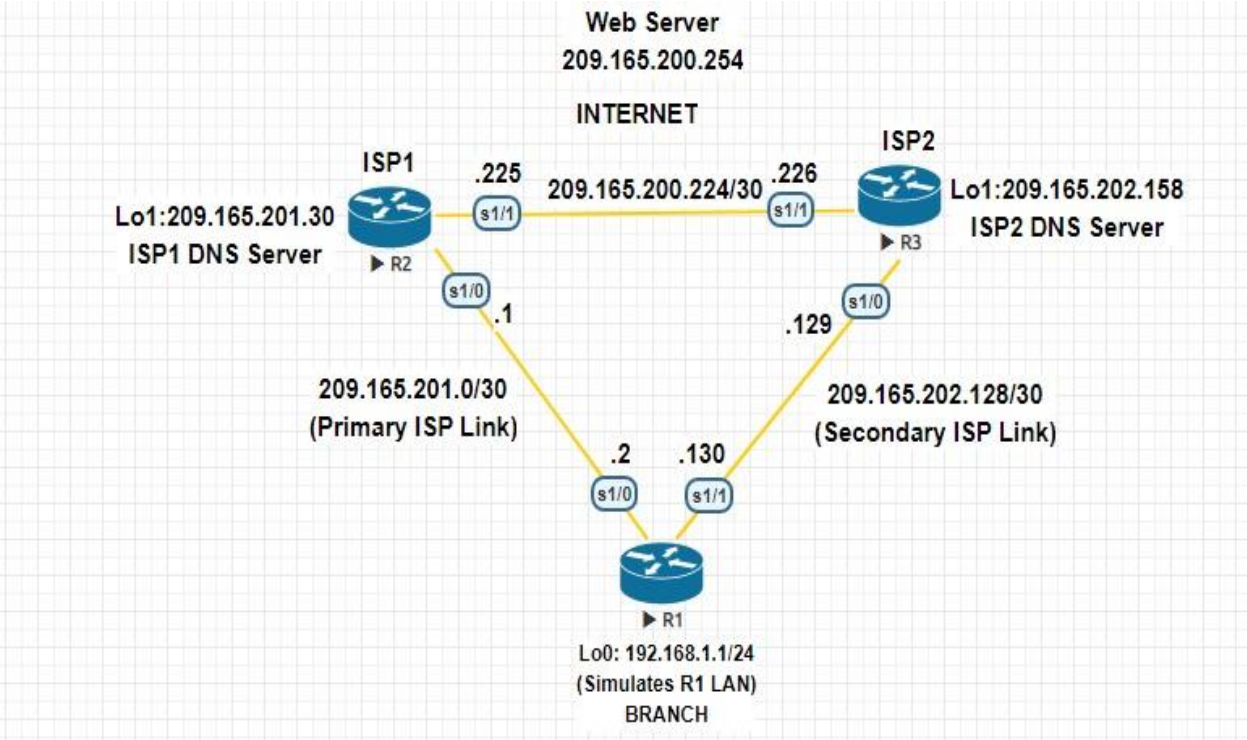
PRACTICAL NO 1

Aim: Configure IP SLA Tracking and Path Control Topology

NETWORK TOPOLOGY :



Tasks :

- **Configure and verify the IP SLA feature.**
- **Test the IP SLA tracking feature.**
- **Verify the configuration and operation using show and debug commands**

Code:

R1

```
Router>enable
Router#conf t
```

Router(config)#hostname R1

R1(config)#interface Loopback 0

R1(config-if)#ip address 192.168.1.1 255.255.255.0

R1(config-if)#exit

R1(config)#interface s1/0

R1(config-if)#ip address 209.165.201.2 255.255.255.252

R1(config-if)#no shutdown

R1(config-if)#exit

R1(config)#interface s1/1

R1(config-if)#ip address 209.165.202.130 255.255.255.252

R1(config-if)#no shutdown

R1(config-if)#exit

R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1

R1(config)#ip sla 12

R1(config-ip-sla)#icmp-echo 209.165.201.30

R1(config-ip-sla-echo)#frequency 11

R1(config-ip-sla-echo)#exit

R1(config)#ip sla schedule 12 life forever start-time now R1#sh ip sla configuration 12

IP SLAs Infrastructure Engine-III

Entry

number: 12

Owner:

Tag:

Operation timeout (milliseconds): 5000

Type of operation to perform: icmp-echo

Target address/Source address: 209.165.201.30/0.0.0.0

Type Of Service parameter: 0x0

Request size (ARR data portion): 28

Verify

data:

No Vrf

Name:

Schedule:

  Operation frequency (seconds): 11 (not considered if randomly scheduled)

  Next Scheduled Start Time: Start Time already passed

  Group Scheduled : FALSE

  Randomly Scheduled : FALSE

  Life (seconds): Forever

  Entry Ageout (seconds): never

  Recurring (Starting Everyday): FALSE

  Status of entry (SNMP RowStatus): Active

Threshold (milliseconds): 5000

Distribution Statistics:

  Number of statistic hours kept: 2

  Number of statistic distribution buckets kept: 1

  Statistic distribution interval (milliseconds):

20 Enhanced History:

History Statistics:

Number of history Lives kept: 0

Number of history Buckets kept: 15

History Filter Type: None

R1#sh ip sla statistics

IPSLAs Latest Operation Statistics

IPSLA operation id: 12

Latest RTT: 11 milliseconds

Latest operation start time: 18:21:25 EET Thu Apr 9 2020

Latest operation return code: OK

Number of successes: 22

Number of failures: 0

Operation time to live: Forever

R1(config)#ip sla 24

R1(config-ip-sla)#icmp-echo 209.165.202.158

R1(config-ip-sla-echo)#frequency 10

R1(config-ip-sla-echo)#exit

R1(config)#ip sla schedule 24 life forever start-time now R1#sh ip sla configuration 24

IP SLAs Infrastructure Engine-III

Entry

number: 24

Owner:

Tag:

Operation timeout (milliseconds): 5000

Type of operation to perform: icmp-echo

Target address/Source address: 209.165.202.158/0.0.0.0

Type Of Service parameter: 0x0

Request size (ARR data portion): 28

Verify

data:

No Vrf

Name:

Schedule:

Operation frequency (seconds): 10 (not considered if randomly scheduled)

Next Scheduled Start Time: Start Time already passed

Group Scheduled : FALSE

Randomly Scheduled : FALSE

Life (seconds): Forever

Entry Ageout (seconds): never

Recurring (Starting Everyday): FALSE

Status of entry (SNMP RowStatus): Active

Threshold (milliseconds): 5000

Distribution Statistics:

Number of statistic hours kept: 2

Number of statistic distribution buckets kept: 1

Statistic distribution interval (milliseconds):

20 Enhanced History:

History Statistics:

Number of history Lives kept: 0

Number of history Buckets kept: 15

History Filter Type: None

R1#sh ip sla statistics 24

IPSLAs Latest Operation Statistics

IPSLA operation id: 24

Latest RTT: 20 milliseconds

Latest operation start time: 18:33:25 EET Thu Apr 9 2020

Latest operation return code: OK

Number of successes: 16

Number of failures: 0

Operation time to live: Forever

R1(config)#no ip route 0.0.0.0 0.0.0.0 209.165.201.1

R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1 5 R1#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

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 i - IS-IS, su - IS-IS summary, L1 - IS-IS

level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * -

candidate default, U - per-user static route o - ODR, P

- periodic downloaded static route, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override

Gateway of last resort is 209.165.201.1 to network 0.0.0.0

S* 0.0.0.0/0 [5/0] via 209.165.201.1

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback0

L 192.168.1.1/32 is directly connected, Loopback0

209.165.201.0/24 is variably subnetted, 2 subnets, 2 masks

C 209.165.201.0/30 is directly connected, Serial1/0

L 209.165.201.2/32 is directly connected, Serial1/0

209.165.202.0/24 is variably subnetted, 2 subnets, 2 masks

C 209.165.202.128/30 is directly connected, Serial1/1

L 209.165.202.130/32 is directly connected, Serial1/1

R1(config)#track 1 ip sla 12 reachability

R1(config-track)#delay down 10 up 1

R1(config-track)#exit

R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1 2 track 1

R1(config)#track 2 ip sla 12 reachability

R1(config-track)#delay down 10 up 1

R1(config-track)#exit

R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1 3 track 2

R1#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

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 i - IS-IS, su - IS-IS summary, L1 - IS-IS

level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * -

candidate default, U - per-user static route o - ODR, P

- periodic downloaded static route, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override

Gateway of last resort is 209.165.201.1 to network 0.0.0.0

S* 0.0.0.0/0 [3/0] via 209.165.201.1

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback0

L 192.168.1.1/32 is directly connected, Loopback0

209.165.201.0/24 is variably subnetted, 2 subnets, 2 masks

C 209.165.201.0/30 is directly connected, Serial1/0

L 209.165.201.2/32 is directly connected, Serial1/0

209.165.202.0/24 is variably subnetted, 2 subnets, 2 masks

C 209.165.202.128/30 is directly connected, Serial1/1

L 209.165.202.130/32 is directly connected, Serial1/1

R1#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

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 i - IS-IS, su - IS-IS summary, L1 - IS-IS

level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * -

candidate default, U - per-user static route o - ODR, P

- periodic downloaded static route, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override

Gateway of last resort is 209.165.201.1 to network 0.0.0.0

S* 0.0.0.0/0 [5/0] via 209.165.201.1

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback0

L 192.168.1.1/32 is directly connected, Loopback0

209.165.201.0/24 is variably subnetted, 2 subnets, 2 masks

C 209.165.201.0/30 is directly connected, Serial1/0

L 209.165.201.2/32 is directly connected, Serial1/0

209.165.202.0/24 is variably subnetted, 2 subnets, 2 masks

C 209.165.202.128/30 is directly connected, Serial1/1

L 209.165.202.130/32 is directly connected, Serial1/1

R1#sh ip sla statistics

IPSLAs Latest Operation Statistics

IPSLA operation id: 12

Latest RTT: NoConnection/Busy/Timeout

Latest operation start time: 19:02:29 EET Thu Apr 9 2020

Latest operation return code: Timeout

Number of successes: 227

Number of failures: 19

Operation time to live: Forever

IPSLA operation id: 24

Latest RTT: 20 milliseconds

Latest operation start time: 19:02:35 EET Thu Apr 9 2020

Latest operation return code: OK

Number of successes: 190

Number of failures: 1

Operation time to live: Forever

R1#trace 209.165.200.254 source 192.168.1.1 Type escape sequence to abort.

Tracing the route to 209.165.200.254

VRF info: (vrf in name/id, vrf out name/id)

1 209.165.201.1 10 msec 14 msec *

R1#sh ip sla statistics

IPSLAs Latest Operation Statistics

IPSLA operation id: 12

Latest RTT: 10 milliseconds

Latest operation start time: 19:07:04 EET Thu Apr 9 2020

Latest operation return code: OK

Number of successes: 236

Number of failures: 35

Operation time to live: Forever

IPSLA operation id: 24

Latest RTT: 21 milliseconds

Latest operation start time: 19:07:05 EET Thu Apr 9 2020

Latest operation return code: OK

Number of successes: 217

Number of failures: 1

Operation time to live: Forever

R1#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

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 i - IS-IS, su - IS-IS summary, L1 - IS-IS

level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * -

candidate default, U - per-user static route o - ODR, P

- periodic downloaded static route, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override

Gateway of last resort is 209.165.201.1 to network 0.0.0.0

S* 0.0.0.0/0 [3/0] via 209.165.201.1

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback0

L 192.168.1.1/32 is directly connected, Loopback0

209.165.201.0/24 is variably subnetted, 2 subnets, 2 masks

C 209.165.201.0/30 is directly connected, Serial1/0

L 209.165.201.2/32 is directly connected, Serial1/0

209.165.202.0/24 is variably subnetted, 2 subnets, 2 masks

C 209.165.202.128/30 is directly connected, Serial1/1

L 209.165.202.130/32 is directly connected, Serial1/1

ISP1 (R2)

```
Router>enable
Router#conf t
Router(config)#hostname ISP1
ISP1(config)#interface Loopback0
ISP1(config-if)#description Simulated Internet Web Server
ISP1(config-if)#ip address 209.165.200.254 255.255.255.255
ISP1(config-if)#exit
ISP1(config)#interface Loopback1
ISP1(config-if)#ip address 209.165.201.30 255.255.255.255
ISP1(config-if)#exit
ISP1(config)#interface s1/0
ISP1(config-if)#ip address 209.165.201.1 255.255.255.252
ISP1(config-if)#no shutdown
ISP1(config-if)#exit
ISP1(config)#interface s1/1
ISP1(config-if)#ip address 209.165.200.225 255.255.255.252
ISP1(config-if)#no shutdown
ISP1(config-if)#exit
ISP1(config)#router eigrp 200
ISP1(config-router)#network 209.165.200.224
ISP1(config-router)#network 209.165.201.0
ISP1(config-router)#no auto-summary
ISP1(config-router)#exit
```

ISP1(config)#ip route 192.168.1.0 255.255.255.0 209.165.201.2

ISP1(config)#interface loopback 1

ISP1(config-if)#shut

ISP1(config)#interface loopback 1

ISP1(config-if)#no shutdown

ISP2 (R3)

Router>enable

Router#conf t

Router(config)#hostname ISP2

ISP2(config)#interface Loopback0

ISP2(config-if)#description Simulated Internet Web Server

ISP2(config-if)#ip address 209.165.200.254 255.255.255.255

ISP2(config-if)#exit

ISP2(config)#interface Loopback1

ISP2(config-if)#ip address 209.165.202.158 255.255.255.255

ISP2(config-if)#exit

ISP2(config)#interface s1/1

ISP2(config-if)#ip address 209.165.200.226 255.255.255.252

ISP2(config-if)#no shutdown

ISP2(config-if)#exit

ISP2(config)#interface s1/0

ISP2(config-if)#ip address 209.165.202.129 255.255.255.252

ISP2(config-if)#no shutdown

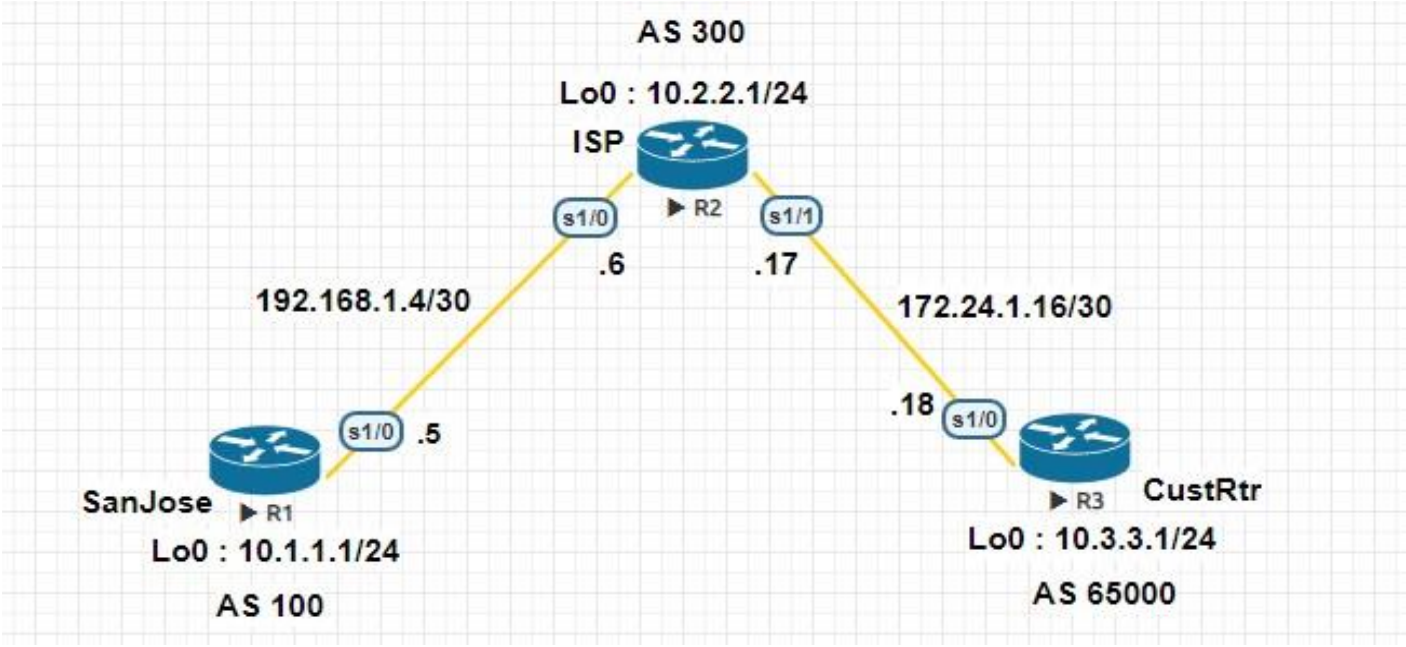
ISP2(config-if)#exit

```
ISP2(config)#router eigrp 200
ISP2(config-router)#network 209.165.200.224
ISP2(config-router)#network 209.165.202.128
ISP2(config-router)#no auto-summary
ISP2(config-router)#exit
ISP2(config)#ip route 192.168.1.0 255.255.255.0 209.165.202.130
```

