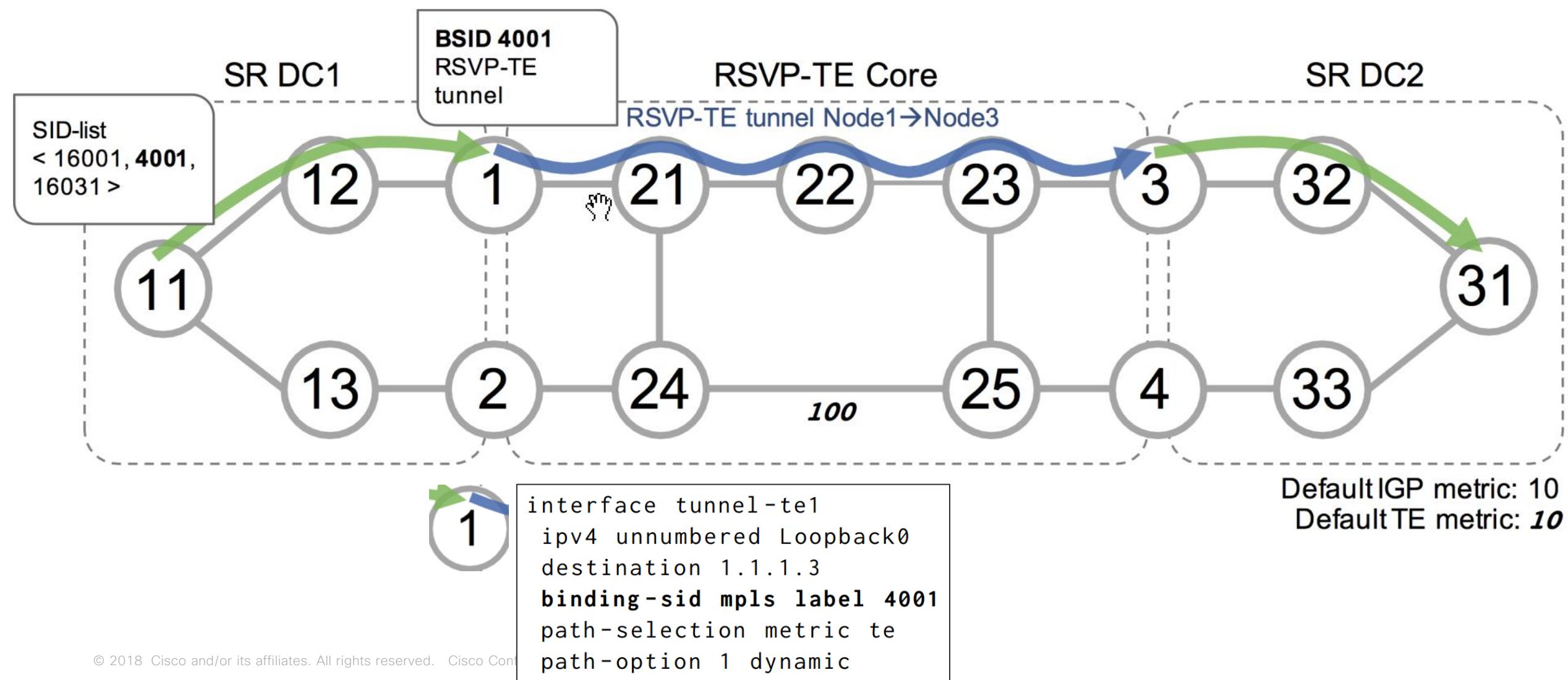
Show mpls traffic tunnel



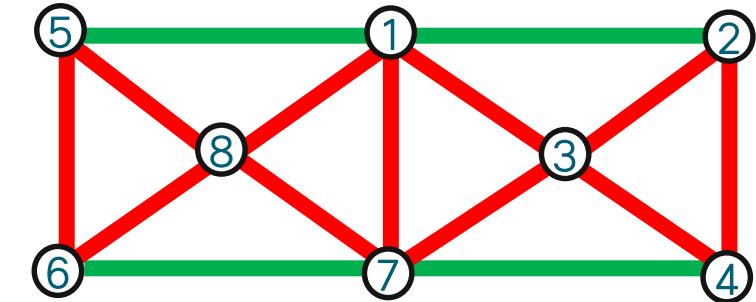
# SR Policy + RSVP\_TE Lab



# Binding SID for RSVP-TE Tunnel



# Setup SR Policy + RSVP\_TE



Python node-5 srte-c4-node1

@Node5  
Trace vrf red 4.4.4.4 (before)  
Ping vrf red 4.4.4.4 repeat 100000

Trace vrf red 4.4.4.4 (after)

Show segment traffic policy

Python node-5-srte-c14-node7

@Node5  
Trace vrf blue 14.14.14.14 (before)  
Ping vrf red 14.14.14.14 repeat 100000

Trace vrf blue 14.14.14.14 (after)

Show segment traffic policy



## 5. LDP to SR Migration



# LDP to SR Migration

```
Python node-1 no-rsvp-te-4
```

```
Python node-7 no-rsvp-te-4
```

```
Python node-4 no-rsvp-te-4215
```

```
Python node-4 no-rsvp-te-475
```

```
Python node-5 no-srte-c4-to-node1
```

```
Python node-5 no-srte-c14-to-node7
```

Before @ Node 2,3,4

Show mpls forwarding | util wc lines

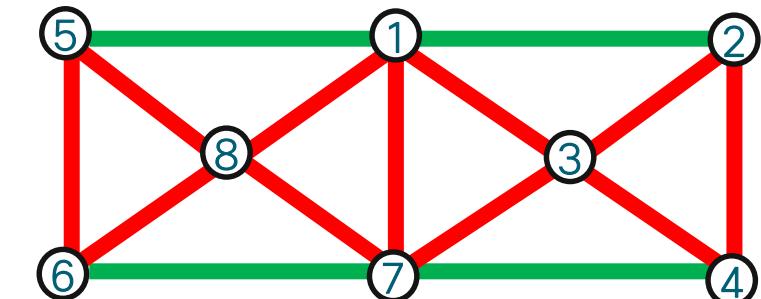
```
Python node-1 migrate-to-sr
```

```
Python node-2 migrate-to-sr
```

```
Python node-3 migrate-to-sr
```

```
Python node-4 migrate-to-sr
```

```
Python node-7 migrate-to-sr
```



```
Python node-1 no-sr-mapping
```

```
Python node-8 no-sr-mapping
```

@Node5

```
Ping sr-mpls 1.1.1.4/32
```

```
Trace sr-mpls multipath 1.1.1.4/32 verbose
```

```
Trace vrf red 4.4.4.4
```

```
Trace vrf blue 14.14.14.14
```

@Node2, 3, 4

Show mpls forwarding (simplicity and reduce label)

Show mpls for | util wc lines



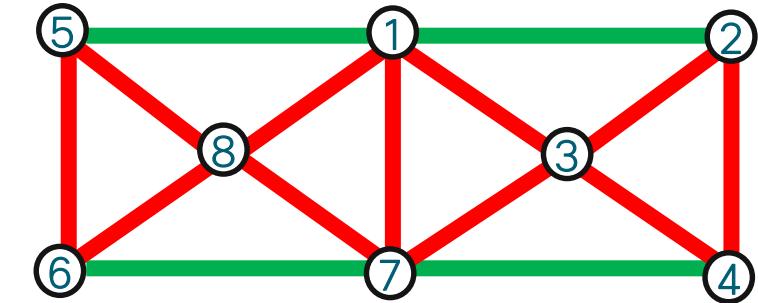
## 6. Microloop Avoidance Segment Routing

# Enable Microloop Avoidance

```
Python node-1 microloop  
Python node-2 microloop  
Python node-3 microloop  
Python node-4 microloop  
Python node-5 microloop  
Python node-6 microloop  
Python node-7 microloop  
Python node-8 microloop
```

@Node ANY

Show run router isis

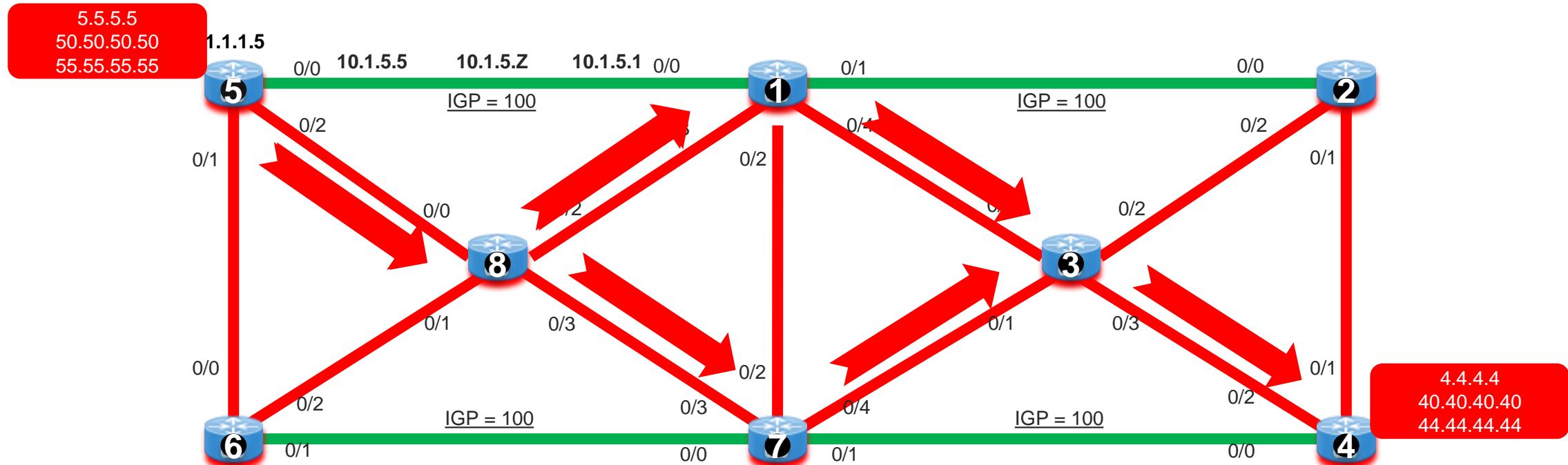




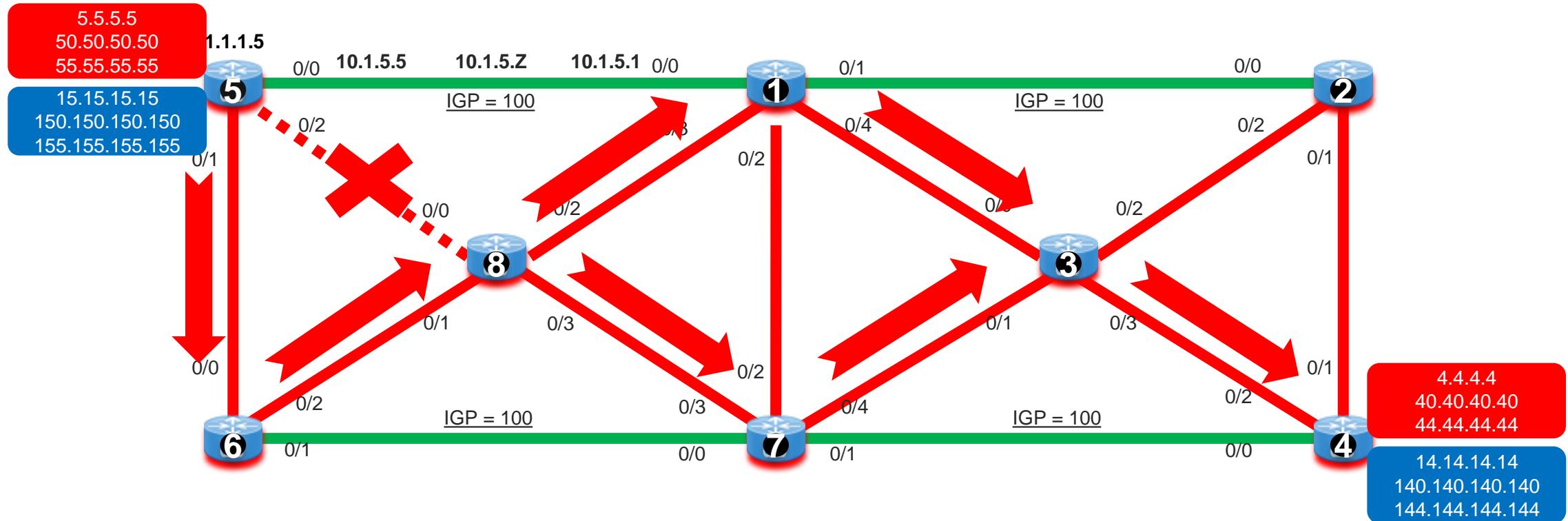
## 7. VPNv4 SR ECMP + Link Failure



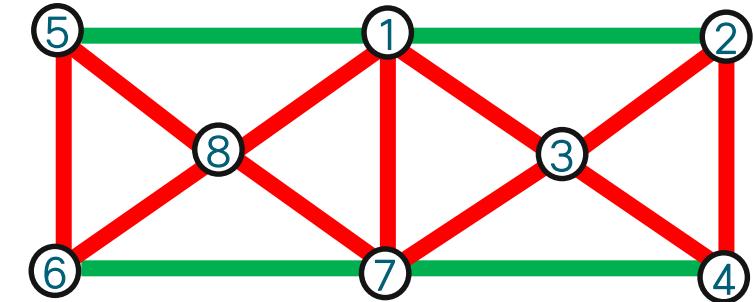
# VPNv4 SR ECMP + Normal Link



# VPNv4 SR ECMP + Link Failure



# VPNv4 SR ECMP + Link Failure



@Node5

Trace vrf red 4.4.4.4 source 5.5.5.5

Trace vrf red 4.4.4.4 source 50.50.50.50

Trace before link failure

Trace after link failure

@Node8

Monitor interface g0/0/0/0 g0/0/0/1 g0/0/0/2 g0/0/0/3

Add 2 telnet Node5

Python node-5-shut-int-2

Python node-5-no-shut-int-2

Ping vrf red 4.4.4.4 source 5.5.5.5 repeat 100000

Ping vrf red 4.4.4.4 source 50.50.50.50 repeat 100000

Node-5 - SecureCRT

File Edit View Options Transfer Script Tools Window Help

Node-5

```
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
Success rate is 100 percent (1989/1989), round-trip min/avg/max = 19/44/99 ms  
RP/0/0/CPU0:Node-5#ping vrf red 4.4.4.4 source 5.5.5.5 rep 100000
```

Node-8 - SecureCRT

File Edit View Options Transfer Script Tools Window Help

Node-1 Node-2 Node-3 Node-4 Node-5 Node-6 Node-7 Node-8

Node-8

Monitor Time: 00:03:42

Protocol: General

Interface	In(bps)	out(bps)
Gi0/0/0/0	7000/ 0%	7000/ 0%
Gi0/0/0/2	1000/ 0%	4000/ 0%
Gi0/0/0/3	7000/ 0%	4000/ 0%

Quit='q', Clear='c', Freeze='f', Thaw='t',  
Next set='n', Prev set='p', Bytes='y', Packets='z'  
(General='g', IPv4 Uni='4u', IPv4 Multi='4m', IPv6 Uni='6u', IPv6 Multi='6m')

File Edit View Options Transfer Script Tools Window Help

Node-5

```
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
!!!!!!  
Success rate is 100 percent (2071/2071), round-trip min/avg/max = 19/44/99 ms  
RP/0/0/CPU0:Node-5#ping vrf red 4.4.4.4 source 50.50.50.50 rep 100000
```

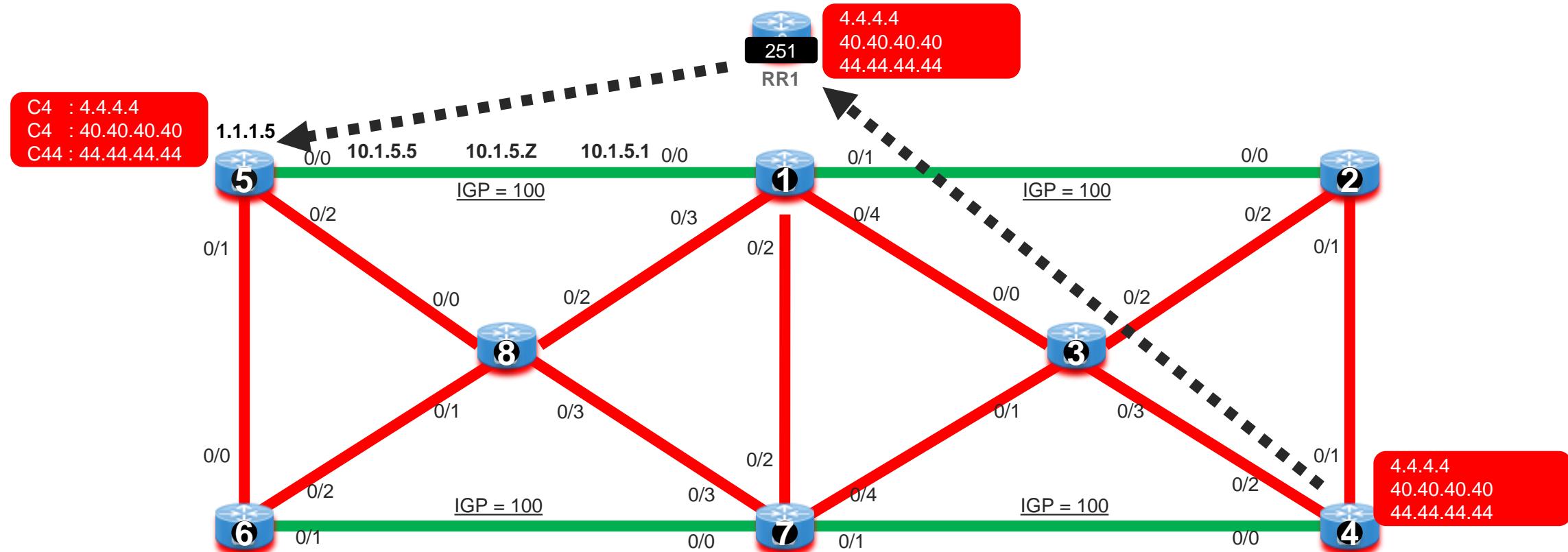


## 8. SR Policy

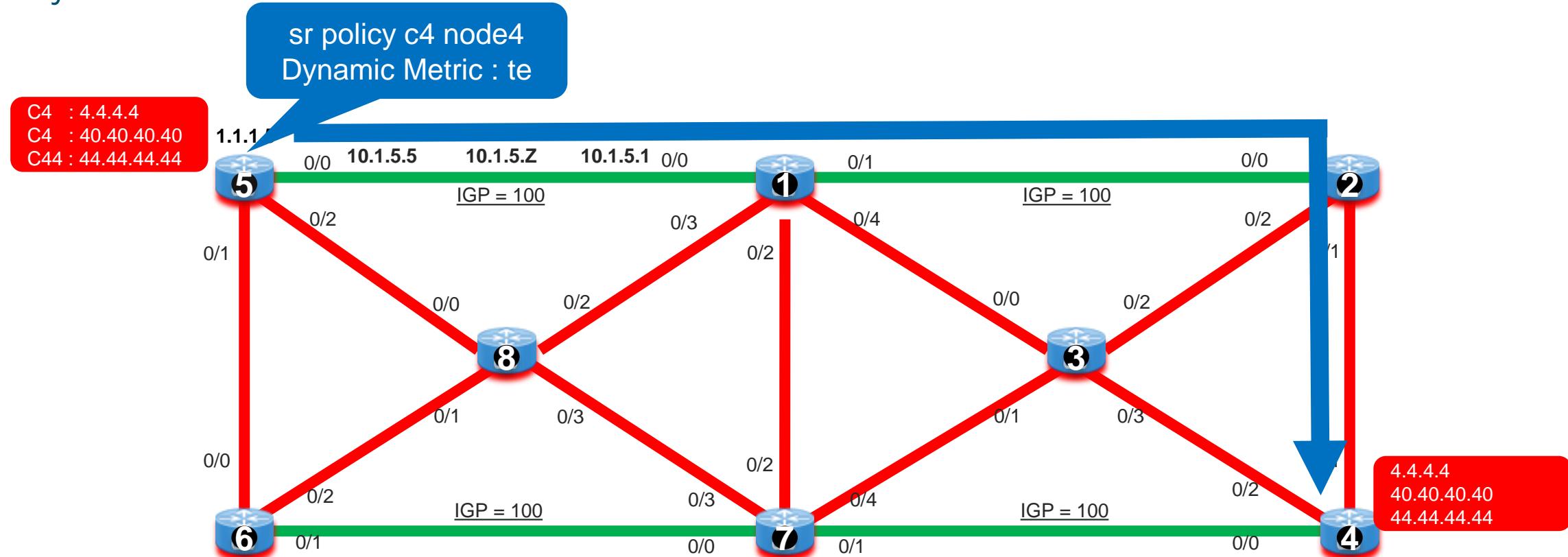
VPNv4 Automated Steering  
(dynamic te metric, link failure, delay increase)



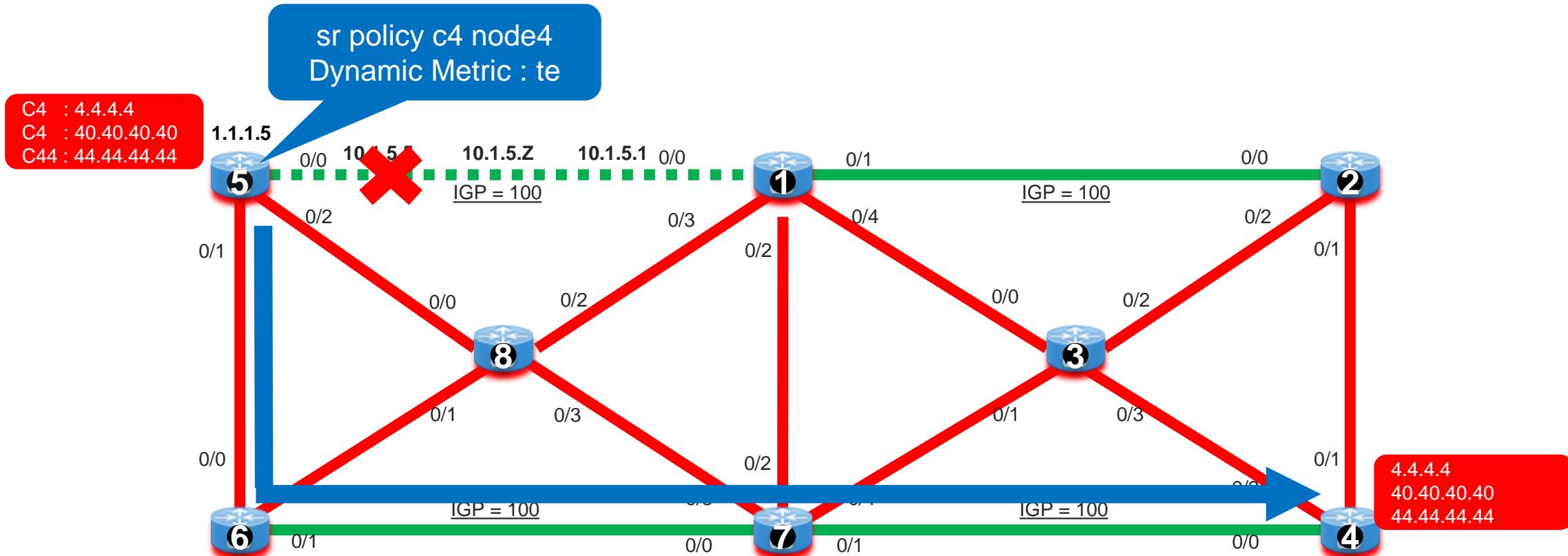
# VPNv4 SR Policy Automated Steering color + end-point



