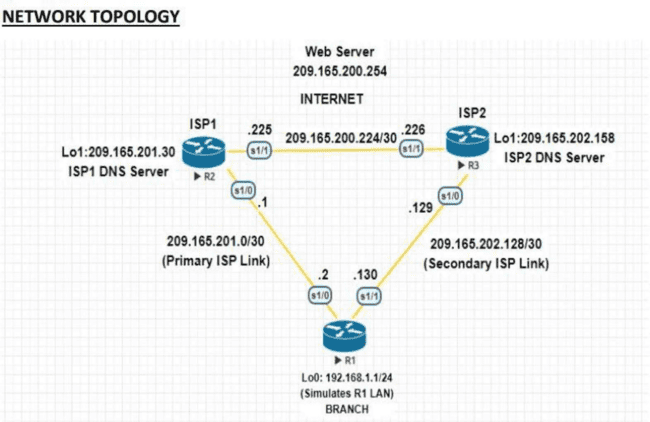
M.Sc. IT Sem II MODERN NETWORKING.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No** | **PRACTICAL** | **DATE** | **SIGN** |
| 1 | Configure IP SLA Tracking and Path Control Topology. |  |  |
| 2 | Using the AS\_PATH Attribute. |  |  |
| 3 | Configuring IBGP and EBGP Sessions, Local  Preference, and MED. |  |  |
| 4 | Secure the Management Plane. |  |  |
| 5 | Configure and Verify Path Control Using PBR. |  |  |
| 6 | IP Service Level Agreements and Remote SPAN in a  Campus Environment. |  |  |
| 7 | Inter-VLAN Routing. |  |  |
| 8 | Simulating an MPLS environment and Simulating VRF. |  |  |
| 9 | Simulating SDN with Open Daylight SDN Controller with the  Mininet Network Emulator.  OF Net SDN network emulator. |  |  |
| 10 | Simulating OpenFlow Using MININET. |  |  |

# Practical 1

**Aim:** - Configure IP SLA Tracking and Path Control Topology.



## R1

Router>enable Router# conf t R

outer(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 R

->1#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 Tim e: 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 (A

RR 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 20

9.165.202.129 255.255.255.252

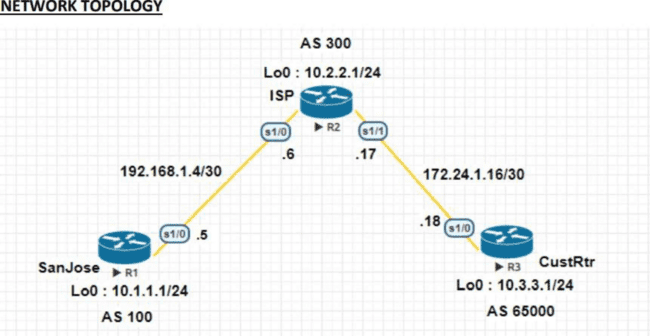
ISP2(config-if)#no shutdown



# Practical 2

**Aim:** - Using the AS\_PATH Attribute.

**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 Weight Path | Next Hop | Metric | LocPrf |
| \*> 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 I SP(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 Pat

Next Hop Metric LocPrf Weight

h \*> 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 30



0 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

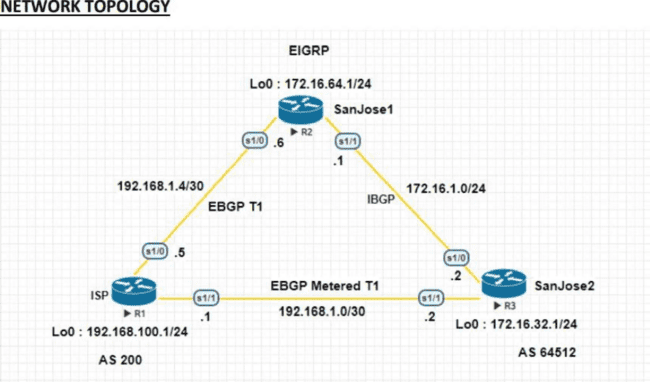
C 10.3.3.0/24 is directly connected, Loopback0