PRACTICAL NO 2

Aim: Using the AS_PATH Attribute

NETWORK TOPOLOGY :



Tasks:

- **Use BGP commands to prevent private AS numbers from being advertised to the outside world.**
- **Use the AS_PATH attribute to filter BGP routes based on their source AS numbers.**

Code:

SanJose

Router>enable

Router#conf t

Router(config)#hostname SanJose

SanJose(config)#interface Loopback0

```
SanJose(config-if)#ip address 10.1.1.1 255.255.255.0
SanJose(config-if)#exit
SanJose(config)#interface Serial1/0
SanJose(config-if)#ip address 192.168.1.5 255.255.255.252
SanJose(config-if)#no shutdown
SanJose(config-if)#end
SanJose(config)#router bgp 100
SanJose(config-router)#network 10.1.1.0 mask 255.255.255.0
SanJose(config-router)#neighbor 192.168.1.6 remote-as 300
SanJose(config-router)#exit
 SanJose#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      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       i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2       ia - IS-IS inter area, * -
candidate default, U - per-user static route       o - ODR, P
- periodic downloaded static route, H - NHRP, l - LISP

      a - application route
      + - replicated route, % - next hop override
 Gateway of last resort is not set
      10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C       10.1.1.0/24 is directly connected, Loopback0
```

L 10.1.1.1/32 is directly connected, Loopback0

B 10.2.2.0/24 [20/0] via 192.168.1.6, 00:05:47 B

10.3.3.0/24 [20/0] via 192.168.1.6, 00:02:13

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.4/30 is directly connected, Serial1/0

L 192.168.1.5/32 is directly connected, Serial1/0

SanJose#sh ip bgp

BGP table version is 4, local router ID is 10.1.1.1

Status codes: s suppressed, d damped, h history, * valid, > best,

i - internal, r RIB-failure, S Stale, m multipath, b backup-

path, f RT-Filter, x best-external, a additional-path, c

RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

	Network	Next Hop	Metric	LocPrf	Weight	Path
*>	10.1.1.0/24	0.0.0.0	0		32768	i
*>	10.2.2.0/24	192.168.1.6	0		0	300 i
*>	10.3.3.0/24	192.168.1.6			0	300 65000 i

SanJose#sh ip bgp

BGP table version is 5, local router ID is 10.1.1.1

Status codes: s suppressed, d damped, h history, * valid, > best,

i - internal, r RIB-failure, S Stale, m multipath, b backup-

path, f RT-Filter, x best-external, a additional-path, c

RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

	Network	Next Hop	Metric	LocPrf	Weight	Path
*>	10.1.1.0/24	0.0.0.0	0		32768	i
*>	10.2.2.0/24	192.168.1.6	0		0	300 i
*>	10.3.3.0/24	192.168.1.6			0	300 i

ISP

```
Router>enable
Router#conf t
Router(config)#hostname ISP
ISP(config)#interface Loopback0
ISP(config-if)#ip address 10.2.2.1 255.255.255.0
ISP(config-if)#exit
ISP(config)#interface Serial1/0
ISP(config-if)#ip address 192.168.1.6 255.255.255.252
ISP(config-if)#no shutdown
ISP(config-if)#exit
ISP(config)#interface Serial1/1
ISP(config-if)#ip address 172.24.1.17 255.255.255.252
ISP(config-if)#no shutdown
ISP(config-if)#end
ISP(config)#router bgp 300
ISP(config-router)#network 10.2.2.0 mask 255.255.255.0
ISP(config-router)#neighbor 192.168.1.5 remote-as 100
```

```
ISP(config-router)#neighbor 172.24.1.18 remote-as 65000
ISP(config)#router bgp 300
ISP(config-router)#neighbor 192.168.1.5 remove-private-as
ISP(config-router)#end
ISP#clear ip bgp * soft
 ISP(config)#ip as-path access-list 1 deny ^100$
ISP(config)#ip as-path access-list 1 permit .*
ISP(config)#router bgp 300
ISP(config-router)#neighbor 172.24.1.18 filter-list 1 out
ISP(config-router)#end
ISP#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      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       i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2       ia - IS-IS inter area, * -
candidate default, U - per-user static route       o - ODR, P
- periodic downloaded static route, H - NHRP, l - LISP
a - application route
      + - replicated route, % - next hop override
 Gateway of last resort is not set
      10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
B       10.1.1.0/24 [20/0] via 192.168.1.5, 00:46:41
```

C 10.2.2.0/24 is directly connected, Loopback0

L 10.2.2.1/32 is directly connected, Loopback0

B 10.3.3.0/24 [20/0] via 172.24.1.18, 00:43:07

172.24.0.0/16 is variably subnetted, 2 subnets, 2 masks

C 172.24.1.16/30 is directly connected, Serial1/1

L 172.24.1.17/32 is directly connected, Serial1/1

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.4/30 is directly connected, Serial1/0

L 192.168.1.6/32 is directly connected, Serial1/0

ISP#show ip bgp regexp ^100$

BGP table version is 4, local router ID is 10.2.2.1

Status codes: s suppressed, d damped, h history, * valid, > best,

i - internal, r RIB-failure, S Stale, m multipath, b backup-

path, f RT-Filter, x best-external, a additional-path, c

RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

Network Next Hop Metric LocPrf Weight Path *> 10.1.1.0/24
192.168.1.5 0 0 100 i

CustRtr

Router>enable

Router#conf t

Router(config)#hostname CustRtr

CustRtr(config)#interface Loopback0

CustRtr(config-if)#ip address 10.3.3.1 255.255.255.0

```
CustRtr(config-if)#exit
CustRtr(config)#interface Serial1/0
CustRtr(config-if)#ip address 172.24.1.18 255.255.255.252
CustRtr(config-if)#no shutdown
CustRtr(config-if)#end
CustRtr(config)#router bgp 65000
CustRtr(config-router)#network 10.3.3.0 mask 255.255.255.0
CustRtr(config-router)#neighbor 172.24.1.17 remote-as 300
CustRtr(config-router)#end
 CustRtr#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      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       i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2       ia - IS-IS inter area, * -
candidate default, U - per-user static route       o - ODR, P
- periodic downloaded static route, H - NHRP, l - LISP
a - application route
      + - replicated route, % - next hop override
 Gateway of last resort is not set
      10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks B       10.2.2.0/24 [20/0]
via 172.24.1.17, 00:45:59
C       10.3.3.0/24 is directly connected, Loopback0
L       10.3.3.1/32 is directly connected, Loopback0
```

172.24.0.0/16 is variably subnetted, 2 subnets, 2 masks

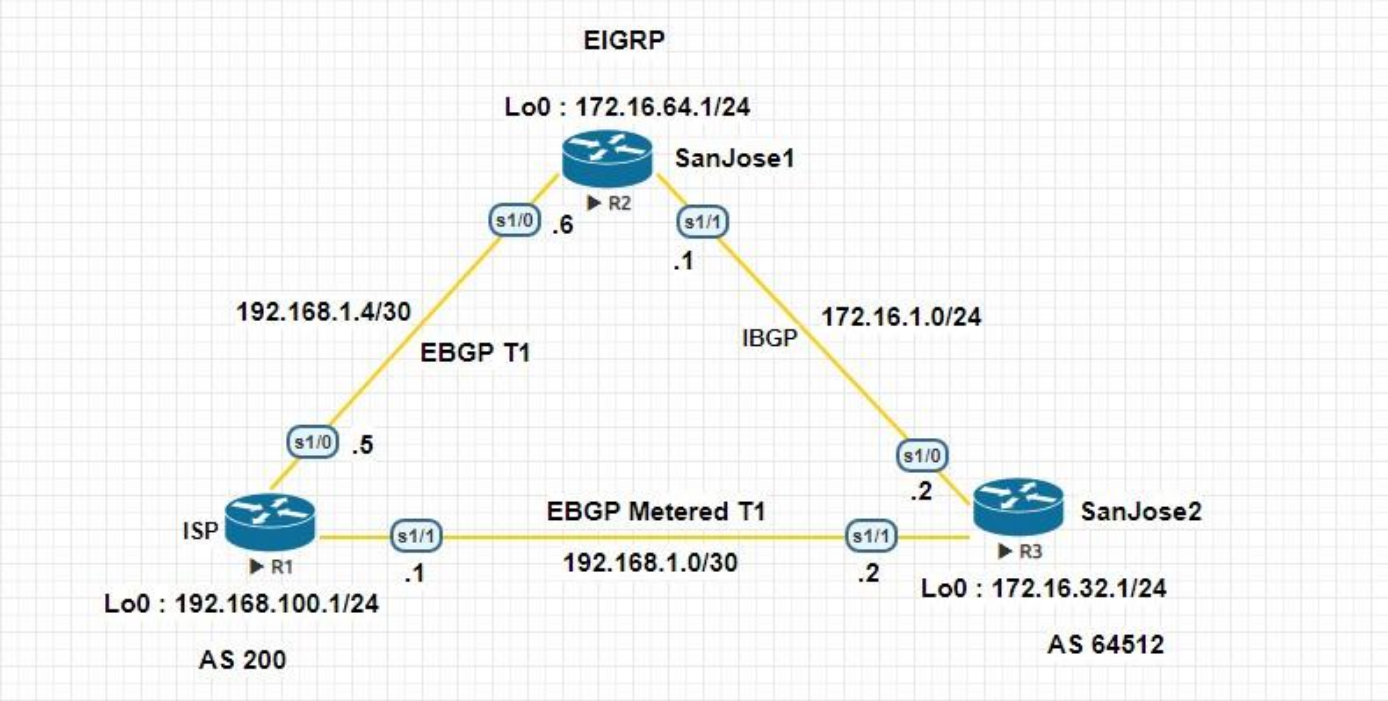
C 172.24.1.16/30 is directly connected, Serial1/0

L 172.24.1.18/32 is directly connected, Serial1/0

PRACTICAL NO 3

Aim: Configuring IBGP and EBGP Sessions, Local Preference, and MED

NETWORK TOPOLOGY:



Tasks:

- **For IBGP peers to correctly exchange routing information, use the nexthop-self command with the Local-Preference and MED attributes.**
- **Ensure that the flat-rate, unlimited-use T1 link is used for sending and receiving data to and from the AS 200 on ISP and that the metered T1 only be used in the event that the primary T1 link has failed**

Code:

R1(ISP)

Router>enable

```
Router#conf t
Router(config)#hostname ISP
ISP(config)#interface Loopback0
ISP(config-if)#ip address 192.168.100.1 255.255.255.0
ISP(config-if)#exit
ISP(config)#interface Serial1/0
ISP(config-if)#ip address 192.168.1.5 255.255.255.252
ISP(config-if)#no shutdown
ISP(config-if)#exit
ISP(config)#interface Serial1/1
ISP(config-if)#ip address 192.168.1.1 255.255.255.252
ISP(config-if)#no shutdown
ISP(config-if)#exit
ISP(config)#router bgp 200
ISP(config-router)#network 192.168.100.0
ISP(config-router)#neighbor 192.168.1.6 remote-as 64512 ISP(config-
router)#neighbor 192.168.1.2 remote-as 64512
ISP(config-router)#exit
ISP#sh ip bgp
BGP table version is 3, local router ID is 192.168.100.1
Status codes: s suppressed, d damped, h history, * valid, > best,
i - internal,              r RIB-failure, S Stale, m multipath, b backup-
path, f RT-Filter,              x best-external, a additional-path, c
RIB-compressed,
```

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

	Network	Next Hop	Metric	LocPrf	Weight	Path
*	172.16.0.0	192.168.1.2	0		0	64512 i
*>		192.168.1.6	0		0	64512 i
*>	192.168.100.0	0.0.0.0	0		32768	i

ISP#ping 172.16.1.1 source

192.168.100.1 Type escape

sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.1.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.100.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 10/10/11 ms

ISP#ping 172.16.32.1 source

192.168.100.1 Type escape

sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.32.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.100.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 15/15/16 ms

```
ISP#ping 172.16.1.2 source
192.168.100.1  Type escape
sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.1.2, timeout is 2 seconds:
Packet sent with a source address of 192.168.100.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 15/17/25
ms

ISP(config)#router bgp 200
ISP(config-router)#network 192.168.1.0 mask 255.255.255.252
ISP(config-router)#network 192.168.1.4 mask 255.255.255.252
ISP(config-router)#exit
ISP#sh ip bgp
BGP table version is 5, local router ID is 192.168.100.1
Status codes: s suppressed, d damped, h history, * valid, > best,
i - internal,              r RIB-failure, S Stale, m multipath, b backup-
path, f RT-Filter,              x best-external, a additional-path, c
RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network         Next Hop          Metric LocPrf Weight Path
*   172.16.0.0      192.168.1.6            0          0 64512 i
*>                  192.168.1.2            0          0 64512 i
```

*> 192.168.1.0/30 0.0.0.0 0 32768 i

*> 192.168.1.4/30 0.0.0.0 0 32768 i

*> 192.168.100.0 0.0.0.0 0 32768 i

ISP#sh ip bgp

BGP table version is 6, local router ID is 192.168.100.1

Status codes: s suppressed, d damped, h history, * valid, > best,

i - internal, r RIB-failure, S Stale, m multipath, b backup-

path, f RT-Filter, x best-external, a additional-path, c

RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

	Network	Next Hop	Metric	LocPrf	Weight	Path
*>	172.16.0.0	192.168.1.6	50		0	64512 i
*		192.168.1.2	75		0	64512 i
*>	192.168.1.0/30	0.0.0.0		0	32768	i
*>	192.168.1.4/30	0.0.0.0		0	32768	i
*>	192.168.100.0	0.0.0.0		0	32768	i

ISP#ping 172.16.1.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.1.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 9/10/11 ms ISP#ping 172.16.1.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 172.16.1.2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 20/21/25 ms

ISP#traceroute 172.16.1.1

Type escape sequence to abort.

