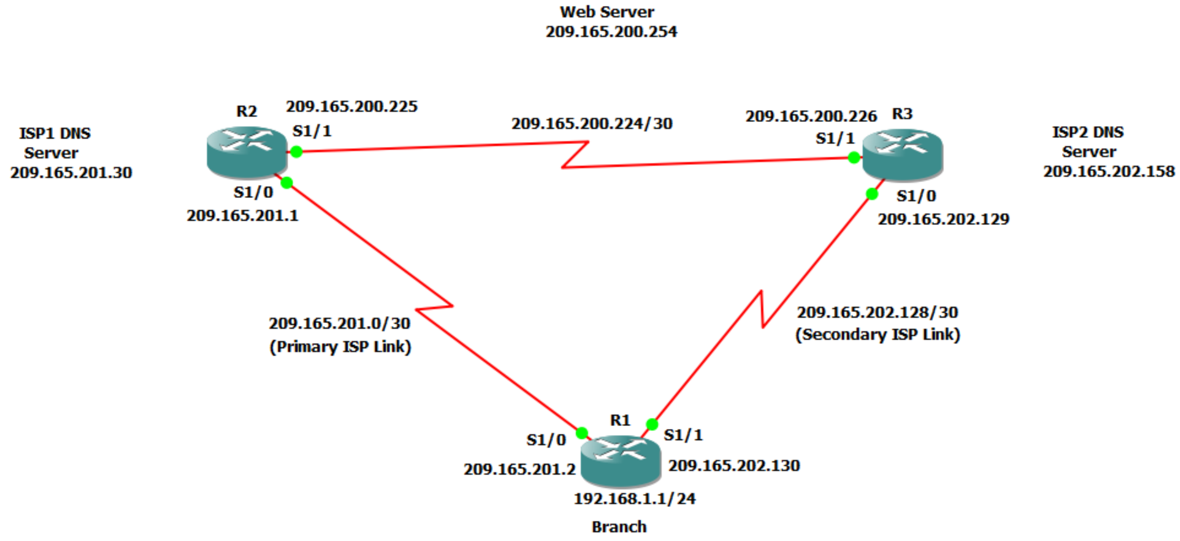
Practical 1

Aim:- Configure IP SLA Tracking and Path Control

Topology:-



Step 1:- Configure loopbacks and assign addresses.

a) Cable the network as shown in the topology diagram. Erase the startup configuration and reload each router to clear the previous configurations. Using the addressing scheme in the diagram, create the loopback interfaces and apply IP addresses to them as well as the serial interfaces on R1, ISP1, and ISP2.

Router R1 Console

interface Loopback0

description R1 LAN

ip address 192.168.1.1 255.255.255.0

exit

interface S1/0

description R1 → ISP1

ip address 209.165.201.2 255.255.255.252

clock rate 128000

bandwidth 128

no shutdown

exit

interface S1/1

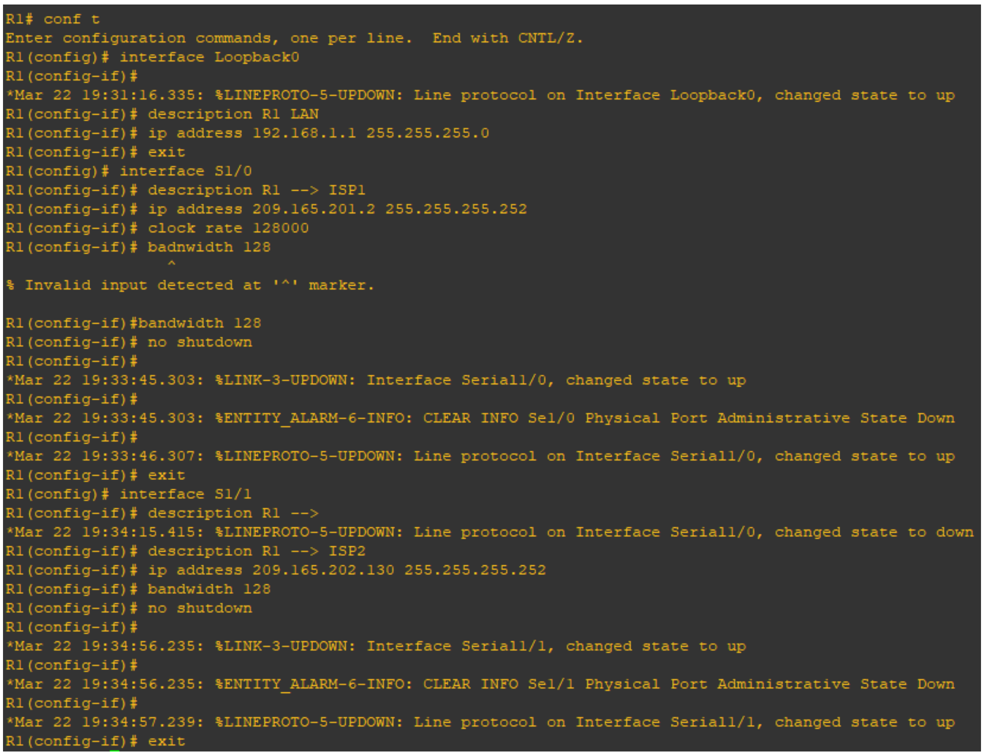
description R1 → ISP2

ip address 209.165.202.130 255.255.255.252

bandwidth 128

no shutdown

exit



```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# interface Loopback0
R1(config-if)#
*Mar 22 19:31:16.335: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R1(config-if)# description R1 LAN
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)# description R1 --> ISP1
R1(config-if)# ip address 209.165.201.2 255.255.255.252
R1(config-if)# clock rate 128000
R1(config-if)# badnwidth 128
                 ^
% Invalid input detected at '^' marker.

R1(config-if)#bandwidth 128
R1(config-if)# no shutdown
R1(config-if)#
*Mar 22 19:33:45.303: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
R1(config-if)#
*Mar 22 19:33:45.303: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
R1(config-if)#
*Mar 22 19:33:46.307: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up
R1(config-if)# exit
R1(config)# interface S1/1
R1(config-if)# description R1 -->
*Mar 22 19:34:15.415: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to down
R1(config-if)# description R1 --> ISP2
R1(config-if)# ip address 209.165.202.130 255.255.255.252
R1(config-if)# bandwidth 128
R1(config-if)# no shutdown
R1(config-if)#
*Mar 22 19:34:56.235: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
R1(config-if)#
*Mar 22 19:34:56.235: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State Down
R1(config-if)#
*Mar 22 19:34:57.239: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up
R1(config-if)# exit
```

Router R2 Console (hostname ISP1)

hostname ISP1

interface Loopback0

description Simulated Internet Web Server

ip address 209.165.200.254 255.255.255.255

exit

interface Loopback1

description ISP1 DNS Server

ip address 209.165.201.30 255.255.255.255

exit

interface S1/0

description ISP1 → R1

ip address 209.165.201.1 255.255.255.252

bandwidth 128

no shutdown

exit

interface S1/1

description ISP1 → ISP2

ip address 209.165.200.225 255.255.255.252

clock rate 128000

bandwidth 128

no shutdown

exit

```
R2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)# hostname ISP1
ISP1(config)# interface Loopback0
ISP1(config-if)#
*Mar 22 19:43:20.407: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to
 up
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)#
*Mar 22 19:44:53.471: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback1, changed state to
 up
ISP1(config-if)# description ISP1 DNS Server
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)# description ISP1 --> R1
ISP1(config-if)# ip address 209.165.201.1 255.255.255.252
ISP1(config-if)# bandwidth 128
ISP1(config-if)# no shutdown
ISP1(config-if)#
*Mar 22 19:46:49.291: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
ISP1(config-if)#
*Mar 22 19:46:49.291: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State D
own
*Mar 22 19:46:50.291: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to
 up
ISP1(config-if)# exit
ISP1(config)# interface S1/1
ISP1(config-if)# description ISP1 --> ISP2
ISP1(config-if)# ip address 209.165.200.225 255.255.255.252
ISP1(config-if)# clock rate 128000
ISP1(config-if)# bandwidth 128
ISP1(config-if)# no shutdown
ISP1(config-if)#
```

Router R3 Console (hostname ISP2)

hostname ISP2

interface Loopback0

description Simulated Internet Web Server

ip address 209.165.200.254 255.255.255.255

exit

interface Loopback1

description ISP2 DNS Server

ip address 209.165.202.158 255.255.255.255

exit

interface S1/0

description ISP2 → R1

ip address 209.165.202.129 255.255.255.252

clock rate 128000

bandwidth 128

no shutdown

exit

interface S1/1

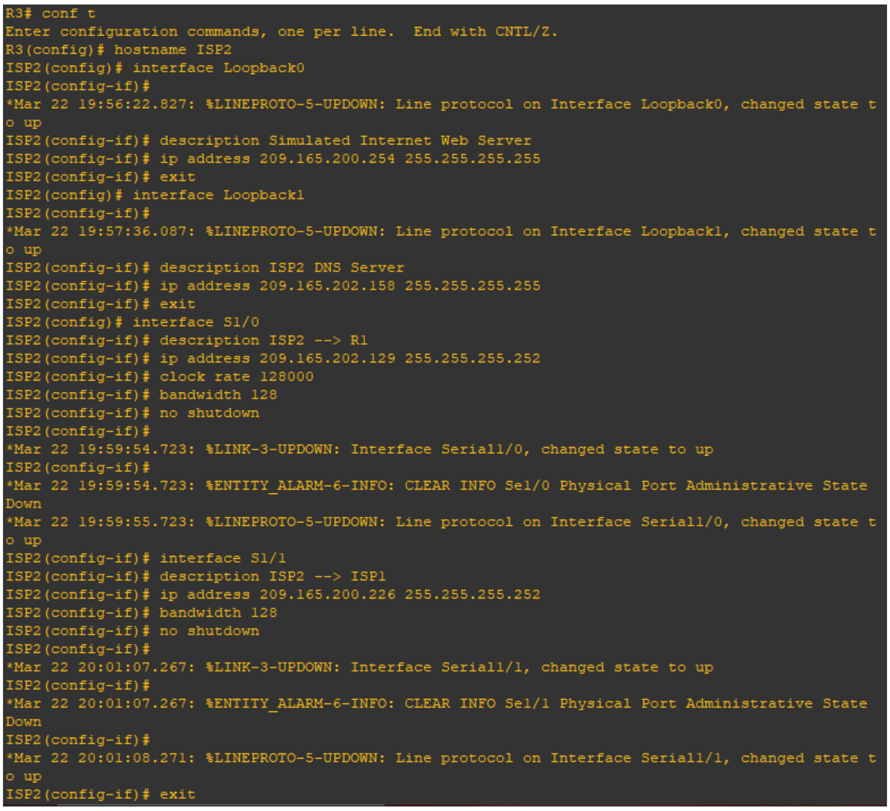
description ISP2 → ISP1

ip address 209.165.200.226 255.255.255.252

bandwidth 128

no shutdown

exit



```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# hostname ISP2
ISP2(config)# interface Loopback0
ISP2(config-if)#
*Mar 22 19:56:22.827: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state t
o up
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)#
*Mar 22 19:57:36.087: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback1, changed state t
o up
ISP2(config-if)# description ISP2 DNS Server
ISP2(config-if)# ip address 209.165.202.158 255.255.255.255
ISP2(config-if)# exit
ISP2(config)# interface S1/0
ISP2(config-if)# description ISP2 --> R1
ISP2(config-if)# ip address 209.165.202.129 255.255.255.252
ISP2(config-if)# clock rate 128000
ISP2(config-if)# bandwidth 128
ISP2(config-if)# no shutdown
ISP2(config-if)#
*Mar 22 19:59:54.723: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
ISP2(config-if)#
*Mar 22 19:59:54.723: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State
Down
*Mar 22 19:59:55.723: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state t
o up
ISP2(config-if)# interface S1/1
ISP2(config-if)# description ISP2 --> ISP1
ISP2(config-if)# ip address 209.165.200.226 255.255.255.252
ISP2(config-if)# bandwidth 128
ISP2(config-if)# no shutdown
ISP2(config-if)#
*Mar 22 20:01:07.267: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
ISP2(config-if)#
*Mar 22 20:01:07.267: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State
Down
ISP2(config-if)#
*Mar 22 20:01:08.271: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state t
o up
ISP2(config-if)# exit
```

b) Verify the configuration by using the **show interfaces description** command. The output from router R1 is shown below.

Router R1 Console

show interfaces description | include up

```
R1# show interfaces description | include up
Se1/0                          up             up        R1 --> ISP1
Se1/1                          up             up        R1 --> ISP2
Lo0                            up             up        R1 LAN
R1#
```

All three interfaces should be active. Troubleshoot if necessary.

Step 2:- Configure static routing.

The current routing policy in the topology is as follows:

1) Router R1 establishes connectivity to the Internet through ISP1 using a default static route.

2) ISP1 and ISP2 have dynamic routing enabled between them, advertising their respective public address pools.

3) ISP1 and ISP2 both have static routes back to the ISP LAN.

a) Implement the routing policies on the respective routers.

Router R1 Console

ip route 0.0.0.0 0.0.0.0 209.165.201.1

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# ip route 0.0.0.0 0.0.0.0 209.165.201.1
R1(config)#
```

Router R2 Console (hostname ISP1)

router eigrp 1

network 209.165.200.224 0.0.0.3

network 209.165.201.0 0.0.0.31

no auto-summary

exit

ip route 192.168.1.0 255.255.255.0 209.165.201.2

```
ISP1(config)# router eigrp 1
ISP1(config-router)# network 209.165.200.224 0.0.0.3
ISP1(config-router)# network 209.165.201.0 0.0.0.31
ISP1(config-router)# exit
ISP1(config)# ip route 192.168.1.0 255.255.255.0 209.165.201.2
ISP1(config)#
```

Router R3 Console (hostname ISP2)

router eigrp 1

network 209.165.200.224 0.0.0.3

network 209.165.202.128 0.0.0.31

no auto-summary

exit

ip route 192.168.1.0 255.255.255.0 209.165.202.130

```
ISP2(config)# router eigrp 1
ISP2(config-router)# network 209.165.200.224 0.0.0.3
ISP2(config-router)# n
*Mar 22 20:18:02.931: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 209.165.200.225 (Serial1/1) is
up: new adjacency
ISP2(config-router)# network 209.165.202.128 0.0.0.31
ISP2(config-router)# no auto-summary
ISP2(config-router)#
*Mar 22 20:18:31.571: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 209.165.200.225 (Serial1/1) is
resync: summary configured
ISP2(config-router)# exit
ISP2(config)# ip route 192.168.1.0 255.255.255.0 209.165.202.130
ISP2(config)#
```

b) The Cisco IOS IP SLA feature enables an administrator to monitor network performance between Cisco devices (switches or routers) or from a Cisco device to a remote IP device. IP SLA probes continuously check the reachability of a specific destination, such as a provider edge router interface, the DNS server of the ISP, or any other specific destination, and can conditionally announce a default route only if the connectivity is verified.

Before implementing the Cisco IOS SLA feature, you must verify reachability to the Internet servers. From router R1, ping the web server, ISP1 DNS server, and ISP2 DNS server to verify connectivity.

Router R1 Console

tclsh

foreach address {

209.165.200.254

209.165.201.30

209.165.202.158

} { ping $address source 192.168.1.1 }

```
R1# tclsh
R1(tcl)# foreach address {
+>(tcl)# 209.165.200.254
+>(tcl)# 209.165.201.30
+>(tcl)# 209.165.202.158
+>(tcl)# } { ping $address source 192.168.1.1 }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.200.254, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/52/64 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.30, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/41/60 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.202.158, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/61/84 ms
R1(tcl)#
```

c) Trace the path taken to the web server, ISP1 DNS server, and ISP2 DNS server.

Router R1 Console

tclsh

foreach address {

209.165.200.254

209.165.201.30

209.165.202.158

} { trace $address source 192.168.1.1 }

```
R1(tcl)# foreach address {
+>(tcl)# 209.165.200.254
+>(tcl)# 209.165.201.30
+>(tcl)# 209.165.202.158
+>(tcl)# } { trace $address source 192.168.1.1 }

Type escape sequence to abort.
Tracing the route to 209.165.200.254

  1 209.165.201.1 44 msec 56 msec 36 msec
Type escape sequence to abort.
Tracing the route to 209.165.201.30

  1 209.165.201.1 68 msec 56 msec 60 msec
Type escape sequence to abort.
Tracing the route to 209.165.202.158

  1 209.165.201.1 52 msec 52 msec 44 msec
  2 209.165.200.226 64 msec 60 msec 64 msec
R1(tcl)#
```

Step 3:- Configure IP SLA probes.

When the reachability tests are successful, you can configure the Cisco IOS IP SLAs probes. Different types of probes can be created, including FTP, HTTP, and jitter probes.

In this scenario, you will configure ICMP echo probes.

a) Create an ICMP echo probe on R1 to the primary DNS server on ISP1 using the ip sla command.

Router R1 Console

ip sla 11

icmp-echo 209.165.201.30

frequency 10

exit

ip sla schedule 11 life forever start-time now

```
R1(config)# ip sla 11
R1(config-ip-sla)# icmp-echo 209.165.201.30
R1(config-ip-sla-echo)# frequency 10
R1(config-ip-sla-echo)# exit
R1(config)# ip sla schedule 11 life forever start-time now
R1(config)#
```

The operation number of 11 is only locally significant to the router. The **frequency 10** command schedules the connectivity test to repeat every 10 seconds. The probe is scheduled to start now and to run forever.

b) Verify the IP SLAs configuration of operation 11 using the **show ip sla configuration 11** command.

Router R1 Console

show ip sla configuration 11

```
R1(config)# ip sla 11
R1(config-ip-sla)# icmp-echo 209.165.201.30
R1(config-ip-sla-echo)# frequency 10
R1(config-ip-sla-echo)# exit
R1(config)# ip sla schedule 11 life forever start-time now
R1(config)# exit
R1#
*Mar 22 20:41:39.291: %SYS-5-CONFIG_I: Configured from console by console
R1#
R1# show ip sla configuration 11
IP SLAs, Infrastructure Engine-II.
Entry number: 11
Owner:
Tag:
Type of operation to perform: icmp-echo
Target address/Source address: 209.165.201.30/0.0.0.0
Operation timeout (milliseconds): 5000
Type Of Service parameters: 0x0
Vrf Name:
Request size (ARR data portion): 28
Verify data: No
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
History Statistics:
   Number of history Lives kept: 0
   Number of history Buckets kept: 15
   History Filter Type: None
Enhanced History:
```

The output lists the details of the configuration of operation 11. The operation is an ICMP echo to 209.165.201.30, with a frequency of 10 seconds, and it has already started (the start time has already passed).

c) Issue the **show ip sla statistics** command to display the number of successes, failures, and results of the latest operations.

Router R1 Console

show ip sla statistics

```
R1# show ip sla statistics

Round Trip Time (RTT) for       Index 11
        Latest RTT: 52 milliseconds
Latest operation start time: *20:46:32.827 UTC Fri Mar 22 2024
Latest operation return code: OK
Number of successes: 53
Number of failures: 0
Operation time to live: Forever
```

You can see that operation 11 has already succeeded five times, has had no failures, and the last operation returned an OK result.

d) Although not actually required because IP SLA session 11 alone could provide the desired fault tolerance, create a second probe, 22, to test connectivity to the second DNS server located on router ISP2.

Router R1 Console

ip sla 22

icmp-echo 209.165.202.158

frequency 10

exit

ip sla schedule 22 life forever start-time now

exit

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# ip sla 22
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 22 life forever start-time now
R1(config)# exit
R1#
```

e) Verify the new probe using the **show ip sla configuration** and **show ip sla statistics** commands.