L 10.3.3.1/32 is directly connected, Loopback0 172.24.0.0/16 is variably subnetted, 2 subnets, 2 mask

s C 172.24.1.16/30 is directly connected, Serial1/0 L 172.24.1.18/32 is directly connected, Serial1/0



# Practical 3

**Aim:** - Configuring IBGP and EBGP Sessions, Local Preference, and MED**. 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 S anJose1(config-router)#exit

SanJose1(config)#router bgp 64512 SanJose1(config-router)#neig

hbor 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

LocPrf

|  |  |  |  |
| --- | --- | --- | --- |
| Network | Next Hop |  | Metric |
| 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  \*> 192.168.1.5 0 0 200 i r i 192.168 1.4/30 172.16.32.1 0 100 | | | | 0 | 0 200 i  200 i |
| r> 192.168.1.5 0 0 200 i | | | |  |  |
| \* i 192.168.100.0 172.16.32.1  i |  | 0 | 100 | 0 200 | |
| \*> 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  200 i | 0 |  | 160 |  | 0 |

\*> 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

LocPrf

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Network | Next Hop |  | Metric | |
| Weight Path \* i 172.16.0.0 |  | 172.16.32.1 | 0 | |
| 100 0 i |  |  |  | |
| \*> 0.0.0.0  32768 i | 0 |  |  | |
| \*> 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 mask

s 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)#exi

t 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)#exi

t 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  200 i | 125 | | 0 | | |
| \*>i 192.168.100.0 172.16.64.1 | 0 160 | |  | | |
| 0 200 i |  | |  | | |

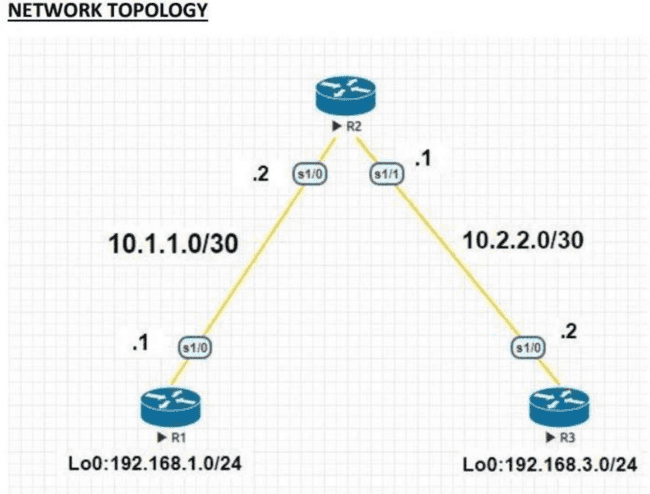


### Code:

-

# Practical 4

**Aim:** Secure the Management Plane.



###### 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 Configure static routes 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 mask

s 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 loca

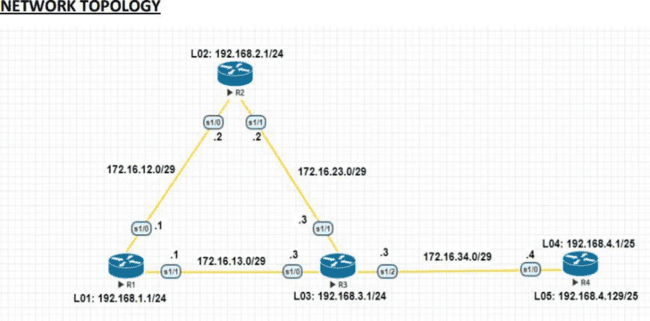
l R3(config)# aaa authentication login TELNET-LOGIN group RADIUS-GROUP localcase R3(config)# line vty 0 4

R3(config-line)# login authentication TELNET-LOGIN R3(config-line)# exit



# Practical 5

**Aim:** Configure and Verify Path Control Using PBR.



###### 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 Seq (sec) (ms) Cnt Num 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 Seq (sec) (ms) Cnt Num 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.