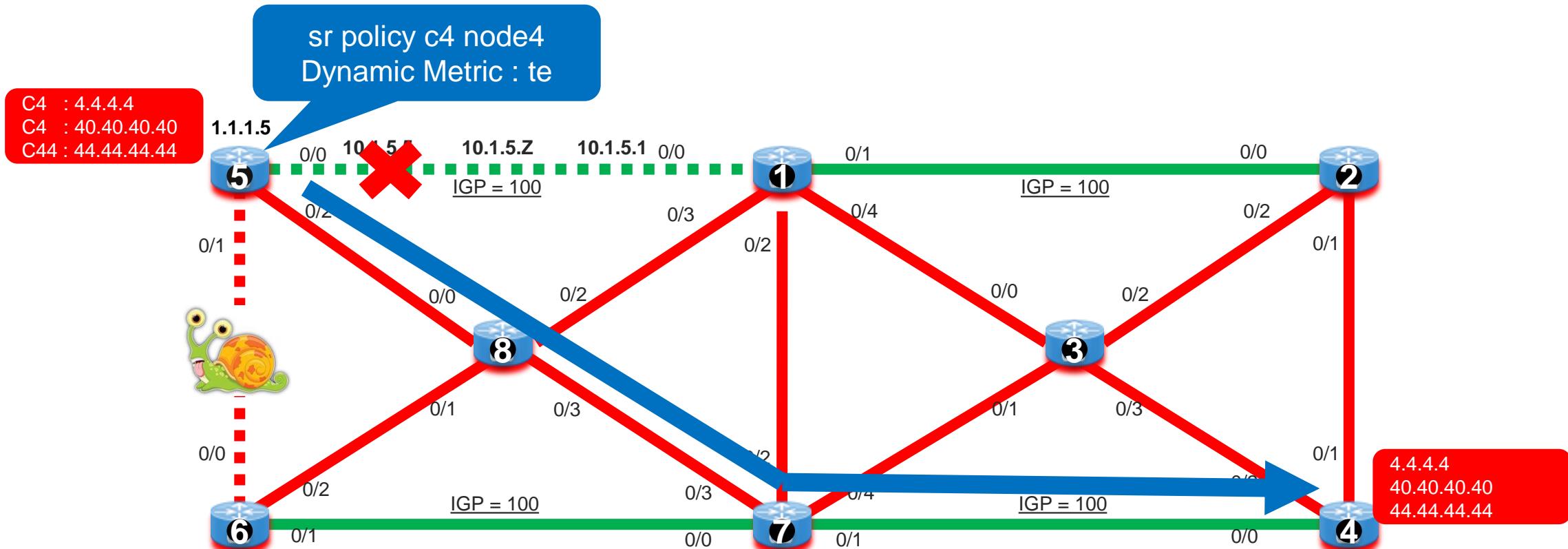
# VPNv4 SR Policy Automated Steering dynamic temetric



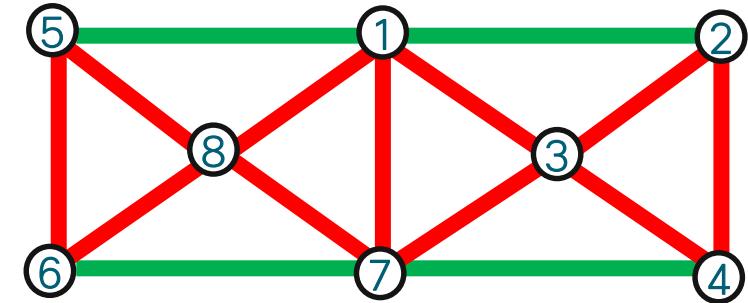
# VPNv4 SR Policy Automated Steering link failure



# VPNv4 SR Policy Automated Steering delay increase



# VPNv4 SR Policy Automated Steering



Python node-5 srte-to-node-4 --> dynamic te color:4

@Node5

traceroute vrf red 4.4.4.4 source 5.5.5.5 - via te  
traceroute vrf red 40.40.40.40 source 5.5.5.5 - via te  
traceroute vrf red 44.44.44.44 source 5.5.5.5 - via igp

Python node-5 shut-int-0 --> link failure

Python node-5 delay-30-int-01 --> delay increase/worse

Python node-5 no-shut-int-0 --> link UP

Python node-5 no-delay-30-int-01 --> delay restore

@Node5

Show segment traffic policy

Show route vrf red

Show bgp vpnv4 uni vrf red

Show cef vrf red 4.4.4.4

Show cef vrf red 44.44.44.44

Show mpls forwarding

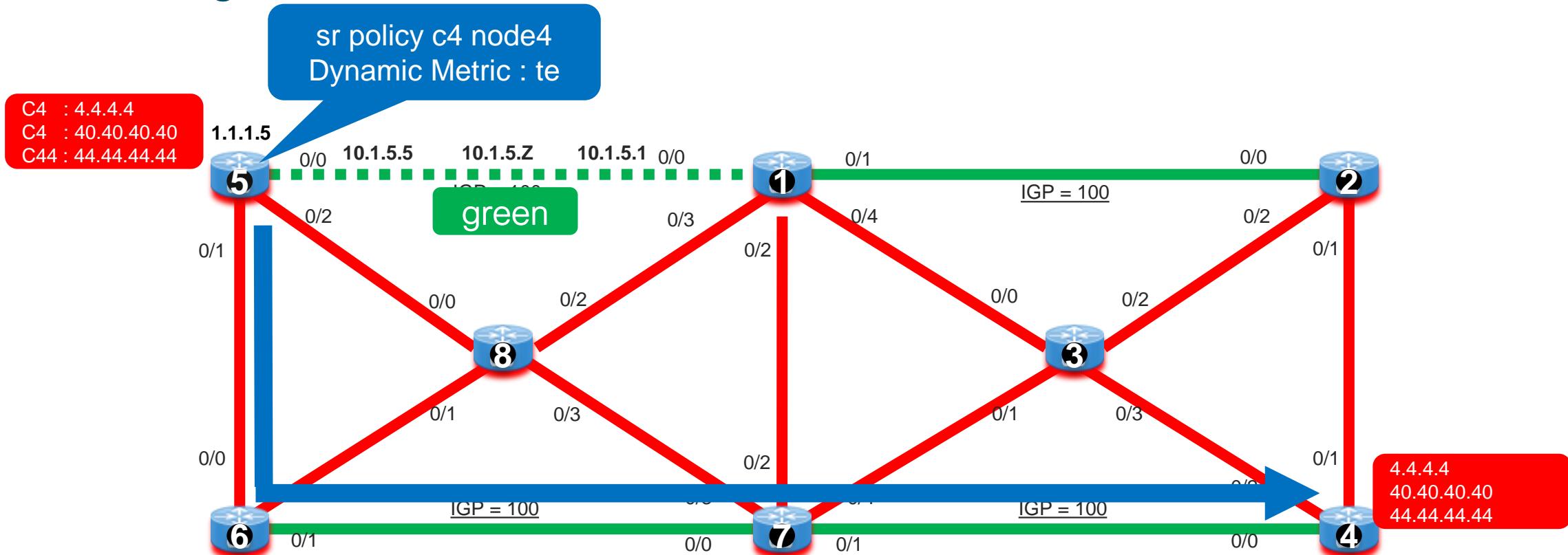
Ping vrf red 4.4.4.4 repeat 100000



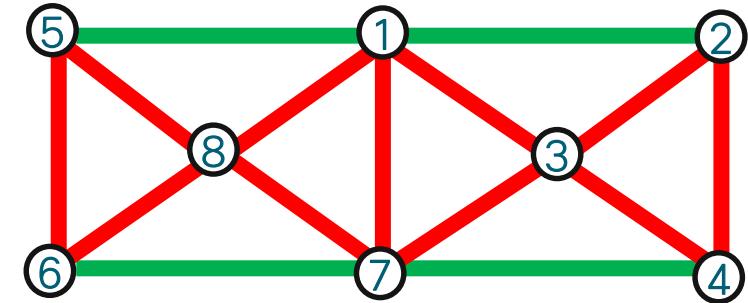
## 9. SR Policy VPNv4 Automated Steering (constraint affinity)



# VPNv4 SR Policy Automated Steering exclude green



# VPNv4 SR Policy Automated Steering - Affinity



Python node-5 exclude-green --> exclude green  
g0/0/0/0

@Node5  
traceroute vrf red 4.4.4.4 source 5.5.5.5 - via te  
traceroute vrf red 40.40.40.40 source 5.5.5.5 - via te  
traceroute vrf red 44.44.44.44 source 5.5.5.5 - via igp

Python node-5 no-exclude-green --> normal link

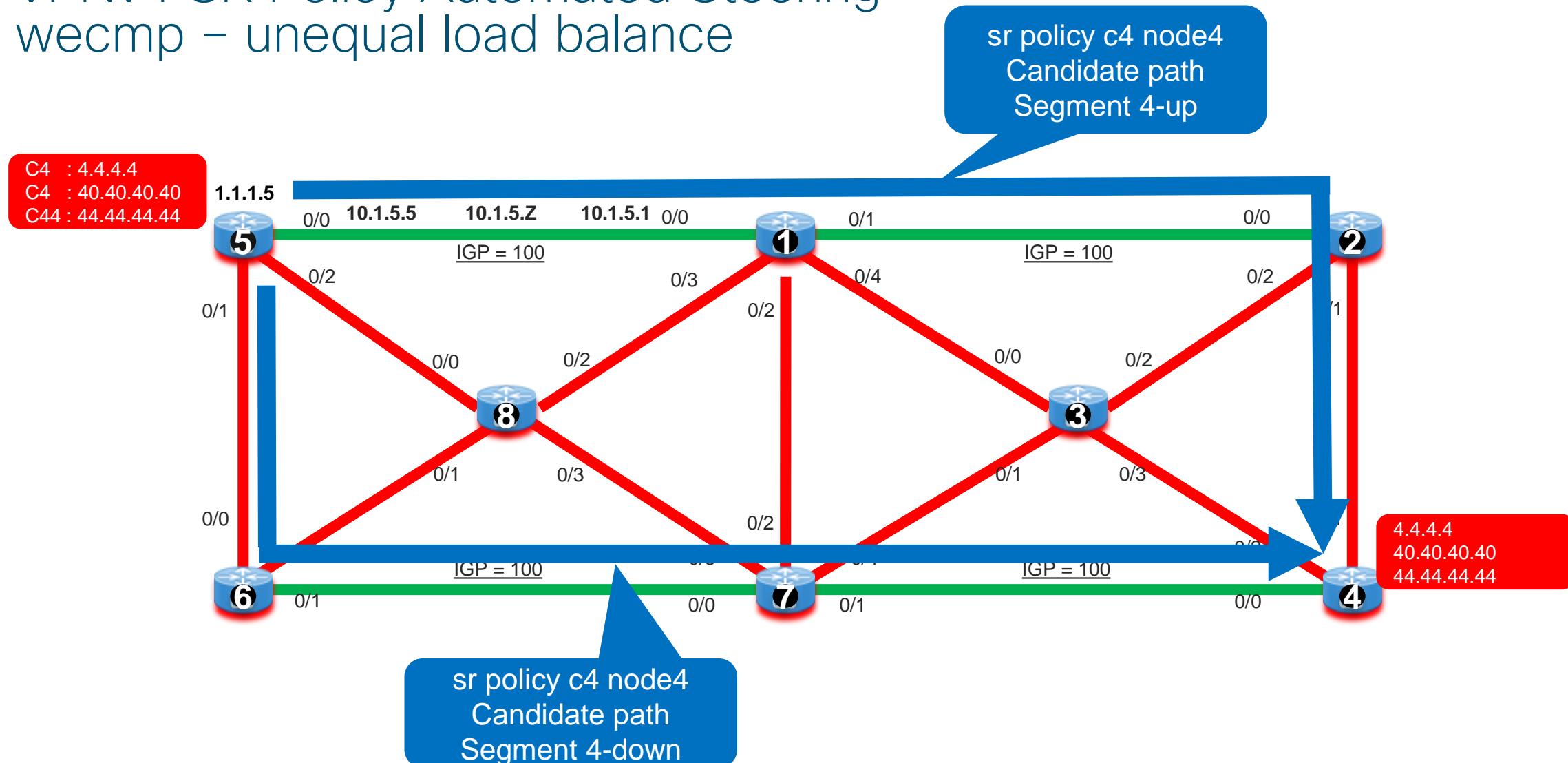
@Node5  
Show segment traffic policy  
Show route vrf red  
Show bgp vpnv4 uni vrf red  
Show cef vrf red 4.4.4.4  
Show cef vrf red 44.44.44.44  
Show mpls forwarding



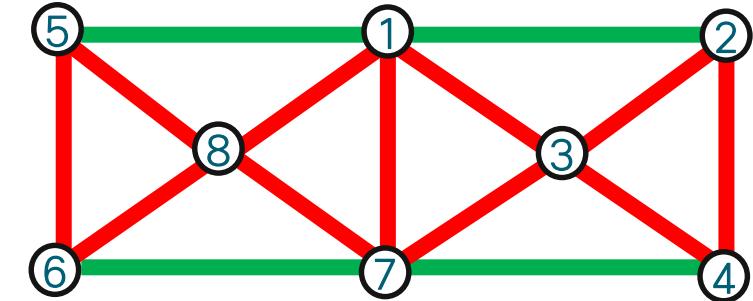
## 10. SR Policy VPNv4 Automated Steering (weighted ecmp - unequal load balance)



# VPNv4 SR Policy Automated Steering wecmp – unequal load balance



# VPNv4 SR Policy Automated Steering - wecmp



```
Python node-5 no-srte-to-node-4 -> clear old srte
```

```
Python node-5 wecmp-up-node-4 -> up 2 : 1
```

```
Python node-5 wecmp-down-node-4 -> down 2 : 1
```

```
Python node-5 no-wecmp-node-4
```

@Node5  
monitor rate

Traceroute

vrf red 4.4.4.4 source 5.5.5.5

vrf red 4.4.4.4 source 50.50.50.50

vrf red 4.4.4.4 source 55.55.55.55

vrf red 40.40.40.40 source 5.5.5.5

vrf red 40.40.40.40 source 50.50.50.50

vrf red 40.40.40.40 source 55.55.55.55

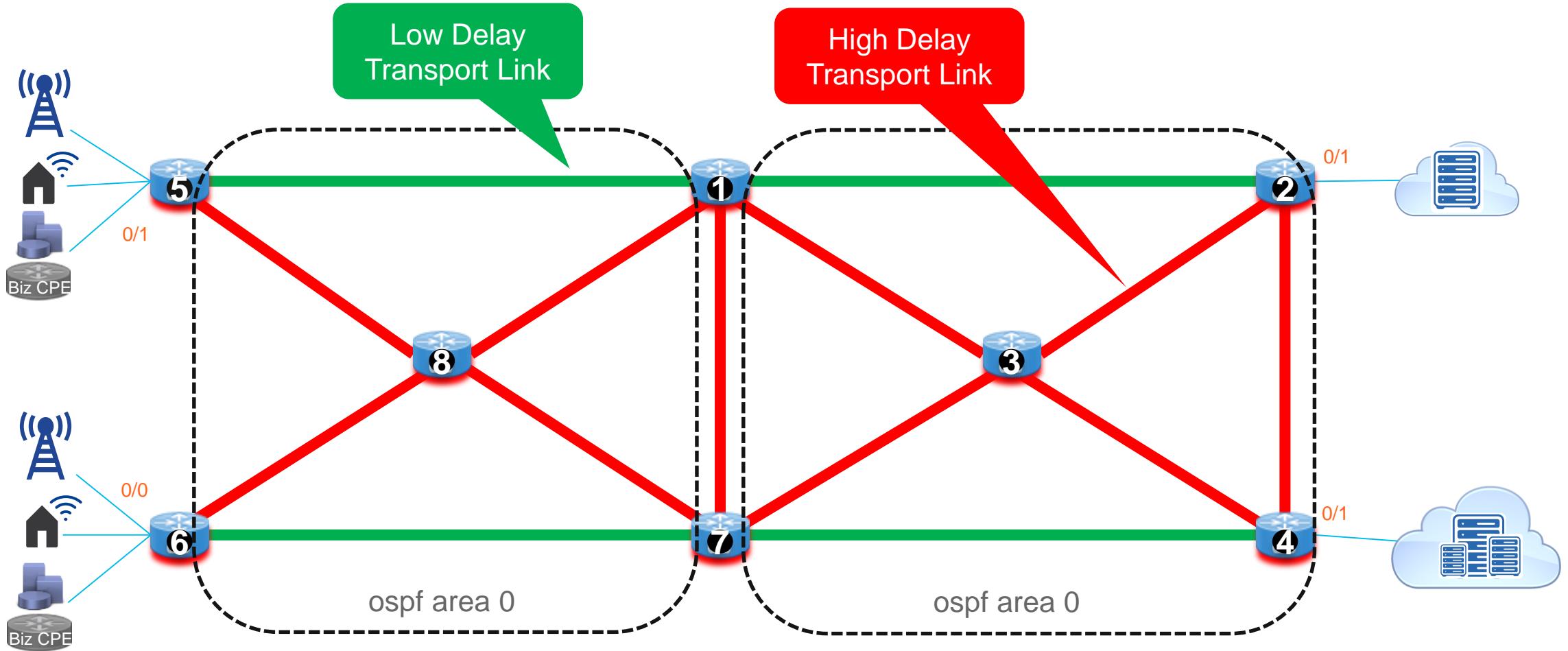
Simple  
Only 1 SR Policy – not required many intf te-tun  
Good scalability



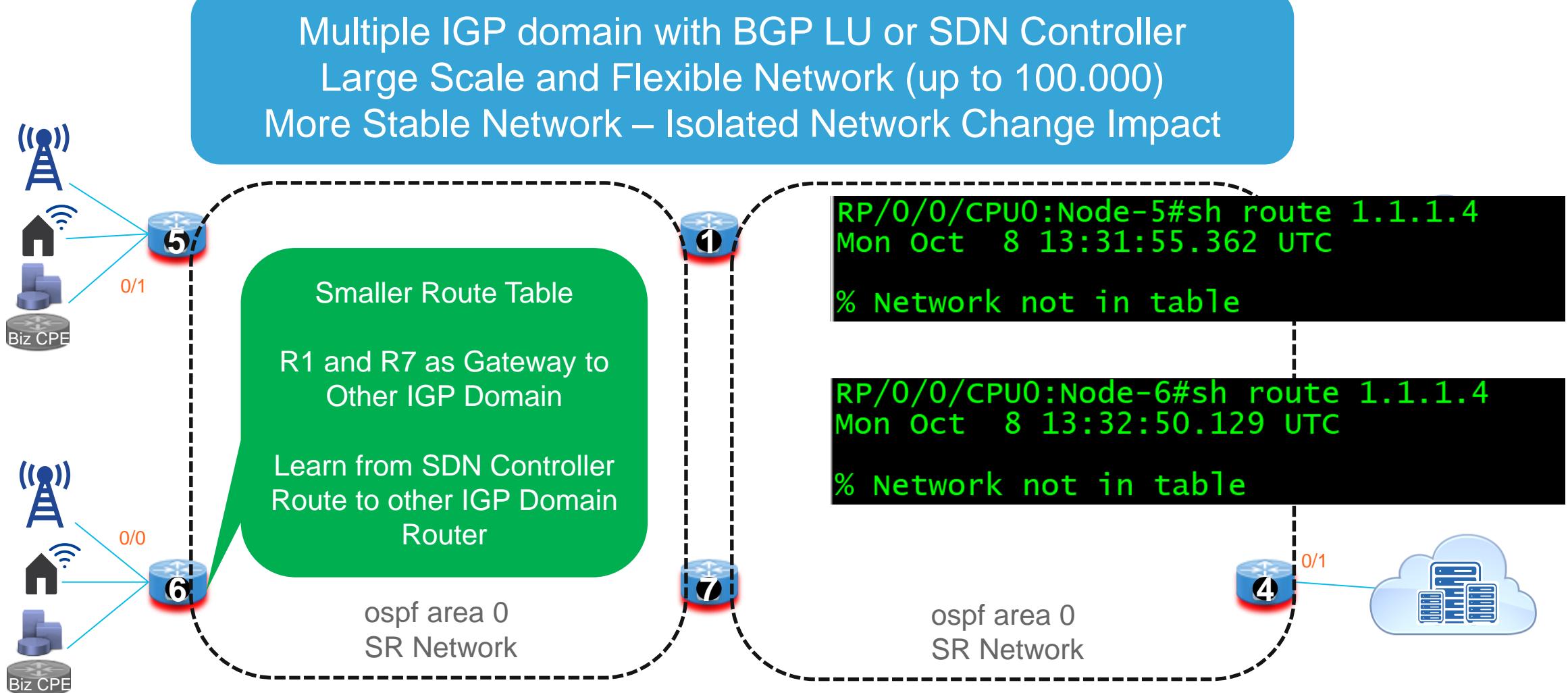
## 11. Use Case Seamless MPLS Multi-IGP Domain - OSPF



# Multi-IGP Domain - OSPF

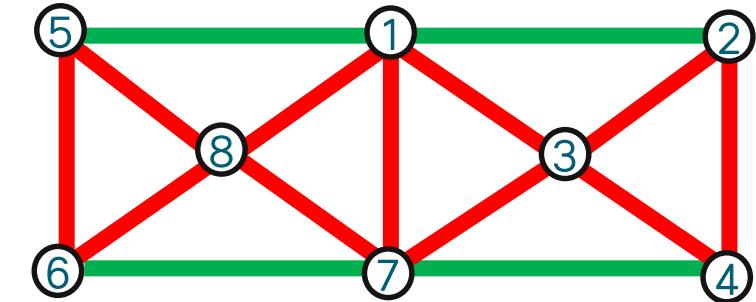


# Segment Routing + Seamless MPLS Architecture for Simple, Flexible and Scalable Network



# Multi-IGP Domain OSPF

```
Python node-1 multi-domain  
Python node-2 multi-domain  
Python node-3 multi-domain  
Python node-4 multi-domain  
Python node-5 multi-domain  
Python node-6 multi-domain  
Python node-7 multi-domain  
Python node-8 multi-domain
```



```
@Node5, 1, 7, 4  
Show run router ospf
```

```
Traceroute  
vrf red 4.4.4.4 source 5.5.5.5  
vrf red 4.4.4.4 source 50.50.50.50  
vrf red 4.4.4.4 source 55.55.55.55
```