Tracing the route to 172.16.1.1

VRF info: (vrf in name/id, vrf out name/id)

1 192.168.1.6 10 msec 10 msec *

ISP#traceroute 172.16.1.2

Type escape sequence to abort.

Tracing the route to 172.16.1.2

VRF info: (vrf in name/id, vrf out name/id)

1 192.168.1.6 10 msec 10 msec 13 msec

2 172.16.1.2 [AS 64512] 20 msec 19 msec *

R2 (SanJose1)

Router>enable

Router#conf t

Router(config)#hostname SanJose1

```
SanJose1(config)#interface Loopback0
SanJose1(config-if)#ip address 172.16.64.1 255.255.255.0
SanJose1(config-if)#ip address 172.16.64.1 255.255.255.0
SanJose1(config-if)#exit
SanJose1(config)#interface Serial1/0
SanJose1(config-if)#ip address 192.168.1.6 255.255.255.252
SanJose1(config-if)#no shutdown
SanJose1(config-if)#exit
SanJose1(config)#interface Serial1/1
SanJose1(config-if)#ip address 172.16.1.1 255.255.255.0
SanJose1(config-if)#no shutdown
SanJose1(config-if)#exit
SanJose1(config)#router eigrp 64512
SanJose1(config-router)#network 172.16.0.0
SanJose1(config-router)#no auto-summary
SanJose1(config-router)#exit
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 172.16.32.1 remote-as 64512
SanJose1(config-router)#neighbor 172.16.32.1 update-source
loopback0
SanJose1(config-router)#exit
SanJose1(config)#ip route 172.16.0.0 255.255.0.0 null 0
SanJose1(config)#router bgp 64512
SanJose1(config-router)#network 172.16.0.0
SanJose1(config-router)#neighbor 192.168.1.5 remote-as 200
```

```
SanJose1(config-router)#exit
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 172.16.32.1 next-hop-self
SanJose1(config-router)#exit

SanJose1#sh ip bgp
BGP table version is 5, local router ID is 172.16.64.1
Status codes: s suppressed, d damped, h history, * valid, > best,
i - internal,               r RIB-failure, S Stale, m multipath, b backup-
path, f RT-Filter,              x best-external, a additional-path, c
RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
* i 172.16.0.0       172.16.32.1              0    100      0 i
 *>                  0.0.0.0                  0         32768 i
* i 192.168.1.0/30   172.16.32.1              0    100      0 200 i
*>                   192.168.1.5              0             0
200 i r i 192.168.1.4/30   172.16.32.1
0    100      0 200 i
r>                   192.168.1.5              0             0 200 i
* i 192.168.100.0    172.16.32.1              0    100      0 200 i
*>                   192.168.1.5              0             0 200 i
```

```
SanJose1(config)#route-map PRIMARY_T1_IN permit 10
SanJose1(config-route-map)#set local-preference 160
SanJose1(config-route-map)#exit
SanJose1(config)#router bgp 64512
SanJose1(config-router)#neighbor 192.168.1.5 route-map
PRIMARY_T1_IN in
SanJose1(config-router)#exit
SanJose1#clear ip bgp * soft

SanJose1#sh ip bgp
BGP table version is 8, local router ID is 172.16.64.1
Status codes: s suppressed, d damped, h history, * valid, > best,
i - internal,               r RIB-failure, S Stale, m multipath, b backup-
path, f RT-Filter,              x best-external, a additional-path, c
RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network          Next Hop            Metric LocPrf Weight Path
 * i 172.16.0.0       172.16.32.1              0    100      0 i
 *>                   0.0.0.0                  0         32768 i
 *>  192.168.1.0/30   192.168.1.5              0    160
0 200 i
```

r> 192.168.1.4/30 192.168.1.5 0 160

0 200 i

*> 192.168.100.0 192.168.1.5 0 160

0 200 i

SanJose1(config)#route-map PRIMARY_T1_MED_OUT permit 10

SanJose1(config-route-map)#set Metric 50

SanJose1(config-route-map)#exit

SanJose1(config)#router bgp 64512

SanJose1(config-router)#neighbor 192.168.1.5 route-map PRIMARY_T1_MED_OUT out

SanJose1(config-router)#exit

SanJose1(config)#exit

SanJose1#clear ip bgp * soft

SanJose1#sh ip bgp

BGP table version is 8, local router ID is 172.16.64.1

Status codes: s suppressed, d damped, h history, * valid, > best,

i - internal, r RIB-failure, S Stale, m multipath, b backup-

path, f RT-Filter, x best-external, a additional-path, c

RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

```
   Network          Next Hop            Metric LocPrf Weight Path
* i 172.16.0.0       172.16.32.1              0    100      0 i
*>                   0.0.0.0                  0         32768 i
*>  192.168.1.0/30   192.168.1.5              0    160
0 200 i

 r>  192.168.1.4/30   192.168.1.5              0    160
0 200 i

*>  192.168.100.0    192.168.1.5              0    160
0 200 i

SanJose1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       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        i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2        ia - IS-IS inter area, * -
candidate default, U - per-user static route        o - ODR, P
- periodic downloaded static route, H - NHRP, l - LISP
a - application route
       + - replicated route, % - next hop override
```

Gateway of last resort is not set

172.16.0.0/16 is variably subnetted, 6 subnets, 3 masks

S 172.16.0.0/16 is directly connected, Null0

C 172.16.1.0/24 is directly connected, Serial1/1

L 172.16.1.1/32 is directly connected, Serial1/1

D 172.16.32.0/24 [90/2297856] via 172.16.1.2, 01:28:25, Serial1/1

C 172.16.64.0/24 is directly connected, Loopback0

L 172.16.64.1/32 is directly connected, Loopback0

192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks

B 192.168.1.0/30 [20/0] via 192.168.1.5, 00:45:28

C 192.168.1.4/30 is directly connected, Serial1/0

L 192.168.1.6/32 is directly connected, Serial1/0

B 192.168.100.0/24 [20/0] via 192.168.1.5, 00:45:28

After issuing ip default-network

SanJose1(config)#ip default-network 192.168.100.0

SanJose1(config)#end

SanJose1#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

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 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP a - application route

+ - replicated route, % - next hop override

Gateway of last resort is 192.168.1.5 to network 192.168.100.0

S* 0.0.0.0/0 [20/0] via 192.168.1.5

172.16.0.0/16 is variably subnetted, 6 subnets, 3 masks

S 172.16.0.0/16 is directly connected, Null0

C 172.16.1.0/24 is directly connected, Serial1/1

L 172.16.1.1/32 is directly connected, Serial1/1

D 172.16.32.0/24 [90/2297856] via 172.16.1.2, 01:33:38, Serial1/1

C 172.16.64.0/24 is directly connected, Loopback0

L 172.16.64.1/32 is directly connected, Loopback0

192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks

B 192.168.1.0/30 [20/0] via 192.168.1.5, 00:50:41

C 192.168.1.4/30 is directly connected, Serial1/0

L 192.168.1.6/32 is directly connected, Serial1/0

B* 192.168.100.0/24 [20/0] via 192.168.1.5, 00:50:41

SanJose1#ping 192.168.1.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 14/15/16 ms

SanJose1#traceroute

192.168.1.2 Type escape

sequence to abort.

Tracing the route to 192.168.1.2

VRF info: (vrf in name/id, vrf out name/id)

1 192.168.1.5 [AS 200] 10 msec 10 msec 10 msec

2 192.168.1.2 [AS 200] 15 msec 15 msec *

SanJose1#ping 192.168.1.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 9/9/11 ms

SanJose1#traceroute

192.168.1.1 Type escape

sequence to abort.

Tracing the route to 192.168.1.1

VRF info: (vrf in name/id, vrf out name/id)

1 192.168.1.5 [AS 200] 10 msec 11 msec *

R3

(SanJose2)

Router>en

Router#conf t

Router(config)#hostname SanJose2

SanJose2(config)#interface Loopback0

SanJose2(config-if)#ip address 172.16.32.1 255.255.255.0

SanJose2(config-if)#exit

SanJose2(config)#interface Serial1/1

SanJose2(config-if)#ip address 192.168.1.2 255.255.255.252

SanJose2(config-if)#no shutdown

SanJose2(config-if)#exit

SanJose2(config)#interface Serial1/0

SanJose2(config-if)#ip address 172.16.1.2 255.255.255.0

SanJose2(config-if)#no shutdown

SanJose2(config-if)#exit

SanJose2(config)#router eigrp 64512

SanJose2(config-router)#network 172.16.0.0

SanJose2(config-router)#no auto-summary

SanJose2(config-router)#exit

SanJose2(config)#router bgp 64512

SanJose2(config-router)#neighbor 172.16.64.1 remote-as 64512

```
SanJose2(config-router)#neighbor 172.16.64.1 update-source
loopback0
SanJose2(config-router)#exit
SanJose2(config)#ip route 172.16.0.0 255.255.0.0 null 0
SanJose2(config)#router bgp 64512
SanJose2(config-router)#network 172.16.0.0
SanJose2(config-router)#neighbor 192.168.1.1 remote-as 200
SanJose2(config-router)#exit

SanJose2#sh ip bgp summary
BGP router identifier 172.16.32.1, local AS number 64512
BGP table version is 4, main routing table version 4
2 network entries using 280 bytes of memory
4 path entries using 320 bytes of memory
4/2 BGP path/bestpath attribute entries using 576 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 1200 total bytes of memory
BGP activity 2/0 prefixes, 4/0 paths, scan interval 60 secs
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ
Up/Down  State/PfxRcd
172.16.64.1     4        64512      31      32        4    0    0 00:24:41        2
192.168.1.1     4          200       8       6        4    0    0 00:01:22        1
```

```
SanJose2#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       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        i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2        ia - IS-IS inter area, * -
candidate default, U - per-user static route        o - ODR, P
- periodic downloaded static route, H - NHRP, l - LISP
a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      172.16.0.0/16 is variably subnetted, 6 subnets, 3 masks
S        172.16.0.0/16 is directly connected, Null0
C        172.16.1.0/24 is directly connected, Serial1/0
L        172.16.1.2/32 is directly connected, Serial1/0
C        172.16.32.0/24 is directly connected, Loopback0
L        172.16.32.1/32 is directly connected, Loopback0
D        172.16.64.0/24 [90/2297856] via 172.16.1.1, 00:08:46,
Serial1/0
      192.168.1.0/24 is variably subnetted, 3 subnets, 2 masks
C        192.168.1.0/30 is directly connected, Serial1/1
L        192.168.1.2/32 is directly connected, Serial1/1
```

B 192.168.1.4/30 [20/0] via 192.168.1.1, 00:02:19

B 192.168.100.0/24 [20/0] via 192.168.1.1, 00:07:40

SanJose2#sh ip bgp

BGP table version is 5, local router ID is 172.16.32.1

Status codes: s suppressed, d damped, h history, * valid, > best,

i - internal, r RIB-failure, S Stale, m multipath, b backup-

path, f RT-Filter, x best-external, a additional-path, c

RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

	Network	Next Hop	Metric	LocPrf	Weight	Path
* i	172.16.0.0	172.16.64.1	0	100	0	i
*>		0.0.0.0	0		32768	i
r i	192.168.1.0/30	192.168.1.5	0			
100	0	200 i				
r>		192.168.1.1				
0	0	200 i				
* i	192.168.1.4/30	192.168.1.5	0	100	0	200 i
*>		192.168.1.1	0		0	200 i
* i	192.168.100.0	192.168.1.5	0	100	0	200 i
*>		192.168.1.1	0		0	200 i

SanJose2(config)#router bgp 64512

```
SanJose2(config-router)#neighbor 172.16.64.1 next-hop-self
SanJose2(config-router)#exit

SanJose2#sh ip bgp
BGP table version is 5, local router ID is 172.16.32.1
Status codes: s suppressed, d damped, h history, * valid, > best,
i - internal,               r RIB-failure, S Stale, m multipath, b backup-
path, f RT-Filter,              x best-external, a additional-path, c
RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

    Network         Next Hop           Metric LocPrf Weight Path
 * i 172.16.0.0      172.16.64.1              0
100      0 i  *>                0.0.0.0
0        32768 i
 r i 192.168.1.0/30   172.16.64.1            0    100
0 200 i  r>                192.168.1.1            0
0 200 i
* i 192.168.1.4/30   172.16.64.1            0    100      0 200 i
*>                192.168.1.1            0           0 200 i
* i 192.168.100.0    172.16.64.1            0    100      0 200 i
*>                192.168.1.1            0           0 200 i
SanJose2(config)#route-map SECONDARY_T1_IN permit 10
```

```
SanJose2(config-route-map)#set local-preference 125
SanJose2(config-route-map)#exit
SanJose2(config)#router bgp 64512
SanJose2(config-router)#neighbor 192.168.1.1 route-map
SECONDARY_T1_IN in
SanJose2(config-router)#exit
SanJose2#clear ip bgp * soft
SanJose2#sh ip bgp
BGP table version is 8, local router ID is 172.16.32.1
Status codes: s suppressed, d damped, h history, * valid, > best,
i - internal,              r RIB-failure, S Stale, m multipath, b backup-
path, f RT-Filter,              x best-external, a additional-path, c
RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

  Network          Next Hop            Metric LocPrf Weight Path
* i 172.16.0.0       172.16.64.1              0    100      0 i
*>                   0.0.0.0                  0         32768 i
r>i 192.168.1.0/30   172.16.64.1              0
160      0 200 i
r                    192.168.1.1              0    125      0
200 i
*>i 192.168.1.4/30   172.16.64.1              0    160      0 200 i
*                    192.168.1.1              0    125      0 200 i
```