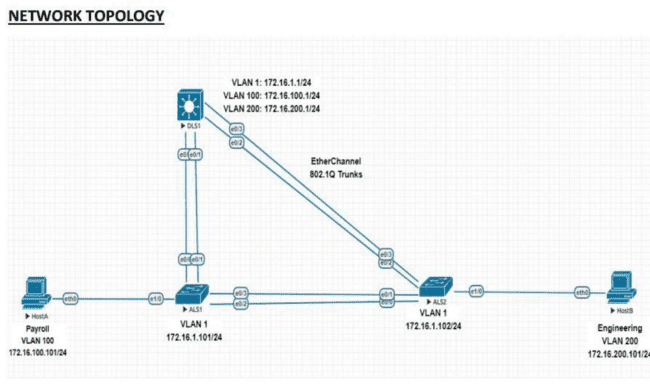
Tracing the route to 192.168.1.1



# Practical 6

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

### 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)#exi

t 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 E nhanced 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)#exi

t 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

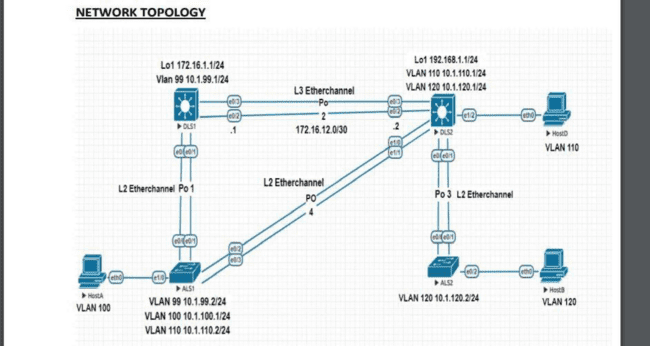
ALS2(config-if)#exit Configure Cisco IOS IP SLA responders. ALS2(config)#ip sla responder

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



# Practical 7

**Aim:** Inter-VLAN Routing.



**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)#exi

t 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 S

witch(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

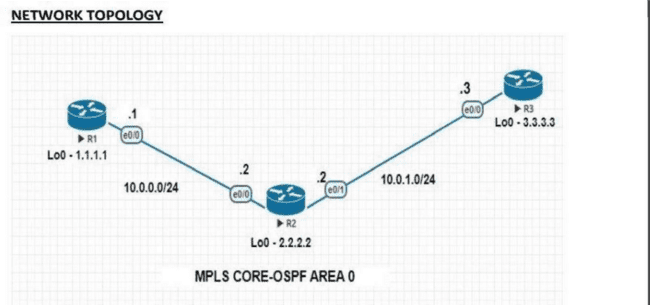


### Code:

-

# Practical 8

**Aim:** Simulating an MPLS environment and Simulating VRF.



**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 R

1#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 Outgoing Prefix Bytes Label Outgoing Next Hop Label Label or Tunnel Id Switched interface 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 r eceive 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 R

outing 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 R

3 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 shu

t 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 osp

f 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 lab el 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 Outgoing Prefix Bytes

Label Outgoing Next Hop Label Label or Tunnel Id Switched interface 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



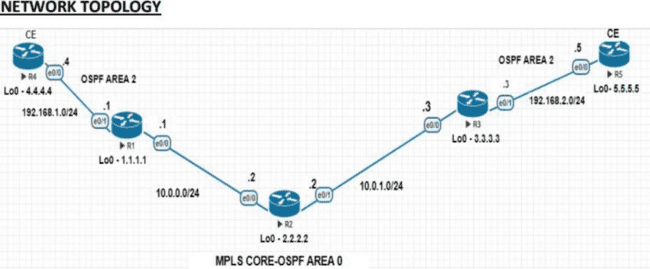
# Practical 9

**Aim:** - Simulating SDN with

 Open Daylight SDN Controller with the Mininet Network Emulator  OF Net SDN network emulator

### 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)#int e0/1

R1(config-if)#ip address 192.168.1.1 255.255.255.0 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(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(config)#ip vrf A-1 R1(config-vrf)#rd 500:1

R1(config-vrf)#route-target import 500:1

R1(config-vrf)#route-target export 500:1 R1(config-vrf)#exit

R1(config)#exit

R1#sh ip vrf Name Default RD Interfaces A-1 500:1 R1#sh ip vrf detail VRF A-1 (VRF Id = 1);



default RD 500:1;

default VPNID Old CLI format, supports IPv4 only Flags: 0xC No interfaces Address family ipv4 unicast (Table ID = 0x1): Flags: 0x0 Export VPN route-target communities RT:500:1 Import VPN route-target communities RT:500:1 No import route-map No global export route- map No export route-map VRF label distribution protocol: not configured VRF label allocation mode: per-prefix