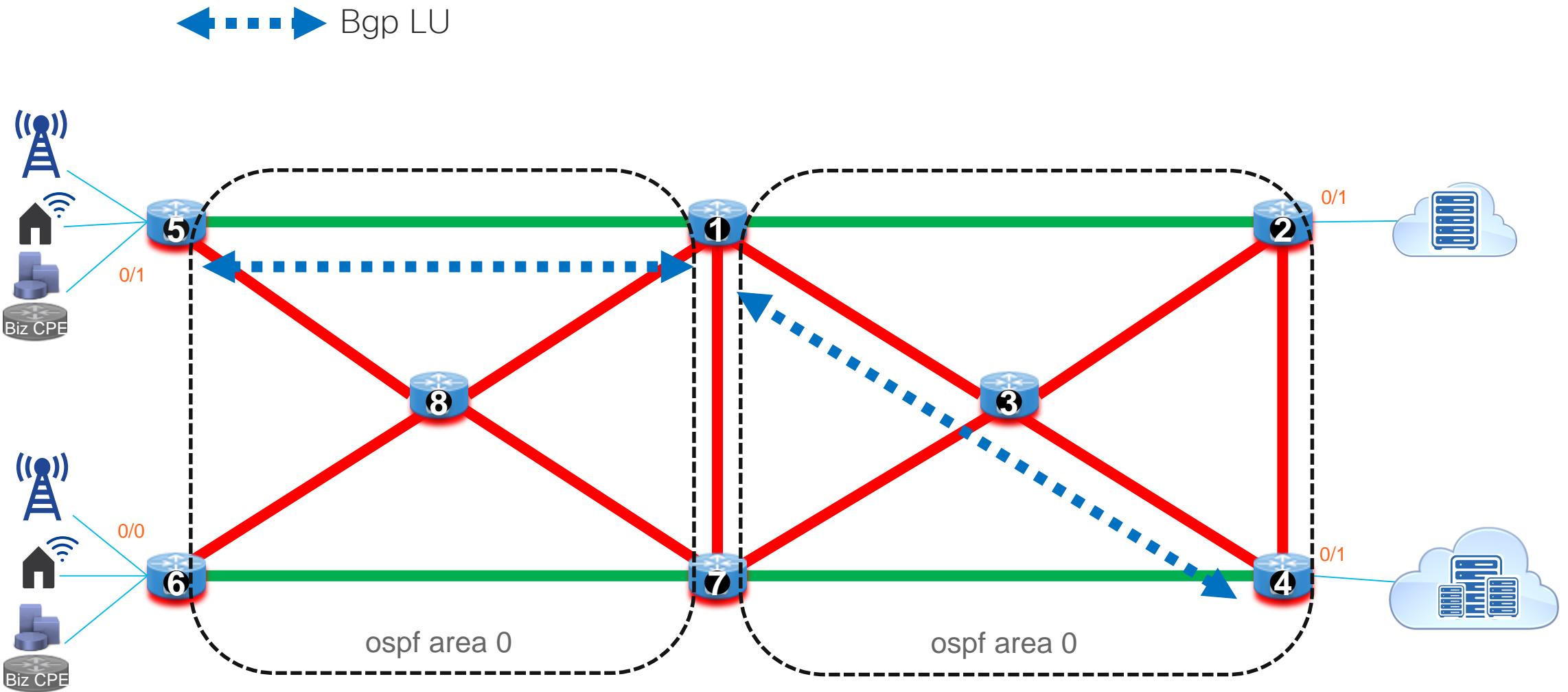
```
vrf red 40.40.40.40 source 5.5.5.5  
vrf red 40.40.40.40 source 50.50.50.50  
vrf red 40.40.40.40 source 55.55.55.55
```



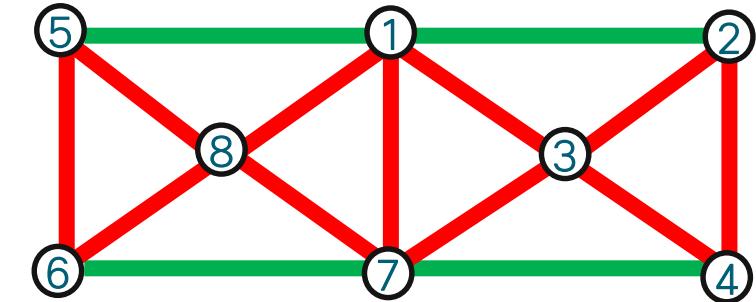
## 12. Use Case Seamless MPLS Multi-IGP Domain – OSPF (SR + BGP LU + BGP Prefix SID)



# Multi-IGP Domain – OSPF (SR + BGP LU + BGP Prefix SID)



# Multi-IGP Domain OSPF (SR + BGP LU + BGP Prefix SID)



```
Python node-1 bgp-lu-prefix-sid  
Python node-4 bgp-lu-prefix-sid  
Python node-5 bgp-lu-prefix-sid
```

```
@Node5  
Show route | in 1.1.1.4  
Show mpls forward | in 16004  
Show bgp ipv4 label  
Show bgp ipv4 label sum  
  
Show run router bgp
```

```
@Node5, 1, 4  
Show run router ospf  
Show bgp vpng4 uni  
Show cef vrf red 4.4.4.4  
Show bgp ipv4 label sum  
Show bgp ipv4 label
```

```
Traceroute  
vrf red 4.4.4.4 source 5.5.5.5  
vrf red 4.4.4.4 source 50.50.50.50  
vrf red 4.4.4.4 source 55.55.55.55
```

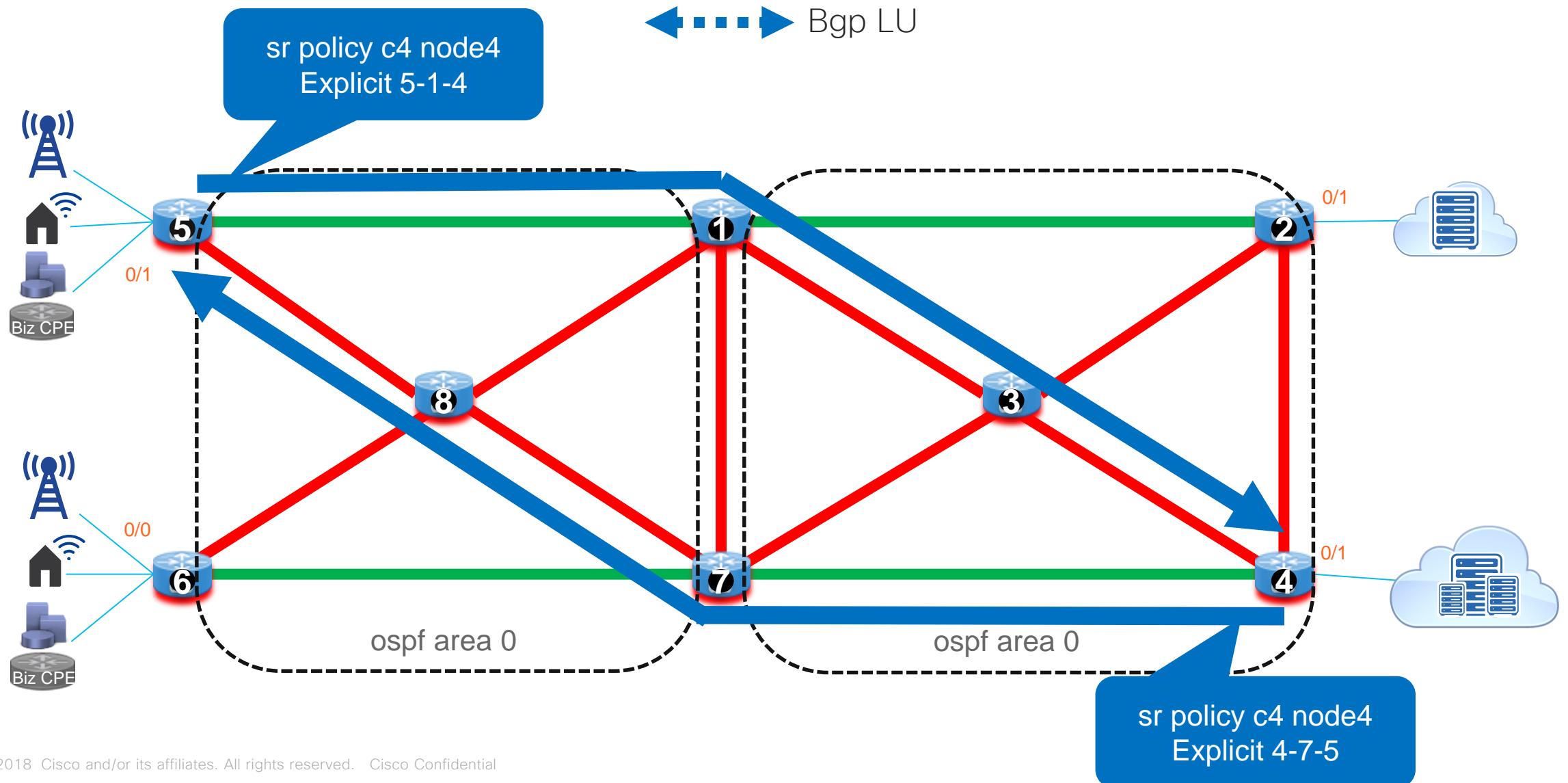
```
vrf red 40.40.40.40 source 5.5.5.5  
vrf red 40.40.40.40 source 50.50.50.50  
vrf red 40.40.40.40 source 55.55.55.55
```



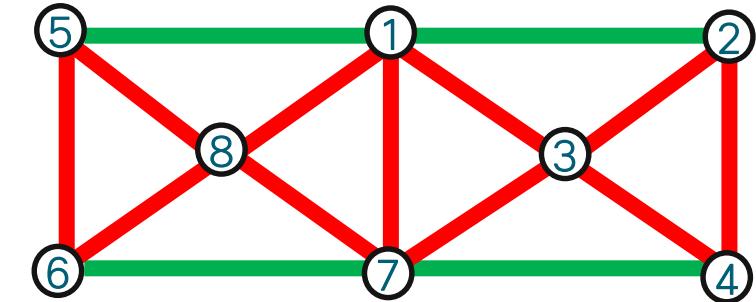
## 13. Use Case Seamless MPLS Multi-IGP Domain - OSPF (SR Policy Explicit + WITH BGP LU)



# Multi-IGP Domain – OSPF (SR Policy Explicit + WITH BGP LU)



# Multi-IGP Domain OSPF (SR Policy Explicit + WITH BGP LU)



Python node-4 srte-red-explicit-to-node-5  
Python node-5 srte-red-explicit-to-node-4

Trace before python

Trace after python

(initial with prefix sid, then  
Change to adjacency label)

@Node5, 1, 4  
Show run router ospf  
Show bgp vpng4 uni  
Show cef vrf red 4.4.4.4

Traceroute

vrf red 4.4.4.4 source 5.5.5.5  
vrf red 4.4.4.4 source 50.50.50.50  
vrf red 4.4.4.4 source 55.55.55.55

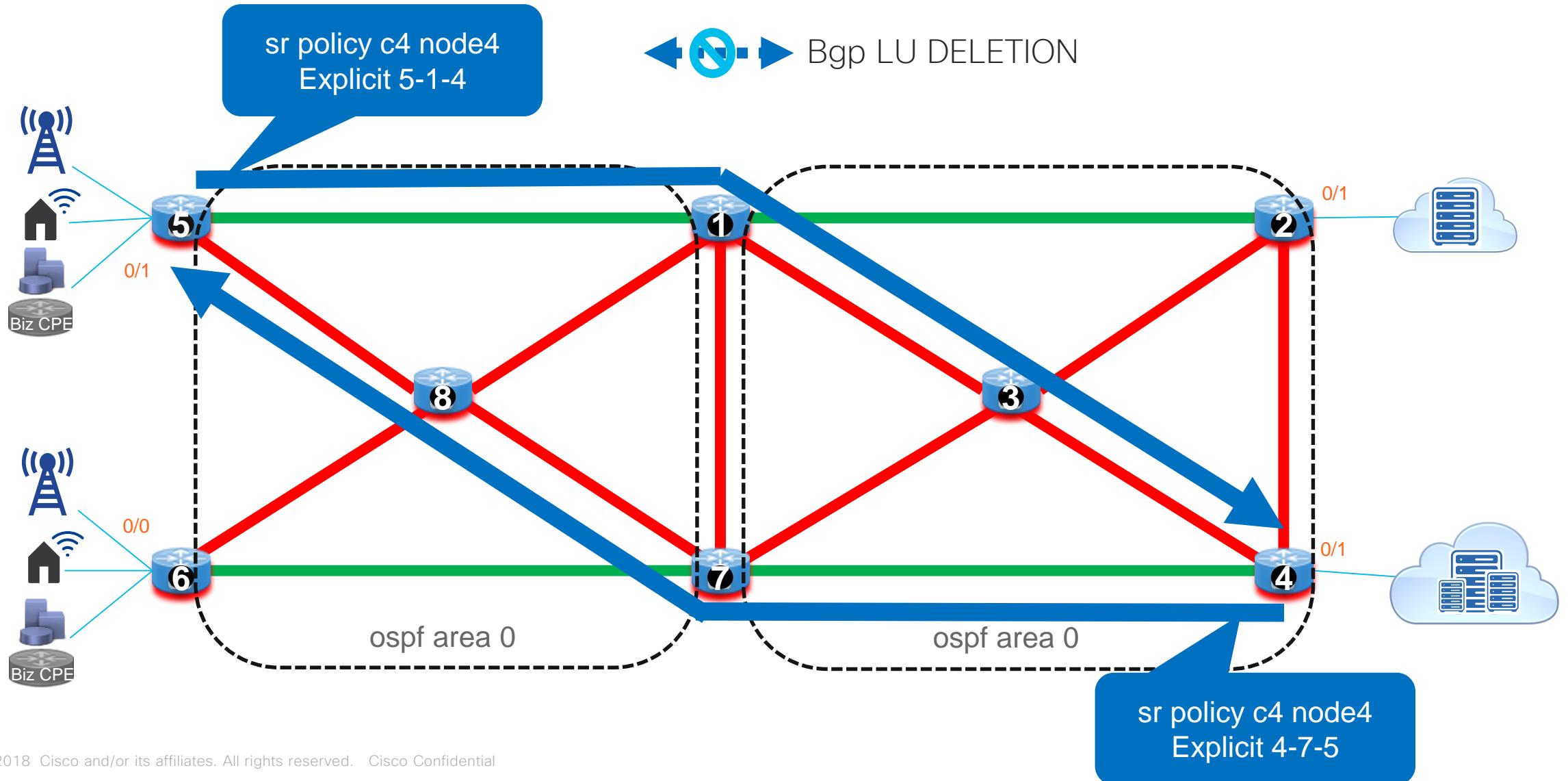
vrf red 40.40.40.40 source 5.5.5.5  
vrf red 40.40.40.40 source 50.50.50.50  
vrf red 40.40.40.40 source 55.55.55.55



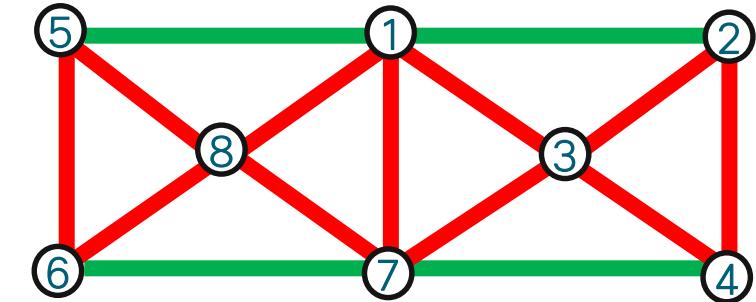
14. Use Case Seamless MPLS  
Multi-IGP Domain - OSPF  
(SR Policy Explicit + **WITHOUT** BGP LU)



# Multi-IGP Domain – OSPF (SR Policy Explicit + WITHOUT BGP LU)



# Multi-IGP Domain OSPF (SR Policy Explicit + WITHOUT BGP LU)



Trace before python

Trace after python

@Node5

Trace vrf red 4.4.4.4

Ping vrf red 4.4.4.4 repeat 100000

Python node-1 no-bgp-lu-prefix-sid  
Python node-4 no-bgp-lu-prefix-sid  
Python node-5 no-bgp-lu-prefix-sid

Trace before python

Trace after python

@Node5

Trace vrf red 4.4.4.4

Ping vrf red 4.4.4.4 repeat 100000

@Node5, 1, 4

Show run router ospf

Show bgp vpng4 uni

Show cef vrf red 4.4.4.4

Traceroute

vrf red 4.4.4.4 source 5.5.5.5

vrf red 4.4.4.4 source 50.50.50.50

vrf red 4.4.4.4 source 55.55.55.55

vrf red 40.40.40.40 source 5.5.5.5

vrf red 40.40.40.40 source 50.50.50.50

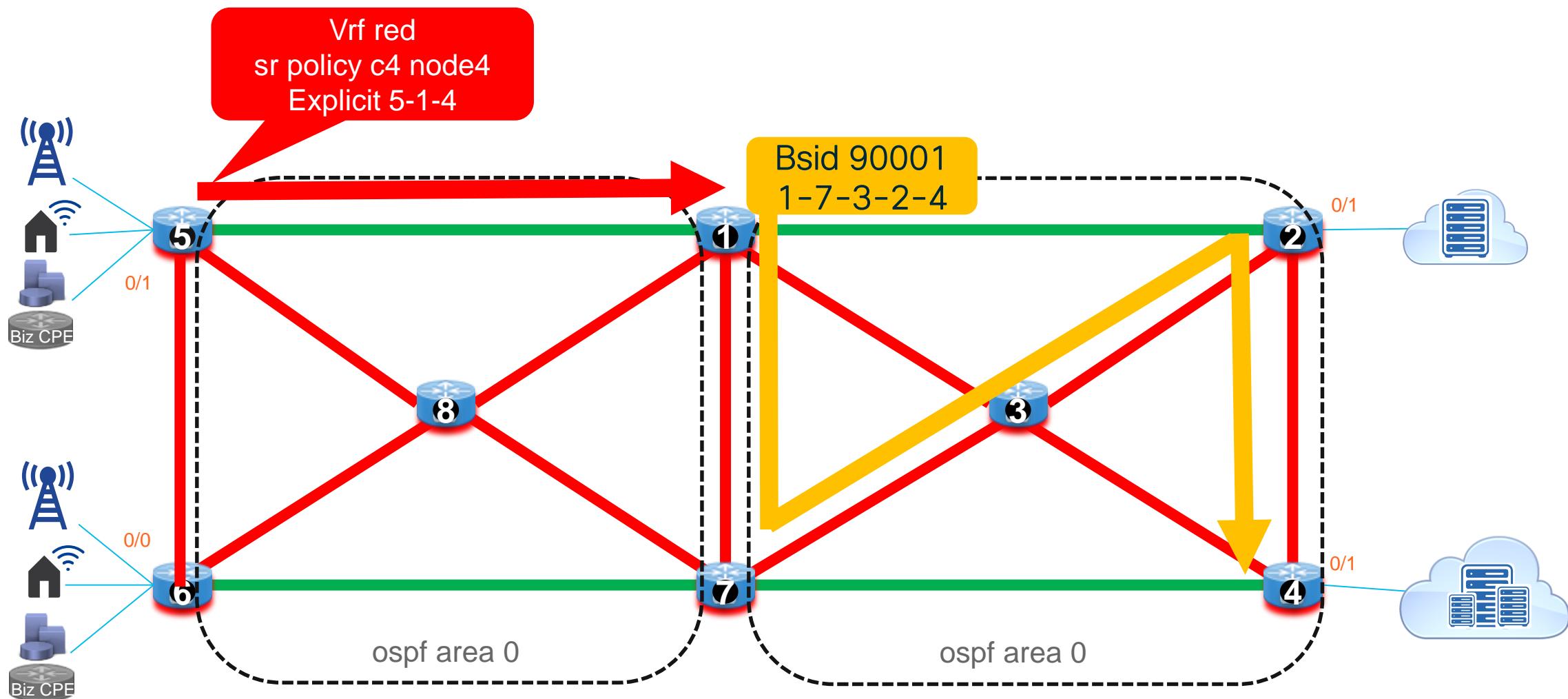
vrf red 40.40.40.40 source 55.55.55.55



## 15. Use Case Seamless MPLS Multi-IGP Domain - OSPF (SR Policy Explicit + Binding SID)



# Multi-IGP Domain – OSPF (SR Policy Explicit + Binding SID)



# Multi-IGP Domain OSPF (SR Policy Explicit + Binding SID)

Clear previous SR-Policy

```
Python node-5 no-srte-red-explicit-to-node-4
```

```
Python node-5 srte-red-bsid-90001
```

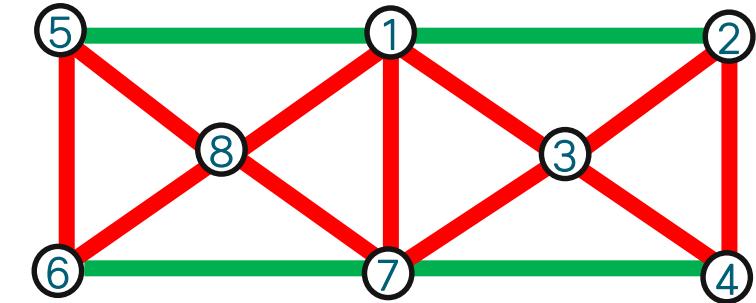
```
Python node-1 srte-bsid-90001-to-node-4
```

Trace before python  
Trace after python

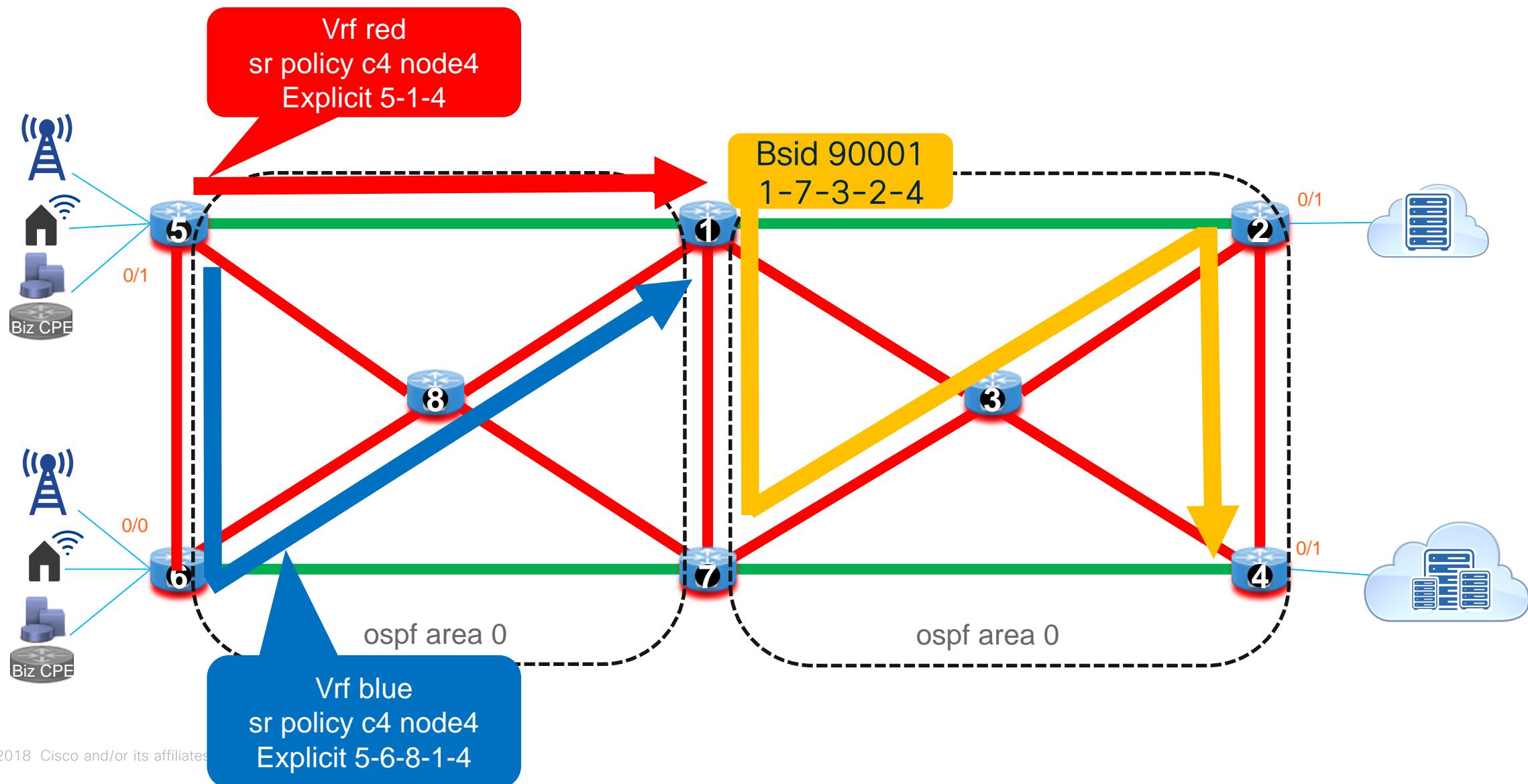
@Node5, 4  
Show run router ospf  
Show bgp vpng4 uni  
Show cef vrf red 4.4.4.4