*>i 192.168.100.0   172.16.64.1   0   160   0 200 i

*   192.168.1.1   0   125   0 200 i

SanJose2(config)#route-map SECONDARY_T1_MED_OUT permit 10

SanJose2(config-route-map)#set Metric 75

SanJose2(config-route-map)#exit

SanJose2(config)#router bgp 64512

SanJose2(config-router)#$2.168.1.1 route-map
SECONDARY_T1_MED_OUT out

SanJose2(config-router)#end

SanJose2#clear ip bgp * soft

SanJose2#sh ip bgp

BGP table version is 8, local router ID is 172.16.32.1

Status codes: s suppressed, d damped, h history, * valid, > best,

i - internal,   r RIB-failure, S Stale, m multipath, b backup-

path, f RT-Filter,   x best-external, a additional-path, c

RIB-compressed,

Origin codes: i - IGP, e - EGP, ? - incomplete

RPKI validation codes: V valid, I invalid, N Not found

  Network   Next Hop   Metric LocPrf Weight Path

 * i 172.16.0.0   172.16.64.1   0   100   0 i

 *>   0.0.0.0   0   32768 i

 r>i 192.168.1.0/30   172.16.64.1   0

160   0 200 i

r 192.168.1.1 0 125 0

200 i

*>i 192.168.1.4/30 172.16.64.1 0 160 0 200 i

* 192.168.1.1 0 125 0 200 i

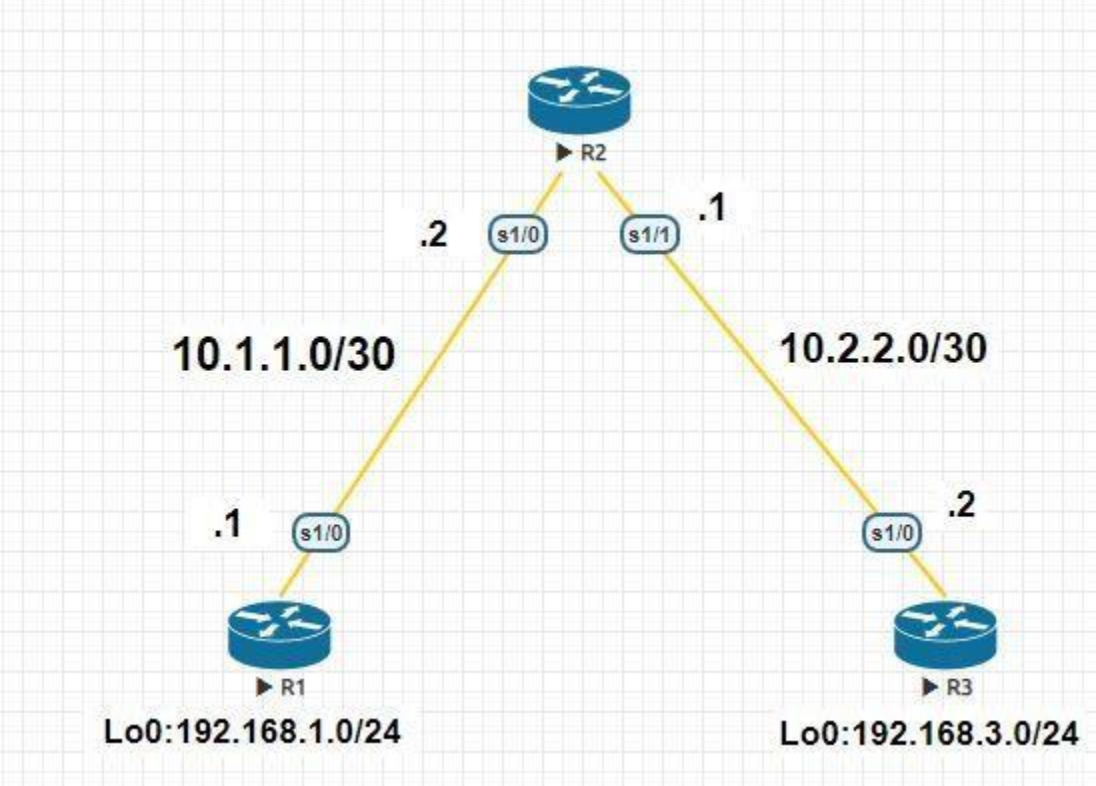
*>i 192.168.100.0 172.16.64.1 0 160 0 200 i

* 192.168.1.1 0 125 0 200 i

PRACTICAL NO 4

Aim: Secure the Management Plane

NETWORK TOPOLOGY :



TASKS:

- **Secure Management Access**
- **Configure enhanced username password security**
- **Enable AAA RADIUS authentication**
- **Enable Secure Remote Management**

Code:

R1

Router>en

Router#conf t

Enter configuration commands, one per line. End with CNTL/Z.

Router(config)#hostname R1

R1(config)#interface Loopback 0

*Dec 19 07:53:42.473: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up

R1(config-if)#ip address 192.168.1.1 255.255.255.0

R1(config-if)#exit

R1(config)#interface s1/0

R1(config-if)#ip address 10.1.1.1 255.255.255.252

R1(config-if)#no shutdown

*Dec 19 07:57:21.998: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up

*Dec 19 07:57:22.999: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up

R1(config-if)#exit

R1(config)#exit

<u>Configure static routes</u>

a. On R1, configure a default static route to ISP.

   R1(config)# ip route 0.0.0.0 0.0.0.0 10.1.1.2

   R1#show ip route

   Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B – BGP 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 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2

ia - IS-IS inter area, * - candidate default,U - per-user static route o - ODR, P - periodic downloaded static route,H - NHRP,l - LISP a - application route

+ - replicated route, % - next hop override

Gateway of last resort is 10.1.1.2 to network 0.0.0.0

S* 0.0.0.0/0 [1/0] via 10.1.1.2

10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks

C 10.1.1.0/30 is directly connected, Serial1/0

L 10.1.1.1/32 is directly connected, Serial1/0

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback0

L 192.168.1.1/32 is directly connected, Loopback0

Secure management access

R1(config)#security passwords min-length 10

R1(config)#enable secret class12345

R1(config)#line console 0

R1(config-line)#password ciscoconpass

R1(config-line)#exec-timeout 5 0

R1(config-line)#login

R1(config-line)#logging synchronous

R1(config-line)#exit

R1(config)#line vty 0 4

R1(config-line)#password ciscovtypass

R1(config-line)#exec-timeout 5 0

R1(config-line)#login

R1(config-line)#exit

R1(config)#line aux 0

R1(config-line)#no exec

R1(config-line)#end

R1(config)#service password-encryption

R1(config)#banner motd $Unauthorized access strictly prohibited!$

R1(config)#exit

Configure enhanced username password security

R1(config)#username JR-ADMIN secret class12345

R1(config)#username ADMIN secret class54321

R1(config)#line console 0

R1(config-line)#login local

R1(config-line)#end

R1(config)#line vty 0 4

R1(config-line)#login local

R1(config-line)#end

Enabling AAA RADIUS Authentication with Local User for Backup

R1(config)# aaa new-model
R1(config)# radius server RADIUS-1
R1(config-radius-server)# address ipv4 192.168.1.101
R1(config-radius-server)# key RADIUS-1-pa55w0rd

R1(config-radius-server)# exit
R1(config)# radius server RADIUS-2
R1(config-radius-server)# address ipv4 192.168.1.102
R1(config-radius-server)# key RADIUS-2-pa55w0rd
R1(config-radius-server)# exit
R1(config)# aaa group server radius RADIUS-GROUP
R1(config-sg-radius)# server name RADIUS-1
R1(config-sg-radius)# server name RADIUS-2
R1(config-sg-radius)# exit
R1(config)# aaa authentication login default group RADIUS-GROUP local R1(config)# aaa authentication login TELNET-LOGIN group RADIUS-GROUP localcase
R1(config)# line vty 0 4
R1(config-line)# login authentication TELNET-LOGIN
R1(config-line)# exit

R2

Router>enable

Router#conf t

Enter configuration commands, one per line. End with CNTL/Z.

Router(config)#hostname R2

R2(config)#interface s1/0

R2(config-if)#ip address 10.1.1.2 255.255.255.252

R2(config-if)#no shutdown

*Dec 19 08:01:10.279: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up

*Dec 19 08:01:11.279: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up

R2(config-if)#exit

R2(config)#interface s1/1

R2(config-if)#ip address 10.2.2.1 255.255.255.252

R2(config-if)#no shutdown

*Dec 19 08:02:33.002: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up

*Dec 19 08:02:34.009: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up

R2(config-if)#exit

R2(config)#exit

Configure static routes

a. On R2, configure two static routes.

R2(config)# ip route 192.168.1.0 255.255.255.0 10.1.1.1

R2(config)# ip route 192.168.3.0 255.255.255.0 10.2.2.2

R2#show ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B – BGP 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

i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia

- IS-IS inter area, * - candidate default, U - per-user static

route o - ODR, P - periodic downloaded static route, H - NHRP,

l - LISP a - application route

+ - replicated route, % - next hop override

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks

C 10.1.1.0/30 is directly connected, Serial1/0

L 10.1.1.2/32 is directly connected, Serial1/0

C 10.2.2.0/30 is directly connected, Serial1/1

L 10.2.2.1/32 is directly connected, Serial1/1

S 192.168.1.0/24 [1/0] via 10.1.1.1

S 192.168.3.0/24 [1/0] via 10.2.2.2

Secure management access

R2(config)#security passwords min-length 10

R2(config)#enable secret class12345

R2(config)#line console 0

R2(config-line)#password ciscoconpass

R2(config-line)#exec-timeout 5 0

R2(config-line)#login

R2(config-line)#logging synchronous

R2(config-line)#exit

R2(config)#line vty 0 4

R2(config-line)#password ciscovtypass

R2(config-line)#exec-timeout 5 0

R2(config-line)#login

R2(config-line)#exit

R2(config)#line aux 0

R2(config-line)#no exec

R2(config-line)#end

R2(config)#service password-encryption

R2(config)#banner motd $Unauthorized access strictly prohibited!$

R2(config)#exit

Configure enhanced username password security

R2(config)#username JR-ADMIN secret class12345

R2(config)#username ADMIN secret class54321

R2(config)#line console 0

R2(config-line)#login local

R2(config-line)#end

R2(config)#line vty 0 4

R2(config-line)#login local

R2(config-line)#end

Enabling AAA RADIUS Authentication with Local User for Backup

R2(config)# aaa new-model
R2(config)# radius server RADIUS-1
R2(config-radius-server)# address ipv4 192.168.1.101
R2(config-radius-server)# key RADIUS-1-pa55w0rd
R2(config-radius-server)# exit
R2(config)# radius server RADIUS-2
R2(config-radius-server)# address ipv4 192.168.1.102

R2(config-radius-server)# key RADIUS-2-pa55w0rd
R2(config-radius-server)# exit
R2(config)# aaa group server radius RADIUS-GROUP
R2(config-sg-radius)# server name RADIUS-1
R2(config-sg-radius)# server name RADIUS-2
R2(config-sg-radius)# exit
R2(config)# aaa authentication login default group RADIUS-GROUP local R2(config)# aaa authentication login TELNET-LOGIN group RADIUS-GROUP localcase
R2(config)# line vty 0 4
R2(config-line)# login authentication TELNET-LOGIN
R2(config-line)# exit

R3

Router>enable

Router#conf t

Enter configuration commands, one per line. End with CNTL/Z.

Router(config)#hostname R3

R3(config)#interface loopback 0

*Dec 19 08:07:50.079: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up

R3(config-if)#ip address 192.168.3.1 255.255.255.0

R3(config-if)#exit

R3(config)#interface s1/0

R3(config-if)#ip address 10.2.2.2 255.255.255.252

R3(config-if)#no shutdown

R3(config-if)#exit

*Dec 19 08:09:26.986: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up

*Dec 19 08:09:27.996: %LINEPROTO-5-UPDOWN: Line protocol on Interface
Serial1/0, changed state to up

R3(config)#end

Configure static routes

a. On R3, configure a default static route to ISP.

R3(config)# ip route 0.0.0.0 0.0.0.0 10.2.2.1

R3#show ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B – BGP 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

i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS

level-2 ia - IS-IS inter area, * - candidate default, U -

per-user static route o - ODR, P - periodic

downloaded static route, H - NHRP, l - LISP a -

application route

+ - replicated route, % - next hop override

Gateway of last resort is 10.2.2.1 to network 0.0.0.0

S* 0.0.0.0/0 [1/0] via 10.2.2.1

10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks

C 10.2.2.0/30 is directly connected, Serial1/0

L 10.2.2.2/32 is directly connected, Serial1/0

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.3.0/24 is directly connected, Loopback0

L 192.168.3.1/32 is directly connected, Loopback0

Secure management access

R3(config)#security passwords min-length 10

R3(config)#enable secret class12345

R3(config)#line console 0

R3(config-line)#password ciscoconpass

R3(config-line)#exec-timeout 5 0

R3(config-line)#login

R3(config-line)#logging synchronous

R3(config-line)#exit

R3(config)#line vty 0 4

R3(config-line)#password ciscovtypass

R3(config-line)#exec-timeout 5 0

R3(config-line)#login

R3(config-line)#exit

R3(config)#line aux 0

R3(config-line)#no exec

R3(config-line)#end

R3(config)#service password-encryption

R3(config)#banner motd $Unauthorized access strictly prohibited!$

Configure enhanced username password security

R3(config)#username JR-ADMIN secret class12345

R3(config)#username ADMIN secret class54321

R3(config)#line console 0

R3(config-line)#login local

R3(config-line)#exit

R3(config)#line vty 0 4

R3(config-line)#login local

R3(config-line)#exit

Enabling AAA RADIUS Authentication with Local User for Backup

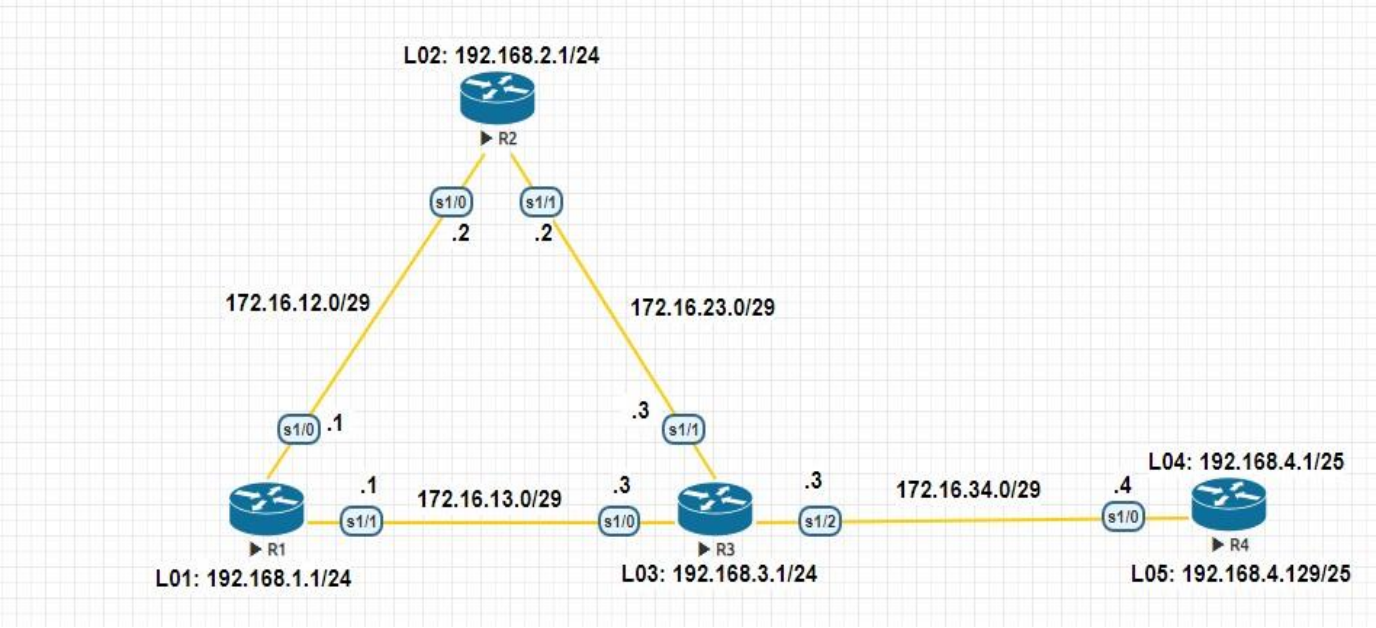
R3(config)# aaa new-model
R3(config)# radius server RADIUS-1
R3(config-radius-server)# address ipv4 192.168.1.101
R3(config-radius-server)# key RADIUS-1-pa55w0rd
R3(config-radius-server)# exit
R3(config)# radius server RADIUS-2
R3(config-radius-server)# address ipv4 192.168.1.102
R3(config-radius-server)# key RADIUS-2-pa55w0rd
R3(config-radius-server)# exit
R3(config)# aaa group server radius RADIUS-GROUP
R3(config-sg-radius)# server name RADIUS-1
R3(config-sg-radius)# server name RADIUS-2
R3(config-sg-radius)# exit

```
R3(config)# aaa authentication login default group RADIUS-GROUP
local R3(config)# aaa authentication login TELNET-LOGIN group
RADIUS-GROUP localcase
R3(config)# line vty 0 4
R3(config-line)# login authentication TELNET-LOGIN
R3(config-line)# exit
```