R1(config)#int e0/1

R1(config-if)#ip vrf forwarding A-1 % Interface Ethernet0/1 IPv4 disabled and address(es) removed due to enabling VRF A-1 R1(config-if)#ip address 192.168.1.1 255.255.255.0 R1(config-if)#end

R1#sh ip route vrf A-1

Routing Table: A-1 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

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks C 192.168.1.0/24 is directly connected, Ethernet0/1

L 192.168.1.1/32 is directly connected, Ethernet0/1 R1#sh ip vrf Name Default RD Interfaces A-1 500:1 Et0/1 R1(config)#router ospf 10 vrf A-1

R1(config-router)#network 192.168.1.0 0.0.0.255 area 10 R1(config-router)#end

R1#sh ip ospf neighbor Neighbor ID Pri State Dead Time Address In

terface 2.2.2.2 1 FULL/DR 00:00:39 10.0.0.2 Ethernet0/0 4.4.4.4 1 FULL/DR 00:00:38

192.168.1.4 Ethernet0/1 R1#sh ip ospf 10 neighbor Neighbor ID Pri State Dead Time Address Interface 4.4.4.4 1 FULL/DR 00:00:38 192.168.1.4 Ethernet0/1

R1#sh ip route vrf A-1 ospf

Routing Table: A-1 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 4.0.0.0/32 is subnetted, 1 subnets O

4.4.4.4 [110/11] via 192.168.1.4, 00:03:58, Ethernet0/1 R1(config)#router bgp 500 R1(config-router)#no bgp default ipv4-unicast

R1(config-router)#neighbor 3.3.3.3 remote-as 500

R1(config-router)#neighbor 3.3.3.3 update-source loopback 0 R1(config-router)#address-family vpnv4 unicast



R1(config-router-af)#neighbor 3.3.3.3 activate R1(config-router-af)#neighbor 3.3.3.3 send- community extended R1(config-router-af)#neighbor 3.3.3.3 next-hop-self R1(config-router- af)#end

R1#sh ip bgp vpnv4 all summary

BGP router identifier 1.1.1.1, local AS number 500 BGP table version is 1, main routing table version 1 Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd 3.3.3.3 4 500 6 7 1 0 0 00:03:19 0

R1(config)#router bgp 500

R1(config-router)#address-family ipv4 vrf A-1

R1(config-router-af)#redistribute ospf 10 vrf A-1 match internal external 1 external 2 R1(config-router-af)#exit R1(config-router)#exit

R1(config)#router ospf 10 vrf A-1

R1(config-router)#redistribute bgp 500 subnets

R1(config-router)#end R1#sh ip bgp vpnv4 all BGP table version is 7, local router ID is 1.1.1.1 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 Route Distinguisher: 500:1 (default for vrf A-1)

\*> 4.4.4.4/32 192.168.1.4 11 32768 ?

\*>i 5.5.5.5/32 3.3.3.3 11 100 0 ?

\*> 192.168.1. 0 0.0.0.0 0 32768 ?

\*>i 192.168.2.0 3.3.3.3

R1#sh ip route vrf A-1

0 100 0 ?

Routing Table: A-1 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

4.0.0.0/32 is subnetted, 1 subnets O 4.4.4.4 [110/11] via 192.168.1.4, 07:36:09, Ethernet0/1

5.0.0.0/32 is subnetted, 1 subnets B 5.5.5.5 [200/11] via 3.3.3.3, 00:06:15 192.168.1.0/24 is

variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, Ethernet0/1 L 192.168.1.1/32 is directly connected, Ethernet0/1 B 192.168.2.0/24 [200/0] via 3.3.3.3, 00:06:15

R1#sh ip route vrf A-1 bgp

Routing Table: A-1 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 5.0.0.0/32 is subnetted, 1 subnets B 5.5.5.5 [200/11] via 3.3.3.3, 00:07:31 B 192.168.2.0/24 [200/0] via 3.3.3.3, 00:07:31