Traceroute  
vrf red 4.4.4.4 source 5.5.5.5

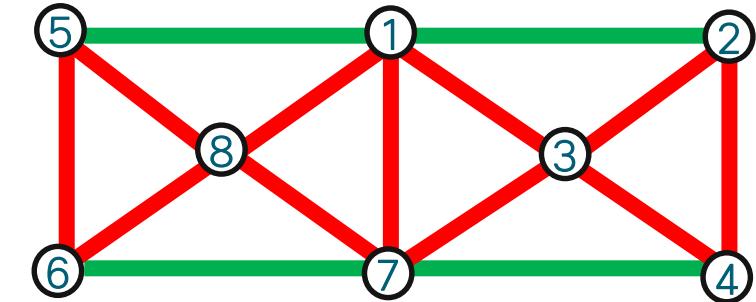
vrf blue 14.14.14.14 source 15.15.15.15



# Multi-IGP Domain – OSPF (SR Policy Explicit + Binding SID)



# Multi-IGP Domain OSPF (SR Policy Explicit + Binding SID)



Python node-5 no-srte-red-explicit-to-node-4

Python node-5 srte-red-bsid-90001  
Python node-5 srte-blue-bsid-90001

Python node-1 srte-bsid-90001-to-node-4

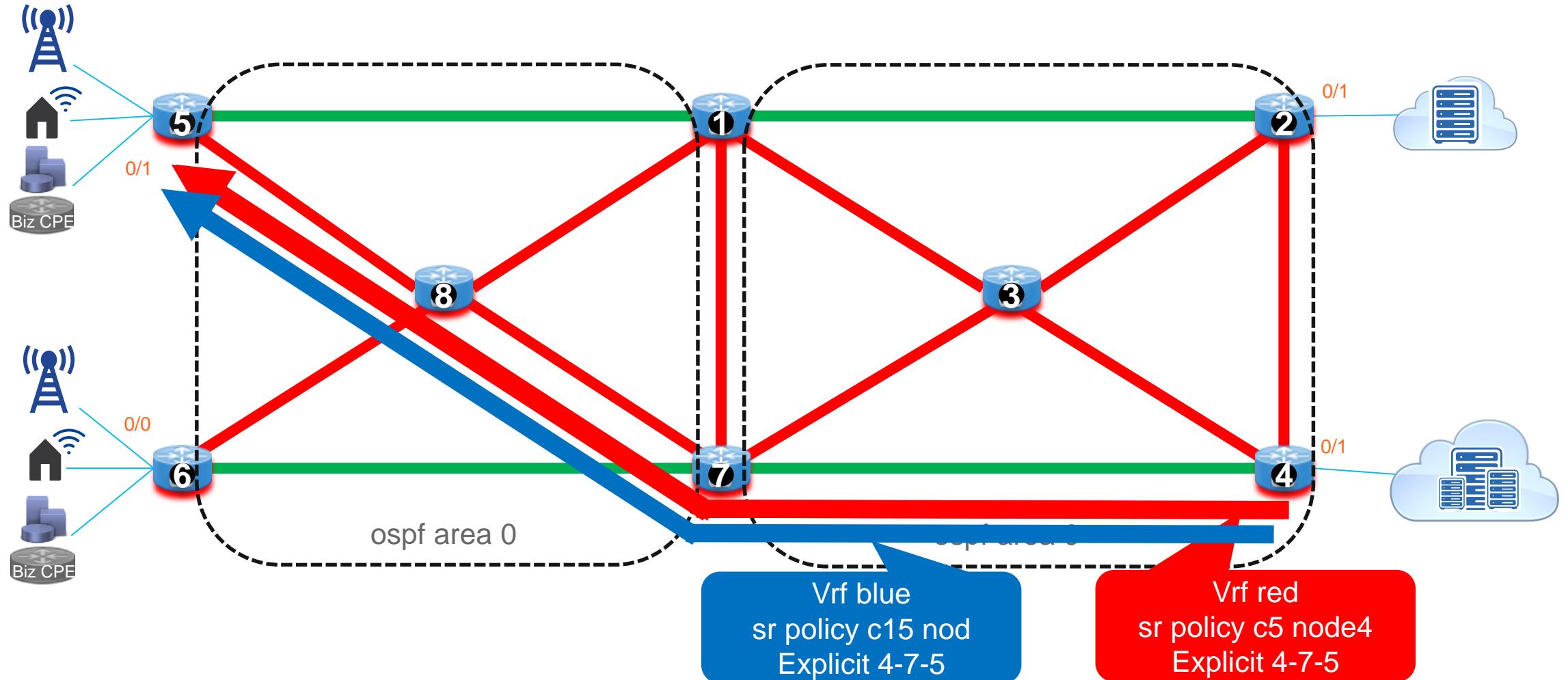
Trace before python  
Trace after python

@Node5, 4  
Show run router ospf  
Show bgp vpng4 uni  
Show cef vrf red 4.4.4.4

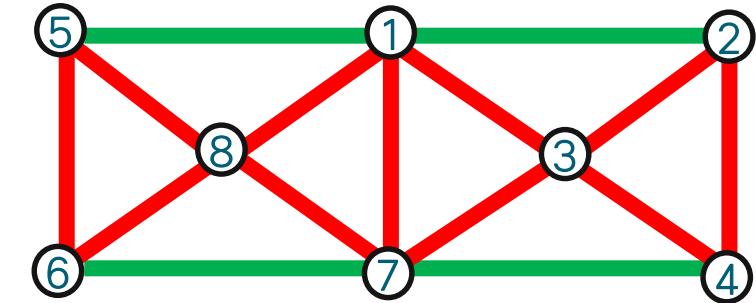
Traceroute  
vrf red 4.4.4.4 source 5.5.5.5

vrf blue 14.14.14.14 source 15.15.15.15

# Multi-IGP Domain – OSPF (SR Policy Explicit + Binding SID)



# Multi-IGP Domain OSPF (SR Policy Explicit + Binding SID)



Python node-5 no-srte-red-explicit-to-node-4

Python node-5 srte-red-bsid-90001

Python node-5 srte-blue-bsid-90001

Python node-1 srte-bsid-90001-to-node-4

Python node-4 srte-blue-explicit-to-node-5

Python node-4 srte-red-explicit-to-node-5

(because no bgp-lu)

@Node5, 4

Show run router ospf

Show bgp vpng4 uni

Show cef vrf red 4.4.4.4

Traceroute

vrf red 4.4.4.4 source 5.5.5.5

vrf blue 14.14.14.14 source 15.15.15.15

Trace before python

Trace after python

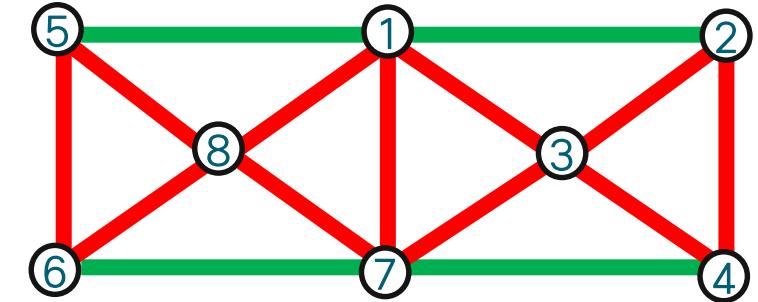
(expect to adjust adjacency label in SR-Policy)



# Clear SR Policy



# Clear SR Policy



```
Python node-5 no-srte-red-bsid-90001  
Python node-5 no-srte-blue-bsid-90001  
Python node-1 no-srte-bsid-90001-to-node-4
```

```
Python node-4 no-srte-blue-explicit-to-node-5  
Python node-4 no-srte-red-explicit-to-node-5
```

@Node5, 4  
Show segment traffic policy

Trace before python  
Trace after python



## 16. SR ODN On-Demand NextHop + SR PCE

# SR ODN + SR PCE

@Node5

Ping vrf red 4.4.4.4 repeat 100000

Python Node-5 odn-c4

Python Node-4 odn-c5

Python node-5 shut-int-0 --> link failure

Python node-5 delay-30-int-01 --> delay increase/worse

Python node-5 no-delay-30-int-01 --> delay restore

Python node-5 no-shut-int-0 --> link UP

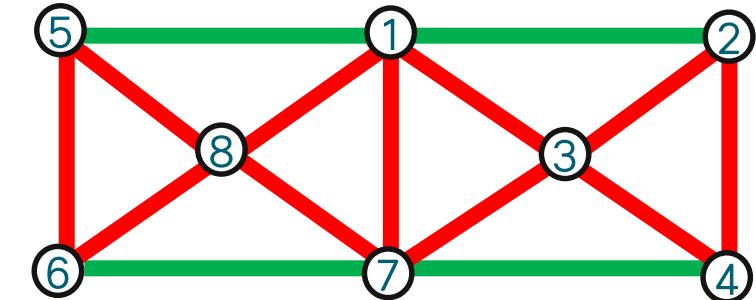
show segment-routing traffic-eng pcc ipv4 peer

Python node-5 no-pcc --> SR PCE Primary down  
- SR PCE Backup → ACTIVE

Python node-5 no-pcc2 --> SR PCE Backup down

Why time out ?

Show segment traffic policy



Python node-5 pcc

→ SR PCE Primary Restore UP

Python node-4 shut-int-lo0-lo40

→ auto-delete SR Policy

@Node5, show segment traffic policy

@SR PCE

Show pce ipv4 cspf source 1.1.1.5 destination  
1.1.1.4 metric-type te

@Node5, Traceroute

vrf red 4.4.4.4 source 5.5.5.5

vrf blue 14.14.14.14 source 15.15.15.15

@Node5

Ping vrf red 4.4.4.4 repeat 100000

# SRTE ODN LOW LATENCY – TE METRIC – VRF Prefix ON

```
segment-routing
traffic-eng
on-demand color 4
dynamic
pce
!
metric
type te
```

```
-----  
RP/0/0/CPU0:Node-5#sh segment-routing traffic-eng pol
```

```
SR-TE policy database
```

```
Name: bgp_AP_2 (Color: 4, End-point: 1.1.1.4)
```

```
Status:
```

```
Admin: up Operational: up for 00:00:18 (since Dec 3 14:41:21.321)
```

```
Candidate-paths:
```

```
Preference 100:
```

```
Dynamic (pce 1.1.1.201) (active)
```

```
Weight: 0, Metric Type: TE
```

**Metric Type: TE, Path Accumulated Metric: 30**  
**80001 [Adjacency-SID, 10.1.5.5 - 10.1.5.1]**  
**80005 [Adjacency-SID, 10.1.2.1 - 10.1.2.2]**  
**17004 [Prefix-SID, 1.1.1.4]**

```
Attributes:
```

```
Binding SID: 80010
```

```
Allocation mode: dynamic
```

```
State: Programmed
```

```
Policy selected: yes
```

```
Forward Class: 0
```

```
Distinguisher: 0
```

```
Auto-policy info:
```

```
Creator: BGP
```

```
IPv6 caps enable: no
```

```
RP/0/0/CPU0:XTC-1#sh pce ipv4 cspf source 1.1.1.5 des 1.1.1.4 metric-type te
Mon Dec 3 14:43:57.646 UTC
Path[0], from 1.1.1.5 to 1.1.1.4, cost=30:
Hop0: 10.1.5.1
Hop1: 10.1.2.2
Hop2: 10.2.4.4

CSPF result: shortest path success (rc=8)
```

```
RP/0/0/CPU0:Node-5#traceroute vrf red 4.4.4.4
Mon Dec 3 14:42:10.385 UTC
```

```
Type escape sequence to abort.
Tracing the route to 4.4.4.4
```

```
1 10.1.5.1 [MPLS: Labels 80005/17004/80007 Exp 0] 39 msec 19 msec 29 msec
2 10.1.2.2 [MPLS: Labels 17004/80007 Exp 0] 49 msec 19 msec 19 msec
3 10.2.4.4 19 msec * 19 msec
```



# Node5- SRTE-ODN + XTC PCE

BGP VPN

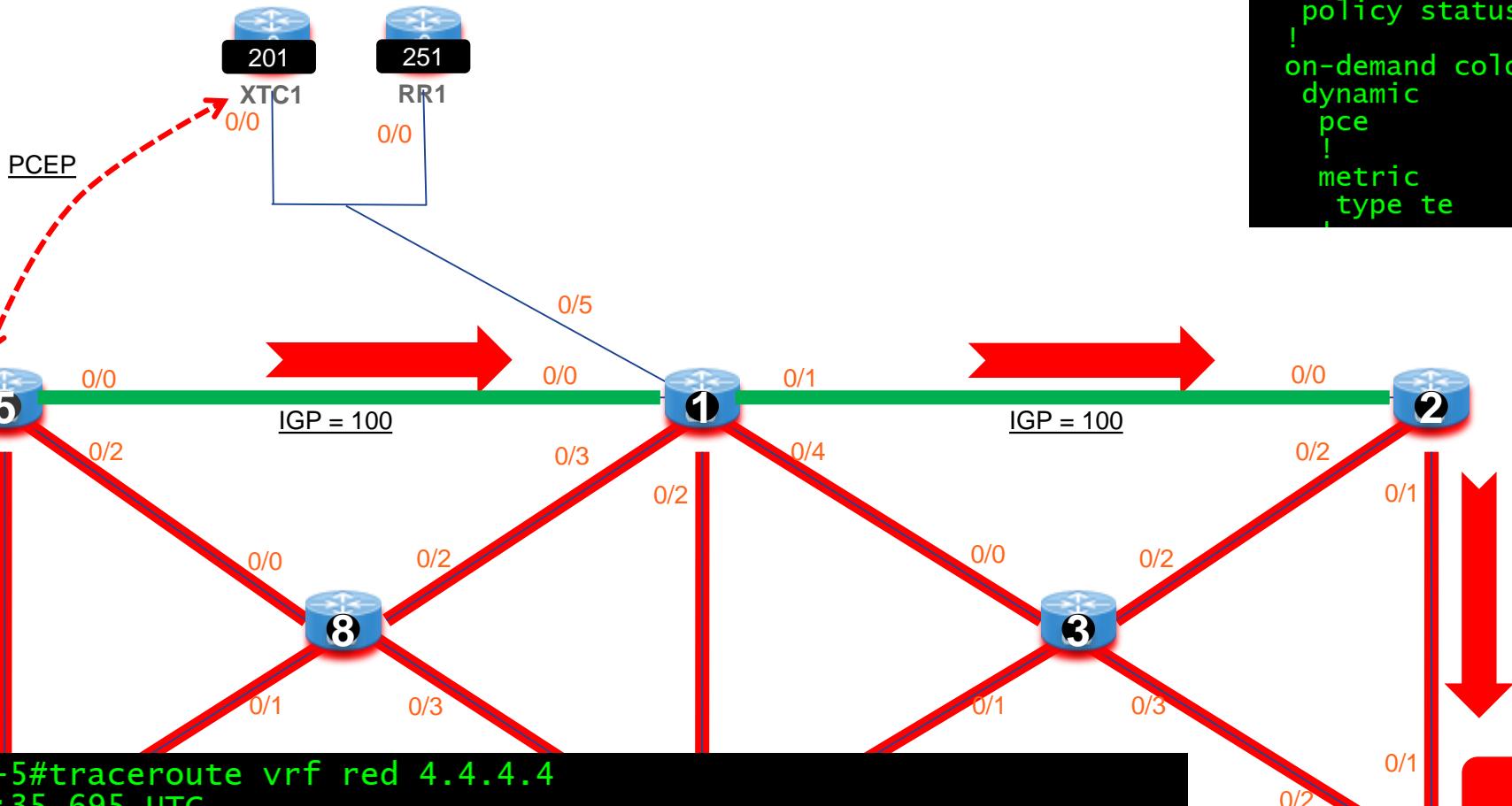
ISIS + SR

IP

+

XTC BGP  
SR CTRL

4.4.4.4 C4



```
RP/0/0/CPU0:Node-5#traceroute vrf red 4.4.4.4
Tue Dec 4 00:39:35.695 UTC
```

Type escape sequence to abort.  
Tracing the route to 4.4.4.4

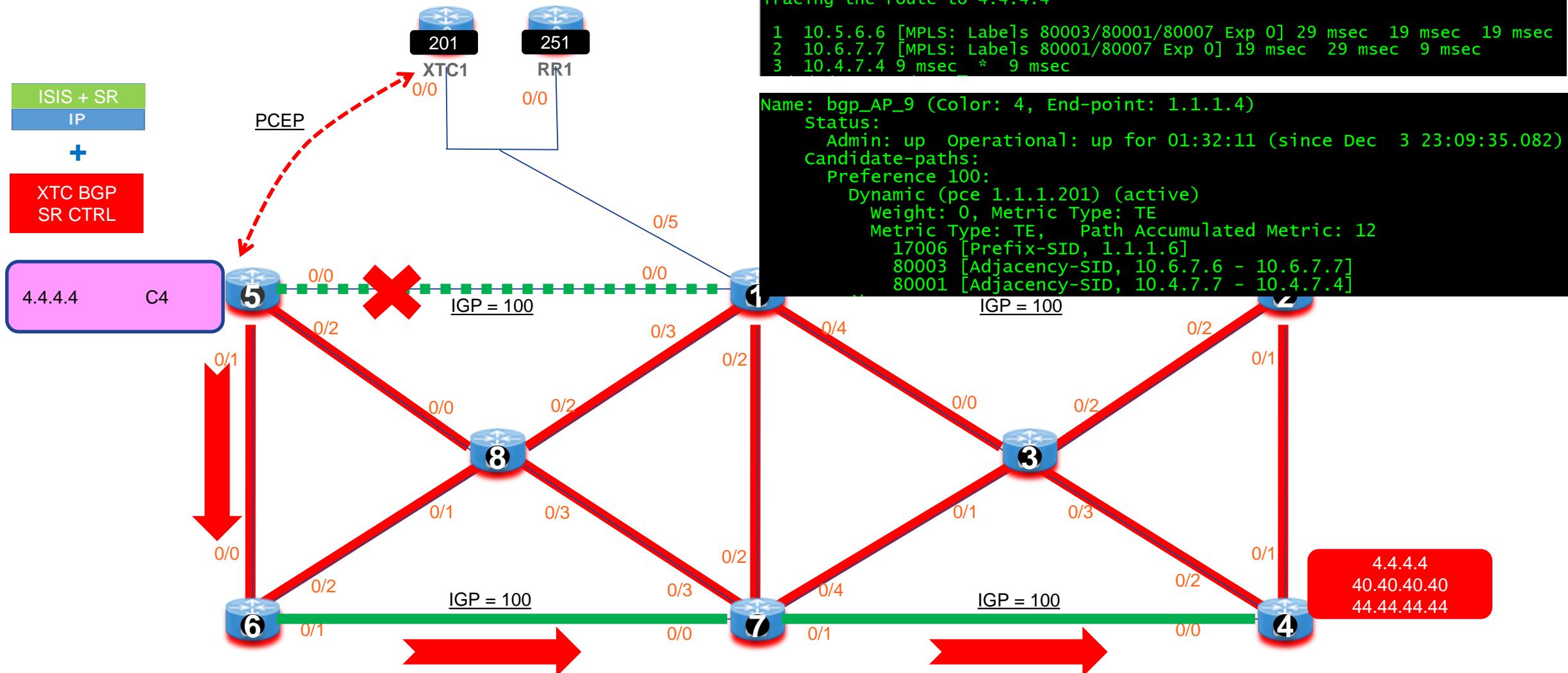
```
1 10.1.5.1 [MPLS: Labels 80005/17004/80007 Exp 0] 19 msec 19 msec 19 msec
2 10.1.2.2 [MPLS: Labels 17004/80007 Exp 0] 19 msec 9 msec 39 msec
3 10.2.4.4 19 msec * 19 msec
```

```
segment-routing
global-block 16000 80000
traffic-eng
logging
policy status
!
on-demand color 4
dynamic
pce
!
metric
type te
```

5

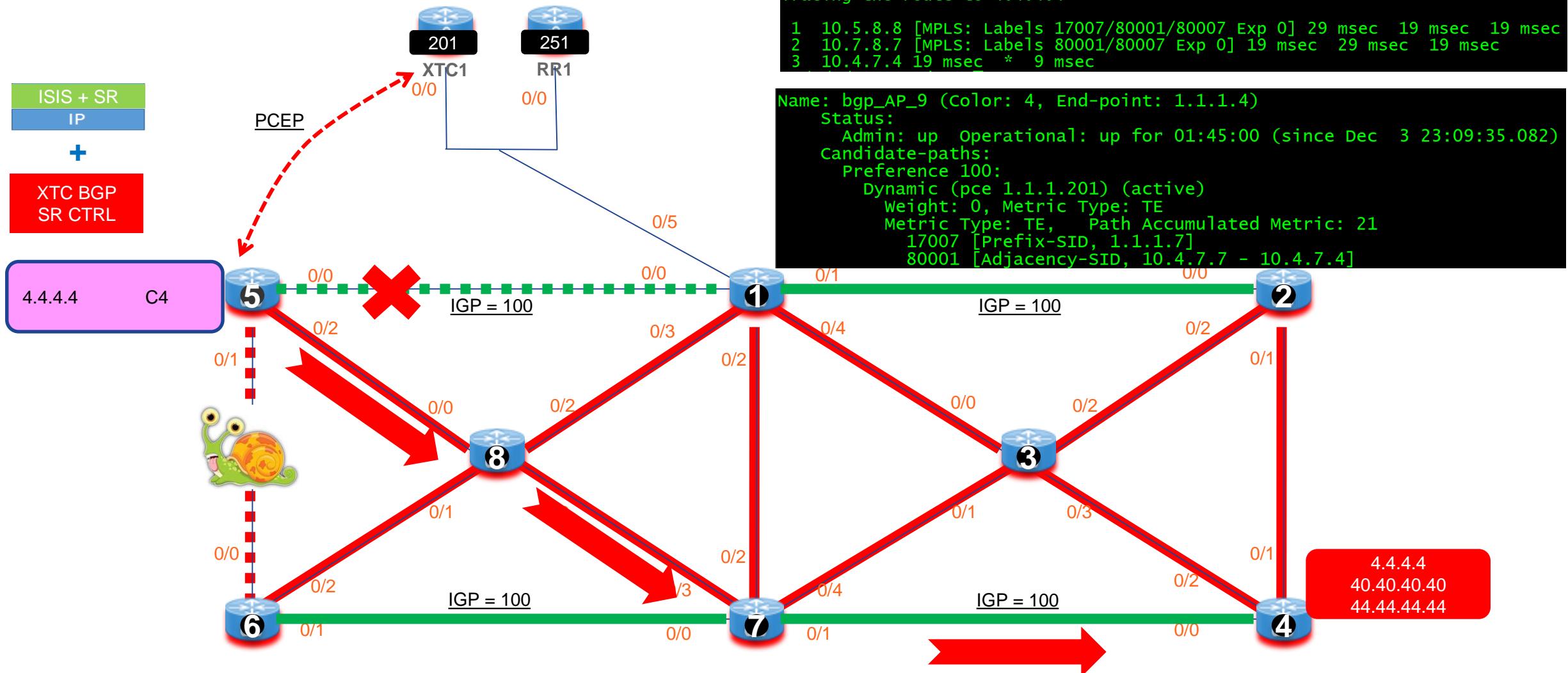
# Node5- SRTE-ODN + XTC PCE ( Link Failure )