Router R1 Console

show ip sla configuration 22

```
R1# show ip sla configuration 22
IP SLAs, Infrastructure Engine-II.
Entry number: 22
Owner:
Tag:
Type of operation to perform: icmp-echo
Target address/Source address: 209.165.202.158/0.0.0.0
Operation timeout (milliseconds): 5000
Type Of Service parameters: 0x0
Vrf Name:
Request size (ARR data portion): 28
Verify data: No
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
History Statistics:
   Number of history Lives kept: 0
   Number of history Buckets kept: 15
   History Filter Type: None
Enhanced History:
```

show ip sla statistics 22

```
R1# show ip sla statistics 22

Round Trip Time (RTT) for       Index 22
        Latest RTT: 68 milliseconds
Latest operation start time: *20:54:24.603 UTC Fri Mar 22 2024
Latest operation return code: OK
Number of successes: 21
Number of failures: 0
Operation time to live: Forever
```

The output lists the details of the configuration of operation 22. The operation is an ICMP echo to 209.165.202.158, with a frequency of 10 seconds, and it has already started (the start time has already passed). The statistics also prove that operation 22 is active.

Step 4:- Configure tracking options.

Although PBR could be used, you will configure a floating static route that appears or disappears depending on the success or failure of the IP SLA.

a) On R1, remove the current default route and replace it with a floating static route having an administrative distance of 5.

Router R1 Console

no ip route 0.0.0.0 0.0.0.0 209.165.201.1

ip route 0.0.0.0 0.0.0.0 209.165.201.1 5

exit

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
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(config)# exit
R1#
*Mar 22 21:04:10.287: %SYS-5-CONFIG_I: Configured from console by console
R1#
```

b) Verify the routing table.

Router R1 Console

show ip route | begin Gateway

```
R1# show ip route | begin Gateway
Gateway of last resort is 209.165.201.1 to network 0.0.0.0

     209.165.201.0/30 is subnetted, 1 subnets
C       209.165.201.0 is directly connected, Serial1/0
     209.165.202.0/30 is subnetted, 1 subnets
C       209.165.202.128 is directly connected, Serial1/1
C    192.168.1.0/24 is directly connected, Loopback0
S*   0.0.0.0/0 [5/0] via 209.165.201.1
R1#
```

Notice that the default static route is now using the route with the administrative distance of 5. The first tracking object is tied to IP SLA object 11.

c) From global configuration mode on R1, use the **track 1 ip sla 11 reachability** command to enter the config-track subconfiguration mode.

Router R1 Console

track 1 rtr 11 reachability

delay down 10 up 1

exit

exit

debug ip routing

conf t

ip route 0.0.0.0 0.0.0.0 209.165.201.1 2 track 1

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#track 1 rtr 11 reachability
R1(config-track)#delay down 10 up 1
R1(config-track)#exit
R1(config)#exit
R1#debug ip routing
IP routing debugging is on
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1 2 track 1
*Apr 25 19:29:32.735: %SYS-5-CONFIG_I: Configured from console by console
R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.201.1 2 track 1
R1(config)#
*Apr 25 19:29:44.627: RT: closer admin distance for 0.0.0.0, flushing 1 routes
*Apr 25 19:29:44.631: RT: NET-RED 0.0.0.0/0
*Apr 25 19:29:44.635: RT: SET_LAST_RDB for 0.0.0.0/0
  NEW rdb: via 209.165.201.1

*Apr 25 19:29:44.639: RT: add 0.0.0.0/0 via 209.165.201.1, static metric [2/0]
*Apr 25 19:29:44.643: RT: NET-RED 0.0.0.0/0
*Apr 25 19:29:44.651: RT: default path is now 0.0.0.0 via 209.165.201.1
*Apr 25 19:29:44.655: RT: new default network 0.0.0.0
*Apr 25 19:29:44.655: RT: NET-RED 0.0.0.0/0
```

track 2 rtr 22 reachability

delay down 10 up 1

exit

exit

debug ip routing

conf t

ip route 0.0.0.0 0.0.0.0 209.165.202.129 3 track 2

exit

show ip route

```
R1(config)# track 2 rtr 22 reachability
R1(config-track)#delay down 10 up 1
R1(config-track)#exit
R1(config)#exit
R1#debug ip routing
IP routing debugging is on
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#ip route 0.0.0.0 0.0.0.0 209.165.202.129 3 track 2
R1(config)#exit
R1#show ip route
Codes: 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

Gateway of last resort is 209.165.201.1 to network 0.0.0.0

     209.165.201.0/30 is subnetted, 1 subnets
C       209.165.201.0 is directly connected, Serial1/0
     209.165.202.0/30 is subnetted, 1 subnets
C       209.165.202.128 is directly connected, Serial1/1
C    192.168.1.0/24 is directly connected, Loopback0
S*   0.0.0.0/0 [2/0] via 209.165.201.1
```

Router R2 Console (hostname ISP1)

conf t

interface loopback 1

shutdown

Router R1 Console

show ip route

```
R1# show ip route
Codes: 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

Gateway of last resort is 209.165.202.129 to network 0.0.0.0

     209.165.201.0/30 is subnetted, 1 subnets
C       209.165.201.0 is directly connected, Serial1/0
     209.165.202.0/30 is subnetted, 1 subnets
C       209.165.202.128 is directly connected, Serial1/1
C    192.168.1.0/24 is directly connected, Loopback0
S*   0.0.0.0/0 [3/0] via 209.165.202.129
```

show ip sla statistics

```
R1# show ip sla statistics

Round Trip Time (RTT) for       Index 11
        Latest RTT: NoConnection/Busy/Timeout
Latest operation start time: *19:39:45.831 UTC Thu Apr 25 2024
Latest operation return code: Timeout
Number of successes: 78
Number of failures: 4
Operation time to live: Forever



Round Trip Time (RTT) for       Index 22
        Latest RTT: 64 milliseconds
Latest operation start time: *19:39:44.507 UTC Thu Apr 25 2024
Latest operation return code: OK
Number of successes: 72
Number of failures: 0
Operation time to live: Forever
```

trace 209.165.200.254 source 192.168.1.1

```
R1# trace 209.165.200.254 source 192.168.1.1

Type escape sequence to abort.
Tracing the route to 209.165.200.254

  1 209.165.202.129 52 msec 56 msec 64 msec
```

Router R2 Console (hostname ISP1)

no shutdown

Router R1 Console

show ip route

```
R1# show ip route
Codes: 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

Gateway of last resort is 209.165.201.1 to network 0.0.0.0

     209.165.201.0/30 is subnetted, 1 subnets
C       209.165.201.0 is directly connected, Serial1/0
     209.165.202.0/30 is subnetted, 1 subnets
C       209.165.202.128 is directly connected, Serial1/1
C    192.168.1.0/24 is directly connected, Loopback0
S*   0.0.0.0/0 [2/0] via 209.165.201.1
```

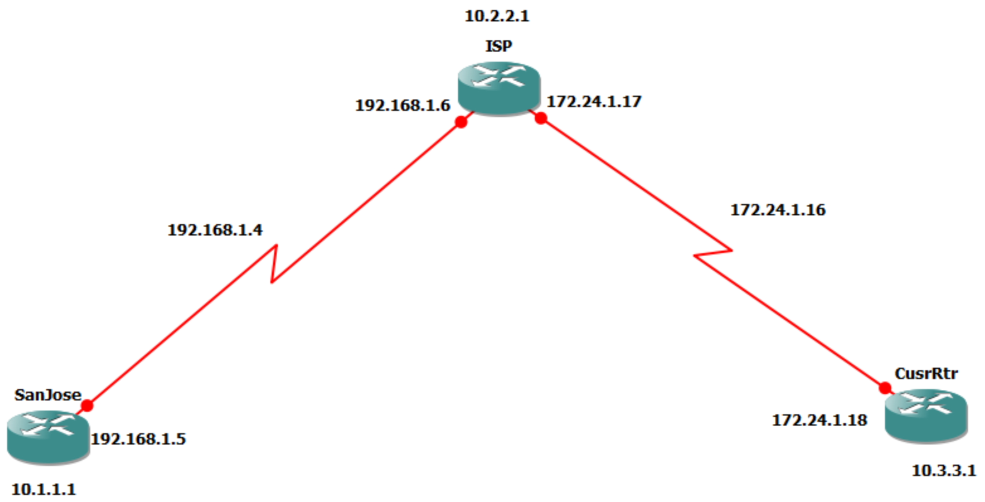
show ip sla statistics

```
R1# show ip sla statistics

Round Trip Time (RTT) for       Index 11
        Latest RTT: 40 milliseconds
Latest operation start time: *19:40:45.831 UTC Thu Apr 25 2024
Latest operation return code: OK
Number of successes: 80
Number of failures: 8
Operation time to live: Forever



Round Trip Time (RTT) for       Index 22
        Latest RTT: 84 milliseconds
Latest operation start time: *19:40:44.507 UTC Thu Apr 25 2024
Latest operation return code: OK
Number of successes: 78
Number of failures: 0
Operation time to live: Forever
```

Practical 2

Aim:- Using the AS_PATH Attribute

Topology:-



Step 1:- Prepare the routers for the lab.

Cable the network as shown in the topology diagram. Erase the startup configuration and reload each router to clear previous configurations.

Step 2:- Configure the hostname and interface addresses.

a) Enter the following configurations into your routers to begin.

Router R1 (hostname SanJose)

hostname SanJose

interface Loopback0

ip address 10.1.1.1 255.255.255.0

exit

interface S1/0

ip address 192.168.1.5 255.255.255.252

clock rate 128000

no shutdown

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# hostname SanJose
SanJose(config)# interface Loopback0
SanJose(config-if)# i
*Mar 21 11:22:55.039: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
SanJose(config-if)# ip address 10.1.1.1 255.255.255.0
SanJose(config-if)# exit
SanJose(config)# interface S1/0
SanJose(config-if)# ip address 192.168.1.5 255.255.255.252
SanJose(config-if)# clock rate 128000
SanJose(config-if)# no shutdown
```

Router R2 (hostname ISP)

hostname ISP

interface Loopback0

ip address 10.2.2.1 255.255.255.0

exit

interface S1/0

ip address 192.168.1.6 255.255.255.252

no shutdown

exit

interface S1/1

ip address 172.24.1.17 255.255.255.252

clock rate 128000

no shutdown

```
R2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)# hostname ISP
ISP(config)# interface Loopback0
ISP(config-if)# ip addr
*Mar 21 11:30:13.375: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
ISP(config-if)# ip address 10.2.2.1 255.255.255.0
ISP(config-if)# exit
ISP(config)# interface S1/0
ISP(config-if)# ip address 192.168.1.6 255.255.255.252
ISP(config-if)# no shutdown
ISP(config-if)# exit
ISP(config)#
*Mar 21 11:31:09.231: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
ISP(config)#
*Mar 21 11:31:09.231: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
ISP(config)#
*Mar 21 11:31:10.235: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up
ISP(config)# interface S1/1
ISP(config-if)# ip address 172.24.1.17 255.255.255.252
ISP(config-if)# clock rate 128000
ISP(config-if)# no shutdown
```

Router R3 (hostname CustRtr)

hostname CustRtr

interface Loopback0

ip address 10.3.3.1 255.255.255.0

exit

interface S1/1

ip address 172.24.1.18 255.255.255.252

no shutdown

```
R3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# hostname CustRtr
CustRtr(config)# interface Loopback0
CustRtr(config-if)# ip
*Mar 21 11:35:41.747: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
CustRtr(config-if)# ip address 10.3.3.1 255.255.255.0
CustRtr(config-if)# exit
CustRtr(config)# interface S1/1
CustRtr(config-if)# ip address 172.24.1.18 255.255.255.252
CustRtr(config-if)# no shutdown
```

b) Use **ping** to test the connectivity between the directly connected routers.

Note:- SanJose will not be able to reach either ISP's loopback (10.2.2.1) or CustRtr's loopback (10.3.3.1), nor will it be able to reach either end of the link joining ISP or CustRtr (172.24.1.17 or 172.24.1.18).

```
SanJose# ping 192.168.1.6

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/50/80 ms
SanJose# ping 10.2.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.2.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
SanJose#
```

Step 3:- Configure BGP

a) Configure BGP for normal operation. Enter the appropriate BGP commands on each router so that they identify their BGP neighbors and advertise their loopback networks.

Router R1 (hostname SanJose)

router bgp 100

neighbor 192.168.1.6 remote-as 300

network 10.1.1.0 mask 255.255.255.0

```
SanJose# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
SanJose(config)# router bgp 100
SanJose(config-router)# neighbor 192.168.1.6 remote-as 300
SanJose(config-router)# network 10.1.1.0 mask 255.255.255.0
SanJose(config-router)#
*Mar 21 11:53:25.735: %BGP-5-ADJCHANGE: neighbor 192.168.1.6 Up
SanJose(config-router)#
```

Router R2 (hostname ISP)

router bgp 300

neighbor 192.168.1.5 remote-as 100

neighbor 172.24.1.18 remote-as 65000

network 10.2.2.0 mask 255.255.255.0

```
ISP# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
ISP(config)# router bgp 300
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)# network 10.2.2.0 mask 255.255.255.0
ISP(config-router)#
*Mar 21 11:53:25.539: %BGP-5-ADJCHANGE: neighbor 192.168.1.5 Up
```

Router R3 (hostname CustRtr)

router bgp 65000

neighbor 172.24.1.17 remote-as 300

network 10.3.3.0 mask 255.255.255.0

```
CustRtr#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
CustRtr(config)# router bgp 65000
CustRtr(config-router)# neighbor 172.24.1.17 remote-as 300
CustRtr(config-router)# network 10.3.3.0 mask 255.255.255.0
CustRtr(config-router)#
*Mar 21 11:56:11.859: %BGP-5-ADJCHANGE: neighbor 172.24.1.17 Up
CustRtr(config-router)#
```

b) Verify that these routers have established the appropriate neighbor relationships by issuing the **show ip bgp neighbors** command on each router.

Router R2 (hostname ISP)

show ip bgp neighbors

```
ISP# show ip bgp neighbors
BGP neighbor is 172.24.1.18,  remote AS 65000, external link
  BGP version 4, remote router ID 10.3.3.1
  BGP state = Established, up for 00:05:59
  Last read 00:00:59, last write 00:00:59, hold time is 180, keepalive interval is 60 seconds
```

```
BGP neighbor is 192.168.1.5,  remote AS 100, external link
  BGP version 4, remote router ID 10.1.1.1
  BGP state = Established, up for 00:09:24
  Last read 00:00:24, last write 00:00:24, hold time is 180, keepalive interval is 60 seconds
```

Step 4:- Remove the private AS.

a) Display the SanJose routing table using the **show ip route** command. SanJose should have a route to both 10.2.2.0 and 10.3.3.0. Troubleshoot if necessary.

Router R1 (hostname SanJose)

show ip route

```
SanJose# show ip route
Codes: 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

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 3 subnets
B       10.3.3.0 [20/0] via 192.168.1.6, 00:12:08
B       10.2.2.0 [20/0] via 192.168.1.6, 00:14:50
C       10.1.1.0 is directly connected, Loopback0
     192.168.1.0/30 is subnetted, 1 subnets
C       192.168.1.4 is directly connected, Serial1/0
SanJose#
```

b) Ping the 10.3.3.1 address from the SanJose.

ping 10.3.3.1

```
SanJose# ping 10.3.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.3.3.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
SanJose#
```

c) Ping again, this time as an extended ping, sourcing from the Loopback0 interface address.

ping 10.3.3.1 source 10.1.1.1

```
SanJose# ping 10.3.3.1 source 10.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.3.3.1, timeout is 2 seconds:
Packet sent with a source address of 10.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/72/96 ms
SanJose#
```

d) Check the BGP table from SanJose by using the **show ip bgp** command. Note the AS path for the 10.3.3.0 network. The AS 65000 should be listed in the path to 10.3.3.0.

show ip bgp

```
SanJose# show 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   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#
```

e) Configure ISP to strip the private AS numbers from BGP routes exchanged with SanJose using the following commands.

Router R2 (hostname ISP)

router bgp 300

neighbor 192.168.1.5 remove-private-as

```
ISP# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
ISP(config)# router bgp 300
ISP(config-router)# neighbor 192.168.1.5 remove-private-as
ISP(config-router)#
```

f) After issuing these commands, use the **clear ip bgp *** command on ISP to re-establish the BGP relationship between the three routers. Wait several seconds and then return to SanJose to check its routing table.

Note:- The **clear ip bgp * soft** command can also be used to force each router to resend its BGP table.

Router R2 (hostname ISP)

clear ip bgp *

```
ISP# clear ip bgp *
ISP#
*Mar 21 12:26:27.259: %BGP-5-ADJCHANGE: neighbor 172.24.1.18 Down User reset
*Mar 21 12:26:27.259: %BGP-5-ADJCHANGE: neighbor 192.168.1.5 Down User reset
ISP#
*Mar 21 12:26:29.091: %BGP-5-ADJCHANGE: neighbor 192.168.1.5 Up
*Mar 21 12:26:29.435: %BGP-5-ADJCHANGE: neighbor 172.24.1.18 Up
ISP#
```

Router R1 (hostname SanJose)

show ip route

```
SanJose# show ip route
Codes: 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

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 3 subnets
B       10.3.3.0 [20/0] via 192.168.1.6, 00:02:06
B       10.2.2.0 [20/0] via 192.168.1.6, 00:01:36
C       10.1.1.0 is directly connected, Loopback0
     192.168.1.0/30 is subnetted, 1 subnets
C       192.168.1.4 is directly connected, Serial1/0
SanJose#
```

SanJose should be able to ping 10.3.3.1 using its loopback0 interface as the source of the ping.

Router R1 (hostname SanJose)

ping 10.3.3.1 source 10.1.1.1

```
SanJose# ping 10.3.3.1 source 10.1.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.3.3.1, timeout is 2 seconds:
Packet sent with a source address of 10.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 64/106/160 ms
SanJose#
```

g) Now check the BGP table on SanJose. The AS_PATH to the 10.3.3.0 network should be AS 300. It no longer has the private AS in the path.

Router R1 (hostname SanJose)

show ip bgp

```
SanJose# show ip bgp
BGP table version is 9, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

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

Step 5:- Use the AS_PATH attribute to filter routes.