R1#ping vrf A-1 4.4.4.4



Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/6 ms 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(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 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)#interface e0/1

R3(config-if)#ip address 192.168.2.3 255.255.255.0 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(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(config)#ip vrf A-2 R3(config-vrf)#rd 500:1

R3(config-vrf)#route-target import 500:1

R3(config-vrf)#route-target export 500:1

R3#sh ip vrf Name Default RD Interfaces A-2 500:1 R3#sh ip vrf detail

VRF A-2 (VRF Id = 1);

default RD 500:1; default VPNID Old CLI format, supports IPv4 only Flags: 0xC No interfaces Address family ipv4 unicast (Table ID = 0x1): Flags: 0x0 Export VPN route-target communities RT:500:1 Import VPN route-target communities RT:500:1 No import route-map No global export route-map No export route-map VRF label distribution protocol: not configured VRF label allocation mode: per-prefix R3(config)#int e0/1 R3(config-if)#ip vrf forwarding A-2 % Interface Ethernet0/1 IPv4 disabled and address(es) removed due to enabling VRF A-2 R3(config-if)#ip address 192.168.2.3 255.255.255.0

R3(config-if)#end

R3#sh ip route vrf A-2 Routing Table: A-2

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

192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks C 192.168.2.0/24 is directly connected, Ethernet0/1 L 192.168.2.3/32 is directly connected,

Ethernet0/1

R3#sh ip vrf Name Default RD Interfaces A-2 500:1 Et0/1 R3(config)#router ospf 10 vrf A-2

R3(config-router)#network 192.168.2.0 0.0.0.255 area 0 R3(config-router)#end R3#sh ip ospf 10 neighbor Neighbor ID Pri State Dead Time Address Interface 5.5.5.5 1 FULL/DR 00:00:33 192.168.2.5 Ethernet0/1

R3#sh ip route vrf A-2 ospf Routing Table: A-2

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

5.0.0.0/32 is subnetted, 1 subnets O 5.5.5.5 [110/11] via 192.168.2.5, 00:06:37, Ethernet0/1

R3(config)#router bgp 500

R3(config-router)#no bgp default ipv4-unicast R3(config-router)#neighbor 1.1.1.1 remote-as 500

R3(config-router)#neighbor 1.1.1.1 update-source loopback 0 R3(config-router)#address-family vpnv4 unicast

R3(config-router-af)#neighbor 1.1.1.1 activate

R3(config-router-af)#neighbor 1.1.1.1 send-community extended R3(config-router-af)#neighbor 1.1.1.1 next-hop-self

R3#sh ip bgp vpnv4 all summary

BGP router identifier 3.3.3.3, local AS number 500 BGP table version is 1, main routing table version 1 Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd 1.1.1.1 4 500 7 6 1 0 0 00:03:01

R3(config)#router bgp 500

R3(config-router)#address-family ipv4 vrf A-2

R3(config-router-af)#redistribute ospf 10 vrf A-2 match internal external 1 external 2 R3(config-router-af)#exit R

3(config-router)#exit R3(config)#router ospf 10 vrf A-2

R3(config-router)#redistribute bgp 500 subnets R3(config-router)#end

R3#sh ip bgp vpnv4 all

BGP table version is 7, local router ID is 3.3.3.3

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 Route Distinguisher: 500:1 (default for vrf A-2)

|  |  |  |
| --- | --- | --- |
| \*>i 4.4.4.4/32 1.1.1.1 | 11 | 100 0 ? |
| \*> 5.5.5.5/32 192.168.2.5 | 11 | 32768 ? |
| \*>i 192.168.1.0 1.1.1.1 | 0 | 100 0 ? |
| \*> 192.168.2.0 0.0.0.0 | 0 | 32768 ? |
| R3#sh ip route vrf A-2 Routing Table: A-2 |  |  |

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

4.0.0.0/32 is subnetted, 1 subnets B 4.4.4.4 [200/11] via 1.1.1.1, 00:55:23 5.0.0.0/32 is

subnetted, 1 subnets O 5.5.5.5 [110/11] via 192.168.2.5, 01:50:21,

Ethernet0/1 B 192.168.1.0/24 [200/0] via 1.1.1.1, 00:55:23 192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks C 192.168.2.0/24 is directly connected,