BGP VPN



# Node5- SRTE-ODN + XTC PCE ( Delay Incident )

BGP VPN



# SRTE ODN – VRF Prefix OFF

```
RP/0/0/CPU0:Node-4#conf t
Mon Dec  3 14:46:06.208 UTC
RP/0/0/CPU0:Node-4(config)#int lo4
RP/0/0/CPU0:Node-4(config-if)#shut
RP/0/0/CPU0:Node-4(config-if)#commit
Mon Dec  3 14:46:12.597 UTC
RP/0/0/CPU0:Node-4(config-if)#
RP/0/0/CPU0:Node-4(config-if)#
RP/0/0/CPU0:Node-4(config-if)#do sh ip int brief
Mon Dec  3 14:49:51.324 UTC

Interface          IP-Address      Status    Protocol  Vrf-Name
Loopback0          1.1.1.4        Up        Up        default
Loopback4          4.4.4.4        Shutdown  Down      red
Loopback14         14.14.14.14   Up        Up        blue
Loopback40         40.40.40.40   Up        Up        red
Loopback44         44.44.44.44   Up        Up        red
```

```
RP/0/0/CPU0:Node-5#sh route vrf red
Mon Dec  3 14:48:43.094 UTC

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

Gateway of last resort is not set
```

```
L  5.5.5.5/32 is directly connected, 01:38:13, Loopback5
B  40.40.40.40/32 [200/0] via 1.1.1.4 (nexthop in vrf default), 01:38:09
B  44.44.44.44/32 [200/0] via 1.1.1.4 (nexthop in vrf default), 01:38:09
L  50.50.50.50/32 is directly connected, 01:38:13, Loopback50
L  55.55.55.55/32 is directly connected, 01:38:13, Loopback55
```

```
RP/0/0/CPU0:Node-5#
RP/0/0/CPU0:Node-5#
RP/0/0/CPU0:Node-5#sh route vrf red 4.4.4.4/32
Mon Dec  3 14:48:47.354 UTC
```

```
% Network not in table
```

```
RP/0/0/CPU0:Node-5#sh segment-routing traffic-eng pol
Mon Dec  3 14:48:51.834 UTC
RP/0/0/CPU0:Node-5#
```

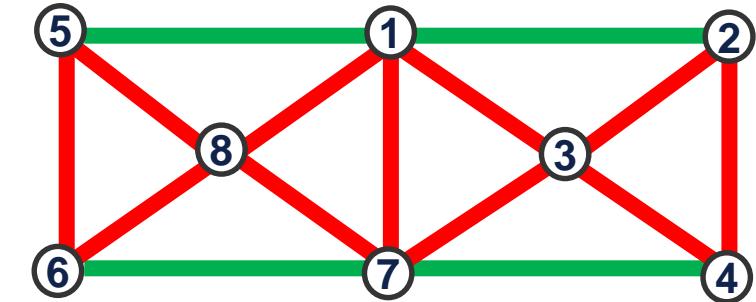




# Clear SR Policy



# Clear SR Policy



Python Node-5 no-odn-c4  
Python Node-4 no-odn-c5

@Node5, 4  
Show segment traffic policy

Trace before python  
Trace after python



## 17. Segment Routing PCE REST API

# SR PCE REST

- RP/0/0/CPU0:XTC-1#sh run pce
- Sun Feb 3 02:36:53.445 UTC
- pce
- address ipv4 1.1.1.201
- rest
- user cisco
- password encrypted 00071A150754 (type password clear cisco – automatically encrypted)
- !
- authentication basic
- !
- logging
- no-path
- fallback
- !
- state-sync ipv4 1.1.1.202
- password encrypted 121A0C041104



# SR PCE REST client – curl & browser

```
← → ⌂ ⓘ Not secure | 198.18.1.31:8080/lsp/delete/simple?peer=1.1.1.4&name=rest_4_5

delete-lsp "rest_4_5" (SR) on peer 1.1.1.4 (Success)

htjun@HTJUN-L90X6 MINGW64 ~
$ curl -u cisco:cisco --raw -vN "http://198.18.1.31:8080/lsp/create/simple?peer=1.1.1.5&name=rest_5_4&type=sr&source=1.1.1.5&destination=1.1.1.4&color=10&hop1-node-sid=16001&hop1-ip-local=1.1.1.1&hop2-node-sid=16002&hop2-ip-local=1.1.1.2&hop3-node-sid=16004&hop3-ip-local=1.1.1.4"
*   Trying 198.18.1.31...
* TCP_NODELAY set
% Total    % Received % Xferd  Average Speed   Time     Time      Time  Current
          Dload  Upload   Total   Spent    Left  Speed
 0       0     0      0      0      0  --::--  --::--  --::--    035
create-lsp "rest_5_4" (sr) on peer 1.1.1.5 (Success)
0

create-lsp "rest_5_4" (sr) on peer 1.1.1.5 (Success) * Connected to 198.18.1.31 (198.18.1.31) port 8080 (#0)
* Server auth using Basic with user 'cisco'
> GET /lsp/create/simple?peer=1.1.1.5&name=rest_5_4&type=sr&source=1.1.1.5&destination=1.1.1.4&color=10&hop1-node-sid=16001&hop1-ip-local=1.1.1.1&hop2-node-sid=16002&hop2-ip-local=1.1.1.2&hop3-node-sid=16004&hop3-ip-local=1.1.1.4 HTTP/1.1
> Host: 198.18.1.31:8080
> Authorization: Basic Y2lzy286Y2lzY28=
> User-Agent: curl/7.57.0
> Accept: */*
>
< HTTP/1.1 200 OK
< Cache-Control: no-cache, no-store
< Content-Type: text/json; charset=utf-8
< Expires: -1
< Transfer-Encoding: chunked
< Connection: keep-alive
<
{ [64 bytes data]
100 53 0 53 0 0 53 0  --::--  --::--  --::--  679
* Connection #0 to host 198.18.1.31 left intact
```

[

# SR PCE REST client - postman

Postman

File Edit View Help

New Import Runner + My Workspace IN SYNC

Hey! You're running a very old version of Postman. Our newest app has a lot more features. [Learn more](#)

Filter

History Collections

U\_Node-4 CREATE SR Policy 4\_to\_5 Color 20 Examples (0)

GET http://198.18.1.3:18080/lsp/create/simple? peer=1.1.1.4&name=rest\_4\_5&type=sr&source=1.1.4&destination=1.1.1.5&color=20

Status: 200 OK Time: 100 ms Size: 212 B

Auth Heads up about auth... Body Cookies Headers (5) Test Results

Params Save Send

Pre-req. Tests Cookies Code

Pretty Raw Preview Save Response

Username: cisco  
Password: cisco Show Password

create-lsp "rest\_4\_5" (sr) on peer 1.1.1.4 (Success)

NETWORK-Slice-D... 9 requests  
NSO-GNS3 9 requests  
SR EPE 3 requests  
XTC 4 requests  
GET SR PCE GET Topol...  
GET Node-4 CREATE S...  
GET U\_Node-4 CREATE..  
GET Node-4 DELETE S...

CONFIDENTIAL BUILD ▾ Confidential 86

# SR PCE REST create\_lsp parameter -1

**/lsp/create/simple – rest url**

peer=1.1.1.2 – pcc (tunnel headend router) address

name=rest\_2\_4 – tunnel name, max name length is restricted to 128 characters. Name cannot contains spaces or special characters (allowed are '-', '\_', '(', ')')

type=sr – setup type. If not specified SR is assumed. Allowed values are sr or rsvp

source=1.1.1.2 – tunnel source address. If not specified "peer" address will be used instead

allow-xtc-reoptimization=0 - REST client prevents XTC to update lsp with new path e.g. in case of link down and REST client has to update path itself. Default value is 1, in that case XTC is allowed to modify lsp.

destination=1.1.1.4 – tunnel destination address

color=10 – SR policy color, mandatory when creating SR policy (not needed for rsvp lsps)

preference=10 – SR policy path preference, default value is 100, (not needed for rsvp lsps)



# SR PCE REST create\_lsp parameter -2

metric-igp=10 - using igp metric as path computation constraint

metric-te=10 - using te metric as path computation constraint

metric-latency=10 - using latency metric as path computation constraint

hop1-adj-sid=24001&hop1-ip-local=99.1.2.2&hop1-ip-remote=99.1.2.1 – path's first hop defined by adj-sid

hop2-adj-sid=28099&hop2-ip-local=99.1.3.1&hop2-ip-remote=99.1.3.3 – path's second hop defined by adj-sid

hop3-adj-sid=24003&hop3-ip-local=99.3.4.3&hop3-ip-remote=99.3.4.4 – path's third hop defined by adj-sid

hopX-node-sid=30001&hopX-ip-local=1.1.1.1

**Example: (no\_space)**

```
curl --raw -vN "http://<xtc-ip-addr>:8080/lsp/create/simple?peer=1.1.1.2&name=rest_2_4&type=sr
&source=1.1.1.2&destination=1.1.1.4&color=10
&hop1-adj-sid=24001&hop1-ip-local=99.1.2.2&hop1-ip-remote=99.1.2.1
&hop2-adj-sid=28099&hop2-ip-local=99.1.3.1&hop2-ip-remote=99.1.3.3
&hop3-adj-sid=24003&hop3-ip-local=99.3.4.3&hop3-ip-remote=99.3.4.4"
```

# SR PCE REST update\_lsp parameter

## /lsp/update/simple – rest url

peer=1.1.1.2 – pcc (tunnel headend router) address

name=rest\_2\_4 – tunnel name, max name length is restricted to 128 characters. Name cannot contains spaces or special characters (allowed are '-', '\_', '(', ')')

type=sr – setup type. If not specified SR is assumed

hop1-adj-sid=24001&hop1-ip-local=99.1.2.2&hop1-ip-remote=99.1.2.1 – path's first hop defined by adj-sid

hop2-adj-sid=28099&hop2-ip-local=99.1.3.1&hop2-ip-remote=99.1.3.3 – path's second hop defined by adj-sid

hop3-adj-sid=24003&hop3-ip-local=99.3.4.3&hop3-ip-remote=99.3.4.4 – path's third hop defined by adj-sid

### Example: (no\_space)

```
curl --raw -vN "http://<xtc-ip-addr>:8080/lsp/update/simple?peer=1.1.1.2&name=rest_2_4
&hop1-adj-sid=24001&hop1-ip-local=99.1.2.2&hop1-ip-remote=99.1.2.1
&hop2-adj-sid=28099&hop2-ip-local=99.1.3.1&hop2-ip-remote=99.1.3.3
&hop3-adj-sid=24003&hop3-ip-local=99.3.4.3&hop3-ip-remote=99.3.4.4"
```

# SR PCE REST delete\_lsp parameter

**/lsp/delete/simple – rest url**

peer=1.1.1.2 – pcc (tunnel headend router) address

name=rest\_2\_4 – tunnel name, max name length is restricted to 128 characters. Name cannot contains spaces or special characters (allowed are '-', '\_', '(', ')')

**Example:**

```
curl --raw -vN "http://<xtc-ip-addr>:8080/lsp/delete/simple?peer=1.1.1.2&name=rest_2_4"
```

# Sample Lab

- curl -u cisco:cisco --raw -vN  
"http://198.18.1.31:8080/lsp/create/simple?peer=1.1.1.5&name=rest\_5\_4&type=sr&source=1.1.1.5&destination=1.1.1.4&color=4&hop1-adj-sid=80001&hop1-ip-local=10.1.5.5&hop1-ip-remote=10.1.5.1&hop2-adj-sid=80001&hop2-ip-local=10.1.2.1&hop2-ip-remote=10.1.2.2&hop3-adj-sid=80006&hop3-ip-local=10.2.4.2&hop3-ip-remote=10.2.4.4"
- curl -u cisco:cisco --raw -vN  
"http://198.18.1.31:8080/lsp/create/simple?peer=1.1.1.5&name=rest\_5\_4&type=sr&source=1.1.1.5&destination=1.1.1.4&color=10&hop1-node-sid=16001&hop1-ip-local=1.1.1.1&hop2-node-sid=16002&hop2-ip-local=1.1.1.2&hop3-node-sid=16004&hop3-ip-local=1.1.1.4"
- curl -u cisco:cisco --raw -vN "http://198.18.1.31:8080/lsp/delete/simple?peer=1.1.1.5&name=rest\_5\_4"
- curl -u cisco:cisco --raw -vN  
"http://198.18.1.31:8080/lsp/create/simple?peer=1.1.1.4&name=rest\_4\_5&type=sr&source=1.1.1.4&destination=1.1.1.5&color=20"
- curl -u cisco:cisco --raw -vN  
"http://198.18.1.31:8080/lsp/create/simple?peer=1.1.1.4&name=rest\_4\_5&type=sr&source=1.1.1.4&destination=1.1.1.5&color=20&metric-igp=10"
- curl -u cisco:cisco --raw -vN "http://198.18.1.31:8080/lsp/delete/simple?peer=1.1.1.4&name=rest\_4\_5"
- curl -u cisco:cisco --raw -vN "http://198.18.1.31:8080/lsp/delete/simple?peer=1.1.1.4&name=rest\_4\_5"

# Lab1a

- curl -u cisco:cisco --raw -vN "http://198.18.1.31:8080/lsp/create/simple?"
- peer=1.1.1.5
- &name=rest\_5\_4
- &type=sr&source=1.1.1.5
- &destination=1.1.1.4
- &color=4
- &metric-te=10"

```
RP/0/0/CPU0:Node-5#show seg tra pol
Wed Feb 27 05:10:27.209 UTC

SR-TE policy database
-----
Name: pcep_rest_5_4 (Color: 4, End-point: 1.1.1.4)
  Status:
    Admin: up  Operational: up for 00:00:50 (since Feb 2
7 05:09:37.361)
  Candidate-paths:
    Preference 100:
      Dynamic (pce 1.1.1.201) (active)
        Metric Type: TE, Path Accumulated Metric: 12
          80020 [Adjacency-SID, 10.1.5.5 - 10.1.5.1]
          80012 [Adjacency-SID, 10.1.2.1 - 10.1.2.2]
          16004 [Prefix-SID, 1.1.1.4]
  Attributes:
    Binding SID: 80001
    Allocation mode: dynamic
    State: Programmed
    Policy selected: yes
    Forward Class: 0
    Steering BGP disabled: no
    IPv6 caps enable: no
    Distinguisher: 0
  Auto-policy info:
    Creator: PCEP
```

ⓘ 198.18.1.31:8080/lsp/create/simple?peer=1.1.1.5&name=rest\_5\_4&type=sr&source=1.1.1.5&destination=1.1.1.4&color=4&metr...

Sign in

http://198.18.1.31:8080

Your connection to this site is not private

Username

Password

← → C ⓘ Not secure | 198.18.1.31:8080/lsp/create/simple?peer=1.1.1.5&name=rest\_5\_4&type=sr&source=1.1.... 🔒 ☆

create-lsp "rest\_5\_4" (sr) on peer 1.1.1.5 (Success)



# SR PCE Verification

@SR PCE

Show pce lsp

Show pce lsp detail

Show pce lsp summary

```
RP/0/0/CPU0:XTC-1#show pce lsp
Wed Feb 27 05:15:15.086 UTC
```

```
PCE's tunnel database:
```

```
-----
```

```
PCC 1.1.1.5:
```

```
Tunnel Name: rest_5_4
```

```
LSPs:
```

```
LSP[0]:
```

```
source 1.1.1.5, destination 1.1.1.4, tunnel ID 11, LSP ID 2
```

```
State: Admin up, Operation active
```

```
Setup type: Segment Routing
```

```
Binding SID: 80001
```

```
Maximum SID Depth: 5
```

```
Absolute Metric Margin: 0
```

```
Relative Metric Margin: 0%
```

```
RP/0/0/CPU0:XTC-1#show pce lsp detail
```

```
Wed Feb 27 05:15:23.945 UTC
```

```
PCE's tunnel database:
```

```
-----
```

```
PCC 1.1.1.5:
```

```
Tunnel Name: rest_5_4
```

```
LSPs:
```

```
LSP[0]:
```

```
source 1.1.1.5, destination 1.1.1.4, tunnel ID 11, LSP ID 2
```

```
State: Admin up, Operation active
```

```
Setup type: Segment Routing
```

```
Binding SID: 80001
```

```
Maximum SID Depth: 5
```

```
Absolute Metric Margin: 0
```

```
Relative Metric Margin: 0%
```

```
Bandwidth: signaled 0 kbps, applied 0 kbps
```

```
PCEP information:
```

```
PLSP-ID 0x8000b, flags: D:1 S:0 R:0 A:1 O:2 C:1
```

```
LSP Role: Single LSP
```

```
State-sync PCE: None
```

```
PCC: 1.1.1.5
```

```
LSP is subdelegated to: None
```

```
Reported path:
```

```
Metric type: TE, Accumulated Metric 12
```

```
SID[0]: Adj, Label 80020, Address: local 10.1.5.5 remote 10.1.5.1
```

```
SID[1]: Adj, Label 80012, Address: local 10.1.2.1 remote 10.1.2.2
```

```
SID[2]: Node, Label 16004, Address 1.1.1.4
```

```
Computed path: (Local PCE)
```

```
Computed Time: Wed Feb 27 05:09:36 UTC 2019 (00:05:48 ago)
```

```
Metric type: TE, Accumulated Metric 12
```

```
SID[0]: Adj, Label 80020, Address: local 10.1.5.5 remote 10.1.5.1
```

```
SID[1]: Adj, Label 80012, Address: local 10.1.2.1 remote 10.1.2.2
```

```
SID[2]: Node, Label 16004, Address 1.1.1.4
```

```
Recorded path:
```

```
None
```

```
Disjoint Group Information:
```

```
Cisco Confidential
```

# Lab1b

- curl -u cisco:cisco --raw -vN "http://198.18.1.31:8080/lsp/create/simple?"
- peer=1.1.1.4
- &name=rest\_4\_5
- &type=sr&source=1.1.1.4
- &destination=1.1.1.5
- &color=5
- &metric-te=10"

```
RP/0/0/CPU0:Node-4#show seg tra pol
Wed Feb 27 05:25:55.820 UTC

SR-TE policy database
-----
Name: pcep_rest_4_5 (color: 5, End-point: 1.1.1.5)
  Status:
    Admin: up  Operational: up for 00:00:22 (since Feb 27 05:25:33.625)
  Candidate-paths:
    Preference 100:
      Dynamic (pce 1.1.1.201) (active)
        Metric Type: TE, Path Accumulated Metric: 30
          80018 [Adjacency-SID, 10.4.7.4 - 10.4.7.7]
          80019 [Adjacency-SID, 10.6.7.7 - 10.6.7.6]
          16005 [Prefix-SID, 1.1.1.5]
  Attributes:
    Binding SID: 80001
    Allocation mode: dynamic
    State: Programmed
    Policy selected: yes
    Forward Class: 0
    Steering BGP disabled: no
    IPv6 caps enable: no
    Distinguisher: 0
  Auto-policy info:
    Creator: PCEP
```

```
RP/0/0/CPU0:Node-5#trace vrf red 4.4.4.4 source 5.5.5.5
Wed Feb 27 05:35:06.557 UTC

Type escape sequence to abort.
Tracing the route to 4.4.4.4

1 10.1.5.1 [MPLS: Labels 80012/16004/80007 Exp 0] 19 msec 19 msec 19 msec
2 10.1.2.2 [MPLS: Labels 16004/80007 Exp 0] 9 msec 19 msec 19 msec
3 10.2.4.4 9 msec * 9 msec
```

```
RP/0/0/CPU0:Node-4#trace vrf red 5.5.5.5 source 4.4.4.4
Wed Feb 27 05:36:08.457 UTC

Type escape sequence to abort.
Tracing the route to 5.5.5.5

1 10.4.7.7 [MPLS: Labels 80019/16005/80007 Exp 0] 19 msec 19 msec 9 msec
2 10.6.7.6 [MPLS: Labels 16005/80007 Exp 0] 9 msec 9 msec 9 msec
3 10.5.6.5 9 msec * 9 msec
```



# Lab2

- curl -u cisco:cisco --raw -vN "http://198.18.1.31:8080/lsp/update/simple?"
- peer=1.1.1.4
- &name=rest\_4\_5
- &type=sr&source=1.1.1.4
- &destination=1.1.1.5
- &color=5
- &hop1-node-sid=16002&hop1-ip-local=1.1.1.2
- &hop2-node-sid=16003&hop2-ip-local=1.1.1.3
- &hop3-node-sid=16007&hop3-ip-local=1.1.1.7
- &hop4-node-sid=16005&hop4-ip-local=1.1.1.5
- &metric-te=10"

```
RP/0/0/CPU0:Node-4#show seg tra pol
Wed Feb 27 05:42:27.860 UTC

SR-TE policy database
-----
Name: pcep_rest_4_5 (Color: 5, End-point: 1.1.1.5)
  Status:
    Admin: up  Operational: up for 00:16:54 (since Feb 27 05:25:33.625)
  Candidate-paths:
    Preference 100:
      Dynamic (pce 1.1.1.201) (active)
        Metric Type: TE, Path Accumulated Metric: 10
          16002 [Prefix-SID, 1.1.1.2]
          16003 [Prefix-SID, 1.1.1.3]
          16007 [Prefix-SID, 1.1.1.7]
          16005 [Prefix-SID, 1.1.1.5]
  Attributes:
    Binding SID: 80001
    Allocation mode: dynamic
    State: Programmed
    Policy selected: yes
    Forward Class: 0
    Steering BGP disabled: no
    IPv6 caps enable: no
    Distinguisher: 0
  Auto-policy info:
    Creator: PCEP
```

```
RP/0/0/CPU0:Node-4#trace vrf red 5.5.5.5 source 4.4.4.4
Wed Feb 27 05:43:18.117 UTC

Type escape sequence to abort.
Tracing the route to 5.5.5.5

 1 10.2.4.2 [MPLS: Labels 16003/16007/16005/80007 Exp 0] 19 msec 19 msec 19 msec
 2 10.2.3.3 [MPLS: Labels 16007/16005/80007 Exp 0] 19 msec 19 msec 19 msec
 3 10.3.7.7 [MPLS: Labels 16005/80007 Exp 0] 19 msec 19 msec 19 msec
 4 10.7.8.8 [MPLS: Labels 16005/80007 Exp 0] 19 msec 19 msec 19 msec
 5 10.5.8.5 19 msec * 19 msec
```





File Edit View Help

New Import Runner

My Workspace ▾



IN SYNC



No Environment



Filter

History

Collections



9 requests

NSO-GNS3  
9 requests

SR EPE  
3 requests

XTC  
4 requests

GET SR PCE GET Topol...