As a final configuration, use the AS_PATH attribute to filter routes based on their origin. In a complex environment, you can use this attribute to enforce routing policy. In this case, the provider router, ISP, must be configured so that it does not propagate routes that originate from AS 100 to the customer router CustRtr.

AS-path access lists are read like regular access lists. The statements are read sequentially, and there is an implicit deny at the end. Rather than matching an address in each statement like a conventional access list, AS path access lists match on something called a regular expression. Regular expressions are a way of matching text patterns and have many uses. In this case, you will be using them in the AS path access list to match text patterns in AS paths.

a) Configure a special kind of access list to match BGP routes with an AS_PATH attribute that both begins and ends with the number 100. Enter the following commands on ISP.

Router R2 (hostname ISP)

ip as-path access-list 1 deny ^100$

ip as-path access-list 1 permit .*

```
ISP# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
ISP(config)# ip as-path access-list 1 deny ^100$
ISP(config)# ip as-path access-list 1 permit .*
ISP(config)#
```

The first command uses the ^ character to indicate that the AS path must begin with the given number 100. The $ character indicates that the AS_PATH attribute must also end with 100. Essentially, this statement matches only paths that are sourced from AS 100. Other paths, which might include AS 100 along the way, will not match this list.

In the second statement, the . (period) is a wildcard, and the * (asterisk) stands for a repetition of the wildcard. Together, .* matches any value of the AS_PATH attribute, which in effect permits any update that has not been denied by the previous access-list statement.

b) Apply the configured access list using the neighbor command with **filter-list** option.

Router R2 (hostname ISP)

router bgp 300

neighbor 172.24.1.18 filter-list 1 out

```
ISP(config)# router bgp 300
ISP(config-router)# neighbor 172.24.1.18 filter-list 1 out
ISP(config-router)#
```

The **out** keyword specifies that the list is applied to routing information sent to this neighbor.

c) Use the **clear ip bgp *** command to reset the routing information. Wait several seconds and then check the routing table for ISP. The route to 10.1.1.0 should be in the routing table.

Note:- To force the local router to resend its BGP table, a less disruptive option is to use the **clear ip bgp * out** or **clear ip bgp * soft** command (the second command performs both outgoing and incoming route resync).

Router R2 (hostname ISP)

clear ip bgp *

```
ISP# clear ip bgp *
ISP#
*Mar 21 12:51:00.739: %BGP-5-ADJCHANGE: neighbor 172.24.1.18 Down User reset
*Mar 21 12:51:00.739: %BGP-5-ADJCHANGE: neighbor 192.168.1.5 Down User reset
*Mar 21 12:51:01.575: %BGP-5-ADJCHANGE: neighbor 192.168.1.5 Up
ISP#
*Mar 21 12:51:02.927: %BGP-5-ADJCHANGE: neighbor 172.24.1.18 Up
ISP#
```

show ip route

```
ISP# show ip route
Codes: 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

Gateway of last resort is not set

     172.24.0.0/30 is subnetted, 1 subnets
C       172.24.1.16 is directly connected, Serial1/1
     10.0.0.0/24 is subnetted, 3 subnets
B       10.3.3.0 [20/0] via 172.24.1.18, 00:02:04
C       10.2.2.0 is directly connected, Loopback0
B       10.1.1.0 [20/0] via 192.168.1.5, 00:02:04
     192.168.1.0/30 is subnetted, 1 subnets
C       192.168.1.4 is directly connected, Serial1/0
ISP#
```

d) Check the routing table for CustRtr. It should not have a route to 10.1.1.0 in its routing table.

Router R3 (hostname CustRtr)

show ip route

```
CustRtr# show ip route
Codes: 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

Gateway of last resort is not set

     172.24.0.0/30 is subnetted, 1 subnets
C       172.24.1.16 is directly connected, Serial1/1
     10.0.0.0/24 is subnetted, 2 subnets
C       10.3.3.0 is directly connected, Loopback0
B       10.2.2.0 [20/0] via 172.24.1.17, 00:03:25
CustRtr#
```

e) Return to ISP and verify that the filter is working as intended. Issue the **show ip bgp regexp ^100$** command.

Router R2 (hostname ISP)

show ip bgp regexp ^100$

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

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

The output of this command shows all matches for the regular expressions that were used in the access list. The path to 10.1.1.0 matches the access list and is filtered from updates to CustRtr.

f) Run the following Tcl script on all routers to verify whether there is connectivity. All pings from ISP should be successful. SanJose should not be able to ping the CustRtr loopback 10.3.3.1 or the WAN link 172.24.1.16/30. CustRtr should not be able to ping the SanJose loopback 10.1.1.1 or the WAN link 192.168.1.4/30.

Router R2 (hostname ISP)

ISP# tclsh

ISP(tcl)# foreach address {

+> 10.1.1.1

+> 10.2.2.1

+> 10.3.3.1

+> 192.168.1.5

+> 192.168.1.6

+> 172.24.1.17

+> 172.24.1.18 } { ping $address }

```
ISP# tclsh
ISP(tcl)# foreach address {
+> 10.1.1.1
+> 10.2.2.1
+> 10.3.3.1
+> 192.168.1.5
+> 192.168.1.6
+> 172.24.1.17
+> 172.24.1.18
+> } { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/41/68 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.3.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/49/128 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/44/80 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/72/112 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.24.1.17, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/76/132 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.24.1.18, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/46/76 ms
ISP(tcl)#
```

Router Interface Summary

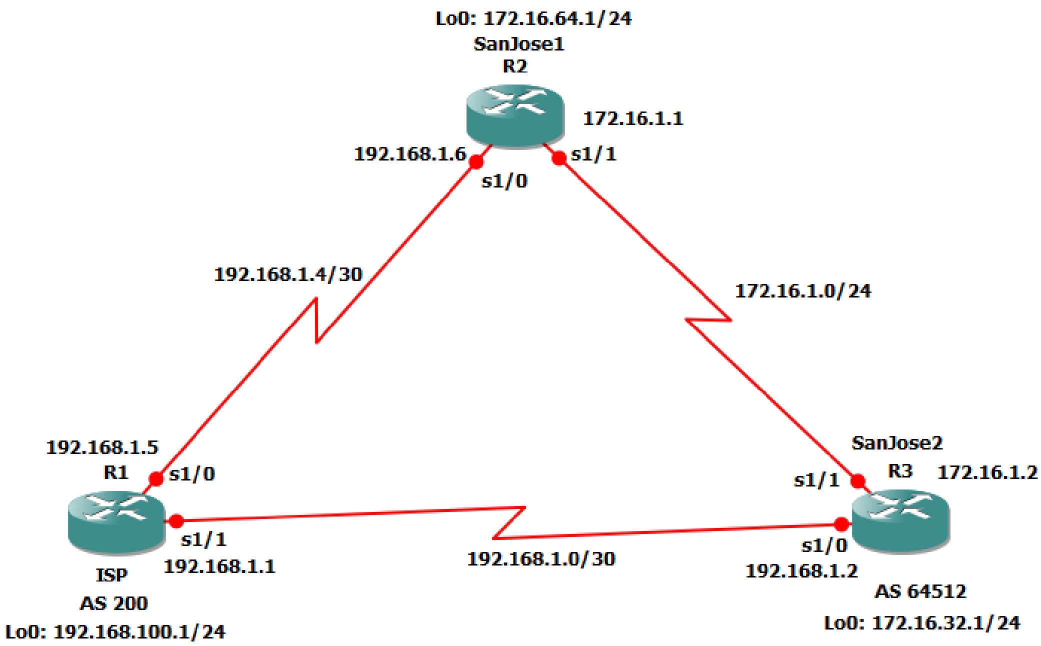
Router Model	**Ethernet Interface #1**	**Ethernet Interface #2**	**Serial Interface #1**	**Serial Interface #2**
1700	Fast Ethernet 0 (FA0)	Fast Ethernet 1 (FA1)	Serial 0 (S0)	Serial 1 (S1)
1800	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2600	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0 (S0/0)	Serial 0/1 (S0/1)
2800	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)

Note:- To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. Rather than list all combinations of configurations for each router class, this table includes identifiers for the possible combinations of Ethernet and serial interfaces in the device. The table does not include any other type of interface, even though a specific router might contain one. For example, for an ISDN BRI interface, the string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.

Practical 3

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

Topology:-



Code:-

Step 1: Configure interface addresses.

a) Using the addressing scheme in the diagram, create the loopback interfaces and apply IPv4 addresses to these and the serial interfaces on ISP (R1), SanJose1 (R2), and SanJose2 (R3). Apply the following configuration to each router along with the appropriate hostname.

Router R1 Console (hostname ISP)

hostname ISP

interface Loopback0

ip address 192.168.100.1 255.255.255.0

exit

interface s1/0

ip address 192.168.1.5 255.255.255.252

clock rate 128000

no shutdown

exit

interface s1/1

ip address 192.168.1.1 255.255.255.252

no shutdown

exit

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# hostname ISP
ISP(config)# interface Loopback0
ISP(config-if)# ip
*Apr 25 20:29:44.879: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
ISP(config-if)# ip address 192.168.100.1 255.255.255.0
ISP(config-if)# exit
ISP(config)# interface s1/0
ISP(config-if)# ip address 192.168.1.5 255.255.255.252
ISP(config-if)# clock rate 128000
ISP(config-if)# no shutdown
ISP(config-if)#
*Apr 25 20:31:41.579: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
ISP(config-if)#
*Apr 25 20:31:41.579: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
ISP(config-if)#
*Apr 25 20:31:42.583: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up
ISP(config-if)# exit
ISP(config)# interface s1/1
ISP(config-if)# ip address
*Apr 25 20:32:06.923: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to down
ISP(config-if)# ip address 192.168.1.1 255.255.255.252
ISP(config-if)# no shutdown
ISP(config-if)#
*Apr 25 20:32:38.231: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
ISP(config-if)#
*Apr 25 20:32:38.231: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State Down
*Apr 25 20:32:39.231: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up
ISP(config-if)# exit
```

Router R2 Console (hostname SanJose1)

hostname SanJose1

interface Loopback0

ip address 172.16.64.1 255.255.255.0

exit

interface s1/0

ip address 192.168.1.6 255.255.255.252

no shutdown

exit

interface s1/1

ip address 172.16.1.1 255.255.255.0

clock rate 128000

no shutdown

exit

```
R2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)# hostname SanJose1
SanJose1(config)# interface Loopback0
SanJose1(config-if)#
*Apr 25 20:35:51.943: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
SanJose1(config-if)# ip address 172.16.64.1 255.255.255.0
SanJose1(config-if)# exit
SanJose1(config)# interface s1/0
SanJose1(config-if)# ip address 192.168.1.6 255.255.255.252
SanJose1(config-if)# no shutdown
SanJose1(config-if)#
*Apr 25 20:40:54.327: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
SanJose1(config-if)#
*Apr 25 20:40:54.327: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
*Apr 25 20:40:55.327: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up
SanJose1(config-if)# exit
SanJose1(config)# interface s1/1
SanJose1(config-if)# ip address 172.16.1.1 255.255.255.0
SanJose1(config-if)# clock rate 128000
SanJose1(config-if)# no shutdown
SanJose1(config-if)#
*Apr 25 20:42:37.891: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
SanJose1(config-if)#
*Apr 25 20:42:37.891: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State Down
SanJose1(config-if)#
*Apr 25 20:42:38.895: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up
SanJose1(config-if)# exit
```

Router R3 Console (hostname SanJose2)

hostname SanJose2

interface Loopback0

ip address 172.16.32.1 255.255.255.0

exit

interface s1/0

ip address 192.168.1.2 255.255.255.252

clock rate 128000

no shutdown

exit

interface s1/1

ip address 172.16.1.2 255.255.255.0

no shutdown

exit

```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# hostname SanJose2
SanJose2(config)# interface Loopback0
SanJose2(config-if)#
*Apr 25 20:49:41.347: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
SanJose2(config-if)# ip address 172.16.32.1 255.255.255.0
SanJose2(config-if)# exit
SanJose2(config)# interface s1/0
SanJose2(config-if)# ip address 192.168.1.2 255.255.255.252
SanJose2(config-if)# clock rate 128000
SanJose2(config-if)# no shutdown
SanJose2(config-if)#
*Apr 25 20:51:53.711: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
SanJose2(config-if)#
*Apr 25 20:51:53.711: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
*Apr 25 20:51:54.711: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up
SanJose2(config-if)# exit
SanJose2(config)# interface s1/1
SanJose2(config-if)# ip address 172.16.1.2 255.255.255.0
SanJose2(config-if)# no shutdown
SanJose2(config-if)#
*Apr 25 20:53:15.071: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
SanJose2(config-if)#
*Apr 25 20:53:15.071: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State Down
SanJose2(config-if)#
*Apr 25 20:53:16.075: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up
SanJose2(config-if)# exit
```

Step 2: Configure EIGRP.

Configure EIGRP between the SanJose1 and SanJose2 routers. (Note: If using an IOS prior to 15.0, use the no auto-summary router configuration command to disable automatic summarization. This command is the default beginning with IOS 15.)

Router R2 Console (hostname SanJose1)

router eigrp 1

network 172.16.0.0

```
SanJose1(config)# router eigrp 1
SanJose1(config-router)# network 172.16.0.0
SanJose1(config-router)#
```

Router R3 Console (hostname SanJose2)

router eigrp 1

network 172.16.0.0

```
SanJose2(config)# router eigrp 1
SanJose2(config-router)# network 172.16.0.0
SanJose2(config-router)#
*Apr 25 21:00:17.371: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 172.16.1.1 (Serial1/1) is up: new adjacency
```

Step 3: Configure IBGP and verify BGP neighbors.

a) Configure IBGP between the SanJose1 and SanJose2 routers.

Router R2 Console (hostname SanJose1)

router bgp 64512

neighbor 172.16.32.1 remote-as 64512

neighbor 172.16.32.1 update-source Loopback0

```
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
```

Router R3 Console (hostname SanJose2)

router bgp 64512

neighbor 172.16.64.1 remote-as 64512

neighbor 172.16.64.1 update-source Loopback0

```
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-
*Apr 25 21:10:35.707: %BGP-5-ADJCHANGE: neighbor 172.16.64.1 Up
SanJose2(config-router)# neighbor 172.16.64.1 update-source Loopback0
```

show ip bgp neighbors

```
SanJose2# show ip bgp neighbors
BGP neighbor is 172.16.64.1,  remote AS 64512, internal link
  BGP version 4, remote router ID 172.16.64.1
  BGP state = Established, up for 00:01:34
  Last read 00:00:33, last write 00:00:33, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                0          0
    Keepalives:             4          4
    Route Refresh:          0          0
    Total:                  5          5
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1/0
 Output queue size : 0
  Index 1, Offset 0, Mask 0x2
  1 update-group member
                                 Sent       Rcvd
  Prefix activity:               ----       ----
    Prefixes Current:               0          0
    Prefixes Total:                 0          0
    Implicit Withdraw:              0          0
    Explicit Withdraw:              0          0
    Used as bestpath:             n/a          0
    Used as multipath:            n/a          0

                                   Outbound    Inbound
  Local Policy Denied Prefixes:    --------    -------
    Total:                                0          0
  Number of NLRIs in the update sent: max 0, min 0
```

Step 4: Configure EBGP and verify BGP neighbors.

a) Configure ISP to run EBGP with SanJose1 and SanJose2. Enter the following commands on ISP.

Router R1 Console (hostname ISP)

router bgp 200

neighbor 192.168.1.6 remote-as 64512

neighbor 192.168.1.2 remote-as 64512

network 192.168.100.0

```
ISP(config)# router bgp 200
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)# network 192.168.100.0
```

b) Configure a discard static route for the 172.16.0.0/16 network. Any packets that do not have a more specific match (longer match) for a 172.16.0.0 subnet will be dropped instead of sent to the ISP. Later in this lab we will configure a default route to the ISP.

Router R2 Console (hostname SanJose1)

ip route 172.16.0.0 255.255.0.0 null0

```
SanJose1(config)# ip route 172.16.0.0 255.255.0.0 null0
```

c) Configure SanJose1 as an EBGP peer to ISP.

Router R2 Console (hostname SanJose1)

router bgp 64512

neighbor 192.168.1.5 remote-as 200

network 172.16.0.0

```
SanJose1(config)# router bgp 64512
SanJose1(config-router)# neighbor 192.168.1.5 remote-as 200
SanJose1(config-router)# network 172.16.0.0
SanJose1(config-router)#
*Apr 25 21:26:13.427: %BGP-5-ADJCHANGE: neighbor 192.168.1.5 Up
```

d) Use the show ip bgp neighbors command to verify that SanJose1 and ISP have reached the established state. Troubleshoot if necessary.

Router R2 Console (hostname SanJose1)

show ip bgp neighbors

```
SanJose1# show ip bgp neighbors
BGP neighbor is 172.16.32.1,  remote AS 64512, internal link
  BGP version 4, remote router ID 172.16.32.1
  BGP state = Established, up for 00:17:25
  Last read 00:00:24, last write 00:00:25, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                2          0
    Keepalives:            20         20
    Route Refresh:          0          0
    Total:                 23         21
  Default minimum time between advertisement runs is 5 seconds
```

```
BGP neighbor is 192.168.1.5,  remote AS 200, external link
  BGP version 4, remote router ID 192.168.100.1
  BGP state = Established, up for 00:02:17
  Last read 00:00:18, last write 00:00:18, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                1          2
    Keepalives:             5          5
    Route Refresh:          0          0
    Total:                  7          8
  Default minimum time between advertisement runs is 30 seconds
```

Router R3 Console (hostname SanJose2)

ip route 172.16.0.0 255.255.0.0 null0

router bgp 64512

neighbor 192.168.1.1 remote-as 200

network 172.16.0.0

```
SanJose2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
SanJose2(config)# ip route 172.16.0.0 255.255.0.0 null0
SanJose2(config)# router bgp 64512
SanJose2(config-router)# neighbor 192.168.1.1 remote-as 200
SanJose2(config-router)# network 172.16.0.0
```

Step 5: View BGP summary output.

Router R2 Console (hostname SanJose2)

show ip bgp summary

```
SanJose2# show ip bgp summary
BGP router identifier 172.16.32.1, local AS number 64512
BGP table version is 5, main routing table version 5
2 network entries using 234 bytes of memory
4 path entries using 208 bytes of memory
5/2 BGP path/bestpath attribute entries using 620 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 1086 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      31        5    0    0 00:25:57        2
192.168.1.1     4   200       6       5        5    0    0 00:01:00        1
```

Step 6: Verify which path the traffic takes.

Router R1 Console (hostname ISP)

clear ip bgp *