PRACTICAL NO 5

Aim: Configure and Verify Path Control Using PBR

NETWORK TOPOLOGY:



Tasks:

- **Configure and verify policy-based routing.**
- **Select the required tools and commands to configure policy-based routing operations.**
- **Verify the configuration and operation by using the proper show and debug commands**

Code:

R1

Router>enable

Router#conf t

Enter configuration commands, one per line. End with CNTL/Z.

```
Router(config)#hostname R1
R1(config)#interface Lo1
R1(config-if)#ip address 192.168.1.1 255.255.255.0
R1(config-if)#exit
R1(config)#interface s1/0
R1(config-if)#ip address 172.16.12.1 255.255.255.248
R1(config-if)#no shutdown
R1(config-if)#exit
R1(config)#interface s1/1
R1(config-if)#ip address 172.16.13.1 255.255.255.248
R1(config-if)#no shutdown
R1(config-if)#exit
R1(config)#router eigrp 100
R1(config-router)#network 192.168.1.0
R1(config-router)#network 172.16.12.0
R1(config-router)#network 172.16.13.0
R1(config-router)#no auto-summary
R1(config-router)#exit

R1#sh ip eigrp neighbors
EIGRP-IPv4 Neighbors for AS(100)
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q
Seq
                                            (sec)         (ms)       Cnt Num
1   172.16.13.3             Se1/1            14 00:04:43   11   100  0  10
```

0 172.16.12.2 Se1/0 12 00:07:05 19 114 0 8

R1#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

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 i - IS-IS, su - IS-IS summary, L1 - IS-IS

level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * -

candidate default, U - per-user static route o - ODR, P

- periodic downloaded static route, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override

Gateway of last resort is not set

172.16.0.0/16 is variably subnetted, 6 subnets, 2 masks

C 172.16.12.0/29 is directly connected, Serial1/0

L 172.16.12.1/32 is directly connected, Serial1/0

C 172.16.13.0/29 is directly connected, Serial1/1

L 172.16.13.1/32 is directly connected, Serial1/1

D 172.16.23.0/29 [90/2681856] via 172.16.13.3, 00:08:31, Serial1/1

[90/2681856] via 172.16.12.2, 00:08:31, Serial1/0

D 172.16.34.0/29 [90/2681856] via 172.16.13.3, 00:08:31, Serial1/1

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback1

L 192.168.1.1/32 is directly connected, Loopback1

D 192.168.2.0/24 [90/2297856] via 172.16.12.2, 00:08:31,

Serial1/0 D 192.168.3.0/24 [90/2297856] via 172.16.13.3,

00:08:31, Serial1/1

192.168.4.0/25 is subnetted, 2 subnets

D 192.168.4.0 [90/2809856] via 172.16.13.3, 00:05:15, Serial1/1

D 192.168.4.128 [90/2809856] via 172.16.13.3, 00:05:15, Serial1/1

R2

Router>enable

Router#conf t

Router(config)#hostname R2

R2(config)#interface Lo2

R2(config-if)#ip address 192.168.2.1 255.255.255.0

R2(config-if)#exit

R2(config)#interface s1/0

R2(config-if)#ip address 172.16.12.2 255.255.255.248

R2(config-if)#no shutdown

R2(config-if)#exit

R2(config)#interface s1/1

R2(config-if)#ip address 172.16.23.2 255.255.255.248

R2(config-if)#no shutdown

R2(config-if)#exit

R2(config)#router eigrp 100

R2(config-router)#network 192.168.2.0 R2(config-

router)#network 172.16.12.0

R2(config-router)#network 172.16.23.0

R2(config-router)#no auto-summary

R2#sh ip eigrp neighbors

EIGRP-IPv4 Neighbors for AS(100)

H	Address	Interface	Hold	Uptime	SRTT	RTO	Q Cnt	Seq Num
			(sec)		(ms)			
1	172.16.23.3	Se1/1	12	00:05:23	12	100	0	11
0	172.16.12.1	Se1/0	12	00:07:45	22	132	0	8

R3

Router>enable

Router#conf t

Router(config)#hostname R3

R3(config)#interface Lo3

R3(config-if)#ip address 192.168.3.1 255.255.255.0

R3(config-if)#exit

R3(config)#interface s1/0

R3(config-if)#ip address 172.16.13.3 255.255.255.248

R3(config-if)#no shutdown

```
R3(config-if)#exit
R3(config)#interface s1/1
R3(config-if)#ip address 172.16.23.3 255.255.255.248
R3(config-if)#no shutdown
R3(config-if)#exit
R3(config)#interface s1/2
R3(config-if)#ip address 172.16.34.3 255.255.255.248
R3(config-if)#no shutdown
R3(config-if)#exit
R3(config)#router eigrp 100
R3(config-router)#network 192.168.3.0
R3(config-router)#network 172.16.13.0 R3(config-
router)#network 172.16.23.0
R3(config-router)#network 172.16.34.0
R3(config-router)#no auto-summary
R3#sh ip eigrp neighbors
EIGRP-IPv4 Neighbors for AS(100)
H   Address                 Interface           Hold Uptime   SRTT   RTO  Q
Seq
                                                (sec)         (ms)       Cnt Num
2   172.16.34.4             Se1/2                14 00:03:09
15   100  0  3 1   172.16.13.1           Se1/0                14
00:06:25   21   126  0  9 0   172.16.23.2           Se1/1
13 00:06:25   20   120  0  9
```

```
R3#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       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        i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2        ia - IS-IS inter area, * -
candidate default, U - per-user static route        o - ODR, P
- periodic downloaded static route, H - NHRP, l - LISP
a - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 7 subnets, 2 masks
D       172.16.12.0/29 [90/2681856] via 172.16.23.2, 00:16:48,
Serial1/1
                       [90/2681856] via 172.16.13.1, 00:16:48, Serial1/0
C       172.16.13.0/29 is directly connected, Serial1/0
L       172.16.13.3/32 is directly connected, Serial1/0
C       172.16.23.0/29 is directly connected, Serial1/1
L       172.16.23.3/32 is directly connected, Serial1/1
C       172.16.34.0/29 is directly connected, Serial1/2
L       172.16.34.3/32 is directly connected, Serial1/2
D     192.168.1.0/24 [90/2297856] via 172.16.13.1, 00:16:48, Serial1/0
```

D 192.168.2.0/24 [90/2297856] via 172.16.23.2, 00:16:48, Serial1/1

192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.3.0/24 is directly connected, Loopback3

L 192.168.3.1/32 is directly connected, Loopback3

192.168.4.0/25 is subnetted, 2 subnets

D 192.168.4.0 [90/2297856] via 172.16.34.4, 00:13:32, Serial1/2

D 192.168.4.128 [90/2297856] via 172.16.34.4, 00:13:32, Serial1/2

R3(config)#ip access-list standard PBR-ACL

R3(config-std-nacl)#remark ACL matches R4 LAN B traffic

R3(config-std-nacl)#permit 192.168.4.128 0.0.0.127

R3(config-std-nacl)#exit

R3(config)#route-map R3-to-R1 permit

R3(config-route-map)#match ip address PBR-ACL

R3(config-route-map)#set ip next-hop 172.16.13.1

R3(config-route-map)#end

R3(config)#int s1/2

R3(config-if)#ip policy route-map R3-to-R1

R3(config-

if)#exit

R3#sh

route-map

route-map R3-to-R1, permit,

sequence 10 Match clauses:

ip address (access-lists):

PBR-ACL Set clauses:

ip next-hop 172.16.13.1

Policy routing matches: 0 packets, 0 bytes

R3(config)#access-list 1 permit 192.168.4.0 0.0.0.255

R4

Router>enable

Router#conf t

Router(config)#hostname R4

R4(config)#interface lo4

R4(config-if)#ip address 192.168.4.1 255.255.255.128

R4(config-if)#exit

R4(config)#interface lo5

R4(config-if)#ip address 192.168.4.129 255.255.255.128

R4(config-if)#exit

R4(config)#interface s1/0

R4(config-if)#ip address 172.16.34.4 255.255.255.248 R4(config-if)#no shutdown

R4(config-if)#exit

R4(config)#router eigrp 100

R4(config-router)#network 192.168.4.0

R4(config-router)#network 172.16.34.0

R4(config-router)#no auto-summary

R4#sh ip eigrp neighbors

EIGRP-IPv4 Neighbors for AS(100)

H	Address	Interface	Hold	Uptime	SRTT	RTO	Q Cnt	Seq Num
			(sec)		(ms)			
0	172.16.34.3	Se1/0	14	00:04:07	25	150	0	9

Before Route Maps

R4#traceroute 192.168.1.1 source

192.168.4.1 Type escape sequence to

abort.

Tracing the route to 192.168.1.1

VRF info: (vrf in name/id, vrf out name/id)

1 172.16.34.3 13 msec 11 msec 10 msec

2 172.16.13.1 20 msec 17 msec *

R4#traceroute 192.168.1.1 source

192.168.4.129 Type escape sequence to

abort.

Tracing the route to 192.168.1.1

VRF info: (vrf in name/id, vrf out name/id)

1 172.16.34.3 15 msec 10 msec 10 msec

2 172.16.13.1 19 msec 24 msec *

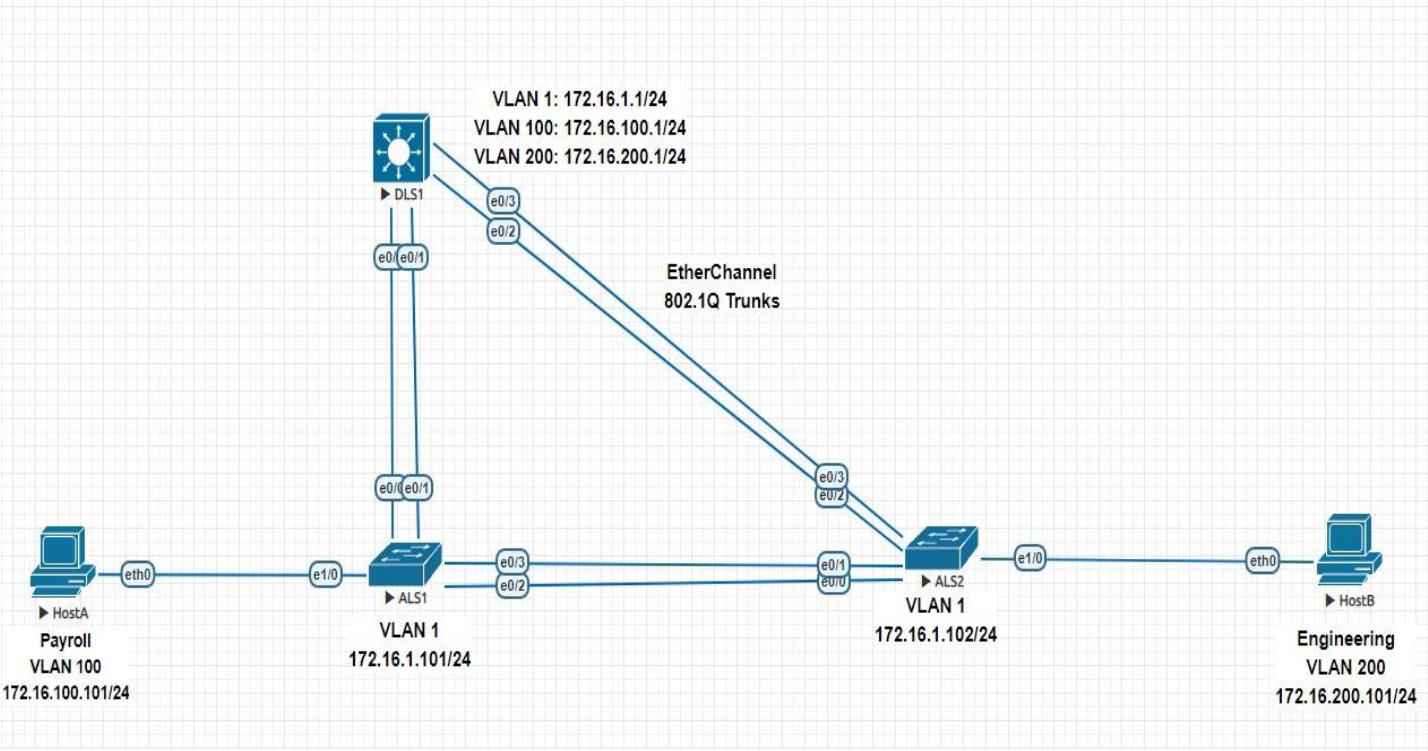
After Route Maps

R4#traceroute 192.168.1.1 source
192.168.4.1 Type escape sequence to
abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id)
1 172.16.34.3 11 msec 10 msec 10 msec
2 172.16.13.1 21 msec 22 msec *
R4#traceroute 192.168.1.1 source
192.168.4.129 Type escape sequence to
abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id)
1 172.16.34.3 10 msec 10 msec 10 msec
2 172.16.13.1 18 msec 18 msec *

PRACTICAL NO 6

Aim: IP Service Level Agreements and Remote SPAN in a Campus Environment

NETWORK TOPOLOGY:



Tasks:

- **Configure trunking, VTP, and SVIs**
- **Implement IP SLAs to monitor various network performance characteristics**
- **Implement Remote Span**

Code:

DLS1

Switch>en

Switch#conf t

Switch(config)#hostname DLS1

DLS1(config)#interface vlan 1

DLS1(config-if)#ip address 172.16.1.1 255.255.255.0

DLS1(config-if)#no shutdown

DLS1(config-if)#exit

Configure the trunks and EtherChannel from DLS1 to ALS1.

DLS1(config)#interface range e0/0-1

DLS1(config-if-range)#switchport trunk encapsulation dot1q

DLS1(config-if-range)#switchport mode trunk

DLS1(config-if-range)#channel-group 1 mode desirable

Creating a port-channel interface Port-channel 1

DLS1(config-if-range)#exit

Configure the trunks and EtherChannel from DLS1 to ALS2.