GET Node-4 CREATE S...

GET U\_Node-4 CREATE..

GET Node-4 DELETE S...

Post-Servi Post-Servi Post-Servi Post-Servi Post-Servi Node-4 CF Nod U\_N + ...

### Node-4 DELETE SR Policy 4\_to\_5

Examples (0) ▾

GET

http://198.18.1.3  
1:8080/lsp/delet  
e/simple?  
peer=1.1.1.4&na  
me=rest\_4\_5

Params

Send

Save

Auth ●  
generated w  
about authorization

Hea  
me=rest\_4\_5

Pre-req.  
Tests

Cookies  
Code

Status: 200 OK Time: 87 ms Size: 212 B

Body

Cookies

Headers (5)

Test Results

Pretty Raw Preview



Save Response

delete-lsp "rest\_4\_5" (SR) on peer 1.1.1.4 (Success)

! Heads up! These parameters hold sensitive data. To keep this data secure while working in a collaborative environment, we recommend using variables. [Learn more about variables](#)

Username

cisco

Password

.....

Show Password

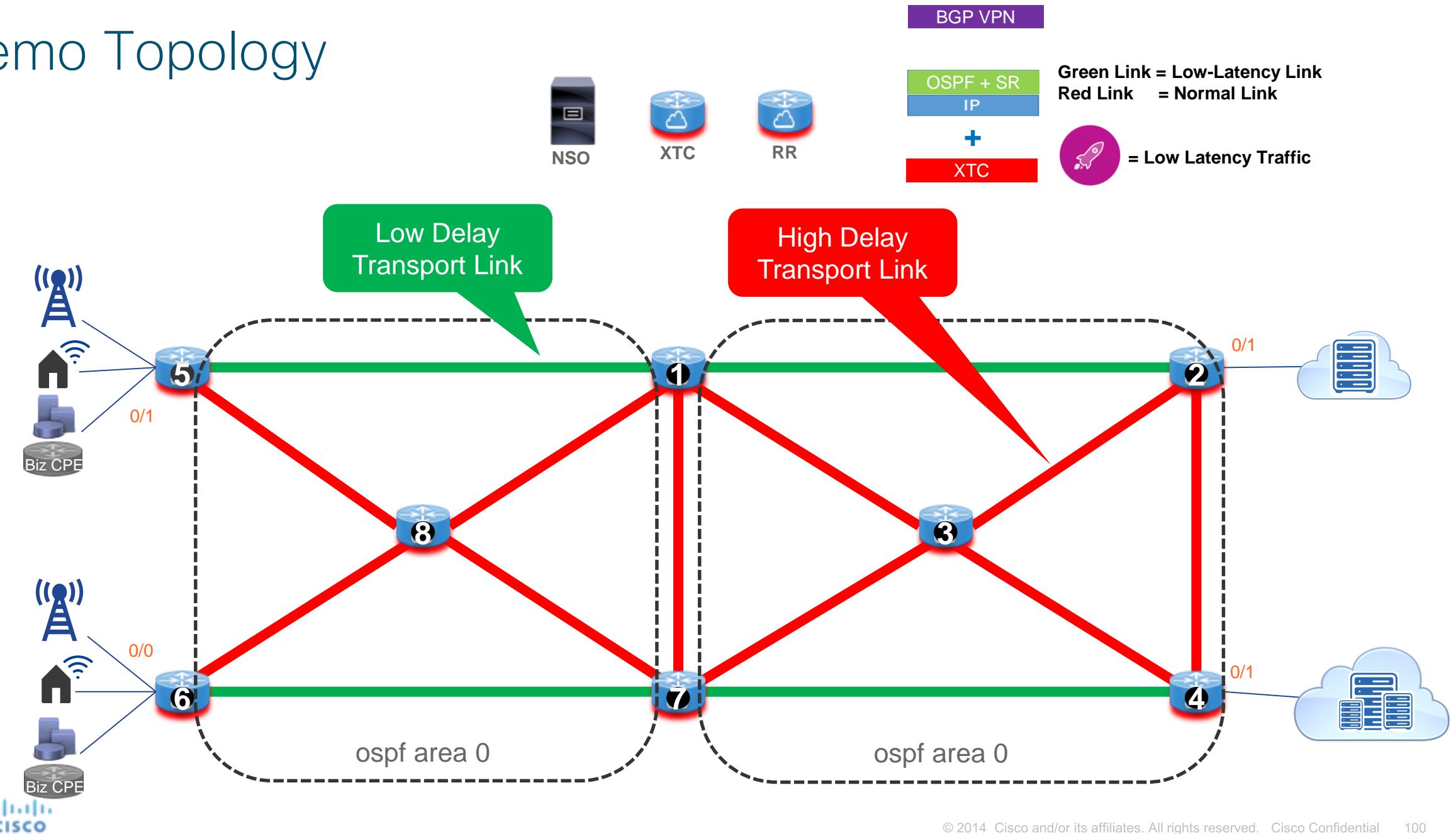


## 18.Network Slicing Automation SR On-Demand-NextHop + XTC + NSO

## Demo – Why ?

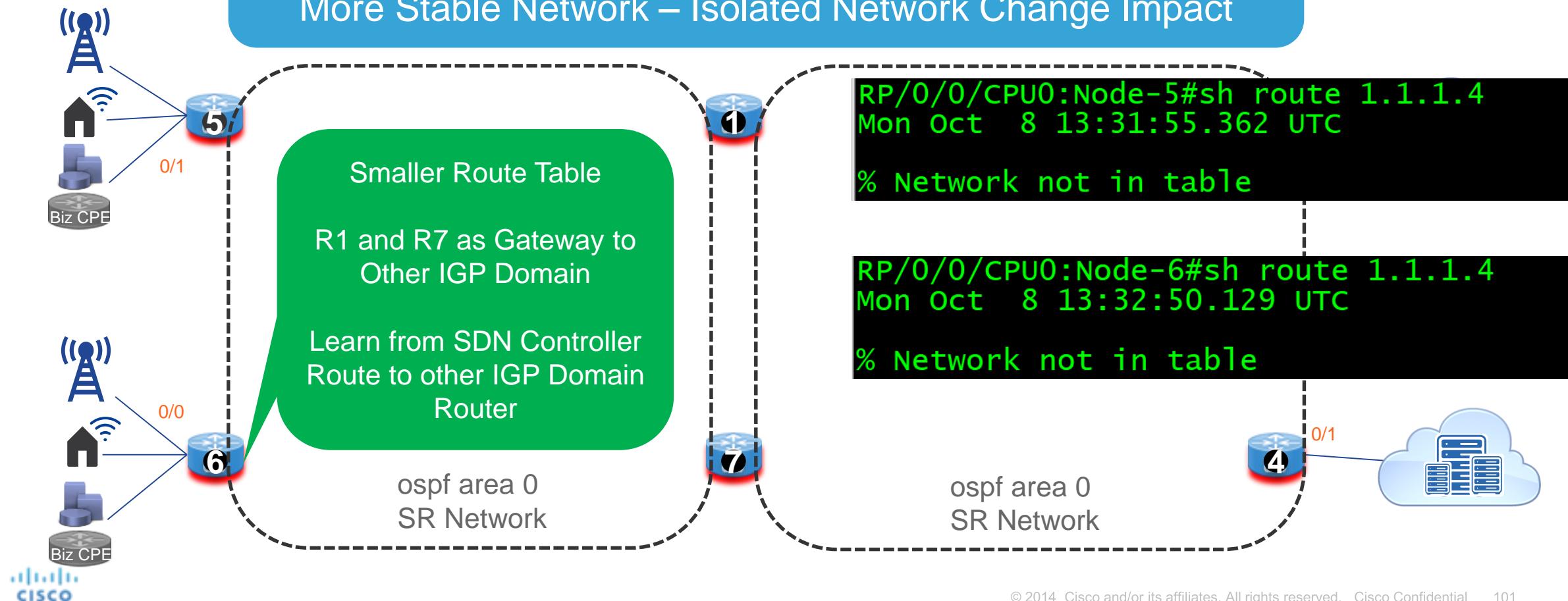
- Can a Telco create **Network Slices** mapping to specific **transport SLA** requirements/intent ?
  - Including **network bandwidth**
  - Including **network delay**
  - Including **path disjointness**
- Can **Traffic Engineered (TE)** path be created **On-Demand** from anywhere to anywhere in a given network slice ?
- Can **Traffic be Automatically Steered** onto these **On-Demand TE paths** ?

# Demo Topology



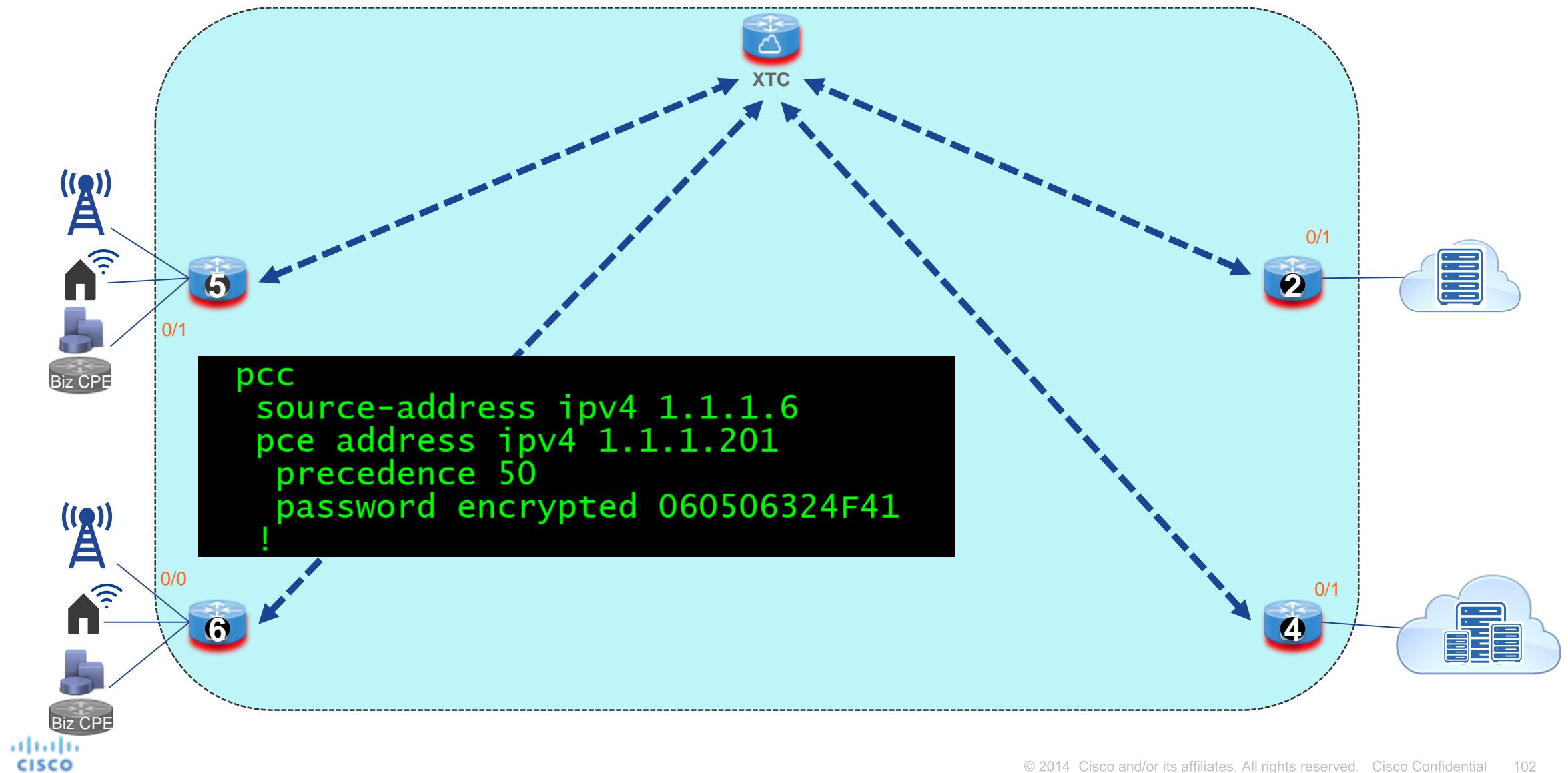
# Segment Routing + Seamless MPLS Architecture for Simple, Flexible and Scalable Network

Multiple IGP domain with BGP LU or SDN Controller  
Large Scale and Flexible Network (up to 100.000)  
More Stable Network – Isolated Network Change Impact



# Demo Learn On-Demand Path from XTC via PCEP

show run segment-routing



# Demo Network Slice Creation

NSO 4.6.1.2 Configuration Editor root ▾

network-slice-srodn:network-slice-srodn{asian-games}/

include subfolders  show actions  show operdata  show empty

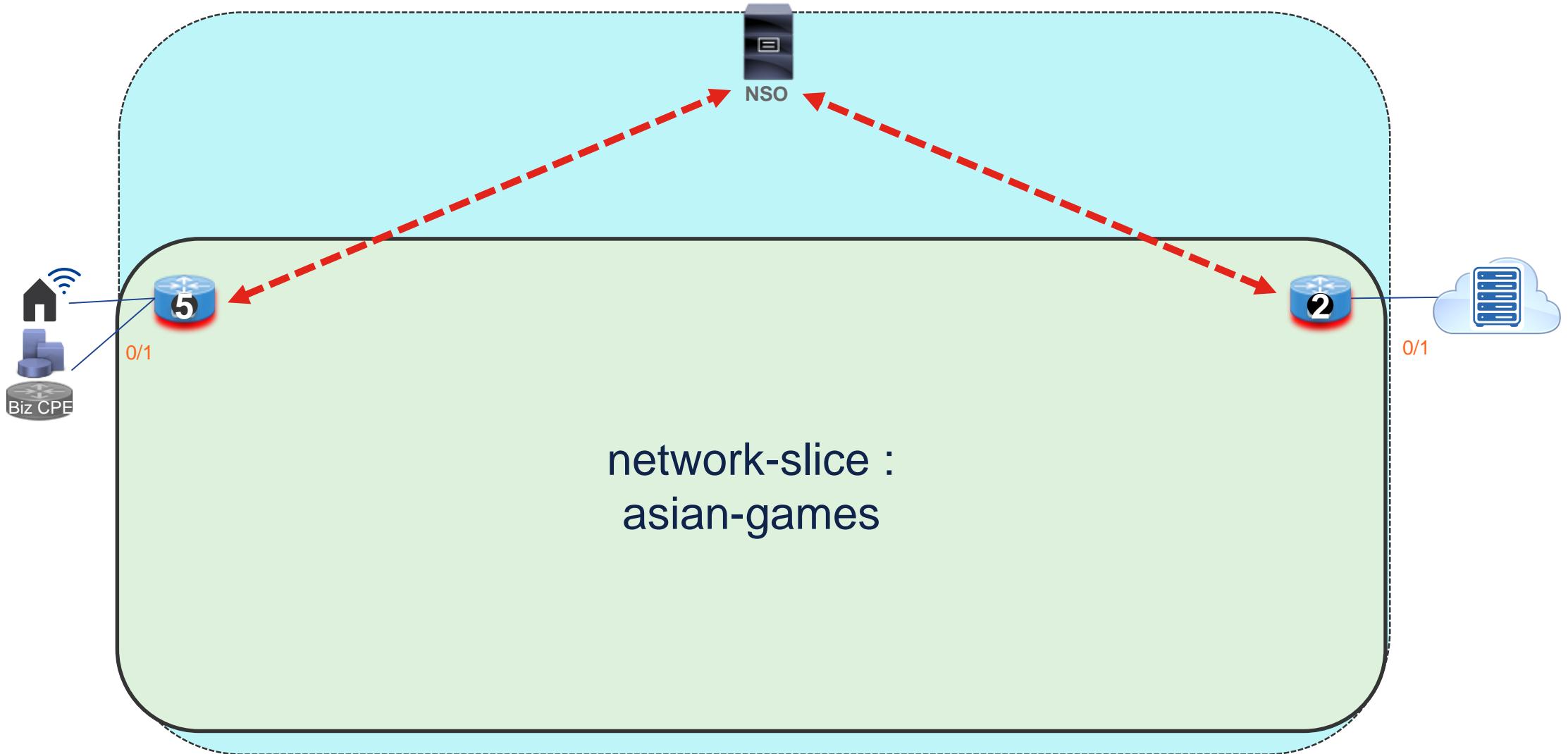
network-slice-name asian-games	disjoint-path (false)
network-slice-id* 100	
low-latency-slice (false)	

node-list/

- node
- Node-2
- Node-5

☰ ⊖ ⊕

# Demo Network Slice Creation



# Demo Node Slice for Service Application

NSO 4.6.1.2 Configuration Editor

network-slice-srodn:network-slice-srodn{asian-games}/node-list{Node-2}/

include subfolders  show actions  show operdata  show empty

node	Node-2					
—node-slice/						
< <input type="checkbox"/> node-slice-name	routing-protocol-to-ce	link-interface-id	link-vlan-id	low-latency-prefix	link-ipv4	>
< <input type="checkbox"/> asian-games-2	connected	0/0/0/1	100	false	2.2.1.0	

NSO 4.6.1.2 Configuration Editor

network-slice-srodn:network-slice-srodn{asian-games}/node-list{Node-5}/

include subfolders  show actions  show operdata  show empty

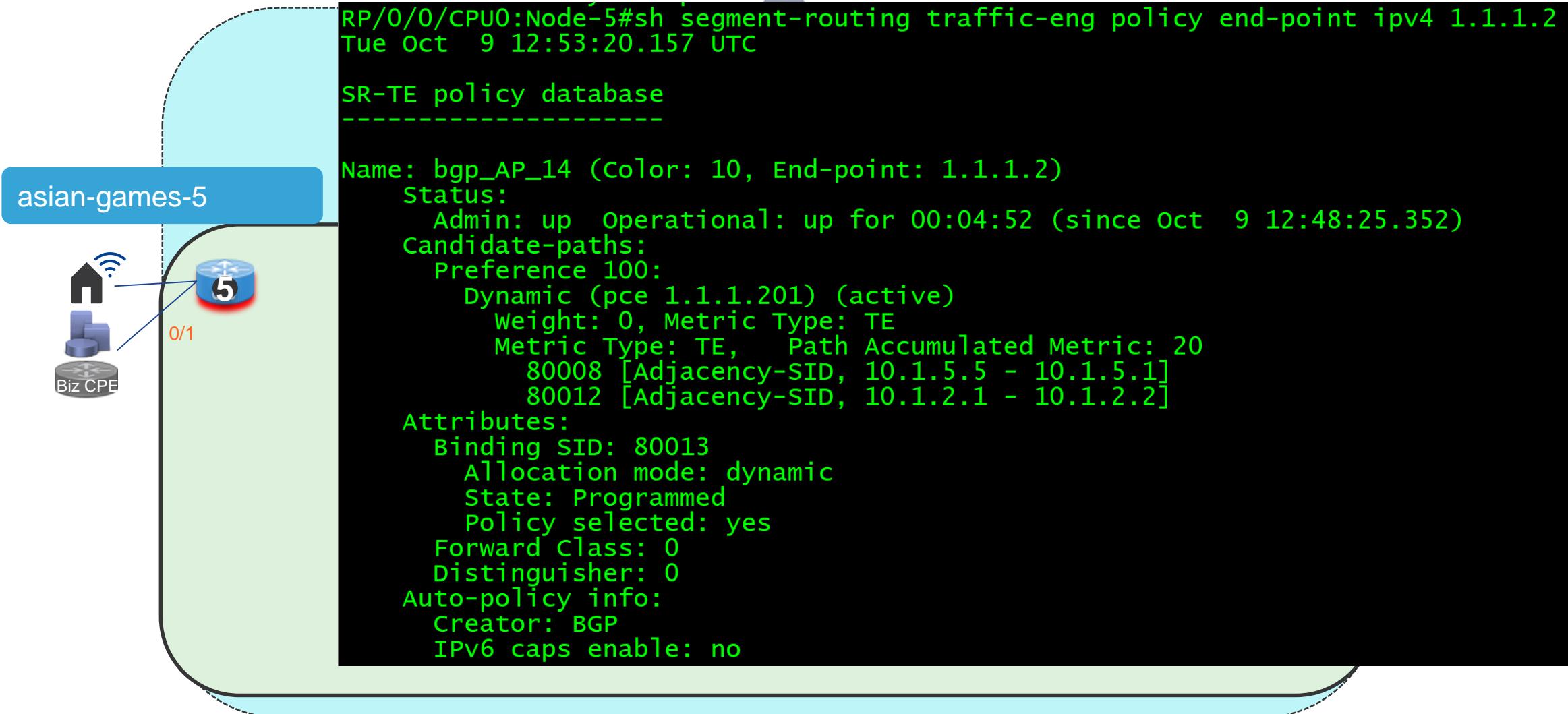
node	Node-5					
—node-slice/						
< <input type="checkbox"/> node-slice-name	routing-protocol-to-ce	link-interface-id	link-vlan-id	low-latency-prefix	link-ipv4	>
< <input type="checkbox"/> asian-games-5	connected	0/0/0/1	100	false	5.5.1.0	