```
ISP# clear ip bgp *
ISP#
*Apr 25 21:42:14.911: %BGP-5-ADJCHANGE: neighbor 192.168.1.2 Down User reset
*Apr 25 21:42:14.911: %BGP-5-ADJCHANGE: neighbor 192.168.1.6 Down User reset
*Apr 25 21:42:15.395: %BGP-5-ADJCHANGE: neighbor 192.168.1.2 Up
*Apr 25 21:42:15.523: %BGP-5-ADJCHANGE: neighbor 192.168.1.6 Up
```

ping 172.16.64.1

ping 172.16.1.1

```
ISP# ping 172.16.64.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.64.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
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 0 percent (0/5)
```

ping 172.16.32.1

ping 172.16.1.2

```
ISP# ping 172.16.32.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.32.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/48/76 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 = 28/48/88 ms
```

show ip bgp

```
ISP# show 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   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
*> 192.168.100.0    0.0.0.0                  0         32768 i
```

ping 172.16.1.1 source 192.168.100.1

ping 172.16.32.1 source 192.168.100.1

ping 172.16.1.2 source 192.168.100.1

ping 172.16.64.1 source 192.168.100.1

```
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 = 44/62/92 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 = 32/48/84 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 = 28/36/48 ms
ISP# ping 172.16.64.1 source 192.168.100.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.64.1, 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 = 48/55/64 ms
```

ping

```
ISP# ping
Protocol [ip]:
Target IP address: 172.16.64.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 192.168.100.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.64.1, 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 = 44/52/64 ms
```

Step 7: Configure the BGP next-hop-self feature.

Router R1 Console (hostname ISP)

a) Issue the following commands on the ISP router.

router bgp 200

network 192.168.1.0 mask 255.255.255.252

network 192.168.1.4 mask 255.255.255.252

end

```
ISP# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
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
```

b) Issue the show ip bgp command to verify that the ISP is correctly injecting its own WAN links into BGP.

show ip bgp

```
ISP# show 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   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
```

c) Verify on SanJose1 and SanJose2 that the opposite WAN link is included in the routing table. The output from SanJose2 is as follows.

Router R3 Console (hostname SanJose2)

show ip route

```
SanJose2# show ip route
Codes: 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

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.16.32.0/24 is directly connected, Loopback0
S       172.16.0.0/16 is directly connected, Null0
C       172.16.1.0/24 is directly connected, Serial1/1
D       172.16.64.0/24 [90/2297856] via 172.16.1.1, 01:28:17, Serial1/1
     192.168.1.0/30 is subnetted, 2 subnets
C       192.168.1.0 is directly connected, Serial1/0
B       192.168.1.4 [20/0] via 192.168.1.1, 00:25:53
B    192.168.100.0/24 [20/0] via 192.168.1.1, 00:45:49
```

d) To better understand the next-hop-self command we will remove ISP advertising its two WAN links and shutdown the WAN link between ISP and SanJose2. The only possible path from SanJose2 to ISP's 192.168.100.0/24 is through SanJose1.

Router R1 Console (hostname ISP)

router bgp 200

no network 192.168.1.0 mask 255.255.255.252

no network 192.168.1.4 mask 255.255.255.252

exit

interface s1/1

shutdown

```
ISP(config)# router bgp 200
ISP(config-router)# no network 192.168.1.0 mask 255.255.255.252
ISP(config-router)# no network 192.168.1.4 mask 255.255.255.252
ISP(config-router)# exit
ISP(config)# interface s1/1
ISP(config-if)# shutdown
ISP(config-if)#
*Apr 25 22:33:33.499: %BGP-5-ADJCHANGE: neighbor 192.168.1.2 Down Interface flap
```

e) Display SanJose2's BGP table using the show ip bgp command and the IPv4 routing table with show ip route.

Router R3 Console (hostname SanJose2)

show ip bgp

```
SanJose2# show ip bgp
BGP table version is 15, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 172.16.0.0       0.0.0.0                  0         32768 i
* i                 172.16.64.1              0    100      0 i
* i192.168.100.0    192.168.1.5              0    100      0 200 i
```

show ip route

```
SanJose2# show ip route
Codes: 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

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.16.32.0/24 is directly connected, Loopback0
S       172.16.0.0/16 is directly connected, Null0
C       172.16.1.0/24 is directly connected, Serial1/1
D       172.16.64.0/24 [90/2297856] via 172.16.1.1, 01:34:52, Serial1/1
```

f) Issue the next-hop-self command on SanJose1 and SanJose2 to advertise themselves as the next hop to their IBGP peer.

Router R2 Console (hostname SanJose1)

router bgp 64512

neighbor 172.16.32.1 next-hop-self

```
SanJose1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
SanJose1(config)# router bgp 64512
SanJose1(config-router)# neighbor 172.16.32.1 next-hop-self
```

Router R3 Console (hostname SanJose2)

router bgp 64512

neighbor 172.16.64.1 next-hop-self

```
SanJose2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
SanJose2(config)# router bgp 64512
SanJose2(config-router)# neighbor 172.16.64.1 next-hop-self
```

g) Reset BGP operation on either router with the clear ip bgp * command.

Router R2 Console (hostname SanJose1)

clear ip bgp *

```
SanJose1# clear ip bgp *
SanJose1#
*Apr 25 22:41:52.675: %BGP-5-ADJCHANGE: neighbor 172.16.32.1 Down User reset
*Apr 25 22:41:52.675: %BGP-5-ADJCHANGE: neighbor 192.168.1.5 Down User reset
*Apr 25 22:41:53.131: %BGP-5-ADJCHANGE: neighbor 192.168.1.5 Up
*Apr 25 22:41:53.543: %BGP-5-ADJCHANGE: neighbor 172.16.32.1 Up
```

Router R3 Console (hostname SanJose2)

clear ip bgp *

```
SanJose2# clear ip bgp *
SanJose2#
*Apr 25 22:52:26.695: %BGP-5-ADJCHANGE: neighbor 172.16.64.1 Down User reset
*Apr 25 22:52:27.059: %BGP-5-ADJCHANGE: neighbor 172.16.64.1 Up
```

h) After the routers have returned to established BGP speakers, issue the show ip bgp command on SanJose2 and notice that the next hop is now SanJose1 instead of ISP.

Router R3 Console (hostname SanJose2)

show ip bgp

```
SanJose2# show ip bgp
BGP table version is 1, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*  172.16.0.0       0.0.0.0                  0         32768 i
* i                 172.16.64.1              0    100      0 i
* i192.168.100.0    172.16.64.1              0    100      0 200 i
```

i) The show ip route command on SanJose2 now displays the 192.168.100.0/24 network because SanJose1 is the next hop, 172.16.64.1, which is reachable from SanJose2.

Router R3 Console (hostname SanJose2)

show ip route

```
SanJose2# show ip route
Codes: 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

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.16.32.0/24 is directly connected, Loopback0
S       172.16.0.0/16 is directly connected, Null0
C       172.16.1.0/24 is directly connected, Serial1/1
D       172.16.64.0/24 [90/2297856] via 172.16.1.1, 01:55:34, Serial1/1
B    192.168.100.0/24 [200/0] via 172.16.64.1, 00:01:24
```

j) Before configuring the next BGP attribute, restore the WAN link between ISP and SanJose3. This will change the BGP table and routing table on both routers. For example, SanJose2's routing table shows 192.168.100.0/24 will now have a better path through ISP.

Router R1 Console (hostname ISP)

interface s1/1

no shutdown

```
ISP(config)# interface s1/1
ISP(config-if)# no shutdown
ISP(config-if)#
*Apr 25 22:59:17.539: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
```

Router R3 Console (hostname SanJose2)

show ip route

```
SanJose2# show ip route
Codes: 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

Gateway of last resort is not set

     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.16.32.0/24 is directly connected, Loopback0
S       172.16.0.0/16 is directly connected, Null0
C       172.16.1.0/24 is directly connected, Serial1/1
D       172.16.64.0/24 [90/2297856] via 172.16.1.1, 01:58:28, Serial1/1
     192.168.1.0/30 is subnetted, 1 subnets
C       192.168.1.0 is directly connected, Serial1/0
B    192.168.100.0/24 [20/0] via 192.168.1.1, 00:00:05
```

Step 8: Set BGP local preference.

At this point, everything looks good, with the exception of default routes, the outbound flow of data, and inbound packet flow.

a) Because the local preference value is shared between IBGP neighbors, configure a simple route map that references the local preference value on SanJose1 and SanJose2. This policy adjusts outbound traffic to prefer the link off the SanJose1 router instead of the metered T1 off SanJose2.

Router R2 Console (hostname SanJose1)

route-map PRIMARY_T1_IN permit 10

set local-preference 150

exit

router bgp 64512

neighbor 192.168.1.5 route-map PRIMARY_T1_IN in

```
SanJose1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
SanJose1(config)# route-map PRIMARY_T1_IN permit 10
SanJose1(config-route-map)# set local-preference 150
SanJose1(config-route-map)# exit
SanJose1(config)# router bgp 64512
SanJose1(config-router)# neighbor 192.168.1.5 route-map PRIMARY_T1_IN in
```

Router R3 Console (hostname SanJose2)

route-map SECONDARY_T1_IN permit 10

set local-preference 125

exit

router bgp 64512

neighbor 192.168.1.1 route-map SECONDARY_T1_IN in

```
SanJose2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
SanJose2(config)# route-map SECONDARY_T1_IN permit 10
SanJose2(config-route-map)# set local-preference 125
SanJose2(config-route-map)# exit
SanJose2(config)# router bgp 64512
SanJose2(config-router)# neighbor 192.168.1.1 route-map SECONDARY_T1_IN in
```

b) Use the clear ip bgp * soft command after configuring this new policy. When the conversations have been reestablished, issue the show ip bgp command on SanJose1 and SanJose2.

Router R2 Console (hostname SanJose1)

clear ip bgp * soft

show ip bgp

```
SanJose1# clear ip bgp * soft
SanJose1# show ip bgp
BGP table version is 6, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
* i172.16.0.0       172.16.32.1              0    100      0 i
*>                  0.0.0.0                  0         32768 i
*> 192.168.100.0    192.168.1.5              0    150      0 200 i
```

Router R3 Console (hostname SanJose2)

clear ip bgp * soft

show ip bgp

```
SanJose2# clear ip bgp * soft
SanJose2# show 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 172.16.0.0       0.0.0.0                  0         32768 i
* i                 172.16.64.1              0    100      0 i
*  192.168.100.0    192.168.1.1              0    125      0 200 i
*>i                 172.16.64.1              0    150      0 200 i
```

Step 9: Set BGP MED.

a) In the previous step we saw that SanJose1 and SanJose2 will route traffic for 192.168.100.0/24 using the link between SanJose1 and ISP. Examine what the return path ISP takes to reach AS 64512. Notice that the return path is different from the original path. This is known as asymmetric routing and is not necessarily an unwanted trait.

Router R1 Console (hostname ISP)

show ip bgp

```
ISP# show ip bgp
BGP table version is 11, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   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
```

show ip route

```
ISP# show ip route
Codes: 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

Gateway of last resort is not set

B    172.16.0.0/16 [20/0] via 192.168.1.6, 00:34:41
     192.168.1.0/30 is subnetted, 2 subnets
C       192.168.1.0 is directly connected, Serial1/1
C       192.168.1.4 is directly connected, Serial1/0
C    192.168.100.0/24 is directly connected, Loopback0
```

b) Use an extended ping command to verify this situation. Specify the record option and compare your output to the following. Notice the return path using the exit interface 192.168.1.1 to SanJose2.

Router R3 Console (hostname SanJose2)

ping

```
SanJose2# ping
Protocol [ip]:
Target IP address: 192.168.100.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 172.16.32.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]: record
Number of hops [ 9 ]:
Loose, Strict, Record, Timestamp, Verbose[RV]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.100.1, timeout is 2 seconds:
Packet sent with a source address of 172.16.32.1
Packet has IP options:  Total option bytes= 39, padded length=40
 Record route: <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
```

```
Reply to request 0 (116 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list

Reply to request 1 (48 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list

Reply to request 2 (56 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list
```

```
Reply to request 3 (56 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list

Reply to request 4 (52 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list

Success rate is 100 percent (5/5), round-trip min/avg/max = 48/65/116 ms
```

c) Create a new policy to force the ISP router to return all traffic via SanJose1. Create a second route map utilizing the MED (metric) that is shared between EBGP neighbors.

Router R2 Console (hostname SanJose1)

route-map PRIMARY_T1_MED_OUT permit 10

set Metric 50

exit

router bgp 64512

neighbor 192.168.1.5 route-map PRIMARY_TI_MED_OUT out

```
SanJose1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
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
```

Router R3 Console (hostname SanJose2)

route-map SECONDARY_T1_MED_OUT permit 10

set Metric 75

exit

router bgp 64512

neighbor 192.168.1.1 route-map SECONDARY_T1_MED_OUT out

```
SanJose2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
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)#neighbor 192.168.1.1 route-map SECONDARY_T1_MED_OUT o$
```

d) Use the clear ip bgp * soft command after issuing this new policy. Issuing the show ip bgp command as follows on SanJose1 or SanJose2 does not indicate anything about this newly defined policy.

Router R2 Console (hostname SanJose1)

clear ip bgp * soft

show ip bgp

```
SanJose1# clear ip bgp * soft
SanJose1# show ip bgp
BGP table version is 6, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
* i172.16.0.0       172.16.32.1              0    100      0 i
*>                  0.0.0.0                  0         32768 i
*> 192.168.100.0    192.168.1.5              0    150      0 200 i
```

Router R3 Console (hostname SanJose2)

clear ip bgp * soft

show ip bgp

```
SanJose2# clear ip bgp * soft
SanJose2# show 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 172.16.0.0       0.0.0.0                  0         32768 i
* i                 172.16.64.1              0    100      0 i
*  192.168.100.0    192.168.1.1              0    125      0 200 i
*>i                 172.16.64.1              0    150      0 200 i
```

e) Reissue an extended ping command with the record command. Notice the change in return path using the exit interface 192.168.1.5 to SanJose1.

Router R3 Console (hostname SanJose2)

ping

```
SanJose2# ping
Protocol [ip]:
Target IP address: 192.168.100.1
Repeat count [5]:
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface: 172.16.32.1
Type of service [0]:
Set DF bit in IP header? [no]:
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]: record
Number of hops [ 9 ]:
Loose, Strict, Record, Timestamp, Verbose[RV]:
Sweep range of sizes [n]:
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.100.1, timeout is 2 seconds:
Packet sent with a source address of 172.16.32.1
Packet has IP options:  Total option bytes= 39, padded length=40
 Record route: <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
```

```
Reply to request 0 (120 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list

Reply to request 1 (68 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list

Reply to request 2 (56 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list
```

```
Reply to request 3 (68 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list

Reply to request 4 (56 ms).  Received packet has options
 Total option bytes= 40, padded length=40
 Record route:
   (172.16.1.2)
   (192.168.1.6)
   (192.168.100.1)
   (192.168.1.5)
   (172.16.1.1)
   (172.16.32.1) <*>
   (0.0.0.0)
   (0.0.0.0)
   (0.0.0.0)
 End of list

Success rate is 100 percent (5/5), round-trip min/avg/max = 56/73/120 ms
```

Step 10: Establish a default route.

The final step is to establish a default route that uses a policy statement that adjusts to changes in the network.

a) Configure ISP to inject a default route to both SanJose1 and SanJose2 using BGP using the default-originate command. This command does not require the presence of 0.0.0.0 in the ISP router. Configure the 10.0.0.0/8 network which will not be advertised using BGP. This network will be used to test the default route on SanJose1 and SanJose2.

Router R1 Console (hostname ISP)

show ip bgp

```
ISP# show ip bgp
BGP table version is 13, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

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

router bgp 200

neighbor 192.168.1.6 default-originate

neighbor 192.168.1.2 default-originate

exit

interface loopback 10

ip address 10.0.0.1 255.255.255.0

```
ISP# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
ISP(config)# router bgp 200
ISP(config-router)#neighbor 192.168.1.6 default-originate
ISP(config-router)#neighbor 192.168.1.2 default-originate
ISP(config-router)#exit
ISP(config)#interface loopback 10
ISP(config-if)#ip address 10.0.0.1 255.255.255.0
ISP(config-if)#
*Apr 25 23:48:48.059: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback10, changed state to up
```

b) Verify that both routers have received the default route by examining the routing tables on SanJose1 and SanJose2. Notice that both routers prefer the route between SanJose1 and ISP.

Router R2 Console (hostname SanJose1)

show ip route

```
SanJose1# show ip route
Codes: 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

Gateway of last resort is 192.168.1.5 to network 0.0.0.0

     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
D       172.16.32.0/24 [90/2297856] via 172.16.1.2, 02:48:43, Serial1/1
S       172.16.0.0/16 is directly connected, Null0
C       172.16.1.0/24 is directly connected, Serial1/1
C       172.16.64.0/24 is directly connected, Loopback0
     192.168.1.0/30 is subnetted, 1 subnets
C       192.168.1.4 is directly connected, Serial1/0
B    192.168.100.0/24 [20/0] via 192.168.1.5, 01:07:07
B*   0.0.0.0/0 [20/0] via 192.168.1.5, 00:01:33
```

Router R3 Console (hostname SanJose2)

show ip route

```
SanJose2# show ip route
Codes: 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

Gateway of last resort is 172.16.64.1 to network 0.0.0.0

     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.16.32.0/24 is directly connected, Loopback0
S       172.16.0.0/16 is directly connected, Null0
C       172.16.1.0/24 is directly connected, Serial1/1
D       172.16.64.0/24 [90/2297856] via 172.16.1.1, 02:50:18, Serial1/1
     192.168.1.0/30 is subnetted, 1 subnets
C       192.168.1.0 is directly connected, Serial1/0
B    192.168.100.0/24 [200/0] via 172.16.64.1, 00:40:11
B*   0.0.0.0/0 [200/0] via 172.16.64.1, 00:02:58
```

c) The preferred default route is by way of SanJose1 because of the higher local preference attribute configured on SanJose1 earlier.

Router R3 Console (hostname SanJose2)

show ip bgp

```
SanJose2# show ip bgp
BGP table version is 7, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*>i0.0.0.0          172.16.64.1              0    150      0 200 i
*                   192.168.1.1              0    125      0 200 i
*> 172.16.0.0       0.0.0.0                  0         32768 i
* i                 172.16.64.1              0    100      0 i
*  192.168.100.0    192.168.1.1              0    125      0 200 i
*>i                 172.16.64.1              0    150      0 200 i
```

d) Using the traceroute command verify that packets to 10.0.0.1 is using the default route through SanJose1.