Ethernet0/1 L 192.168.2.3/32 is directly connected, Ethernet0/1 R3#ping vrf A-2 5.5.5.5 T ype escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds: !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms R4 Router>enable

Router#conf t Router(config)#hostname R4 R4(config)#int loopback 0

R4(config-if)#ip address 4.4.4.4 255.255.255.255 R4(config-if)#exit

R4(config)#int e0/0

R4(config-if)#ip address 192.168.1.4 255.255.255.0 R4(config-if)#no shutdown

R4(config-if)#exit R4(config)#router ospf 1

R4(config-router)#network 4.4.4.0 0.0.0.255 area 10

R4(config-router)#network 192.168.1.0 0.0.0.255 area 10 R4(config-router)#exit

R4#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

5.0.0.0/32 is subnetted, 1 subnets O IA 5.5.5.5 [110/21] via 192.168.1.1, 00:23:41, Ethernet0/0 O IA 192.168.2.0/24 [110/11] via 192.168.1.1, 00:23:41,

Ethernet0/0 R4#ping 5.5.5.5 source lo 0 Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds: Packet sent with a source address of 4.4.4.4 !!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms R5 Router>enable

Router#conf t Router(config)#hostname R5 R5(config)#int loopback 0



R5(config-if)#ip address 5.5.5.5 255.255.255.255 R5(config-if)#exit

R5(config)#int e0/0

R5(config-if)#ip address 192.168.2.5 255.255.255. R5(config-if)#no shutdown

R5(config-if)#exit R5(config)#router ospf 1

R5(config-router)#network 5.5.5.0 0.0.0.255 area 0

R5(config-router)#network 192.168.2.0 0.0.0.255 area 0 R5(config-router)#exit

R5#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 4.0.0.0/32 is subnetted, 1 subnets O IA 4.4.4.4 [110/21] via 192.168.2.3, 00:23:51, Ethernet0/0 O IA 192.168.1.0/24 [110/11] via 192.168.2.3, 00:23:51,

Ethernet0/0

R5#ping 4.4.4.4 source lo 0

Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds: Packet sent with a source address of 5.5.5.5 !!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/3 ms



### Code:

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# Practical 10

**Aim:** Simulating OpenFlow Using MININET.

To simulate an OpenFlow-based SDN network using Mininet.

### Step-by-Step Procedure:

**Step 1: Update and Install Mininet Open Terminal and run:**

sudo apt update

sudo apt install mininet -y

### Alternatively, install from source:

git clone https://github.com/mininet/mininet.git cd mininet

sudo ./util/install.sh -a

### Step 2: Run a Basic OpenFlow Topology

**Start a simple topology with 1 switch and 2 hosts:**

sudo mn --topo=single,2 --controller=remote,ip=127.0.0.1 --switch ovsk  This creates:

 1 Open vSwitch (ovsk)

 2 Hosts

 Connected to a remote controller (yet to be started)

### Step 3: Verify Network Connectivity

Inside the Mininet CLI  see mininet> prompt): mininet> pingall

 This will check connectivity between the hosts.

To show switch info: mininet> sh ovs-vsctl show



### Step 4: Install and Run the POX Controller

**Open a new terminal (do not close the Mininet window)**

git clone https://github.com/noxrepo/pox.git cd pox

./pox.py forwarding.l2\_learning

 This will start a Layer 2 learning switch controller.

### Step 5: Run Mininet with POX Controller

In the original terminal (or a new one if needed), run this command:

sudo mn --topo=tree,depth=2 --controller=remote,ip=127.0.0.1,port=6633 --switch ovsk

 Creates a **tree topology** with depth 2.

 Connects to the POX controller on the default OpenFlow port 6633.

### Step 6: Monitor OpenFlow Communication Open a new terminal and run:

sudo tcpdump -i any port 6633

 This will show OpenFlow messages between the switch and controller.

### Step 7: View Flow Rules on Switch

In Mininet CLI, check the switch name with:

mininet> sh ovs-vsctl show

Then, dump flow table (replace br0 with switch name if different): sudo ovs-ofctl dump-flows br0