DLS1(config)#interface range e0/2-3

DLS1(config-if-range)#switchport trunk encapsulation dot1q

DLS1(config-if-range)#switchport mode trunk

DLS1(config-if-range)#channel-group 2 mode desirable

Creating a port-channel interface Port-channel 2

DLS1(config-if-range)#exit

Configure VTP on DLS1 and create VLANs 100 and 200 for the domain

DLS1(config)#vtp domain SWPOD

Changing VTP domain name from NULL to SWPOD

```
DLS1(config)#vtp version 2
DLS1(config)#vlan 100
DLS1(config-vlan)#name Payroll
DLS1(config-vlan)#exit
DLS1(config)#vlan 200
DLS1(config-vlan)#name Engineering
DLS1(config-vlan)#exit
```

On DLS1, create the SVIs for VLANs 100 and 200. Note that the corresponding Layer 2 VLANs must be configured for the Layer 3 SVIs to activate

```
DLS1(config)#interface vlan 100
DLS1(config-if)#ip address 172.16.100.1 255.255.255.0
DLS1(config-if)#no shutdown
DLS1(config-if)#exit
DLS1(config)#interface vlan 200
DLS1(config-if)#ip address 172.16.200.1 255.255.255.0
DLS1(config-if)#no shutdown
DLS1(config-if)#exit
```

The ip routing command is also needed to allow the DLS1 switch to act as a Layer 3 device to route between these VLANs. Because the VLANs are all considered directly connected, a routing protocol is not needed at this time. The default configuration on 3560 switches is no ip routing.

```
DLS1(config)#ip routing
```

```
DLS1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       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        i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2        ia - IS-IS inter area, * -
candidate default, U - per-user static route        o - ODR, P
- periodic downloaded static route, H - NHRP, l - LISP
a - application route
       + - replicated route, % - next hop override
Gateway of last resort is not set
      172.16.0.0/16 is variably subnetted, 6 subnets, 2 masks
C        172.16.1.0/24 is directly connected, Vlan1
L        172.16.1.1/32 is directly connected, Vlan1
C        172.16.100.0/24 is directly connected, Vlan100
L        172.16.100.1/32 is directly connected, Vlan100
C        172.16.200.0/24 is directly connected, Vlan200
L        172.16.200.1/32 is directly connected, Vlan200
```

Configure the Cisco IOS IP SLA source to measure network performance

```
DLS1(config)#ip sla 1
DLS1(config-ip-sla)#icmp-echo 172.16.100.101
```

```
DLS1(config-ip-sla-echo)#exit
DLS1(config)#ip sla 2
DLS1(config-ip-sla)#icmp-echo 172.16.200.101
DLS1(config-ip-sla-echo)#exit
DLS1(config)#ip sla 3
DLS1(config-ip-sla)#udp-jitter 172.16.1.101 5000
DLS1(config-ip-sla-jitter)#exit
DLS1(config)#ip sla 4
DLS1(config-ip-sla)#udp-jitter 172.16.1.102 5000
DLS1(config-ip-sla-jitter)#exit
DLS1(config)#ip sla schedule 1 life forever start-time now
DLS1(config)#ip sla schedule 2 life forever start-time now
DLS1(config)#ip sla schedule 3 life forever start-time now
DLS1(config)#ip sla schedule 4 life forever start-time now
```

Monitor IP SLAs operations

```
DLS1#show ip sla configuration 1
IP SLAs Infrastructure Engine-III
Entry
number: 1
Owner:
Tag:
Operation timeout (milliseconds): 5000
Type of operation to perform: icmp-echo
```

Target address/Source address: 172.16.100.101/0.0.0.0

Type Of Service parameter: 0x0

Request size (ARR data portion): 28

Data pattern: 0xABCDABCD

Verify

data:

No Vrf

Name:

Schedule:

Operation frequency (seconds): 60 (not considered if randomly scheduled)

Next Scheduled Start Time: Start Time already passed

Group Scheduled : FALSE

Randomly Scheduled : FALSE

Life (seconds): Forever

Entry Ageout (seconds): never

Recurring (Starting Everyday): FALSE

Status of entry (SNMP RowStatus): Active

Threshold (milliseconds): 5000

Distribution Statistics:

Number of statistic hours kept: 2

Number of statistic distribution buckets kept: 1

Statistic distribution interval (milliseconds):

20 Enhanced History:

History Statistics:

Number of history Lives kept: 0

Number of history Buckets kept: 15

History Filter Type: None

DLS1#show ip sla configuration 3

IP SLAs Infrastructure Engine-III

Entry

number: 3

Owner:

Tag:

Operation timeout (milliseconds): 5000

Type of operation to perform: udp-jitter

Target address/Source address: 172.16.1.101/0.0.0.0

Target port/Source port: 5000/0

Type Of Service parameter: 0x0

Request size (ARR data portion): 32

Packet Interval (milliseconds)/Number of packets: 20/10

Verify

data:

No Vrf

Name:

Control Packets:

enabled Schedule:

Operation frequency (seconds): 60 (not considered if randomly scheduled)

Next Scheduled Start Time: Start Time already passed

Group Scheduled : FALSE

Randomly Scheduled : FALSE

Life (seconds): Forever

Entry Ageout (seconds): never

Recurring (Starting Everyday): FALSE

Status of entry (SNMP RowStatus): Active

Threshold (milliseconds): 5000

Distribution Statistics:

Number of statistic hours kept: 2

Number of statistic distribution buckets kept: 1

Statistic distribution interval (milliseconds):

20 Enhanced History:

Percentile:

DLS1#show ip sla application

IP Service Level Agreements

Version: Round Trip Time MIB 2.2.0, Infrastructure Engine-III

Supported Operation Types:

icmpEcho, path-echo, path-jitter, udpEcho,

tcpConnect, http dns, udpJitter, dhcp, ftp, lsp Group,

lspPing, lspTrace pseudowirePing, udpApp, wspApp,

mcast, generic

Supported Features:

IPSLAs Event Publisher

IP SLAs low memory water mark: 225778552

Estimated system max number of entries: 165365

Estimated number of configurable operations: 165241

Number of Entries configured : 4

Number of active Entries   : 4

Number of pending Entries   : 0

Number of inactive Entries   : 0

Time of last change in whole IP SLAs: *14:08:46.139 EET Sat Apr 11 2020

DLS1#show ip sla statistics 1

IPSLAs Latest Operation Statistics

IPSLA operation id: 1

    Latest RTT: 1 milliseconds

Latest operation start time: 14:34:23 EET Sat Apr 11 2020

Latest operation return code: OK

Number of successes: 26

Number of failures: 1

Operation time to live: Forever

DLS1#show ip sla statistics 3

IPSLAs Latest Operation Statistics

IPSLA operation id: 3

Type of operation: udp-jitter

    Latest RTT: 1 milliseconds

Latest operation start time: 14:34:36 EET Sat Apr 11 2020

Latest operation return

code: OK RTT Values:

Number Of RTT: 10 RTT Min/Avg/Max: 1/1/2

milliseconds Latency one-way time:

Number of Latency one-way Samples: 6

Source to Destination Latency one way Min/Avg/Max: 0/0/1 milliseconds Destination to Source Latency one way Min/Avg/Max: 0/0/1 milliseconds Jitter Time:

Number of SD Jitter Samples: 9

Number of DS Jitter Samples: 9

Source to Destination Jitter Min/Avg/Max: 0/1/1

milliseconds Destination to Source Jitter Min/Avg/Max:

0/1/1 milliseconds Over Threshold:

Number Of RTT Over Threshold: 0

(0%) Packet Loss Values:

Loss Source to Destination: 0

Source to Destination Loss Periods Number: 0

Source to Destination Loss Period Length Min/Max: 0/0

Source to Destination Inter Loss Period Length Min/Max: 0/0

Loss Destination to Source: 0

Destination to Source Loss Periods Number: 0

Destination to Source Loss Period Length Min/Max: 0/0

Destination to Source Inter Loss Period Length Min/Max: 0/0

Out Of Sequence: 0 Tail

Drop: 0 Packet Late Arrival: 0

Packet Skipped: 0 Voice Score

Values:

Calculated Planning Impairment Factor (ICPIF): 0

Mean Opinion Score (MOS): 0

Number of successes: 27

Number of failures: 0

Operation time to live: Forever

Configure Remote Span

DLS1(config)#vlan 100

DLS1(config-vlan)#remote-span

DLS1(config-vlan)#exit

DLS1(config)#monitor session 1 source interface e0/0 both

DLS1(config)# monitor session 1 destination remote vlan 100

ALS1

Switch>en

Switch#conf t

Switch(config)#hostname ALS1

ALS1(config)#interface vlan 1

ALS1(config-if)#ip address 172.16.1.101 255.255.255.0

ALS1(config-if)#no shutdown

ALS1(config-if)#exit

ALS1(config)#ip default-gateway 172.16.1.1

Configure the trunks and EtherChannel between ALS1 and DLS1

ALS1(config)#interface range e0/0-1

ALS1(config-if-range)# switchport trunk encapsulation dot1q

ALS1(config-if-range)#switchport mode trunk

ALS1(config-if-range)#channel-group 1 mode desirable

Creating a port-channel interface Port-channel 1

ALS1(config-if-range)#exit

Configure the trunks and EtherChannel between ALS1 and ALS2

ALS1(config)#interface range e0/2-3

ALS1(config-if-range)#switchport trunk encapsulation dot1q

ALS1(config-if-range)#switchport mode trunk

ALS1(config-if-range)#channel-group 2 mode desirable

Creating a port-channel interface Port-channel 2

Configure VTP on ALS1

ALS1(config)#vtp mode client

Setting device to VTP Client mode for VLANS.

ALS1(config)#int e1/0

ALS1(config-if)#switchport mode access

ALS1(config-if)#switchport access vlan 100

ALS1(config-if)#exit

Configure Cisco IOS IP SLA responders.

ALS1(config)#ip sla responder

ALS1(config)#ip sla responder udp-echo ipaddress 172.16.1.1 port 5000

ALS1#show ip sla responder

General IP SLA Responder on Control port 1967

General IP SLA Responder on Control V2 port 1167

General IP SLA Responder is: Enabled

Number of control message received: 16 Number of errors: 0 Recent sources:

172.16.1.1 [14:23:36.259 EET Sat Apr 11 2020] 172.16.1.1 [14:22:36.257 EET Sat Apr 11 2020]

172.16.1.1 [14:21:36.255 EET Sat Apr 11 2020]

172.16.1.1 [14:20:36.256 EET Sat Apr 11 2020] 172.16.1.1 [14:19:36.258 EET Sat Apr 11 2020] Recent error sources:

Number of control v2 message received: 0 Number of errors: 0 Recent sources:

Recent error sources:

Permanent Port IP SLA Responder

Permanent Port IP SLA Responder is:

Enabled udpEcho Responder:

IP Address	Port
172.16.1.1	5000

ALS2

Switch>en

Switch#conf t

Enter configuration commands, one per line. End with CNTL/Z.

Switch(config)#hostname ALS2

ALS2(config)#interface vlan 1

ALS2(config-if)#ip address 172.16.1.102 255.255.255.0

ALS2(config-if)#no shutdown

ALS2(config-if)#exit

ALS2(config)#ip default-gateway 172.16.1.1

Configure the trunks and EtherChannel between ALS2 and ALS1

ALS2(config)#interface range e0/0-1

ALS2(config-if-range)#switchport trunk encapsulation dot1q

ALS2(config-if-range)#switchport mode trunk

ALS2(config-if-range)#channel-group 2 mode desirable

Creating a port-channel interface Port-channel 2

ALS2(config-if-range)#exit

Configure the trunks and EtherChannel between ALS2 and DLS1

ALS2(config)#interface range e0/2-3

ALS2(config-if-range)#switchport trunk encapsulation dot1q

ALS2(config-if-range)#switchport mode trunk

ALS2(config-if-range)#channel-group 1 mode desirable

Creating a port-channel interface Port-channel 1

ALS2(config-if-range)#exit

Configure VTP on ALS2

ALS2(config)#vtp mode client

Setting device to VTP Client mode for VLANS

ALS2(config)#int e1/0

ALS2(config-if)#switchport mode access

ALS2(config-if)#switchport access vlan 200

ALS2(config-if)#exit

Configure Cisco IOS IP SLA responders.

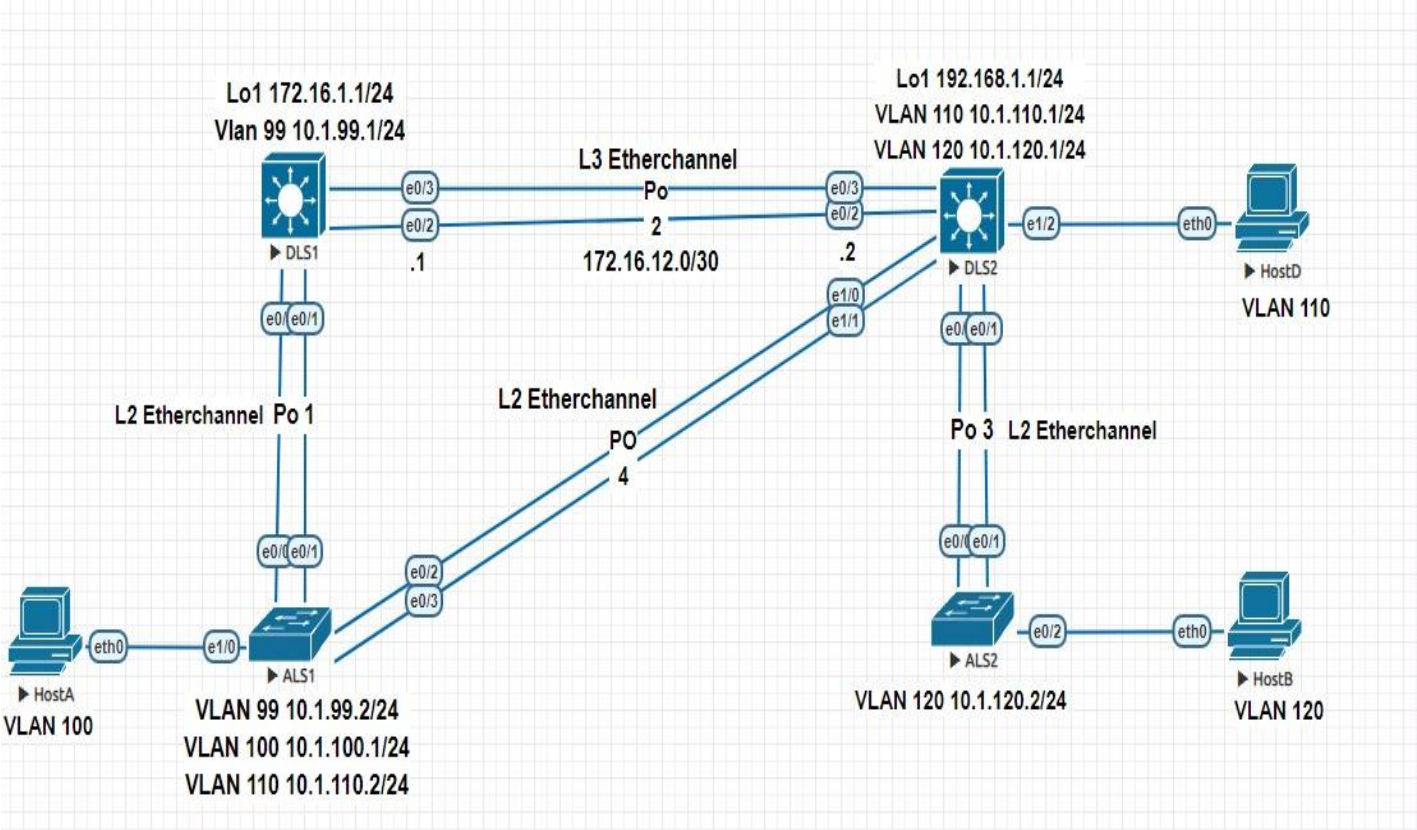
ALS2(config)#ip sla responder

ALS2(config)#ip sla responder udp-echo ipaddress 172.16.1.1 port 5000

PRACTICAL NO 7

Aim: Inter-VLAN Routing

NETWORK TOPOLOGY:



Tasks:

- **Implement a Layer 3 EtherChannel**
- **Implement Static Routing**
- **Implement Inter-Vlan Routing**

Code:

DLS1

Switch>enable

Switch#conf t

Switch(config)#hostname DLS1

DLS1(config)#interface loopback 1

DLS1(config-if)#ip address 172.16.1.1 255.255.255.0

DLS1(config-if)#exit

DLS1(config)#interface vlan 99

DLS1(config-if)#ip address 10.1.99.1 255.255.255.0

DLS1(config-if)#no shutdown

Implement a Layer 3 EtherChannel

DLS1(config)#int range e0/2-3

DLS1(config-if-range)#no switchport

DLS1(config-if-range)#no ip address

DLS1(config-if-range)#channel-group 2 mode on

Creating a port-channel interface Port-channel 2

DLS1(config-if-range)#exit

DLS1(config)#interface port-channel 2

DLS1(config-if)#ip address 172.16.12.1 255.255.255.252

DLS1(config-if)#end

DLS1(config)#int range e0/0-1

DLS1(config-if-range)#switchport trunk encapsulation dot1q

DLS1(config-if-range)#switchport mode trunk DLS1(config-if-range)#channel-group 1 mode desirable

Creating a port-channel interface Port-channel 1

DLS1(config-if-range)#end

DLS1#sh interfaces trunk

Port Mode Encapsulation Status Native vlan

Po1 on 802.1q trunking 1

Port Vlans allowed on trunk

Po1 1-4094

Port Vlans allowed and active in management domain

Po1 1,99

Port Vlans in spanning tree forwarding state and not pruned

Po1 1,99

Implement Static Routing

DLS1(config)#ip routing

DLS1(config)#ip route 192.168.1.0 255.255.255.252 172.16.12.2

DLS1(config)# ip route 192.168.1.0 255.255.255.0 10.1.120.1

DLS1(config)# ip route 192.168.1.0 255.255.255.0 10.1.110.1

DLS1#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

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 i - IS-IS, su - IS-IS summary, L1 - IS-IS

level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * -

candidate default, U - per-user static route o - ODR, P

- periodic downloaded static route, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks

C 10.1.99.0/24 is directly connected, Vlan99

L 10.1.99.1/32 is directly connected, Vlan99

172.16.0.0/16 is variably subnetted, 4 subnets, 3 masks

C 172.16.1.0/24 is directly connected, Loopback1

L 172.16.1.1/32 is directly connected, Loopback1

C 172.16.12.0/30 is directly connected, Port-channel2

L 172.16.12.1/32 is directly connected, Port-channel2

192.168.1.0/30 is subnetted, 1 subnets

S 192.168.1.0 [1/0] via 172.16.12.2

DLS2

Switch>en

Switch#conf t

Switch(config)#hostname DLS2

DLS2(config)#interface loopback 1

DLS2(config-if)#ip address 192.168.1.1 255.255.255.0

DLS2(config-if)#exit

DLS2(config)#interface vlan 110

DLS2(config-if)#ip address 10.1.110.1 255.255.255.0

DLS2(config-if)#no shutdown

DLS2(config-if)#exit

DLS2(config)#interface vlan 120

DLS2(config-if)#ip address 10.1.120.1 255.255.255.0

DLS2(config-if)#no shutdown

DLS2(config-if)#exit

Implement a Layer 3 EtherChannel

DLS2(config)#interface range e0/2-3

DLS2(config-if-range)#no switchport

DLS2(config-if-range)#no ip

DLS2(config-if-range)#no ip address

DLS2(config-if-range)#channel-group 2 mode on

Creating a port-channel interface Port-channel 2

DLS2(config-if-range)#exit

DLS2(config)#interface port-channel 2

DLS2(config-if)#ip address 172.16.12.2 255.255.255.252

DLS2(config-if)#end

DLS2(config)#interface range e0/0-1

DLS2(config-if-range)#switchport trunk encapsulation dot1q

DLS2(config-if-range)#switchport mode trunk

DLS2(config-if-range)#channel-group 3 mode desirable

Creating a port-channel interface Port-channel 3

DLS2(config-if-range)#exit

DLS2(config)#interface range e1/0-1

```
DLS2(config-if-range)#switchport trunk encapsulation dot1q
DLS2(config-if-range)#switchport mode trunk
DLS2(config-if-range)#channel-group 4 mode desirable
Creating a port-channel interface Port-channel 4
DLS2(config-if-range)#end
DLS2#sh interfaces trunk
Port        Mode             Encapsulation  Status        Native vlan
Po3         on               802.1q
trunking      1 Po4         on
802.1q         trunking      1
Port        Vlans allowed on trunk
Po3
1-4094
Po4
1-4094
Port        Vlans allowed and active in management domain
Po3
1,110,120
Po4
1,110,120
Port        Vlans in spanning tree forwarding state and not pruned
Po3
1,110,120
```

Po4

1,110,120

Implement Static Routing

DLS2(config)#ip routing

DLS2(config)#ip route 172.16.1.0 255.255.255.252 172.16.12.1

DLS2(config)# ip route 172.16.1.0 255.255.255.0 10.1.99.1 Configure the host ports for the appropriate VLANs according to the diagram

DLS2(config)#interface e1/2

DLS2(config-if)#switchport mode access

DLS2(config-if)#switchport access vlan 110

DLS2#sh ip route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP

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 i - IS-IS, su - IS-IS summary, L1 - IS-IS

level-1, L2 - IS-IS level-2 ia - IS-IS inter area, * -

candidate default, U - per-user static route o - ODR, P

- periodic downloaded static route, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks

C 10.1.110.0/24 is directly connected, Vlan110

L 10.1.110.1/32 is directly connected, Vlan110

C 10.1.120.0/24 is directly connected, Vlan120

L 10.1.120.1/32 is directly connected, Vlan120

172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks

S 172.16.1.0/30 [1/0] via 172.16.12.1

C 172.16.12.0/30 is directly connected, Port-channel2

L 172.16.12.2/32 is directly connected, Port-channel2

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Loopback1

L 192.168.1.1/32 is directly connected, Loopback1

ALS1

Switch>en

Switch#conf t

Switch(config)#hostname ALS1

ALS1(config)#ip default-gateway 10.1.99.1

ALS1(config)#ip default-gateway 10.1.110.1

ALS1(config)#ip default-gateway 10.1.100.2

Implement a Layer 3 EtherChannel

ALS1(config)#int range e0/0-1

ALS1(config-if-range)#switchport trunk encapsulation dot1q

ALS1(config-if-range)#switchport mode trunk

ALS1(config-if-range)#channel-group 1 mode desirable

Creating a port-channel interface Port-channel 1

```
ALS1(config-if-range)#exit
ALS1(config)#int range e0/2-3
ALS1(config-if-range)#switchport trunk encapsulation dot1q
ALS1(config-if-range)#switchport mode trunk
ALS1(config-if-range)#channel-group 4 mode desirable
Creating a port-channel interface Port-channel 4
ALS1(config-if-range)#end

ALS1#sh etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      N - not in use, no
aggregation        f - failed to
allocate aggregator        M - not in
use, minimum links not met
        m - not in use, port not aggregated due to minimum
links not met        u - unsuitable for bundling        w -
waiting to be aggregated        d - default port
        A - formed by Auto LAG
Number of channel-groups in use: 2
Number of aggregators:          2
Group  Port-channel  Protocol    Ports
1      Po1(SU)         PAgP      Et0/0(P)    Et0/1(P)
```

4 Po4(SU) PAgP Et0/2(P) Et0/3(P)

Configure the host ports for the appropriate VLANs according to the diagram

ALS1(config)#interface e1/0

ALS1(config-if)#switchport mode access

ALS1(config-if)#switchport access vlan 100

ALS2

Switch>en

Switch#conf t

Switch(config)#hostname ALS2

ALS2(config)#ip default-gateway 10.1.120.1

Implement a Layer 3 EtherChannel

ALS2(config)#int range e0/0-1

ALS2(config-if-range)#switchport trunk encapsulation dot1q

ALS2(config-if-range)#switchport mode trunk

ALS2(config-if-range)#channel-group 3 mode desirable

Creating a port-channel interface Port-channel 3

ALS2(config-if-range)#end

ALS2#sh etherchannel summary

Flags: D - down P - bundled in port-channel

I - stand-alone s - suspended

H - Hot-standby (LACP only)

R - Layer3 S - Layer2

U - in use N - not in use, no aggregation f - failed to allocate aggregator M - not in use, minimum links not met

m - not in use, port not aggregated due to minimum links not met u - unsuitable for bundling w - waiting to be aggregated d - default port

A - formed by Auto LAG

Number of channel-groups in use: 1

Number of aggregators: 1

Group	Port-channel	Protocol	Ports
3	Po3(SU)	PAgP	Et0/0(P) Et0/1(P)

Configure the host ports for the appropriate VLANs according to the diagram

```
ALS2(config)#interface e0/2
ALS2(config-if)#switchport mode access
ALS2(config-if)#switchport access vlan 120
```

HOST A

```
VPCS> ip 10.1.100.1 255.255.255.0 10.1.100.2
```

HOST B

```
VPCS> ip 10.1.120.2 255.255.255.0 10.1.120.1
```

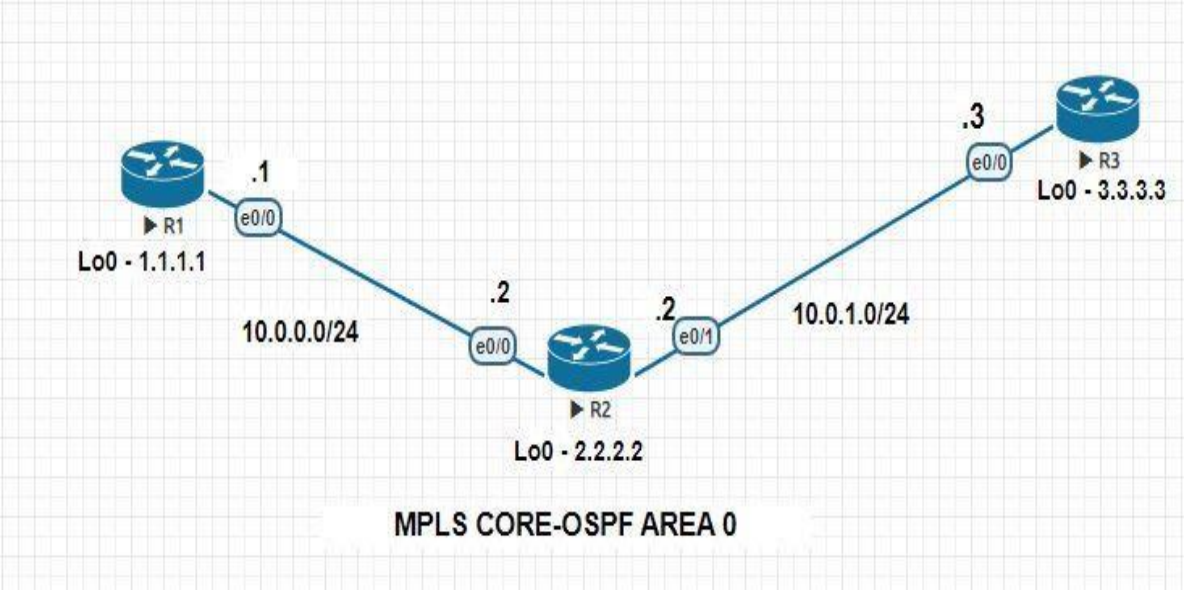
HOST D

```
VPCS> ip 10.1.110.2 255.255.255.0 10.1.110.1
```

PRACTICAL NO 8

Aim: Simulating MPLS environment

NETWORK TOPOLOGY:



Tasks:

- **Configure the basic IP Addressing according to the diagram**
- **Configure OSPF Area 0 as IGP Protocol running inside the MPLS SP Network**
- **Advertise the loopback 0 interface also inside the IGP**
- **Configure MPLS on all Routers**
- **Configure LDP router ID has to be the loopback 0 ID**
- **Configure the routers to select the labels as below**
  - **R1-100-199**
  - **R2-200-299**
  - **R3-300-399**

Code:

R1

```
Router>enable
Router#conf t
Router(config)#hostname R1
R1(config)# interface loopback 0
R1(config-if)#ip address 1.1.1.1 255.255.255.255
R1(config-if)#exit
R1(config)#int e0/0
R1(config-if)#ip address 10.0.0.1 255.255.255.0
R1(config-if)#no shut
R1(config)#router ospf 1
R1(config-router)#network 1.1.1.0 0.0.0.255 area 0
R1(config-router)#network 10.0.0.0 0.0.0.255 area 0
R1(config-router)#exit
R1#show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       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        i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2        ia - IS-IS inter area, * -
candidate default, U - per-user static route        o - ODR, P
```

- periodic downloaded static route, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override

Gateway of last resort is not set

2.0.0.0/32 is subnetted, 1 subnets

O 2.2.2.2 [110/11] via 10.0.0.2, 00:15:40, Ethernet0/0

3.0.0.0/32 is subnetted, 1 subnets

O 3.3.3.3 [110/21] via 10.0.0.2, 00:04:01, Ethernet0/0

10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks

O 10.0.1.0/24 [110/20] via 10.0.0.2, 00:09:25, Ethernet0/0

R1#sh ip cef

Prefix	Next Hop	Interface
0.0.0.0/0	no route	
0.0.0.0/8	drop	
0.0.0.0/32	receive	
1.1.1.1/32	receive	Loopback0
2.2.2.2/32	10.0.0.2	Ethernet0/0
3.3.3.3/32	10.0.0.2	Ethernet0/0
10.0.0.0/24	attached	Ethernet0/0
10.0.0.0/32	receive	Ethernet0/0
10.0.0.1/32	receive	Ethernet0/0
10.0.0.2/32	attached	Ethernet0/0
10.0.0.255/32	receive	Ethernet0/0

```
10.0.1.0/24         10.0.0.2           Ethernet0/0
127.0.0.0/8         drop
224.0.0.0/4         drop
224.0.0.0/24        receive
240.0.0.0/4         drop
255.255.255.255/32   receive

R1#sh ip route 2.2.2.2
Routing entry for 2.2.2.2/32
  Known via "ospf 1", distance 110, metric 11, type intra area
  Last update from 10.0.0.2 on Ethernet0/0, 00:30:34
ago   Routing Descriptor Blocks:
* 10.0.0.2, from 2.2.2.2, 00:30:34 ago, via Ethernet0/0
      Route metric is 11, traffic share count is 1

R1#sh ip route 3.3.3.3
Routing entry for 3.3.3.3/32
  Known via "ospf 1", distance 110, metric 21, type intra area
  Last update from 10.0.0.2 on Ethernet0/0, 00:11:43
ago   Routing Descriptor Blocks:
* 10.0.0.2, from 3.3.3.3, 00:11:43 ago, via Ethernet0/0
      Route metric is 21, traffic share count is 1
```

```
R1#sh ip cef
2.2.2.2 2.2.2.2/32
  nexthop 10.0.0.2 Ethernet0/0

R1#sh ip cef
3.3.3.3
3.3.3.3/32
  nexthop 10.0.0.2 Ethernet0/0

R1(config)#mpls label range 100 199
R1(config)#mpls label protocol ldp
R1(config)#mpls ldp router-id loopback 0
R1(config)#int e0/0
R1(config-if)#mpls ip

R1#sh mpls interfaces
Interface              IP         Tunnel   BGP Static Operational
Ethernet0/0      Yes (ldp)     No       No  No     Yes

R1#sh mpls ldp neighbor
    Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 1.1.1.1:0
        TCP connection: 2.2.2.2.27963 - 1.1.1.1.646
        State: Oper; Msgs sent/rcvd: 13/14; Downstream
        Up time: 00:05:21
```

LDP discovery sources:

Ethernet0/0, Src IP addr: 10.0.0.2

Addresses bound to peer LDP Ident:

10.0.0.2 10.0.1.2 2.2.2.2

R1#sh ip cef

3.3.3.3

3.3.3.3/32

nexthop 10.0.0.2 Ethernet0/0 label 201

R1#sh ip cef

2.2.2.2 2.2.2.2/32

nexthop 10.0.0.2 Ethernet0/0

R1#sh mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Label Switched	Outgoing interface	Next Hop
100	Pop Label	2.2.2.2/32	0	Et0/0	10.0.0.2
101	201	3.3.3.3/32	0	Et0/0	10.0.0.2
102	Pop Label	10.0.1.0/24	0	Et0/0	10.0.0.2

R1#sh mpls ldp bindings lib

entry: 1.1.1.1/32, rev 2 local

binding: label: imp-null

remote binding: lsr: 2.2.2.2:0,

label: 200   lib entry: 2.2.2.2/32,

rev 4

local binding: label: 100

remote binding: lsr: 2.2.2.2:0,

label: imp-null   lib entry: 3.3.3.3/32,

rev 6 local binding: label: 101

remote binding: lsr:

2.2.2.2:0, label: 201   lib entry:

10.0.0.0/24, rev 8 local

binding: label: imp-null

remote binding: lsr: 2.2.2.2:0,

label: imp-null   lib entry:

10.0.1.0/24, rev 10 local binding:

label: 102

remote binding: lsr: 2.2.2.2:0, label: imp-null

R1#ping 3.3.3.3 source 10.0.0.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:

Packet sent with a source address of 10.0.0.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms

R1#traceroute 3.3.3.3 source

10.0.0.1 Type escape sequence

to abort.