Router R3 Console (hostname SanJose2)

traceroute 10.0.0.1

```
SanJose2# traceroute 10.0.0.1

Type escape sequence to abort.
Tracing the route to 10.0.0.1

  1 172.16.1.1 64 msec 48 msec 64 msec
  2 192.168.1.5 [AS 200] 76 msec 64 msec 76 msec
```

e) Next, test how BGP adapts to using a different default route when the path between SanJose1 and ISP goes down.

Router R1 Console (hostname ISP)

interface s1/0

shutdown

```
ISP(config)# interface s1/0
ISP(config-if)# shutdown
ISP(config-if)#
*Apr 25 23:56:24.279: %BGP-5-ADJCHANGE: neighbor 192.168.1.6 Down Interface flap
```

f) Verify that both routers are modified their routing tables with the default route using the path between SanJose2 and ISP.

Router R2 Console (hostname SanJose1)

show ip route

```
SanJose1# show ip route
Codes: 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

Gateway of last resort is 172.16.32.1 to network 0.0.0.0

     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
D       172.16.32.0/24 [90/2297856] via 172.16.1.2, 02:56:05, Serial1/1
S       172.16.0.0/16 is directly connected, Null0
C       172.16.1.0/24 is directly connected, Serial1/1
C       172.16.64.0/24 is directly connected, Loopback0
B    192.168.100.0/24 [200/0] via 172.16.32.1, 00:00:54
B*   0.0.0.0/0 [200/0] via 172.16.32.1, 00:00:54
```

Router R3 Console (hostname SanJose2)

show ip route

```
SanJose2# show ip route
Codes: 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

Gateway of last resort is 192.168.1.1 to network 0.0.0.0

     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.16.32.0/24 is directly connected, Loopback0
S       172.16.0.0/16 is directly connected, Null0
C       172.16.1.0/24 is directly connected, Serial1/1
D       172.16.64.0/24 [90/2297856] via 172.16.1.1, 02:57:36, Serial1/1
     192.168.1.0/30 is subnetted, 1 subnets
C       192.168.1.0 is directly connected, Serial1/0
B    192.168.100.0/24 [20/0] via 192.168.1.1, 00:02:15
B*   0.0.0.0/0 [20/0] via 192.168.1.1, 00:02:15
```

g) Verify the new path using the traceroute command to 10.0.0.1 from SanJose1. Notice the default route is now through SanJose2.

Router R2 Console (hostname SanJose1)

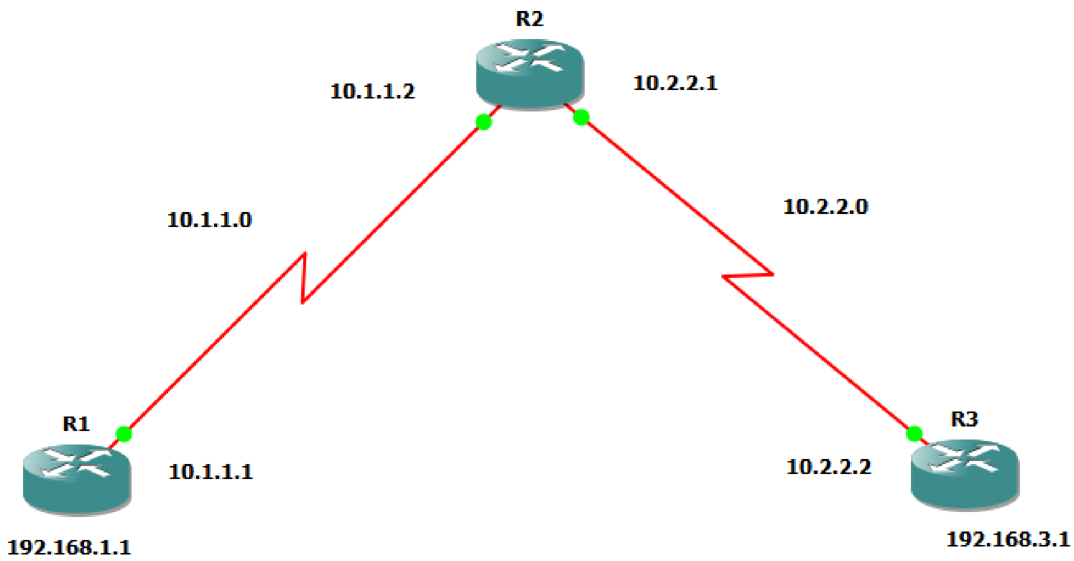
traceroute 10.0.0.1

```
SanJose1# traceroute 10.0.0.1

Type escape sequence to abort.
Tracing the route to 10.0.0.1

  1 172.16.1.2 52 msec 48 msec 32 msec
  2 192.168.1.1 [AS 200] 76 msec 64 msec 76 msec
```

Practical 4

Aim:- Secure the Management Plane

Topology:-



Step 1:- Configure loopbacks and assign addresses.

Cable the network as shown in the topology diagram. Erase the startup configuration and reload each router to clear previous configurations. Using the addressing scheme in the diagram, apply the IP addresses to the interfaces on the R1, R2, and R3 routers.

Router R1 Console

hostname R1

interface Loopback0

description R1 LAN

ip address 192.168.1.1 255.255.255.0

exit

interface S1/0

description R1 → R2

ip address 10.1.1.1 255.255.255.252

clock rate 128000

no shutdown

end

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# interface Loopback0
R1(config-if)# descr
*Mar 21 17:34:20.199: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R1(config-if)# description R1 LAN
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)# description R1 --> R2
R1(config-if)# ip address 10.1.1.1 255.255.255.252
R1(config-if)# clock rate 128000
R1(config-if)# no shutdown
R1(config-if)#
*Mar 21 17:36:13.547: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
R1(config-if)#
*Mar 21 17:36:13.551: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
*Mar 21 17:36:14.551: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up
R1(config-if)# end
R1#
*Mar 21 17:36:19.303: %SYS-5-CONFIG_I: Configured from console by console
R1#
```

Router R2 Console

hostname R2

interface S1/0

description R2 → R1

interface S1/0

ip address 10.1.1.2 255.255.255.252

no shutdown

exit

interface S1/1

description R2 → R3

ip address 10.2.2.1 255.255.255.252

clock rate 128000

no shutdown

end

```
R2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)# interface S1/0
R2(config-if)# description R2 --> R1
R2(config-if)# interface S1/0
R2(config-if)# ip address 10.1.1.2 255.255.255.252
R2(config-if)# no shutdown
R2(config-if)# exit
*Mar 21 17:40:59.699: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
R2(config-if)# exit
R2(config)#
*Mar 21 17:40:59.703: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
R2(config)#
*Mar 21 17:41:00.707: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up
R2(config)# interface S1/1
R2(config-if)# description R2 --> R3
R2(config-if)# ip address 10.2.2.1 255.255.255.252
R2(config-if)# clock rate 128000
R2(config-if)# no shutdown
R2(config-if)#
*Mar 21 17:41:48.987: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
R2(config-if)#
*Mar 21 17:41:48.987: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State Down
*Mar 21 17:41:49.987: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up
R2(config-if)# end
R2#
*Mar 21 17:41:54.515: %SYS-5-CONFIG_I: Configured from console by console
R2#
```

Router R3 Console

hostname R3

interface Loopback0

description R3 LAN

ip address 192.168.3.1 255.255.255.0

exit

interface S1/1

description R3 → R2

ip address 10.3.3.1 255.255.255.252

no shutdown

end

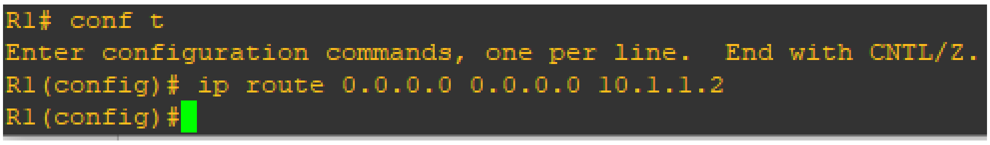
```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# interface Loopback0
R3(config-if)#
*Mar 21 17:49:03.619: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R3(config-if)# description R3 LAN
R3(config-if)# ip address 192.168.3.1 255.255.255.0
R3(config-if)# exit
R3(config)# interface S1/1
R3(config-if)# description R3 --> R2
R3(config-if)# ip address 10.2.2.2 255.255.255.252
R3(config-if)# no shutdown
R3(config-if)#
*Mar 21 17:50:21.787: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
R3(config-if)#
*Mar 21 17:50:21.787: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State Down
*Mar 21 17:50:22.787: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up
R3(config-if)# end
R3#
*Mar 21 17:50:27.271: %SYS-5-CONFIG_I: Configured from console by console
R3#
```

Step 2:- Configure Static Routes.

a) On R1, configure a default static route to R2.

Router R1 Console

ip route 0.0.0.0 0.0.0.0 10.1.1.2

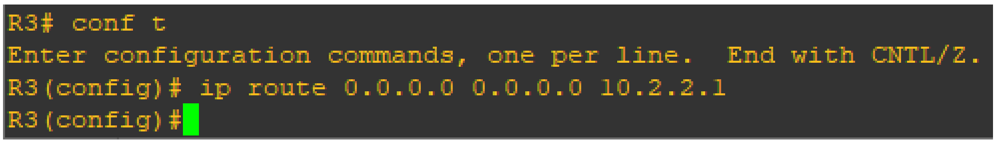


```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# ip route 0.0.0.0 0.0.0.0 10.1.1.2
R1(config)#
```

b) On R3, configure a default static route to R2.

Router R3 Console

ip route 0.0.0.0 0.0.0.0 10.2.2.1



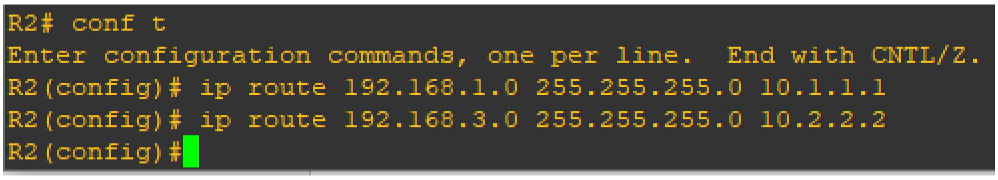
```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# ip route 0.0.0.0 0.0.0.0 10.2.2.1
R3(config)#
```

c) On R2, configure two static routes

Router R2 Console

ip route 192.168.1.0 255.255.255.0 10.1.1.1

ip route 192.168.3.0 255.255.255.0 10.2.2.2



```
R2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
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(config)#
```

d) From the R1 router, run the following Tcl script to verify connectivity.

R1# tclsh

R1(tcl)# foreach address {

+> (tcl)# 192.168.1.1

+> (tcl)# 10.1.1.1

+> (tcl)# 10.1.1.2

+> (tcl)# 10.2.2.1

+> (tcl)# 10.2.2.2

+> (tcl)# 192.168.3.1

+> (tcl)# } { ping $address }

```
R2# tclsh
R2(tcl)# foreach address {
+>(tcl)# 192.168.1.1
+>(tcl)# 10.1.1.1
+>(tcl)# 10.1.1.2
+>(tcl)# 10.2.2.1
+>(tcl)# 10.2.2.2
+>(tcl)# 192.168.3.1
+>(tcl)#} { ping $address }

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 = 28/43/60 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/36/56 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/72/116 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/78/132 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/48/88 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 24/38/68 ms
R2(tcl)#
```

Step 3:- Secure management access.

a) On R1, use the **security passwords** command to set a minimum password length of 10 characters.

Router R1 Console

security passwords min-length 10

```
R1(config)# security passwords min-length 10
R1(config)#
```

b) Configure the enable secret encrypted password on both routers.

Router R1 Console

enable secret class12345

```
R1(config)# enable secret class12345
R1(config)#
```

Note:- Passwords in this task are set to a minimum of 10 characters but are relatively simple for the benefit of performing the lab. More complex passwords are recommended in a production network.

c) Configure a console password and enable login for routers. For additional security, the **exec-timeout** command causes the line to log out after 5 minutes of inactivity. The **logging synchronous** command prevents console messages from interrupting command entry.

Note: To avoid repetitive logins during this lab, the **exec-timeout** command can be set to 0 0, which prevents it from expiring. However, this is not considered a good security practice.

Router R1 Console

line console 0

password ciscoconpass

exec-timeout 5 0

login

logging synchronous

exit

```
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)#
```

d) Configure the password on the vty lines for router R1

Router R1 Console

line vty 0 4

password ciscovtypass

exec-timeout 5 0

login

logging synchronous

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)# logging synchronous
R1(config-line)# exit
R1(config)#
```

e) The aux port is a legacy port used to manage a router remotely using a modem and is hardly ever used. Therefore, disable the aux port.

Router R1 Console

line aux 0

no exec

end

```
R1(config)# line aux 0
R1(config-line)# no exec
R1(config-line)# end
R1#
*Mar 21 18:34:53.355: %SYS-5-CONFIG_I: Configured from console by console
R1#
```

f) Enter privileged EXEC mode and issue the **show run** command. Can you read the enable secret password?

Router R1 Console

show run

```
line con 0
 exec-timeout 5 0
 privilege level 15
 password ciscoconpass
 logging synchronous
 login
 stopbits 1
line aux 0
 exec-timeout 0 0
 privilege level 15
 logging synchronous
 no exec
 stopbits 1
line vty 0 4
 exec-timeout 5 0
 password ciscovtypass
 logging synchronous
 login
!
!
end

R1#
```

g) Use the **service password-encryption** command to encrypt the line console and vty passwords.

Router R1 Console

service password-encryption

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# service password-encryption
R1(config)#
```

Note:- Password encryption is applied to all the passwords, including the username passwords, the authentication key passwords, the privileged command password, the console and the virtual terminal line access passwords, and the BGP neighbor passwords.

h) Issue the **show run** command. Can you read the console, aux, and vty passwords?

Router R1 Console

show run

```
line con 0
 exec-timeout 5 0
 privilege level 15
 password 7 121A0C0411040F0B243B253B20
 logging synchronous
 login
 stopbits 1
line aux 0
 exec-timeout 0 0
 privilege level 15
 logging synchronous
 no exec
 stopbits 1
line vty 0 4
 exec-timeout 5 0
 password 7 05080F1C2243581D0015160118
 logging synchronous
 login
!
!
end
```

Note:- Type 7 passwords are encrypted using a Vigenère cipher which can be easily reversed. Therefore this command primarily protects from shoulder surfing attacks.

i) Configure a warning to unauthorized users with a message-of-the-day (MOTD) banner using the **banner motd** command. When a user connects to one of the routers, the MOTD banner appears before the login prompt. In this example, the dollar sign ($) is used to start and end the message.

Router R1 Console

banner motd $Unauthorized access strictly prohibited!$

exit

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# banner motd $Unauthorized access strictly prohibited!$
R1(config)# exit
R1#
*Mar 21 18:47:19.687: %SYS-5-CONFIG_I: Configured from console by console
R1#
```

j) Issue the **show run** command. What does the $ convert to in the output?

```
banner motd ^CUnauthorized access strictly prohibited!^C
!
line con 0
 exec-timeout 5 0
 privilege level 15
 password 7 121A0C0411040F0B243B253B20
 logging synchronous
 login
 stopbits 1
line aux 0
 exec-timeout 0 0
 privilege level 15
 logging synchronous
 no exec
 stopbits 1
line vty 0 4
 exec-timeout 5 0
 password 7 05080F1C2243581D0015160118
 logging synchronous
 login
!
!
end
```

k) Exit privileged EXEC mode using the **disable** or **exit** command and press **Enter** to get started. Does the MOTD banner look like what you created with the **banner motd** command? If the MOTD banner is not as you wanted it, recreate it using the **banner motd** command.

l) Repeat the configuration portion of steps 3a through 3k on router R3.

Step 4:- Configure enhanced username password security.

To increase the encryption level of console and VTY lines, it is recommended to enable authentication using the local database. The local database consists of usernames and password combinations that are created locally on each device. The local and VTY lines are configured to refer to the local database when authenticating a user.

a) To create local database entry encrypted to level 4 (SHA256), use the **username name secret** password global configuration command. In global configuration mode, enter the following command:

Router R1 Console

username JR-ADMIN secret class12345

username ADMIN secret class54321

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# username JR-ADMIN secret class12345
R1(config)# username ADMIN secret class54321
R1(config)#
```

Note:- An older method for creating local database entries is to use the **username name password password** command.

b) Set the console line to use the locally defined login accounts.

Router R1 Console

line console 0

login local

exit

```
R1(config)# line console 0
R1(config-line)# login local
R1(config-line)# exit
R1(config)#
```

c) Set the vty lines to use the locally defined login accounts.

Router R1 Console

Line vty 0 4

login local

exit

```
R1(config)# line vty 0 4
R1(config-line)# login local
R1(config-line)#exit
R1(config)#
```

d) Repeat the steps 4a to 4c on R3.

```
R3(config)# username JR-ADMIN secret class12345
R3(config)# username ADMIN secret class54321
R3(config)#
R3(config)# line console 0
R3(config-line)# login local
R3(config-line)# exit
R3(config)#
R3(config)# line vty 0 4
R3(config-line)# login local
R3(config-line)# exit
R3(config)#
```

e) To verify the configuration, telnet to R3 from R1 and login using the ADMIN local database account.

Router R1 Console

telnet 10.2.2.2

```
R1# telnet 10.2.2.2
Trying 10.2.2.2 ... Open
Unauthorized access strictly prohibited!

User Access Verification

Username: ADMIN
Password:
R3>
```

Step 5:- Enabling AAA RADIUS Authentication with Local User for Backup.

Authentication, authorization, and accounting (AAA) is a standards-based framework that can be implemented to control who is permitted to access a network (authenticate), what they can do on that network (authorize), and audit what they did while accessing the network (accounting).

a) Always have local database accounts created before enabling AAA. Since we created two local database accounts in the previous step, then we can proceed and enable AAA on R1.

Router R1 Console

aaa new-model

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# aaa new-model
R1(config)#
```

Note:- Although the following configuration refers to two RADIUS servers, the actual RADIUS server implementation is beyond the scope. Therefore, the goal of this step is to provide an example of how to configure a router to access the servers.

b) Configure the specifics for the first RADIUS server located at 192.168.1.101. Use **RADIUS-1-pa55w0rd** as the server password.

Router R1 Console

radius-server host 192.168.1.101 key RADIUS-1-pa55w0rd

c) Configure the specifics for the second RADIUS server located at 192.168.1.102. Use **RADIUS-2-pa55w0rd** as the server password.

Router R1 Console

radius-server host 192.168.1.102 key RADIUS-2-pa55w0rd

```
R1(config)# radius-server host 192.168.1.101 key RADIUS-1-pa55w0rd
R1(config)# radius-server host 192.168.1.102 key RADIUS-2-pa55w0rd
R1(config)#
```

d) Assign both RADIUS servers to a server group.