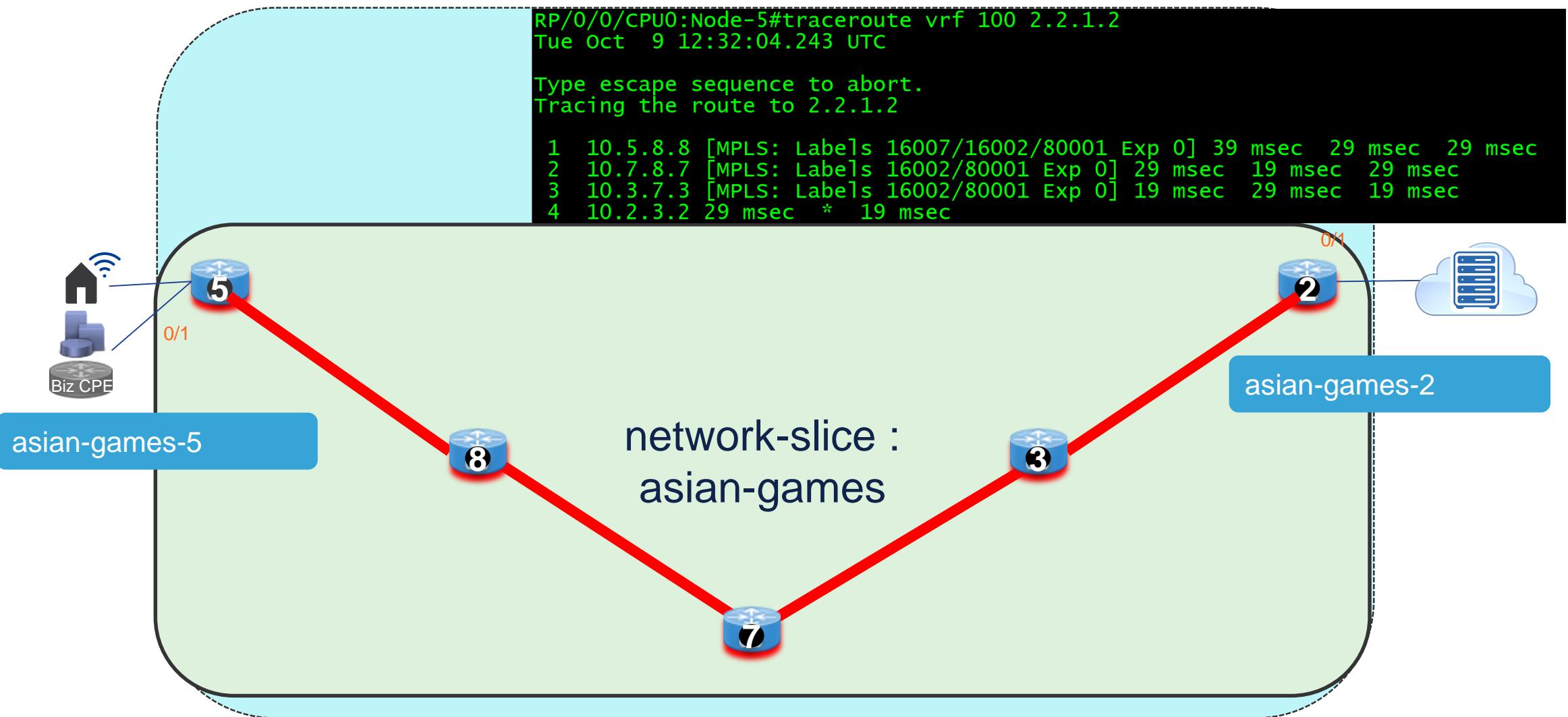
# Demo Node Slice Creation



# Demo Segment Routing On Demand NextHop (BGP)



# Demo SR On-Demand Automated Steered TE Path – Normal Path



# Demo Node Slice for Service Application

NSO 4.6.1.2 Configuration Editor

root

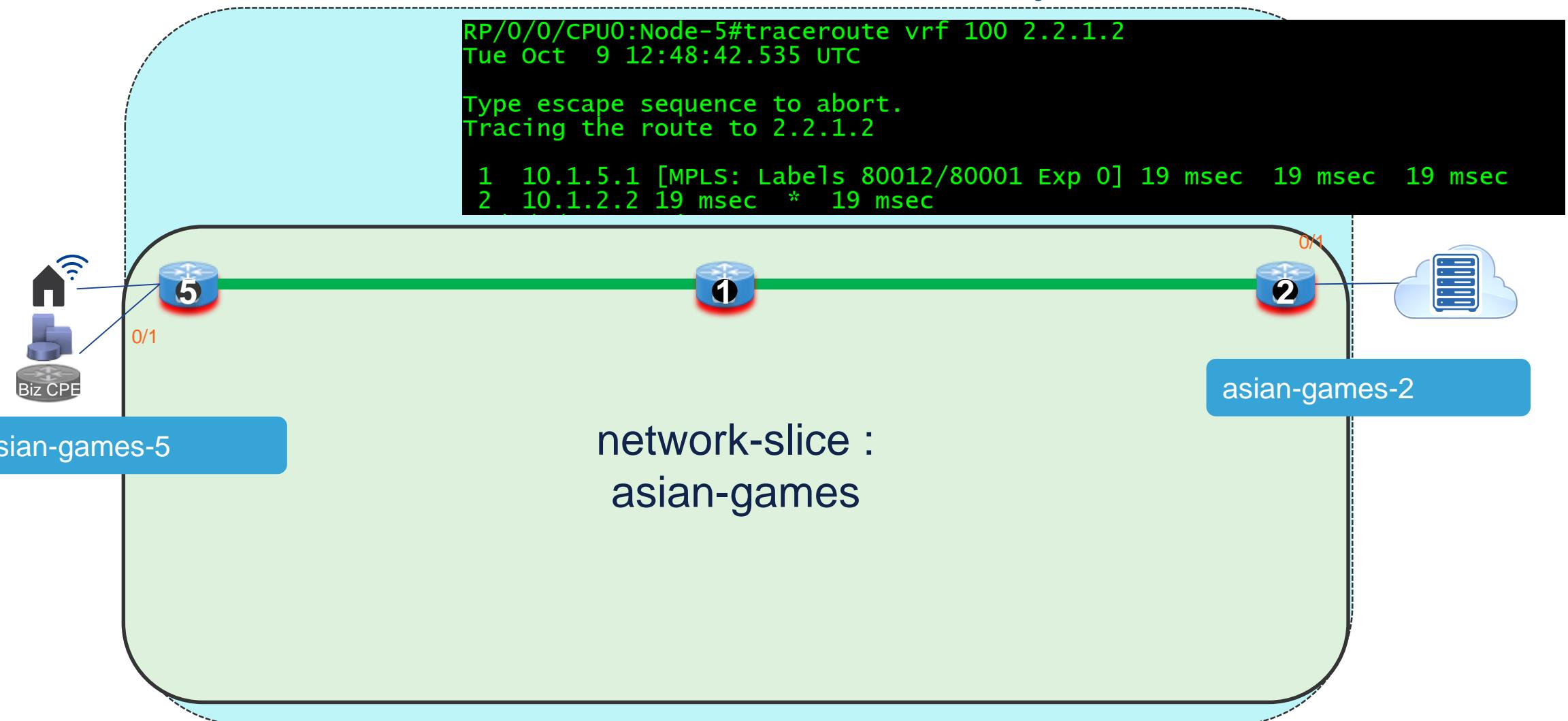
network-slice-srodn:network-slice-srodn{asian-games}/node-list{Node-2}/

include subfolders  show actions  show operdata  show empty

node	Node-2
node-slice/	
node-slice-name	asian-games-2
routing-protocol-to-ce	connected
link-interface-id	0/0/0/1
link-vlan-id	100
low-latency-prefix	true
link-ipv4	2.2.1.0

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# Demo SR On-Demand Automated Steered TE Path - Low Latency Path



# Demo Traffic Service Maps to Transport SLA Intent



# Demo Traffic Service Maps to Transport SLA Intent

NSO 4.6.1.2 Configuration Editor

t network-slice-srodn:network-slice-srodn{4g-slice400-jakarta}/node-list{Node-4}/

include subfolders  show actions  show operdata  show empty

node	Node-4
node-slice/	
<input type="checkbox"/>	node-slice-name routing-protocol-to-ce link-interface-id link-vlan-id low-latency-prefix link-ipv4
<input type="checkbox"/>	4g-v401-ip4-signalling connected 0/0/0/1 401 false 4.4.1.0
<input type="checkbox"/>	4g-v402-ip4-bearer connected 0/0/0/1 402 false 4.4.2.0
<input type="checkbox"/>	4g-v403-ip4-oam connected 0/0/0/1 403 false 4.4.3.0

NSO 4.6.1.2 Configuration Editor

t network-slice-srodn:network-slice-srodn{4g-slice400-jakarta}/node-list{Node-5}/

include subfolders  show actions  show operdata  show empty

node	Node-5
node-slice/	
<input type="checkbox"/>	node-slice-name routing-protocol-to-ce link-interface-id link-vlan-id low-latency-prefix link-ipv4
<input type="checkbox"/>	4g-v401-ip5-signalling connected 0/0/0/1 401 false 4.5.1.0
<input type="checkbox"/>	4g-v402-ip5-bearer connected 0/0/0/1 402 false 4.5.2.0
<input type="checkbox"/>	4g-v403-ip5-oam connected 0/0/0/1 403 false 4.5.3.0

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t network-slice-srodn:network-slice-srodn{4g-slice400-jakarta}/node-list{Node-6}/

 include subfolders |  show actions  show operdata  show empty

## node

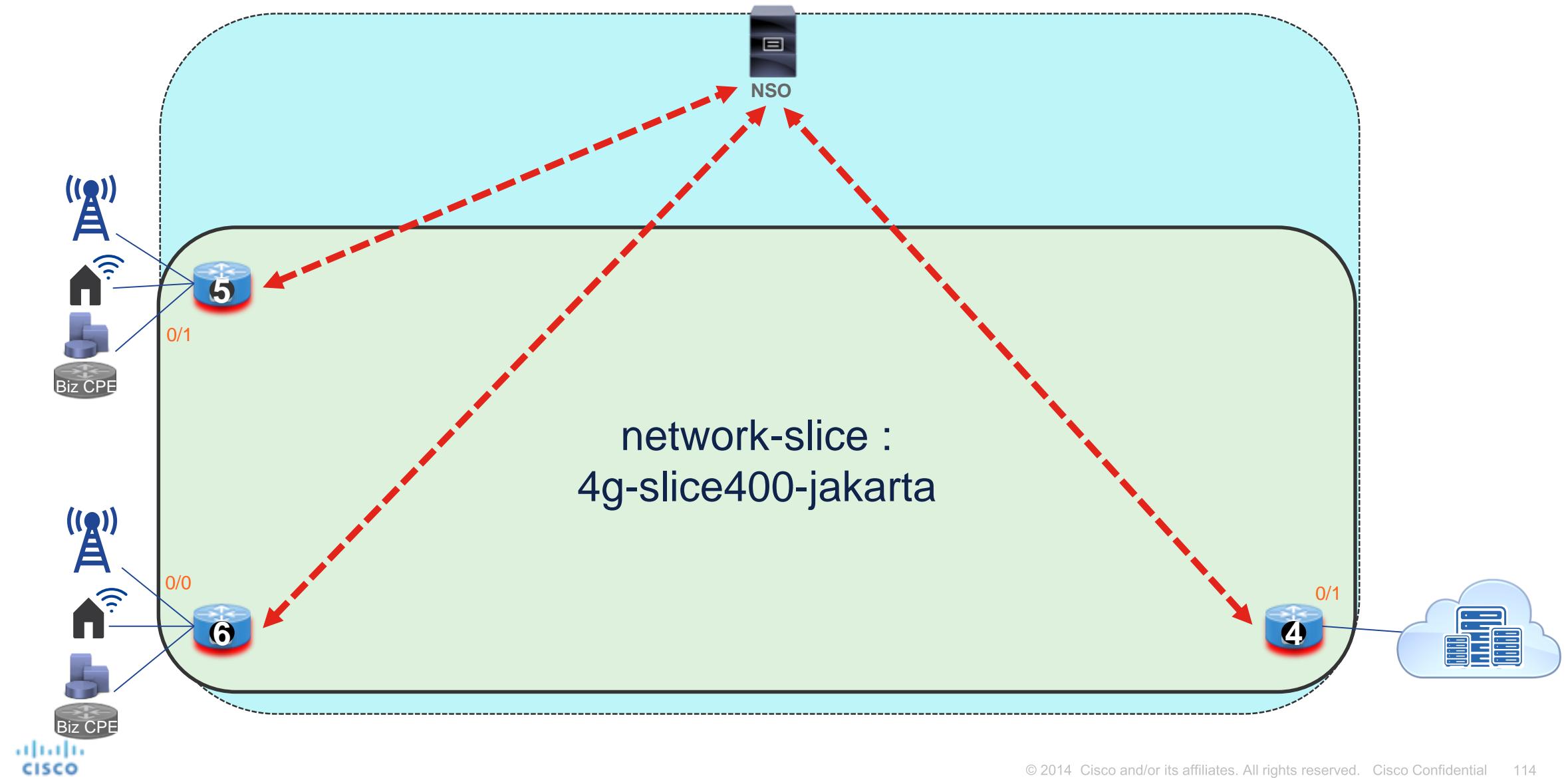
Node-6

—node-slice/

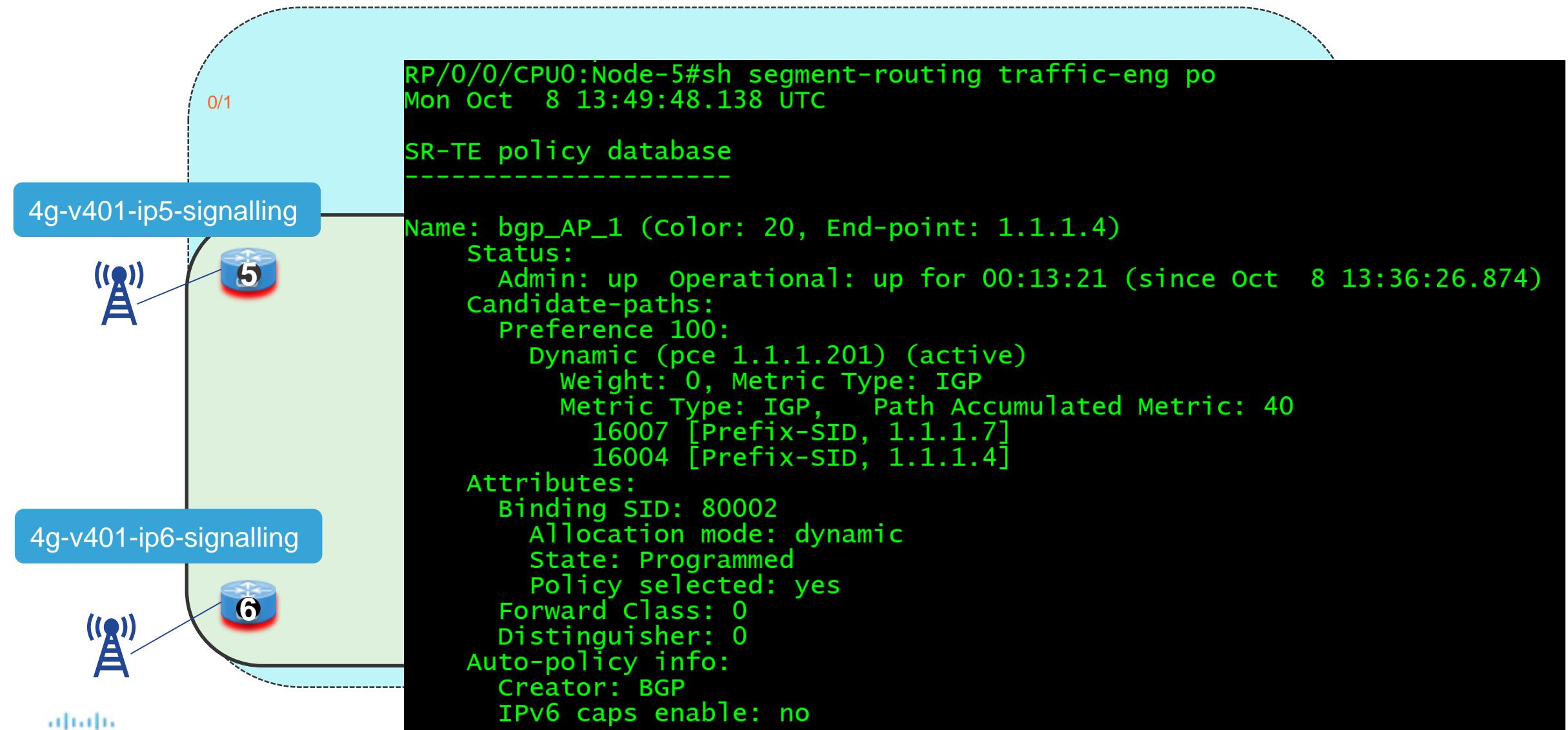
<input type="checkbox"/>	node-slice-name	routing-protocol-to-ce	link-interface-id	link-vlan-id	low-latency-prefix	link-ipv4-prefix
<input type="checkbox"/>	4g-v401-ip6-signalling	connected	0/0/0/0	401	false	4.6.1.0
<input type="checkbox"/>	4g-v402-ip6-bearer	connected	0/0/0/0	402	false	4.6.2.0
<input type="checkbox"/>	4g-v403-ip6-oam	connected	0/0/0/0	403	false	4.6.3.0



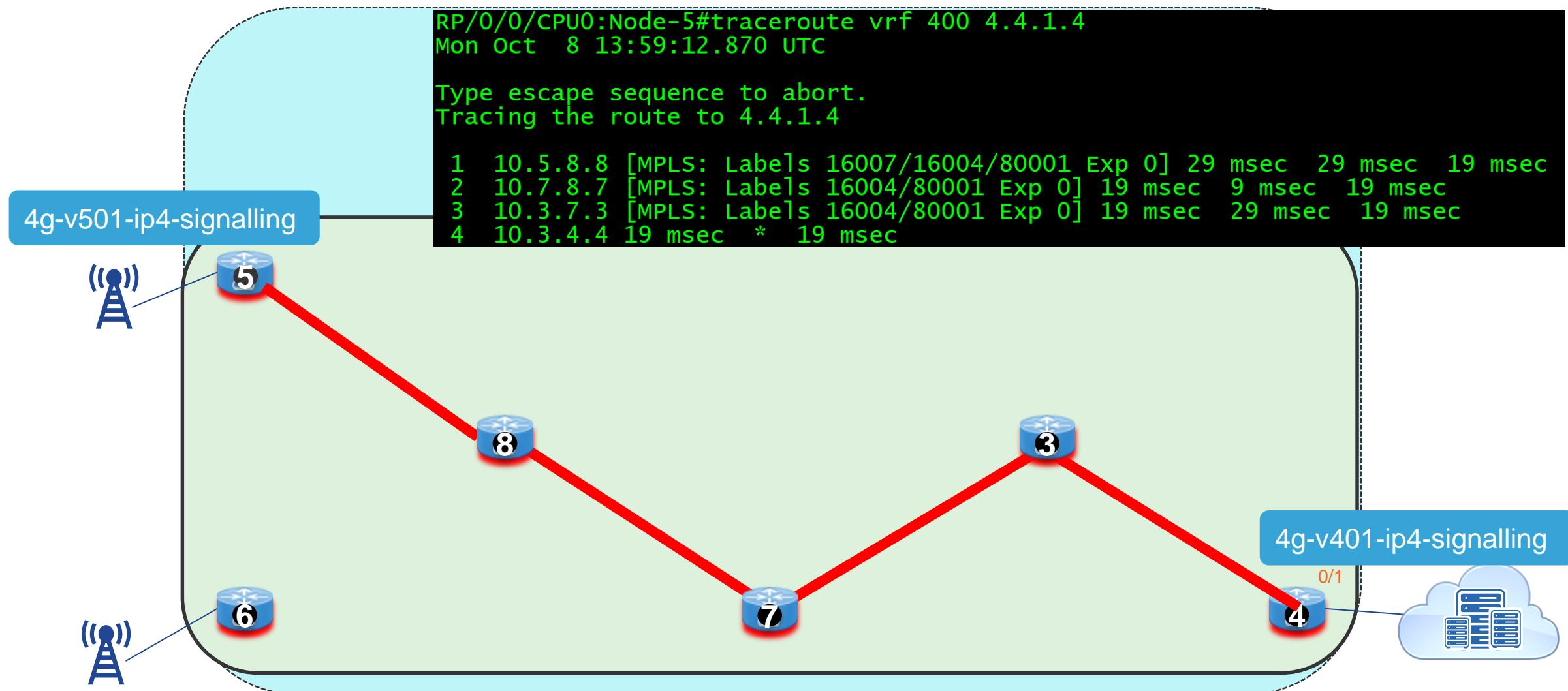
# Demo Network Slice Creation



# Demo Segment Routing On Demand NextHop (BGP)



# Demo SR On-Demand Automated Steered TE Path – Normal Path



# Demo SR On-Demand Automated Steered TE Path - Low Latency Path

NSO 4.6.1.2 Configuration Editor

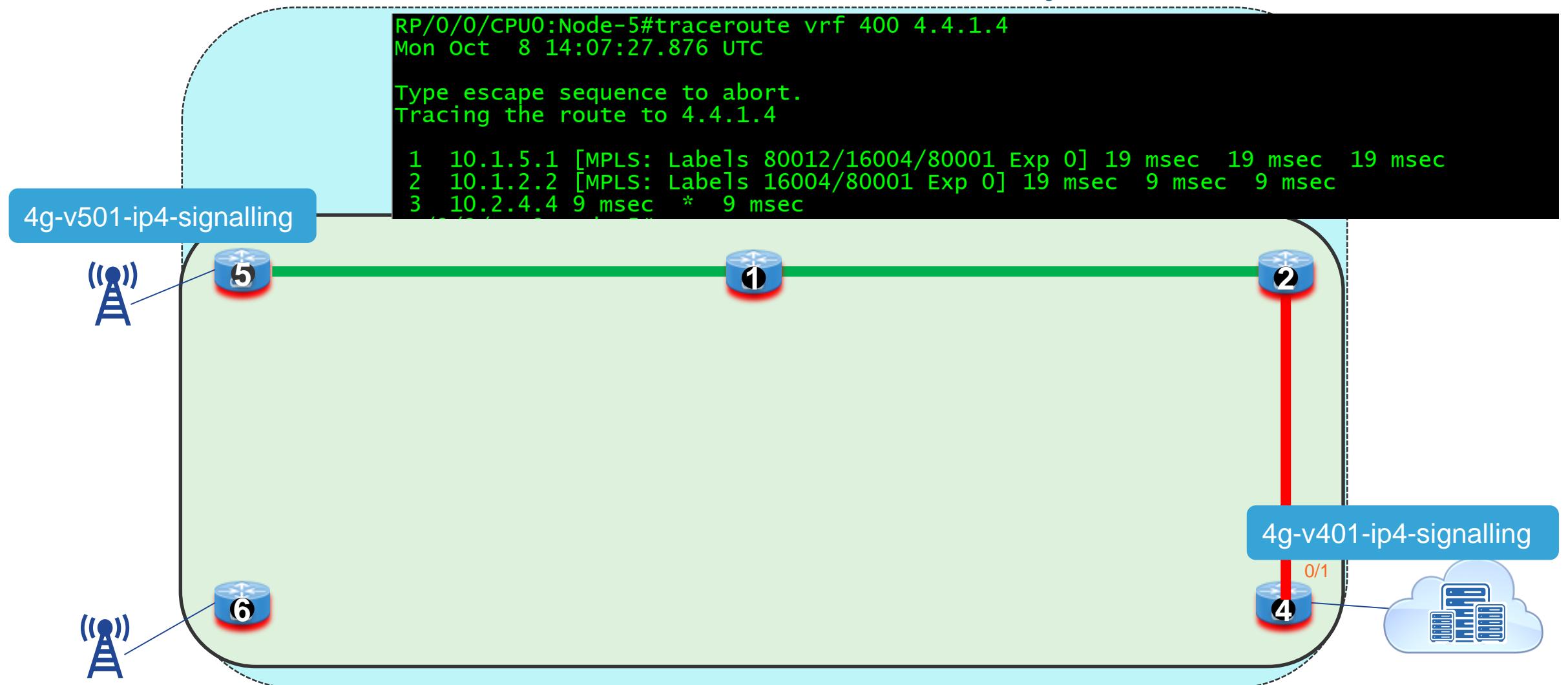
network-slice-srodn:network-slice-srodn{4g-slice400-jakarta}/node-list{Node-4}/