Tracing the route to 3.3.3.3

VRF info: (vrf in name/id, vrf out name/id)

1 10.0.0.2 [MPLS: Label 201 Exp 0] 1 msec 1 msec 0 msec

2 10.0.1.3 1 msec 2 msec *

R1#ping 2.2.2.2 source

10.0.0.1 Type escape

sequence to abort.

Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:

Packet sent with a source address of 10.0.0.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 5/5/6 ms

R1#traceroute 2.2.2.2 source

10.0.0.1 Type escape sequence

to abort.

Tracing the route to 2.2.2.2

VRF info: (vrf in name/id, vrf out name/id)

1 10.0.0.2 2 msec 1 msec *

R2

Router>enable

```
Router#conf t
Router(config)#hostname R2
R2(config)# interface loopback 0
R2(config-if)#ip address 2.2.2.2 255.255.255.255
R2(config-if)# exit
R2(config)#int e0/0
R2(config-if)#ip address 10.0.0.2 255.255.255.0
R2(config-if)#no shut
R2(config)#int e0/1
R2(config-if)#ip address 10.0.1.2 255.255.255.0
R2(config-if)#no shut
R2(config)#router ospf 1
R2(config-router)#network 2.2.2.0 0.0.0.255 area 0
R2(config-router)#network 10.0.0.0 0.0.0.255 area 0 R2(config-
router)#network 10.0.1.0 0.0.0.255 area 0
R2(config-router)#exit
R2#show ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       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        i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2        ia - IS-IS inter area, * -
candidate default, U - per-user static route        o - ODR, P
```

- periodic downloaded static route, H - NHRP, l - LISP

a - application route

+ - replicated route, % - next hop override

Gateway of last resort is not set

1.0.0.0/32 is subnetted, 1 subnets

O 1.1.1.1 [110/11] via 10.0.0.1, 00:15:32, Ethernet0/0

3.0.0.0/32 is subnetted, 1 subnets

O 3.3.3.3 [110/11] via 10.0.1.3, 00:03:58, Ethernet0/1

R2#sh ip cef

Prefix Next Hop Interface

0.0.0.0/0 no route

0.0.0.0/8 drop

0.0.0.0/32 receive

1.1.1.1/32 10.0.0.1

Ethernet0/0 2.2.2.2/32 receive

Loopback0

3.3.3.3/32 10.0.1.3 Ethernet0/1

10.0.0.0/24 attached Ethernet0/0

10.0.0.0/32 receive Ethernet0/0

10.0.0.1/32 attached Ethernet0/0

10.0.0.2/32 receive Ethernet0/0

10.0.0.255/32 receive Ethernet0/0

10.0.1.0/24 attached Ethernet0/1

```
10.0.1.0/32         receive           Ethernet0/1
10.0.1.2/32         receive           Ethernet0/1
10.0.1.3/32         attached          Ethernet0/1
10.0.1.255/32       receive           Ethernet0/1
127.0.0.0/8         drop
224.0.0.0/4         drop
224.0.0.0/24        receive
240.0.0.0/4         drop
255.255.255.255/32  receive

R2#sh ip route 1.1.1.1
Routing entry for 1.1.1.1/32
  Known via "ospf 1", distance 110, metric 11, type intra area
  Last update from 10.0.0.1 on Ethernet0/0, 00:33:11
ago   Routing Descriptor Blocks:
* 10.0.0.1, from 1.1.1.1, 00:33:11 ago, via Ethernet0/0
      Route metric is 11, traffic share count is 1

R2#sh ip route 3.3.3.3
Routing entry for 3.3.3.3/32
  Known via "ospf 1", distance 110, metric 11, type intra area
  Last update from 10.0.1.3 on Ethernet0/1, 00:21:49
ago   Routing Descriptor Blocks:
* 10.0.1.3, from 3.3.3.3, 00:21:49 ago, via Ethernet0/1
      Route metric is 11, traffic share count is 1
```

```
R2#sh ip cef
1.1.1.1 1.1.1.1/32
  nexthop 10.0.0.1 Ethernet0/0
R2#sh ip cef
3.3.3.3 3.3.3.3/32
  nexthop 10.0.1.3 Ethernet0/1
R2(config)#mpls label range 200 299
R2(config)#mpls label protocol ldp
R2(config)#mpls ldp router-id loopback 0
R2(config)#int e0/0
R2(config-if)#mpls ip
R2(config-if)#int e0/1
R2(config-if)#mpls ip
R2#sh mpls interfaces
Interface              IP         Tunnel   BGP Static Operational
Ethernet0/0            Yes (ldp)  No       No  No     Yes
Ethernet0/1            Yes (ldp)  No       No  No     Yes
R2#sh mpls forwarding-table
Local      Outgoing   Prefix          Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
200        Pop Label  1.1.1.1/32      0             Et0/0      10.0.0.1
201        Pop Label  3.3.3.3/32      1266          Et0/1      10.0.1.3
R2#sh mpls ldp neighbor
    Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 2.2.2.2:0
```

TCP connection: 1.1.1.1.646 - 2.2.2.2.27963

State: Oper; Msgs sent/rcvd: 41/42; Downstream

Up time: 00:29:24

LDP discovery sources:

Ethernet0/0, Src IP addr: 10.0.0.1

Addresses bound to peer LDP Ident:

10.0.0.1 1.1.1.1

Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 2.2.2.2:0

TCP connection: 3.3.3.3.44196 - 2.2.2.2.646

State: Oper; Msgs sent/rcvd: 38/38; Downstream

Up time: 00:27:24

LDP discovery sources:

Ethernet0/1, Src IP addr: 10.0.1.3

Addresses bound to peer LDP Ident:

10.0.1.3 3.3.3.3

R2#sh mpls ldp

bindings lib

entry:

1.1.1.1/32, rev 2

local binding:

label: 200

remote binding: lsr: 1.1.1.1:0, label:

imp-null remote binding: lsr:

3.3.3.3:0, label: 300 lib entry:

2.2.2.2/32, rev 4 local binding:
label: imp-null remote binding:
lsr: 1.1.1.1:0, label: 100 remote
binding: lsr: 3.3.3.3:0, label: 301 lib
entry: 3.3.3.3/32, rev 6 local
binding: label: 201

remote binding: lsr: 1.1.1.1:0,
label: 101 remote binding: lsr:
3.3.3.3:0, label: imp-null lib entry:
10.0.0.0/24, rev 8 local binding:
label: imp-null

remote binding: lsr: 1.1.1.1:0,
label: imp-null remote binding:
lsr: 3.3.3.3:0, label: 302 lib entry:
10.0.1.0/24, rev 10 local binding:
label: imp-null remote binding:
lsr: 1.1.1.1:0, label: 102 remote
binding: lsr: 3.3.3.3:0, label: imp-null

R2#ping 1.1.1.1 source 10.0.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
Packet sent with a source address of 10.0.0.2
!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R2#traceroute 1.1.1.1 source

10.0.0.2 Type escape sequence

to abort.

Tracing the route to 1.1.1.1

VRF info: (vrf in name/id, vrf out name/id)

1 10.0.0.1 2 msec 1 msec *

R2#ping 3.3.3.3 source 10.0.1.2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:

Packet sent with a source address of 10.0.1.2

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R2#traceroute 3.3.3.3 source

10.0.1.2 Type escape sequence

to abort.

Tracing the route to 3.3.3.3

VRF info: (vrf in name/id, vrf out name/id)

1 10.0.1.3 0 msec 1 msec *

R3

Router>enable

```
Router#conf t
Router(config)#hostname R3
R3(config)#interface loopback 0
R3(config-if)#ip address 3.3.3.3 255.255.255.255
R3(config-if)#exit
R3(config)#int e0/0
R3(config-if)#ip address 10.0.1.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#exit
R3(config)#router ospf 1
R3(config-router)#network 3.3.3.0 0.0.0.255 area 0
R3(config-router)#network 10.0.1.0 0.0.0.255 area 0
R3(config-router)#exit

R3#sh ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       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        i - IS-IS, su - IS-IS summary, L1 - IS-IS
level-1, L2 - IS-IS level-2        ia - IS-IS inter area, * -
candidate default, U - per-user static route        o - ODR, P
- periodic downloaded static route, H - NHRP, l - LISP
a - application route
```

+ - replicated route, % - next hop override

Gateway of last resort is not set

1.0.0.0/32 is subnetted, 1 subnets

O 1.1.1.1 [110/21] via 10.0.1.2, 00:03:45, Ethernet0/0

2.0.0.0/32 is subnetted, 1 subnets

O 2.2.2.2 [110/11] via 10.0.1.2, 00:03:45, Ethernet0/0

10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks

O 10.0.0.0/24 [110/20] via 10.0.1.2, 00:03:45, Ethernet0/0

R3#sh ip cef

Prefix	Next Hop	Interface
0.0.0.0/0	no route	
0.0.0.0/8	drop	
0.0.0.0/32	receive	
1.1.1.1/32	10.0.1.2	Ethernet0/0
2.2.2.2/32	10.0.1.2	Ethernet0/0
3.3.3.3/32	receive	Loopback0
10.0.0.0/24	10.0.1.2	Ethernet0/0
10.0.1.0/24	attached	Ethernet0/0
10.0.1.0/32	receive	Ethernet0/0
10.0.1.2/32	attached	Ethernet0/0
10.0.1.3/32	receive	Ethernet0/0
10.0.1.255/32	receive	Ethernet0/0

127.0.0.0/8 drop

224.0.0.0/4 drop

224.0.0.0/24 receive

240.0.0.0/4 drop

255.255.255.255/32 receive

R3#sh ip route 1.1.1.1

Routing entry for 1.1.1.1/32

Known via "ospf 1", distance 110, metric 21, type intra area

Last update from 10.0.1.2 on Ethernet0/0, 00:23:51 ago Routing Descriptor Blocks:

* 10.0.1.2, from 1.1.1.1, 00:23:51 ago, via Ethernet0/0

Route metric is 21, traffic share count is 1

R3#sh ip route 2.2.2.2

Routing entry for 2.2.2.2/32

Known via "ospf 1", distance 110, metric 11, type intra area

Last update from 10.0.1.2 on Ethernet0/0, 00:23:58

ago Routing Descriptor Blocks:

* 10.0.1.2, from 2.2.2.2, 00:23:58 ago, via Ethernet0/0

Route metric is 11, traffic share count is 1

R3#sh ip cef

1.1.1.1 1.1.1.1/32

nexthop 10.0.1.2 Ethernet0/0

```
R3#sh ip cef
2.2.2.2 2.2.2.2/32
  nexthop 10.0.1.2 Ethernet0/0

R3(config)#mpls label range 300 399
R3(config)#mpls label protocol ldp
R3(config)#mpls ldp router-id loopback 0
R3(config)#int e0/0
R3(config-if)#mpls ip

R3#sh mpls interfaces
Interface              IP           Tunnel   BGP Static Operational
Ethernet0/0            Yes (ldp)    No       No  No     Yes

R3#sh mpls ldp binding      lib
entry: 1.1.1.1/32, rev 2        local
binding:  label: 300        remote
binding: lsr: 2.2.2.2:0, label: 200
lib entry: 2.2.2.2/32, rev 4
local binding:  label: 301
       remote binding: lsr: 2.2.2.2:0,
label: imp-null   lib entry: 3.3.3.3/32,
rev 6        local binding:  label: imp-
```

null remote binding: lsr:

2.2.2.2:0, label: 201 lib entry:

10.0.0.0/24, rev 8 local binding:

label: 302

remote binding: lsr: 2.2.2.2:0, label:

imp-null lib entry: 10.0.1.0/24, rev 10

local binding: label: imp-null

remote binding: lsr: 2.2.2.2:0, label: imp-null

R3#sh mpls ldp neighbor

Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 3.3.3.3:0

TCP connection: 2.2.2.2.646 - 3.3.3.3.44196

State: Oper; Msgs sent/rcvd: 51/51; Downstream

Up time: 00:38:15

LDP discovery sources:

Ethernet0/0, Src IP addr: 10.0.1.2

Addresses bound to peer LDP Ident:

10.0.0.2 10.0.1.2 2.2.2.2

R3#sh mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Label Switched	Outgoing interface	Next Hop
300	200	1.1.1.1/32	0	Et0/0	10.0.1.2
301	Pop Label	2.2.2.2/32	0	Et0/0	10.0.1.2
302	Pop Label	10.0.0.0/24	0	Et0/0	10.0.1.2

R3#sh ip cef

1.1.1.1 1.1.1.1/32

nexthop 10.0.1.2 Ethernet0/0 label 200

R3#sh ip cef

2.2.2.2 2.2.2.2/32

nexthop 10.0.1.2

Ethernet0/0 R3#ping

1.1.1.1 source 10.0.1.3

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:

Packet sent with a source address of 10.0.1.3

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/3 ms

R3#traceroute 1.1.1.1 source

10.0.1.3 Type escape sequence

to abort.

Tracing the route to 1.1.1.1

VRF info: (vrf in name/id, vrf out name/id)

1 10.0.1.2 [MPLS: Label 200 Exp 0] 1 msec 2 msec 1 msec

2 10.0.0.1 2 msec 2 msec *

R3#ping 2.2.2.2 source

10.0.1.3 Type escape

sequence to abort.

Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:

Packet sent with a source address of 10.0.1.3

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1

ms R3#traceroute 2.2.2.2 source 10.0.1.3 Type escape sequence to

abort.

Tracing the route to 2.2.2.2

VRF info: (vrf in name/id, vrf out name/id)

1 10.0.1.2 2 msec 2 msec *