Router R1 Console

aaa group server radius RADIUS-GROUP

server 192.168.1.101

server 192.168.1.102

exit

```
R1(config)# aaa group server radius RADIUS-GROUP
R1(config-sg-radius)# server 192.168.1.101
R1(config-sg-radius)# server 192.168.1.102
R1(config-sg-radius)# exit
```

e) Enable the default AAA authentication login to attempt to validate against the server group. If they are not available, then authentication should be validated against the local database.

Router R1 Console

aaa authentication login default group RADIUS-GROUP local

```
R1(config)# aaa authentication login default group RADIUS-GROUP local
```

Note:- Once this command is configured, all line access methods default to the default authentication method. The local option enables AAA to refer to the local database. Only the password is case sensitive.

f) Enable the default AAA authentication Telnet login to attempt to validate against the server group. If they are not available, then authentication should be validated against a case sensitive local database.

Router R1 Console

aaa authentication login TELNET-LOGIN group RADIUS-GROUP local-case

```
R1(config)# aaa authentication login TELNET-LOGIN group RADIUS-GROUP local-case
```

Note:- Unlike the local option that makes the password is case sensitive, local-case makes the username and password case sensitive.

g) Alter the vty lines to use the TELNET-LOGIN AAA authentication method.

Router R1 Console

line vty 0 4

login authentication TELNET-LOGIN

exit

```
R1(config)# line vty 0 4
R1(config-line)# login authentication TELNET-LOGIN
R1(config-line)# exit
R1(config)#
```

h) Repeat the steps 5a to 5g on R3.

```
R3(config)# aaa new-model
R3(config)# radius-server host 192.168.1.101 key RADIUS-1-pa55w0rd
R3(config)# radius-server host 192.168.1.102 key RADIUS-2-pa55w0rd
R3(config)# aaa group server radius RADIUS-GROUP
R3(config-sg-radius)# server 192.168.1.101
R3(config-sg-radius)# server 192.168.1.102
R3(config-sg-radius)# exit
R3(config)# aaa authentication login default group RADIUS-GROUP local
R3(config)# aaa authentication login TELNET-LOGIN group RADIUS-GROUP local-case
R3(config)# line vty 0 4
R3(config-line)# login authentication TELNET-LOGIN
R3(config-line)# exit
R3(config)#
```

i) To verify the configuration, telnet to R3 from R1 and login using the ADMIN local database account.

Router R1 Console

telnet 10.2.2.2

```
R1# telnet 10.2.2.2
Trying 10.2.2.2 ... Open
Unauthorized access strictly prohibited!

User Access Verification

Username: admin
Password:

% Authentication failed

Username: ADMIN
Password:

R3>
```

Note:- The first login attempt did not use the correct username (i.e., ADMIN) which is why it failed.

Note:- The actual login time is longer since the RADIUS servers are not available.

Step 6:- Enabling secure remote management using SSH

Traditionally, remote access on routers was configured using Telnet on TCP port 23. However, Telnet was developed in the days when security was not an issue; therefore, all Telnet traffic is forwarded in plaintext.

Secure Shell (SSH) is a network protocol that establishes a secure terminal emulation connection to a router or other networking device. SSH encrypts all information that passes over the network link and provides authentication of the remote computer. SSH is rapidly replacing Telnet as the remote login tool of choice for network professionals.

Note:- For a router to support SSH, it must be configured with local authentication, (AAA services, or username) or password authentication. In this task, you configure an SSH username and local authentication.

In this step, you will enable R1 and R3 to support SSH instead of Telnet.

a) SSH requires that a device name and a domain name be configured. Since the router already has a name assigned, configure the domain name.

Router R1 Console

ip domain-name ccnasecurity.com

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# ip domain-name ccnasecurity.com
```

b) The router uses the RSA key pair for authentication and encryption of transmitted SSH data. Although optional it may be wise to erase any existing key pairs on the router.

Router R1 Console

crypto key zeroize rsa

Note:- If no keys exist, you might receive this message: % No Signature RSA Keys found in configuration.

```
R1(config)# crypto key zeroize rsa
% No Signature RSA Keys found in configuration.
```

c) Generate the RSA encryption key pair for the router. Configure the RSA keys with 1024 for the number of modulus bits. The default is 512, and the range is from 360 to 2048.

Router R1 Console

crypto key generate rsa general-keys modulus 1024

```
R1(config)# crypto key generate rsa general-keys modulus 1024
The name for the keys will be: R1.ccnasecurity.com

% The key modulus size is 1024 bits
% Generating 1024 bit RSA keys, keys will be non-exportable...[OK]

R1(config)#
*Mar 21 20:12:58.079: %SSH-5-ENABLED: SSH 1.99 has been enabled
R1(config)#
```

d) Cisco routers support two versions of SSH:

• SSH version 1 (SSHv1): Original version but has known vulnerabilities.

• SSH version 2 (SSHv2): Provides better security using the Diffie-Hellman key exchange and the strong integrity-checking message authentication code (MAC).

The default setting for SSH is SSH version 1.99. This is also known as compatibility mode and is merely an indication that the server supports both SSH version 2 and SSH version 1. However, best practices are to enable version 2 only.

Configure SSH version 2 on R1.

Router R1 Console

ip ssh version 2

```
R1(config)# ip ssh version 2
R1(config)#
```

e) Configure the vty lines to use only SSH connections.

Router R1 Console

line vty 0 4

transport input ssh

end

```
R1(config)# line vty 0 4
R1(config-line)# transport input ssh
R1(config-line)# end
R1#
*Mar 21 20:17:46.307: %SYS-5-CONFIG_I: Configured from console by console
```

Note:- SSH requires that the **login local** command be configured. However, in the previous step we enabled AAA authentication using the TELNET-LOGIN authentication method, therefore **login local** is not necessary.

Note:- If you add the keyword **telnet** to the **transport input** command, users can log in using Telnet as well as SSH. However, the router will be less secure. If only SSH is specified, the connecting host must have an SSH client installed.

f) Verify the SSH configuration using the **show ip ssh** command.

Router R1 Console

show ip ssh

```
R1# show ip ssh
SSH Enabled - version 2.0
Authentication timeout: 120 secs; Authentication retries: 3
R1#
```

g) Repeat the steps from 6a to 6f on R3

```
R3(config)# ip domain-name ccnasecurity.com
R3(config)# crypto key zeroize rsa
% No Signature RSA Keys found in configuration.

R3(config)# crypto key generate rsa general-keys modulus 1024
The name for the keys will be: R3.ccnasecurity.com

% The key modulus size is 1024 bits
% Generating 1024 bit RSA keys, keys will be non-exportable...[OK]

R3(config)#
*Mar 21 20:24:51.939: %SSH-5-ENABLED: SSH 1.99 has been enabled
R3(config)# ip ssh version 2
R3(config)#
R3(config)# line vty 0 4
R3(config-line)# transport input ssh
R3(config-line)# end
R3#
*Mar 21 20:25:39.939: %SYS-5-CONFIG_I: Configured from console by console
R3# show ip ssh
SSH Enabled - version 2.0
Authentication timeout: 120 secs; Authentication retries: 3
R3#
```

h) Although a user can SSH from a host using the SSH option of TeraTerm of PuTTY, a router can also SSH to another SSH enabled device. SSH to R3 from R1.

Router R1 Console

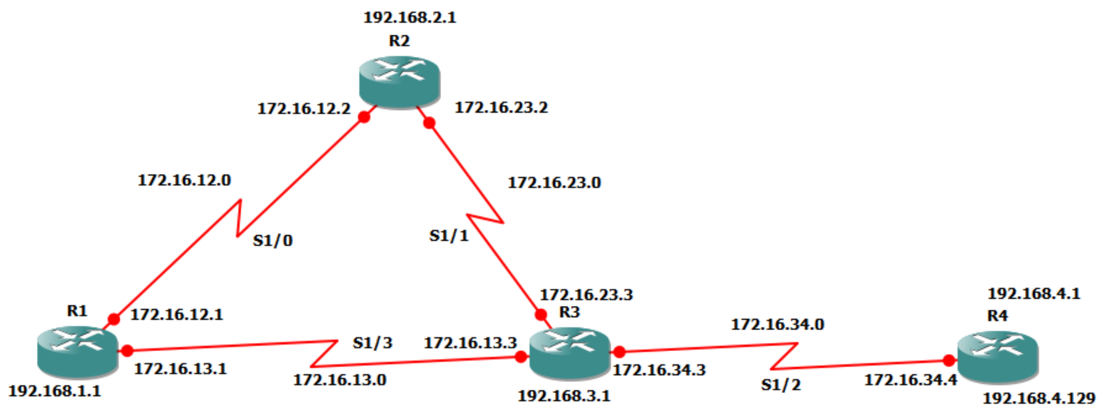
ssh –l ADMIN 10.2.2.2

```
R1#
R1# ssh -l ADMIN 10.2.2.2

Password:
Unauthorized access strictly prohibited!
R3>
R3> en
Password:
R3#
```

Practical 5

Aim:- Configure and Verify Path Control Using PBR

Topology:-



Step 1:- Configure loopbacks and assign addresses.

a) Cable the network as shown in the topology diagram. Erase the startup configuration, and reload each router to clear previous configurations.

b) Using the addressing scheme in the diagram, create the loopback interfaces and apply IP addresses to these and the serial interfaces on R1, R2, R3, and R4. On the serial interfaces connecting R1 to R3 and R3 to R4, specify the bandwidth as 64 Kb/s and set a clock rate on the DCE using the clock rate 64000 command. On the serial interfaces connecting R1 to R2 and R2 to R3, specify the bandwidth as 128 Kb/s and set a clock rate on the DCE using the clock rate 128000 command.

Router R1 Console

interface Lo1

description R1 LAN

ip address 192.168.1.1 255.255.255.0

exit

interface S1/0

description R1 → R2

ip address 172.16.12.1 255.255.255.248

clock rate 128000

bandwidth 128

no shutdown

exit

interface S1/3

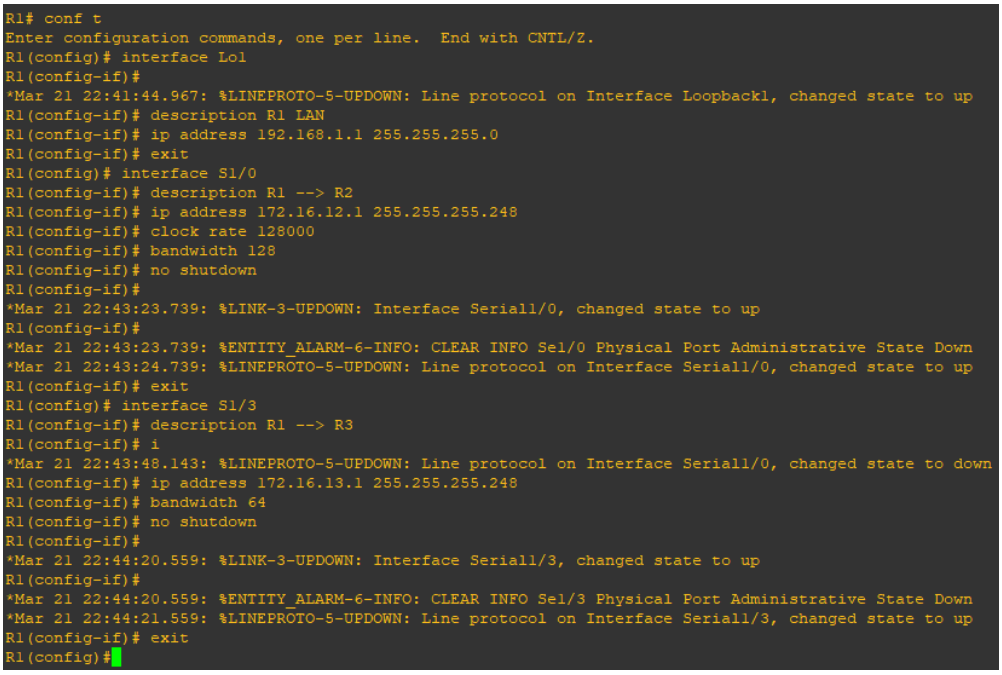
description R1 → R3

ip address 172.16.13.1 255.255.255.248

bandwidth 64

no shutdown

exit



```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# interface Lo1
R1(config-if)#
*Mar 21 22:41:44.967: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback1, changed state to up
R1(config-if)# description R1 LAN
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)# description R1 --> R2
R1(config-if)# ip address 172.16.12.1 255.255.255.248
R1(config-if)# clock rate 128000
R1(config-if)# bandwidth 128
R1(config-if)# no shutdown
R1(config-if)#
*Mar 21 22:43:23.739: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
R1(config-if)#
*Mar 21 22:43:23.739: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
*Mar 21 22:43:24.739: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up
R1(config-if)# exit
R1(config)# interface S1/3
R1(config-if)# description R1 --> R3
R1(config-if)# i
*Mar 21 22:43:48.143: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to down
R1(config-if)# ip address 172.16.13.1 255.255.255.248
R1(config-if)# bandwidth 64
R1(config-if)# no shutdown
R1(config-if)#
*Mar 21 22:44:20.559: %LINK-3-UPDOWN: Interface Serial1/3, changed state to up
R1(config-if)#
*Mar 21 22:44:20.559: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/3 Physical Port Administrative State Down
*Mar 21 22:44:21.559: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/3, changed state to up
R1(config-if)# exit
R1(config)#
```

Router R2 Console

interface Lo2

description R2 LAN

ip address 192.168.2.1 255.255.255.0

exit

interface S1/0

description R2 → R1

ip address 172.16.12.2 255.255.255.248

bandwidth 128

no shutdown

exit

interface S1/1

description R2 → R3

ip address 172.16.23.2 255.255.255.248

clock rate 128000

bandwidth 128

no shutdown

exit

```
R2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)# interface Lo2
R2(config-if)#
*Mar 21 22:48:41.835: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback2, changed state to up
R2(config-if)# description R2 LAN
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)# description R2 --> R1
R2(config-if)# ip address 172.16.12.2 255.255.255.248
R2(config-if)# bandwidth 128
R2(config-if)# no shutdown
R2(config-if)#
*Mar 21 22:50:41.515: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
R2(config-if)#
*Mar 21 22:50:41.519: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
R2(config-if)#
*Mar 21 22:50:42.523: %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)# description R2 --> R3
R2(config-if)# ip address 172.16.23.2 255.255.255.248
R2(config-if)# clock rate 128000
R2(config-if)# bandwidth 128
R2(config-if)# no shutdown
R2(config-if)#
*Mar 21 22:52:08.027: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
R2(config-if)#
*Mar 21 22:52:08.031: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State Down
R2(config-if)#
*Mar 21 22:52:09.035: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up
R2(config-if)# exit
R2(config)#
```

Router R3 Console

interface Lo3

description R3 LAN

ip address 192.168.3.1 255.255.255.0

exit

interface S1/3

description R3 → R1

ip address 172.16.13.3 255.255.255.248

clock rate 64000

bandwidth 64

no shutdown

exit

interface S1/1

description R3 → R2

ip address 172.16.23.3 255.255.255.248

bandwidth 128

no shutdown

exit

interface S1/2

description R3 → R4

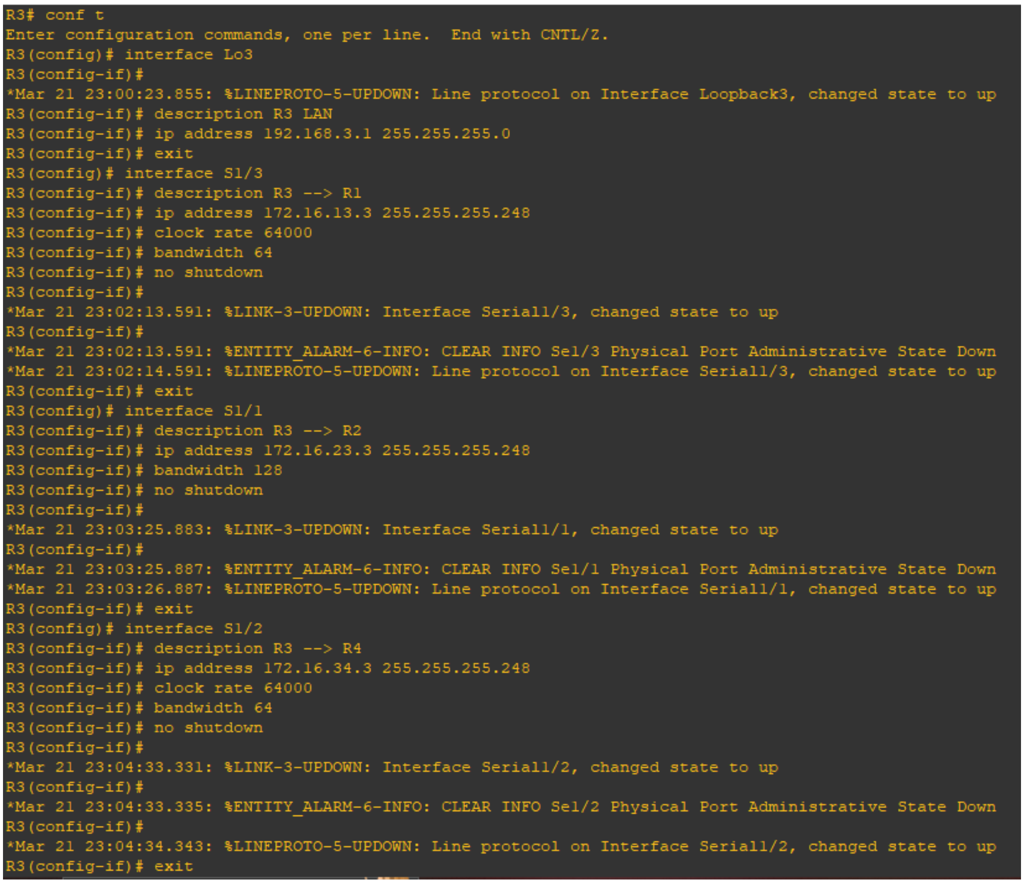
ip address 172.16.34.3 255.255.255.248

clock rate 64000

bandwidth 64

no shutdown

exit