include subfolders  show actions  show operdata  show empty

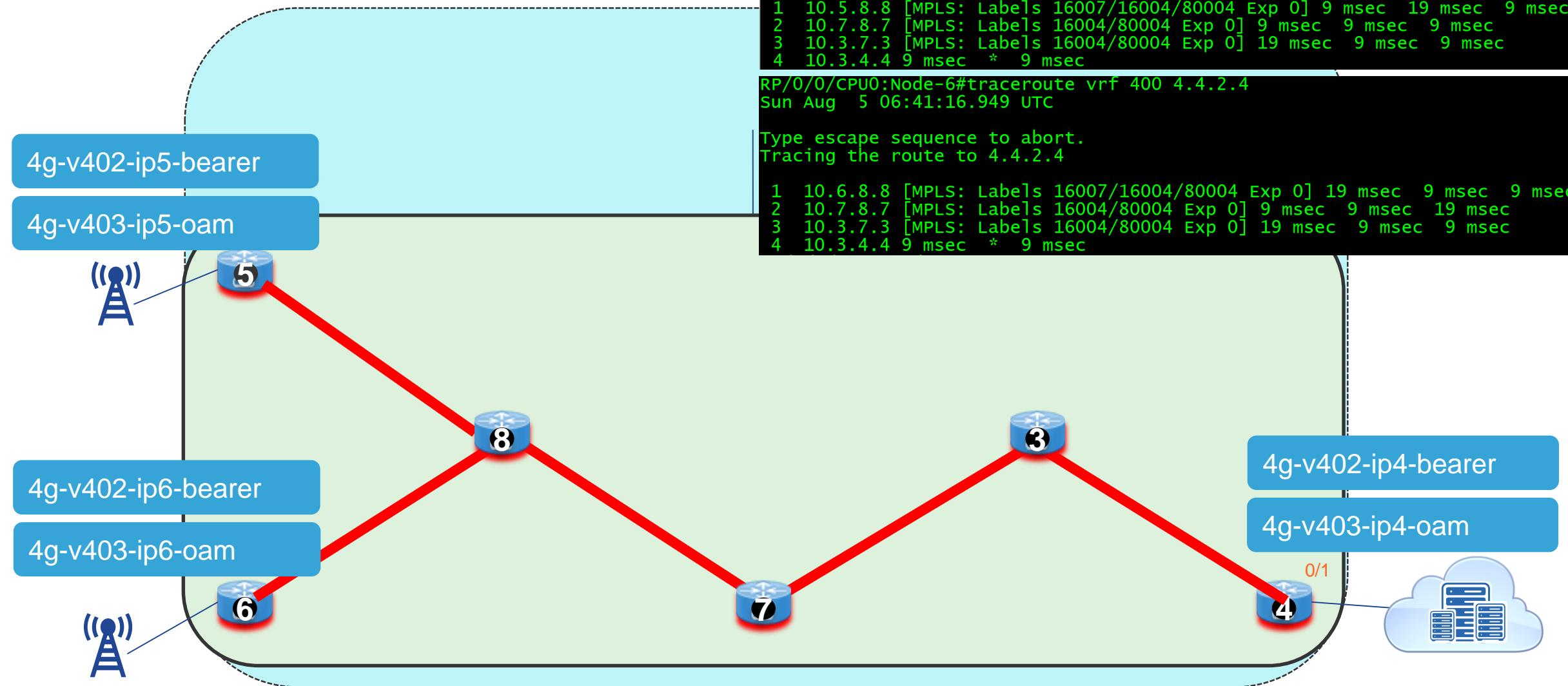
node	Node-4					
—node-slice/						
<input type="checkbox"/>	node-slice-name	routing-protocol-to-ce	link-interface-id	link-vlan-id	low-latency-prefix	link-ipv4-
<input type="checkbox"/>	4g-4-signalling	connected	0/0/0/1	401	true	4.4.1.0

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# Demo SR On-Demand Automated Steered TE Path - Low Latency Path



# Demo Normal Joint Path



# Demo Disjoint-Path SLA Intent

NSO 4.6.1.2 Configuration Editor root

network-slice-srodn:network-slice-srodn{4g-slice400-jakarta}/

include subfolders  show actions  show operdata  show empty

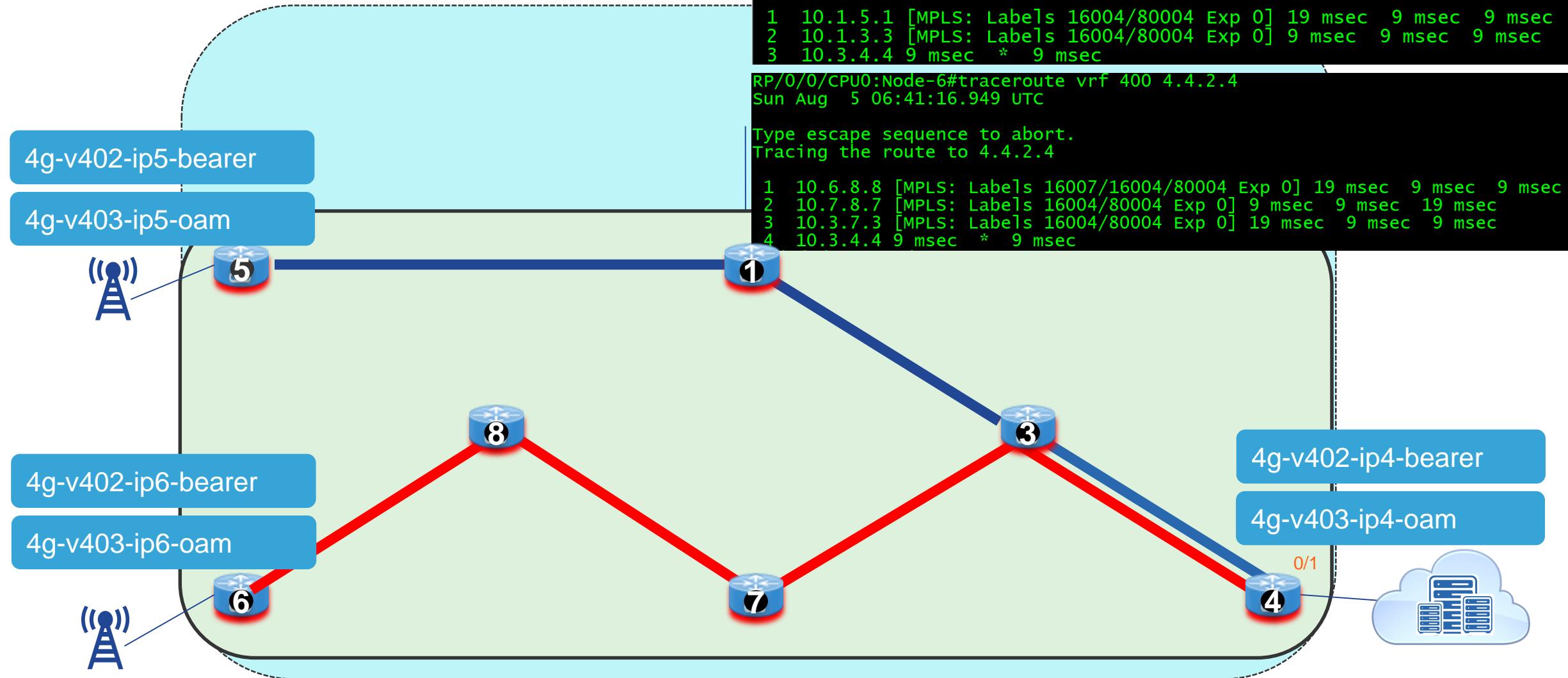
network-slice-name 4g-slice400-jakarta	disjoint-path true
network-slice-id*	400
low-latency-slice (false)	

—node-list/—

- node
- Node-4
- Node-5
- Node-6

  - +

# Demo Disjoint-Path SLA Intent



# Demo Low-Latency SLA Path for Critical Service Traffic

NSO 4.6.1.2 Configuration Editor

network-slice-srodn:network-slice-srodn{4g-slice400-jakarta}/node-list{Node-4}/node-slice{ }

include subfolders  show actions  show operdata  show empty

<input type="checkbox"/>	node-slice-name	routing-protocol-to-ce	link-interface-id	link-vlan-id	low-latency-prefix	link-ipv4
•	4g-v401-ip4-signalling	connected	0/0/0/1	401	true	4.4.1.0
•	4g-v402-ip4-bearer	connected	0/0/0/1	402	false	4.4.2.0
•	4g-v403-ip4-oam	connected	0/0/0/1	403	false	4.4.3.0

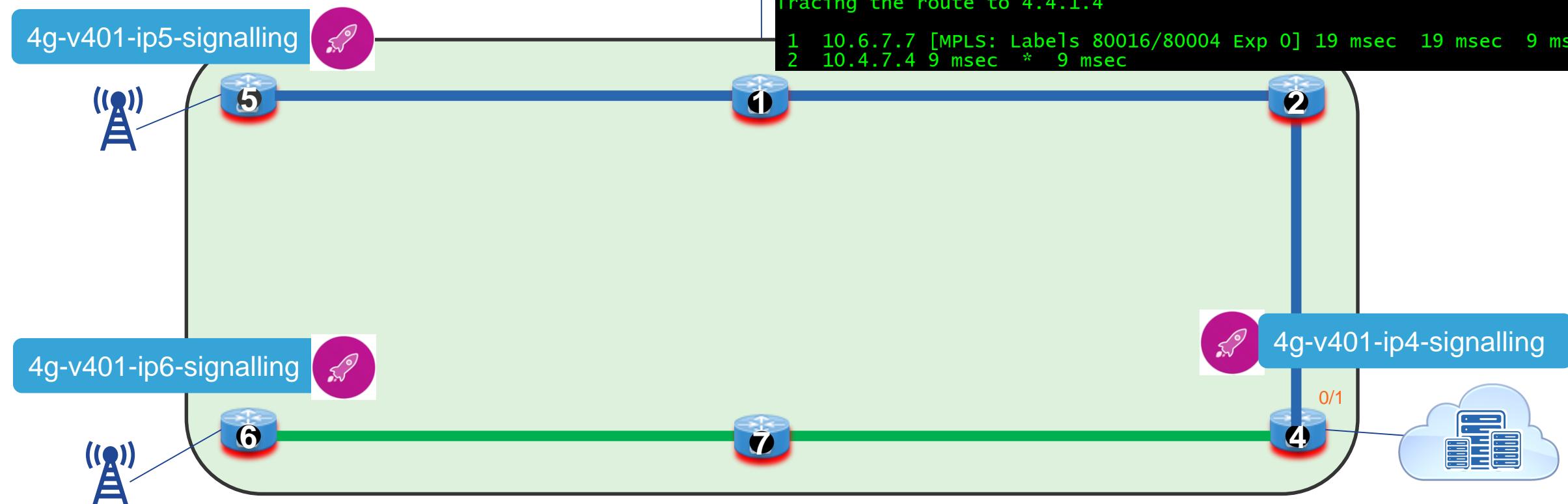
NSO 4.6.1.2 Configuration Editor

network-slice-srodn:network-slice-srodn{4g-slice400-jakarta}/node-list{Node-5}/node-slice{ }

include subfolders  show actions  show operdata  show empty

<input type="checkbox"/>	node-slice-name	routing-protocol-to-ce	link-interface-id	link-vlan-id	low-latency-prefix	link-ipv4
•	4g-v401-ip5-signalling	connected	0/0/0/1	401	true	4.5.1.0
•	4g-v402-ip5-bearer	connected	0/0/0/1	402	false	4.5.2.0
•	4g-v403-ip5-oam	connected	0/0/0/1	403	false	4.5.3.0

# Demo Low-Latency SLA Path For Critical Service Traffic



```
RP/0/0/CPU0:Node-5#traceroute vrf 400 4.4.1.4
Sun Aug  5 07:18:29.440 UTC
```

```
Type escape sequence to abort.
Tracing the route to 4.4.1.4
```

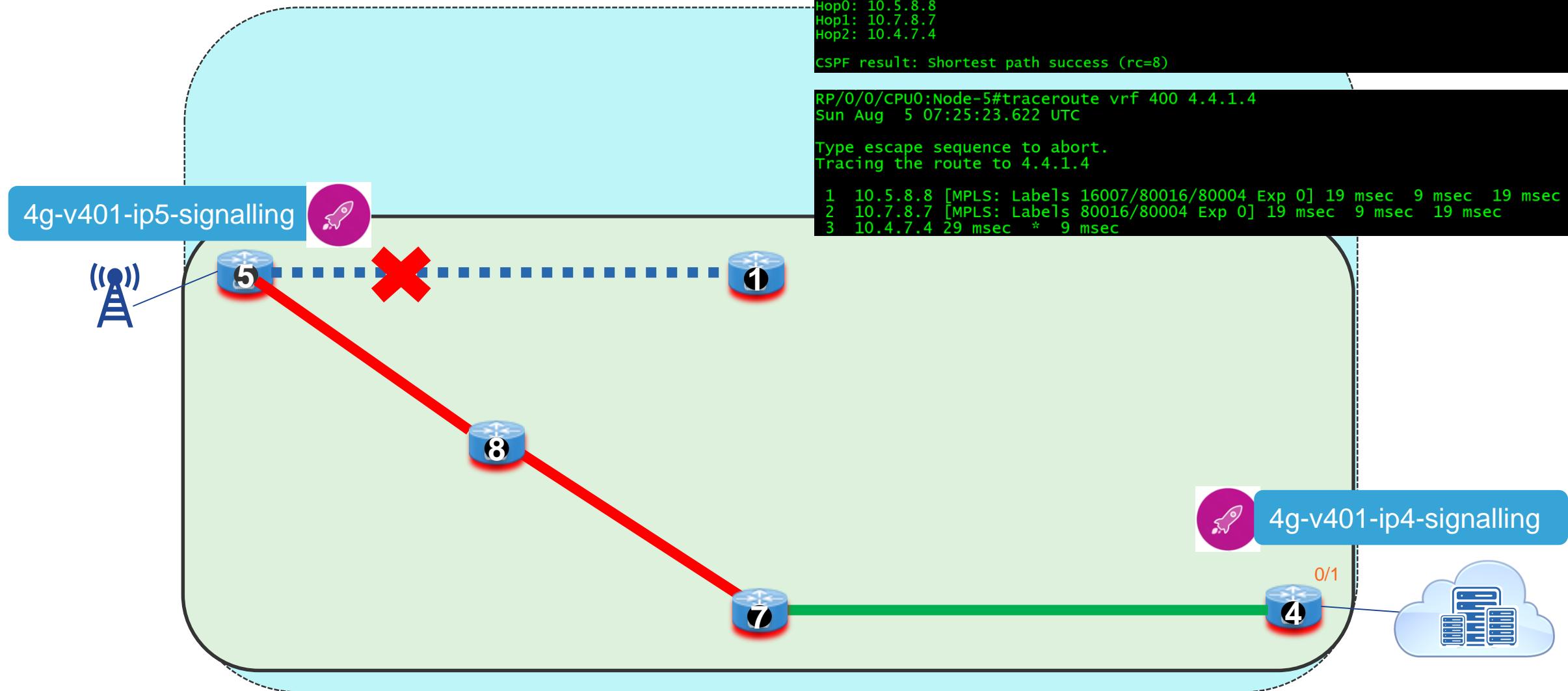
```
1 10.1.5.1 [MPLS: Labels 80012/16004/80004 Exp 0] 9 msec 9 msec 19 msec
2 10.1.2.2 [MPLS: Labels 16004/80004 Exp 0] 9 msec 9 msec 9 msec
3 10.2.4.4 9 msec * 9 msec
```

```
RP/0/0/CPU0:Node-6#traceroute vrf 400 4.4.1.4
Sun Aug  5 07:19:11.923 UTC
```

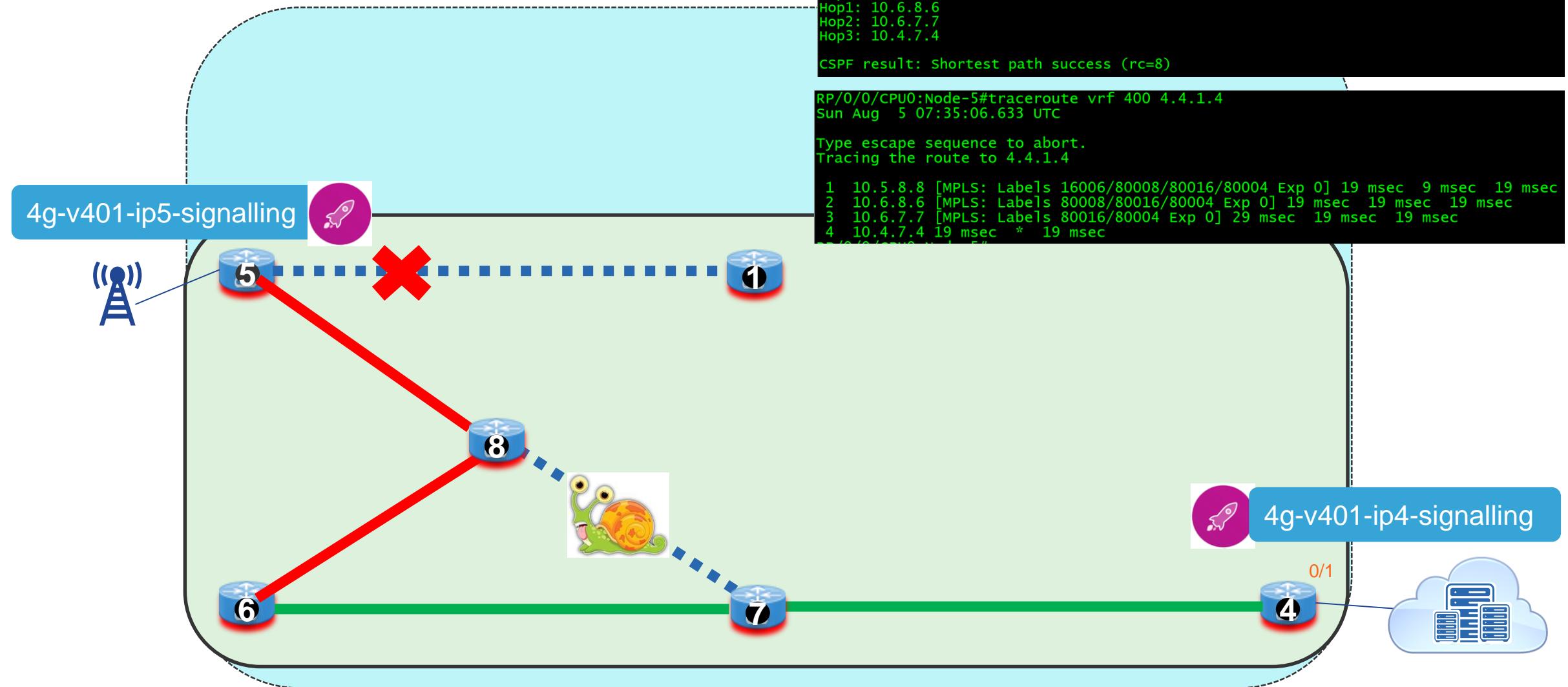
```
Type escape sequence to abort.
Tracing the route to 4.4.1.4
```

```
1 10.6.7.7 [MPLS: Labels 80016/80004 Exp 0] 19 msec 19 msec 9 msec
2 10.4.7.4 9 msec * 9 msec
```

# Demo Link Failure Incident Automated TE Path Reroute



# Demo High Delay Link Incident Automated TE Path Reroute



# Demo Apply Low Latency SLA Path for All Network Slice Traffic Service

NSO 4.6.1.2 Configuration Editor

network-slice-srodn:network-slice-srodn{4g-slice400-jakarta}/

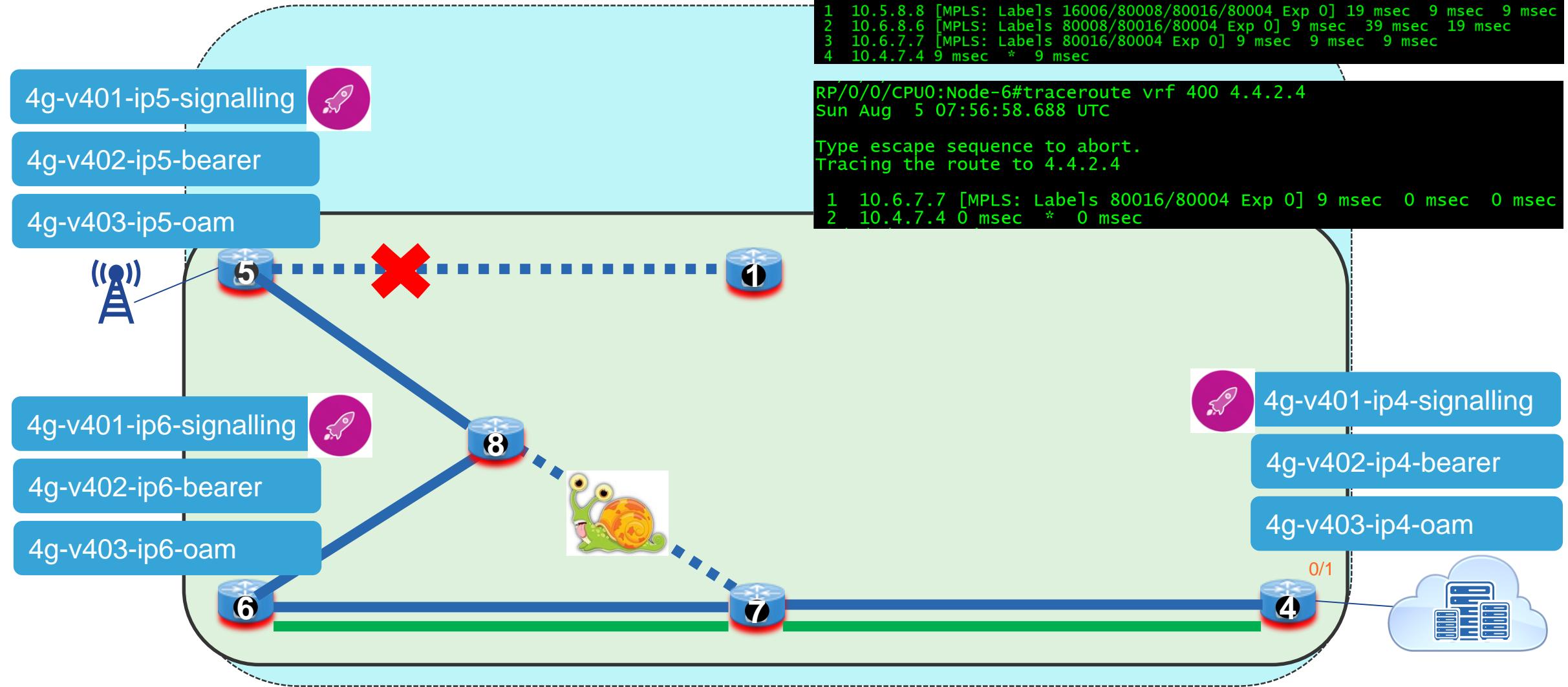
include subfolders  show actions  show operdata  show empty

network-slice-name 4g-slice400-jakarta	disjoint-path true
network-slice-id* 400	
• low-latency-slice true	

node-list/

- node
- Node-4
- Node-5
- Node-6

# Demo Low Latency SLA Path For All Service Traffic





# Thank You