```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# interface Lo3
R3(config-if)#
*Mar 21 23:00:23.855: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback3, changed state to up
R3(config-if)# description R3 LAN
R3(config-if)# ip address 192.168.3.1 255.255.255.0
R3(config-if)# exit
R3(config)# interface S1/3
R3(config-if)# description R3 --> R1
R3(config-if)# ip address 172.16.13.3 255.255.255.248
R3(config-if)# clock rate 64000
R3(config-if)# bandwidth 64
R3(config-if)# no shutdown
R3(config-if)#
*Mar 21 23:02:13.591: %LINK-3-UPDOWN: Interface Serial1/3, changed state to up
R3(config-if)#
*Mar 21 23:02:13.591: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/3 Physical Port Administrative State Down
*Mar 21 23:02:14.591: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/3, changed state to up
R3(config-if)# exit
R3(config)# interface S1/1
R3(config-if)# description R3 --> R2
R3(config-if)# ip address 172.16.23.3 255.255.255.248
R3(config-if)# bandwidth 128
R3(config-if)# no shutdown
R3(config-if)#
*Mar 21 23:03:25.883: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
R3(config-if)#
*Mar 21 23:03:25.887: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State Down
*Mar 21 23:03:26.887: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up
R3(config-if)# exit
R3(config)# interface S1/2
R3(config-if)# description R3 --> R4
R3(config-if)# ip address 172.16.34.3 255.255.255.248
R3(config-if)# clock rate 64000
R3(config-if)# bandwidth 64
R3(config-if)# no shutdown
R3(config-if)#
*Mar 21 23:04:33.331: %LINK-3-UPDOWN: Interface Serial1/2, changed state to up
R3(config-if)#
*Mar 21 23:04:33.335: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/2 Physical Port Administrative State Down
R3(config-if)#
*Mar 21 23:04:34.343: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/2, changed state to up
R3(config-if)# exit
```

Router R4 Console

interface Lo4

description R4 LAN A

ip address 192.168.4.1 255.255.255.128

exit

interface Lo5

description R4 LAN B

ip address 192.168.4.129 255.255.255.128

exit

interface S1/2

description R4 → R3

ip address 172.16.34.4 255.255.255.248

bandwidth 64

no shutdown

exit

```
R4# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R4(config)# interface Lo4
R4(config-if)#
*Mar 21 23:08:22.299: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback4, changed state to up
R4(config-if)# description R4 LAN A
R4(config-if)# ip address 192.168.4.1 255.255.255.128
R4(config-if)# exit
R4(config)# interface Lo5
R4(config-if)#
*Mar 21 23:09:06.187: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback5, changed state to up
R4(config-if)# description R4 LAN B
R4(config-if)# ip address 192.168.4.129 255.255.255.128
R4(config-if)# exit
R4(config)# interface S1/2
R4(config-if)# description R4 --> R3
R4(config-if)# ip address 172.16.34.4 255.255.255.248
R4(config-if)# bandwidth 64
R4(config-if)# no shutdown
R4(config-if)#
*Mar 21 23:10:43.515: %LINK-3-UPDOWN: Interface Serial1/2, changed state to up
R4(config-if)#
*Mar 21 23:10:43.515: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/2 Physical Port Administrative State Down
*Mar 21 23:10:44.515: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/2, changed state to up
R4(config-if)# exit
```

c) Verify the configuration with the **show ip interface brief**, **show interfaces description** commands. The output from router R3 is shown below.

Router R3 Console

show ip interface brief | include up

```
R3# show ip interface brief | include up
Serial1/1                  172.16.23.3     YES manual up                    up
Serial1/2                  172.16.34.3     YES manual up                    up
Serial1/3                  172.16.13.3     YES manual up                    up
Loopback3                  192.168.3.1     YES manual up                    up
R3#
```

show interfaces description | include up

```
R3# show interfaces description | include up
Se1/1                          up             up        R3 --> R2
Se1/2                          up             up        R3 --> R4
Se1/3                          up             up        R3 --> R1
Lo3                            up             up        R3 LAN
R3#
```

Step 3:- Configure basic EIGRP

a) Implement EIGRP AS 1 over the serial and loopback interfaces as you have configured it for the other EIGRP labs.

b) Advertise networks 172.16.12.0/29, 172.16.13.0/29, 172.16.23.0/29, 172.16.34.0/29, 192.168.1.0/24, 192.168.2.0/24, 192.168.3.0/24, and 192.168.4.0/24 from their respective routers.

Router R1 Console

router eigrp 1

network 192.168.1.0

network 172.16.12.0 0.0.0.7

network 172.16.13.0 0.0.0.7

no auto-summary

```
R1(config)# router eigrp 1
R1(config-router)# network 192.168.1.0
R1(config-router)# network 172.16.12.0 0.0.0.7
R1(config-router)# network 172.16.13.0 0.0.0.7
R1(config-router)# no auto-summary
R1(config-router)#
```

Router R2 Console

router eigrp 1

network 192.168.2.0

network 172.16.12.0 0.0.0.7

network 172.16.23.0 0.0.0.7

no auto-summary

```
R2(config)# router eigrp 1
R2(config-router)# network 192.168.2.0
R2(config-router)# network 172.16.12.0 0.0.0.7
R2(config-router)# n
*Mar 21 23:22:59.655: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 172.16.12.1 (Serial1/0) is up: new adjacency
R2(config-router)# network 172.16.23.0 0.0.0.7
R2(config-router)# no auto-summary
```

Router R3 Console

router eigrp 1

network 192.168.3.0

network 172.16.13.0 0.0.0.7

network 172.16.23.0 0.0.0.7

network 172.16.34.0 0.0.0.7

no auto-summary

```
R3(config)# router eigrp 1
R3(config-router)# network 192.168.3.0
R3(config-router)# network 172.16.13.0 0.0.0.7
R3(config-router)#
*Mar 21 23:26:19.335: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 172.16.13.1 (Serial1/3) is up: new adjacency
R3(config-router)# network 172.16.23.0 0.0.0.7
R3(config-router)#
*Mar 21 23:26:46.083: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 172.16.23.2 (Serial1/1) is up: new adjacency
R3(config-router)# network 172.16.34.0 0.0.0.7
R3(config-router)# no auto-summary
```

Router R4 Console

router eigrp 1

network 192.168.4.0

network 172.16.34.0 0.0.0.7

no auto-summary

```
R4(config)# router eigrp 1
R4(config-router)# network 192.168.4.0
R4(config-router)# network 172.16.34.0 0.0.0.7
R4(config-router)# no
*Mar 21 23:29:36.571: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 172.16.34.3 (Serial1/2) is up: new adjacency
R4(config-router)# no auto-summary
```

Step 4:- Verify EIGRP connectivity.

a) Verify the configuration by using the **show ip eigrp neighbors** command to check which routers have EIGRP adjacencies.

Router R1 Console

show ip eigrp neighbors

```
R1# show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
1   172.16.13.3             Se1/3             10 00:05:50  100  2280  0  27
0   172.16.12.2             Se1/0             11 00:09:10   94  1140  0  22
```

Router R2 Console

show ip eigrp neighbors

```
R2# show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface        Hold Uptime   SRTT   RTO  Q  Seq
                                             (sec)         (ms)       Cnt Num
1   172.16.23.3             Se1/1              13 00:06:47  107   1140  0  26
0   172.16.12.1             Se1/0              10 00:10:33   97   1140  0  24
```

Router R3 Console

show ip eigrp neighbors

```
R3# show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface        Hold Uptime   SRTT   RTO  Q  Seq
                                             (sec)         (ms)       Cnt Num
2   172.16.34.4             Se1/2              11 00:04:44   79   2280  0  6
1   172.16.23.2             Se1/1              13 00:07:35   98   1140  0  23
0   172.16.13.1             Se1/3              12 00:08:02  103   2280  0  25
```

Router R4 Console

show ip eigrp neighbors

```
R4# show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface        Hold Uptime   SRTT   RTO  Q  Seq
                                             (sec)         (ms)       Cnt Num
0   172.16.34.3             Se1/2              12 00:05:24   81   2280  0  30
```

b) Run the following Tcl script on all routers to verify full connectivity.

Router R1 Console

R1# tclsh

foreach address {

172.16.12.1

172.16.12.2

172.16.13.1

172.16.13.3

172.16.23.2

172.16.23.3

172.16.34.3

172.16.34.4

192.168.1.1

192.168.2.1

192.168.3.1

192.168.4.1

192.168.4.129

} { ping $address }

```
R1# tclsh
R1(tcl)# foreach address {
+>(tcl)# 172.16.12.1
+>(tcl)#172.16.12.2
+>(tcl)#172.16.13.1
+>(tcl)#172.16.13.3
+>(tcl)#172.16.23.2
+>(tcl)#172.16.23.3
+>(tcl)#172.16.34.3
+>(tcl)#172.16.34.4
+>(tcl)#192.168.1.1
+>(tcl)#192.168.2.1
+>(tcl)#192.168.3.1
+>(tcl)#192.168.4.1
+>(tcl)#192.168.4.129
+>(tcl)#} { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.12.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/113/256 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.12.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/64/104 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.13.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 76/141/196 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.13.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 24/57/84 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.23.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/73/100 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.23.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 108/140/196 ms
```

Step 5:- Verify the current path.

Before you configure PBR, verify the routing table on R1.

a) On R1, use the **show ip route** command. Notice the next-hop IP address for all networks discovered by EIGRP.

Router R1 Console

show ip route | begin Gateway

```
R1# show ip route | begin Gateway
Gateway of last resort is not set

      172.16.0.0/29 is subnetted, 4 subnets
D        172.16.34.0 [90/41024000] via 172.16.13.3, 00:13:18, Serial1/3
D        172.16.23.0 [90/21024000] via 172.16.12.2, 00:13:37, Serial1/0
C        172.16.12.0 is directly connected, Serial1/0
C        172.16.13.0 is directly connected, Serial1/3
      192.168.4.0/25 is subnetted, 2 subnets
D        192.168.4.0 [90/41152000] via 172.16.13.3, 00:10:37, Serial1/3
D        192.168.4.128 [90/41152000] via 172.16.13.3, 00:10:37, Serial1/3
C     192.168.1.0/24 is directly connected, Loopback1
D     192.168.2.0/24 [90/20640000] via 172.16.12.2, 00:13:37, Serial1/0
D     192.168.3.0/24 [90/21152000] via 172.16.12.2, 00:13:37, Serial1/0
```

b) On R4, use the **traceroute** command to the R1 LAN address and source the ICMP packet from R4 LAN A and LAN B.

Note:- You can specify the source as the interface address (for example 192.168.4.1) or the interface designator (for example, Fa0/0).

Router R4 Console

traceroute 192.168.1.1 source 192.168.4.1   (R4 LAN A)

traceroute 192.168.1.1 source 192.168.4.129   (R4 LAN B)

```
R4# traceroute 192.168.1.1 source 192.168.4.1

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 172.16.34.3 64 msec 64 msec 108 msec
  2 172.16.23.2 164 msec 136 msec 144 msec
  3 172.16.12.1 248 msec 160 msec 112 msec
R4#
R4# traceroute 192.168.1.1 source 192.168.4.129

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 172.16.34.3 52 msec 76 msec 44 msec
  2 172.16.23.2 152 msec 76 msec 124 msec
  3 172.16.12.1 120 msec 192 msec 196 msec
```

Notice that the path taken for the packets sourced from the R4 LANs are going through R3 →R2 → R1.

c) On R3, use the show ip route command and note that the preferred route from R3 to R1 LAN 192.168.1.0/24 is via R2 using the R3 exit interface S1/1.

Router R3 Console

show ip route | begin Gateway

```
R3# show ip route | begin Gateway
Gateway of last resort is not set

     172.16.0.0/29 is subnetted, 4 subnets
C       172.16.34.0 is directly connected, Serial1/2
C       172.16.23.0 is directly connected, Serial1/1
D       172.16.12.0 [90/21024000] via 172.16.23.2, 00:20:42, Serial1/1
C       172.16.13.0 is directly connected, Serial1/3
     192.168.4.0/25 is subnetted, 2 subnets
D       192.168.4.0 [90/40640000] via 172.16.34.4, 00:17:43, Serial1/2
D       192.168.4.128 [90/40640000] via 172.16.34.4, 00:17:43, Serial1/2
D    192.168.1.0/24 [90/21152000] via 172.16.23.2, 00:20:42, Serial1/1
D    192.168.2.0/24 [90/20640000] via 172.16.23.2, 00:20:42, Serial1/1
C    192.168.3.0/24 is directly connected, Loopback3
```

d) On R3, use the **show interfaces S1/3** and **show interfaces S1/1** commands.

Router R3 Console

show interfaces S1/3

```
R3# show interfaces S1/3
Serial1/3 is up, line protocol is up
  Hardware is M4T
  Description: R3 --> R1
  Internet address is 172.16.13.3/29
  MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, crc 16, loopback not set
  Keepalive set (10 sec)
  Restart-Delay is 0 secs
  Last input 00:00:02, output 00:00:03, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: weighted fair
  Output queue: 0/1000/64/0 (size/max total/threshold/drops)
     Conversations  0/1/256 (active/max active/max total)
     Reserved Conversations 0/0 (allocated/max allocated)
     Available Bandwidth 48 kilobits/sec
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     784 packets input, 52753 bytes, 0 no buffer
     Received 338 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     701 packets output, 48000 bytes, 0 underruns
     0 output errors, 0 collisions, 2 interface resets
     0 output buffer failures, 0 output buffers swapped out
     2 carrier transitions     DCD=up  DSR=up  DTR=up  RTS=up  CTS=up
```

Router R3 Console

show interfaces S1/1

```
R3# show interfaces S1/1
Serial1/1 is up, line protocol is up
  Hardware is M4T
  Description: R3 --> R2
  Internet address is 172.16.23.3/29
  MTU 1500 bytes, BW 128 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, crc 16, loopback not set
  Keepalive set (10 sec)
  Restart-Delay is 0 secs
  Last input 00:00:00, output 00:00:04, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: weighted fair
  Output queue: 0/1000/64/0 (size/max total/threshold/drops)
     Conversations  0/1/256 (active/max active/max total)
     Reserved Conversations 0/0 (allocated/max allocated)
     Available Bandwidth 96 kilobits/sec
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     753 packets input, 49853 bytes, 0 no buffer
     Received 344 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     713 packets output, 47351 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 output buffer failures, 0 output buffers swapped out
     2 carrier transitions     DCD=up  DSR=up  DTR=up  RTS=up  CTS=up
```

Notice that the bandwidth of the serial link between R3 and R1 (S1/3) is set to 64 Kb/s, while the bandwidth of the serial link between R3 and R2 (S1/1) is set to 128 Kb/s.

e) Confirm that R3 has a valid route to reach R1 from its serial 0/0/0 interface using the **show ip eigrp topology 192.168.1.0** command.

Router R3 Console

show ip eigrp topology 192.168.1.0

```
R3# show ip eigrp topology 192.168.1.0
IP-EIGRP (AS 1): Topology entry for 192.168.1.0/24
  State is Passive, Query origin flag is 1, 1 Successor(s), FD is 21152000
  Routing Descriptor Blocks:
  172.16.23.2 (Serial1/1), from 172.16.23.2, Send flag is 0x0
      Composite metric is (21152000/20640000), Route is Internal
      Vector metric:
        Minimum bandwidth is 128 Kbit
        Total delay is 45000 microseconds
        Reliability is 255/255
        Load is 1/255
        Minimum MTU is 1500
        Hop count is 2
  172.16.13.1 (Serial1/3), from 172.16.13.1, Send flag is 0x0
      Composite metric is (40640000/128256), Route is Internal
      Vector metric:
        Minimum bandwidth is 64 Kbit
        Total delay is 25000 microseconds
        Reliability is 255/255
        Load is 1/255
        Minimum MTU is 1500
        Hop count is 1
```

As indicated, R4 has two routes to reach 192.168.1.0. However, the metric for the route to R1 (172.16.13.1) is much higher (40640000) than the metric of the route to R2 (21152000), making the route through R2 the successor route.

Step 6:- Configure PBR to provide path control.

Now you will deploy source-based IP routing by using PBR. You will change a default IP routing decision based on the EIGRP-acquired routing information for selected IP source-to-destination flows and apply a different next-hop router.

Recall that routers normally forward packets to destination addresses based on information in their routing table. By using PBR, you can implement policies that selectively cause packets to take different paths based on source address, protocol type, or application type. Therefore, PBR overrides the router's normal routing behavior.

Configuring PBR involves configuring a route map with match and set commands and then applying the route map to the interface.

a) On router R3, create a standard access list called **PBR-ACL** to identify the R4 LAN B network.

Router R3 Console

ip access-list standard PBR-ACL

remark ACL matches R4 LAN B traffic

permit 192.168.4.128 0.0.0.127

exit

```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
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)#
```

b) Create a route map called **R3-to-R1** that matches PBR-ACL and sets the next-hop interface to the R1 S1/1 interface.

Router R3 Console

route-map R3-to-R1 permit

description RM to forward LAN B traffic to R1

match ip address PBR-ACL

set ip next-hop 172.16.13.1

exit

```
R3(config)# route-map R3-to-R1 permit
R3(config-route-map)# description RM to forward LAN B traffic to R1
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)# exit
R3(config)#
```

c) Apply the R3-to-R1 route map to the serial interface on R3 that receives the traffic from R4. Use the **ip policy route-map** command on interface S1/2.

Router R3 Console

interface S1/2

ip policy route-map R3-to-R1

end

```
R3(config)# interface S1/2
R3(config-if)# ip policy route-map R3-to-R1
R3(config-if)# end
R3#
```

d) On R3, display the policy and matches using the **show route-map** command.

Router R3 Console

show route-map

```
R3# show 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#
```

Note:- There are currently no matches because no packets matching the ACL have passed through R3 S1/2.

Step 7:- Test the policy.

Now we are ready to test the policy configured on R3. Enable the **debug ip policy** command on R3 so that you can observe the policy decision-making in action. To help filter the traffic, first create a standard ACL that identifies all traffic from the R4 LANs.

a) On R3, create a standard ACL which identifies all of the R4 LANs.

Router R3 Console

access-list 1 permit 192.168.4.0 0.0.0.255

exit

```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# access-list 1 permit 192.168.4.0 0.0.0.255
R3(config)# exit
R3#
```

b) Enable PBR debugging only for traffic that matches the R4 LANs.

Router R3 Console

debug ip policy ?

debug ip policy 1

```
R3# debug ip policy ?
  <1-199>   Access list
  dynamic   dynamic PBR
  <cr>

R3# debug ip policy 1
Policy routing debugging is on for access list 1
R3#
```

c) Test the policy from R4 with the traceroute command, using R4 LAN A as the source network.

Router R4 Console

traceroute 192.168.1.1 source 192.168.4.1

```
R4# traceroute 192.168.1.1 source 192.168.4.1

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 172.16.34.3 56 msec 64 msec 84 msec
  2 172.16.23.2 160 msec 116 msec 140 msec
  3 172.16.12.1 208 msec 196 msec 112 msec
```

Notice the path taken for the packet sourced from R4 LAN A is still going through R3 → R2 → R1.

As the traceroute was being executed, router R3 should be generating the following debug output.

```
R3#
*Mar 22 00:16:32.679: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1, len 28, FIB policy rejected(no match) - no
rmal forwarding
*Mar 22 00:16:32.879: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1, len 28, FIB policy rejected(no match) - no
rmal forwarding
*Mar 22 00:16:32.979: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1, len 28, FIB policy rejected(no match) - no
rmal forwarding
*Mar 22 00:16:33.119: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1, len 28, FIB policy rejected(no match) - no
rmal forwarding
*Mar 22 00:16:33.307: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1, len 28, FIB policy rejected(no match) - no
rmal forwarding
R3#
*Mar 22 00:16:33.527: IP: s=192.168.4.1 (Serial1/2), d=192.168.1.1, len 28, FIB policy rejected(no match) - no
rmal forwarding
```

d) Test the policy from R4 with the **traceroute** command, using R4 LAN B as the source network.

Router R4 Console

traceroute 192.168.1.1 source 192.168.4.129

```
R4# traceroute 192.168.1.1 source 192.168.4.129

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 172.16.34.3 52 msec 76 msec 92 msec
  2 172.16.13.1 140 msec 200 msec 96 msec
R4#
```

Now the path taken for the packet sourced from R4 LAN B is R3 → R1, as expected.

The debug output on R3 also confirms that the traffic meets the criteria of the R3-to-R1 policy.

```
R3#
*Mar 22 00:19:47.851: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1, len 28, FIB policy match
*Mar 22 00:19:47.851: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1, g=172.16.13.1, len 28, FIB policy routed
*Mar 22 00:19:48.031: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1, len 28, FIB policy match
*Mar 22 00:19:48.035: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1, g=172.16.13.1, len 28, FIB policy routed
*Mar 22 00:19:48.223: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1, len 28, FIB policy match
*Mar 22 00:19:48.223: IP: s=192.168.4.129 (Serial1/2), d=192.168.1.1, g=172.16.13.1, len 28, FIB policy routed
R3#
```

e) On R3, display the policy and matches using the show route-map command.

Router R3 Console

show route-map

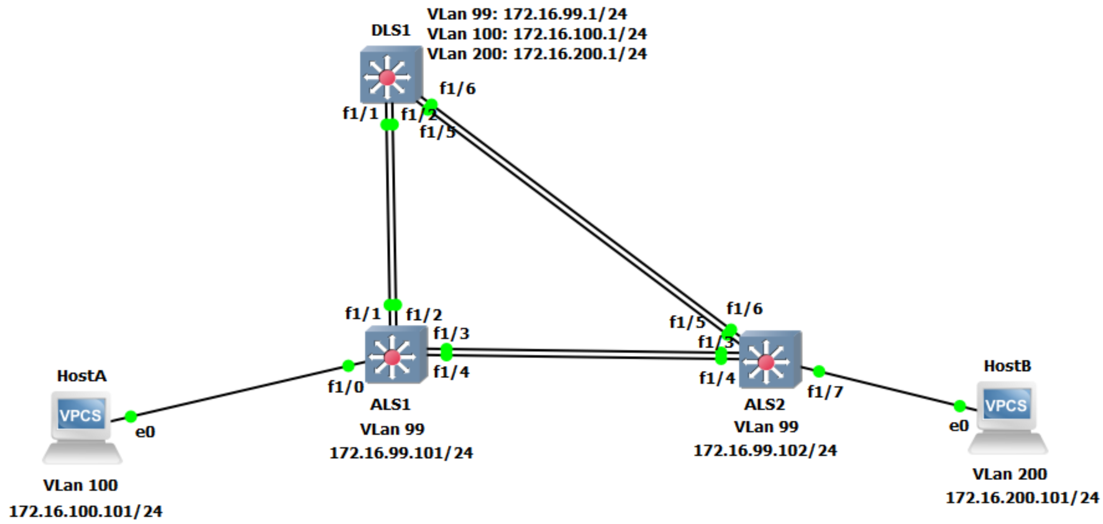
```
R3# show route-map
route-map R3-to-R1, permit, sequence 10
  Match clauses:
    ip address (access-lists): PBR-ACL
  Set clauses:
    ip next-hop 172.16.13.1
  Policy routing matches: 3 packets, 96 bytes
```

Note:- There are now matches to the policy because packets matching the ACL have passed through R3 S1/2.

Practical 6

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

Topology:-



Part 1: Prepare for the Lab

Step 1: Configure basic switch parameters.

Configure an IP address on the management VLAN according to the diagram. VLAN 1 is the default management VLAN, but following best practice, we will use a different VLAN. In this case, VLAN 99.

Enter basic configuration commands on each switch according to the diagram.

DSL1 Console:

interface vlan 99

ip address 172.16.99.1 255.255.255.0

no shutdown

enable secret password

line vty 0 15

no login

privilege level 15

```
DLS1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
DLS1(config)# interface vlan 99
DLS1(config-if)# ip address 172.16.99.1 255.255.255.0
DLS1(config-if)# no shutdown
```

```
DLS1(config)# enable secret password
DLS1(config)# line vty 0 15
DLS1(config-line)# no login
DLS1(config-line)# privilege level 15
```

ALS1 Console:

interface vlan 99

ip address 172.16.99.101 255.255.255.0

no shutdown

exit

enable secret password

line vty 0 15

no login

privilege level 15

```
ALS1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
ALS1(config)# interface vlan 99
ALS1(config-if)# ip address 172.16.99.101 255.255.255.0
ALS1(config-if)#no shutdown
ALS1(config-if)#exit
ALS1(config)#enable secret password
ALS1(config)#line vty 0 15
ALS1(config-line)#no login
ALS1(config-line)#privilege level 15
```

ALS2 Console:

interface vlan 99

ip address 172.16.99.102 255.255.255.0

no shutdown

exit

enable secret password

line vty 0 15

no login

privilege level 15

```
ALS2(config)# interface vlan 99
ALS2(config-if)# ip address 172.16.99.102 255.255.255.0
ALS2(config-if)#no shutdown
ALS2(config-if)#exit
ALS2(config)#enable secret password
ALS2(config)#line vty 0 15
ALS2(config-line)#no login
ALS2(config-line)#privilege level 15
```

Configure default gateways on ALS1 and ALS2. These are access layer switches operating as Layer 2 devices and need a default gateway to send traffic from their management interface to other networks. Configure both ALS1 and ALS2.

ALS1 Console:

ip default-gateway 172.16.99.1

ALS2 Console:

ip default-gateway 172.16.99.1

Step 2: Configure host PCs.

Configure PCs Host A and Host B with the IP address and subnet mask shown in the topology. Host A is in VLAN 100 with a default gateway of 172.16.100.1. Host B is in VLAN 200 with a default gateway of 172.16.200.1.

hostA Console:

ip 172.16.100.101/24 172.16.100.1

```
HostA> ip 172.16.100.101/24 172.16.100.1
Checking for duplicate address...
PC1 : 172.16.100.101 255.255.255.0 gateway 172.16.100.1
```

hostB Console:

ip 172.16.200.101/24 172.16.200.1

Step 3: Configure trunks and EtherChannels between switches.

Configure the trunks and EtherChannel from DLS1 to ALS1

DLS1 Console:

vlan 666

name NATIVE_DO_NOT_USE

exit

interface ran f 1/1 – 2

switchport trunk encapsulation dot1q

switchport mode trunk

channel-group 1 mode on

no shutdown

exit

```
DLS1(config)# interface ran f 1/1 - 2
DLS1(config-if-range)# switchport trunk encapsulation dot1q
DLS1(config-if-range)# switchport mode trunk
DLS1(config-if-range)#
*Mar  1 00:42:59.543: %DTP-5-TRUNKPORTON: Port Fa1/1 has become dot1q trunk
*Mar  1 00:43:00.371: %DTP-5-TRUNKPORTON: Port Fa1/2 has become dot1q trunk
DLS1(config-if-range)# channel-group 1 mode on
Creating a port-channel interface Port-channel1
DLS1(config-if-range)#
*Mar  1 00:43:25.531: %EC-5-BUNDLE: Interface Fa1/1 joined port-channel Po1
*Mar  1 00:43:25.943: %EC-5-BUNDLE: Interface Fa1/2 joined port-channel Po1
DLS1(config-if-range)#
*Mar  1 00:43:28.375: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-chann
el1, changed state to up
DLS1(config-if-range)# no shutdown
DLS1(config-if-range)# exit
```

Configure the trunks and EtherChannel from DLS1 to ALS2

DLS1 Console:

interface ran f 1/5 – 6

switchport trunk encapsulation dot1q

switchport mode trunk

channel-group 2 mode on

no shutdown

exit

```
DLS1(config)# interface ran f 1/5 - 6
DLS1(config-if-range)# switchport trunk encapsulation dot1q
DLS1(config-if-range)# switchport mode trunk
DLS1(config-if-range)#
*Mar  1 00:48:58.619: %DTP-5-TRUNKPORTON: Port Fa1/5-6 has become dot1q trunk
DLS1(config-if-range)# channel-group 2 mode on
Creating a port-channel interface Port-channel2
DLS1(config-if-range)#
*Mar  1 00:49:25.219: %EC-5-BUNDLE: Interface Fa1/5 joined port-channel Po2
*Mar  1 00:49:25.627: %EC-5-BUNDLE: Interface Fa1/6 joined port-channel Po2
DLS1(config-if-range)#
*Mar  1 00:49:28.067: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-chann
el2, changed state to up
DLS1(config-if-range)# no shutdown
DLS1(config-if-range)# exit
```

Configure the trunks and EtherChannel from ALS1 and DLS1

ALS1 Console:

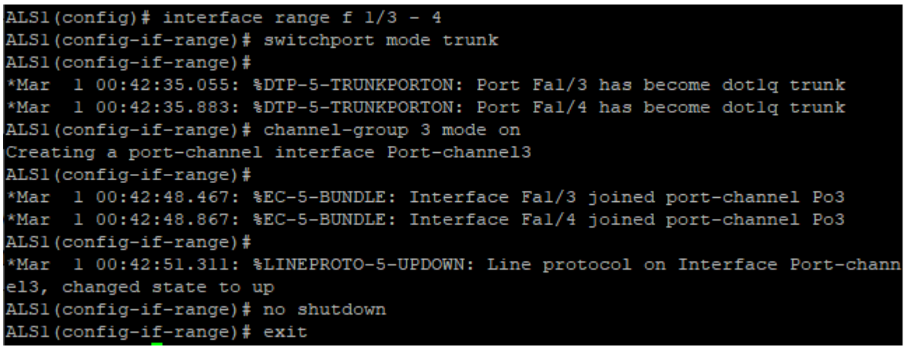
interface range f 1/3 – 4

switchport mode trunk

channel-group 3 mode on

no shutdown

exit



```
ALS1(config)# interface range f 1/3 - 4
ALS1(config-if-range)# switchport mode trunk
ALS1(config-if-range)#
*Mar  1 00:42:35.055: %DTP-5-TRUNKPORTON: Port Fa1/3 has become dot1q trunk
*Mar  1 00:42:35.883: %DTP-5-TRUNKPORTON: Port Fa1/4 has become dot1q trunk
ALS1(config-if-range)# channel-group 3 mode on
Creating a port-channel interface Port-channel3
ALS1(config-if-range)#
*Mar  1 00:42:48.467: %EC-5-BUNDLE: Interface Fa1/3 joined port-channel Po3
*Mar  1 00:42:48.867: %EC-5-BUNDLE: Interface Fa1/4 joined port-channel Po3
ALS1(config-if-range)#
*Mar  1 00:42:51.311: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-chann
el3, changed state to up
ALS1(config-if-range)# no shutdown
ALS1(config-if-range)# exit
```

Configure the trunks and EtherChannel from ALS1 and ALS2

ALS1 Console:

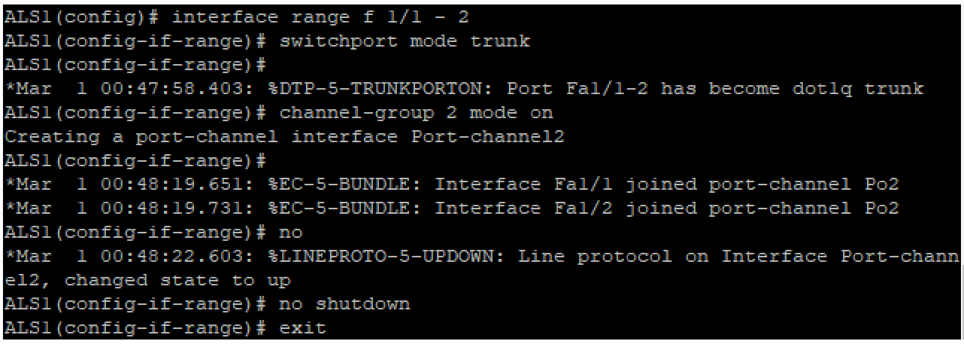
interface range f 1/1 – 2

switchport mode trunk

channel-group 2 mode on

no shutdown

exit



```
ALS1(config)# interface range f 1/1 - 2
ALS1(config-if-range)# switchport mode trunk
ALS1(config-if-range)#
*Mar  1 00:47:58.403: %DTP-5-TRUNKPORTON: Port Fa1/1-2 has become dot1q trunk
ALS1(config-if-range)# channel-group 2 mode on
Creating a port-channel interface Port-channel2
ALS1(config-if-range)#
*Mar  1 00:48:19.651: %EC-5-BUNDLE: Interface Fa1/1 joined port-channel Po2
*Mar  1 00:48:19.731: %EC-5-BUNDLE: Interface Fa1/2 joined port-channel Po2
ALS1(config-if-range)# no
*Mar  1 00:48:22.603: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-chann
el2, changed state to up
ALS1(config-if-range)# no shutdown
ALS1(config-if-range)# exit
```

Configure the trunks and EtherChannel from ALS2 and DLS1

ALS2 Console:

interface range f 1/3 – 4

switchport mode trunk

channel-group 3 mode on

no shutdown

exit

```
ALS2(config)# interface range f 1/3 - 4
ALS2(config-if-range)# switchport mode trunk
ALS2(config-if-range)#
*Mar  1 00:48:45.279: %DTP-5-TRUNKPORTON: Port Fa1/3-4 has become dot1q trunk
ALS2(config-if-range)# channel-group 3 mode on
Creating a port-channel interface Port-channel3
ALS2(config-if-range)#
*Mar  1 00:48:56.863: %EC-5-BUNDLE: Interface Fa1/3 joined port-channel Po3
*Mar  1 00:48:56.907: %EC-5-BUNDLE: Interface Fa1/4 joined port-channel Po3
ALS2(config-if-range)#
*Mar  1 00:48:59.747: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-chann
el3, changed state to up
ALS2(config-if-range)# no shutdown
ALS2(config-if-range)# exit
```

Configure the trunks and EtherChannel from ALS2 and ALS1

interface range f 1/5 – 6

switchport mode trunk

channel-group 2 mode on

no shutdown

exit

```
ALS2(config)# interface range f 1/5 - 6
ALS2(config-if-range)# switchport mode trunk
ALS2(config-if-range)#
*Mar  1 00:51:25.623: %DTP-5-TRUNKPORTON: Port Fa1/5-6 has become dot1q trunk
ALS2(config-if-range)# channel-group 2 mode on
Creating a port-channel interface Port-channel2
ALS2(config-if-range)#
*Mar  1 00:51:45.295: %EC-5-BUNDLE: Interface Fa1/5 joined port-channel Po2
*Mar  1 00:51:45.311: %EC-5-BUNDLE: Interface Fa1/6 joined port-channel Po2
ALS2(config-if-range)#
*Mar  1 00:51:48.231: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-chann
el2, changed state to up
ALS2(config-if-range)# no shutdown
ALS2(config-if-range)# exit
```

Step 4: Configure VTP on ALS1 and ALS2.

ALS1 Console:

vtp mode client

```
ALS1(config)# vtp mode client
Setting device to VTP CLIENT mode.
```

ALS2 Console:

vtp mode client

```
ALS2(config)# vtp mode client
Setting device to VTP CLIENT mode.
```

Step 5: Configure VTP on DLS1.

Create the VTP domain on DLS1, and create VLANs 100 and 200 for the domain.

vtp domain SWPOD

vtp version 2

vlan 99

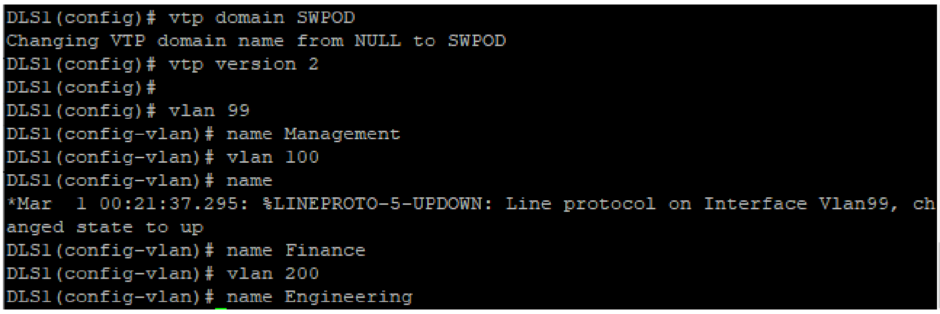
name Management

vlan 100

name Finance

vlan 200

name Engineering



```
DLS1(config)# vtp domain SWPOD
Changing VTP domain name from NULL to SWPOD
DLS1(config)# vtp version 2
DLS1(config)#
DLS1(config)# vlan 99
DLS1(config-vlan)# name Management
DLS1(config-vlan)# vlan 100
DLS1(config-vlan)# name
*Mar  1 00:21:37.295: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan99, ch
anged state to up
DLS1(config-vlan)# name Finance
DLS1(config-vlan)# vlan 200
DLS1(config-vlan)# name Engineering
```

Step 6: Configure access ports.

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

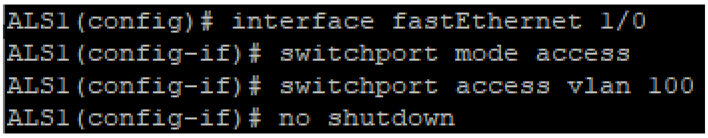
ALS1 Console:

interface fastEthernet 1/0

switchport mode access

switchport access vlan 100

no shutdown



```
ALS1(config)# interface fastEthernet 1/0
ALS1(config-if)# switchport mode access
ALS1(config-if)# switchport access vlan 100
ALS1(config-if)# no shutdown
```

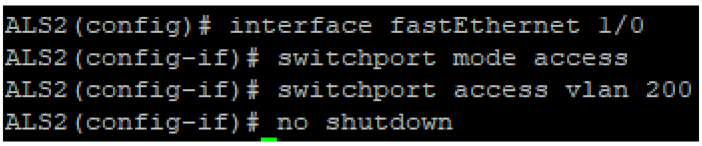
ALS2 Console:

interface fastEthernet 1/0

switchport mode access

switchport access vlan 200

no shutdown



```
ALS2(config)# interface fastEthernet 1/0
ALS2(config-if)# switchport mode access
ALS2(config-if)# switchport access vlan 200
ALS2(config-if)# no shutdown
```

Step 7: Configure VLAN interfaces and enable routing.

DLS1 Console:

interface vlan 100

ip address 172.16.100.1 255.255.255.0

exit

interface vlan 200

ip address 172.16.200.1 255.255.255.0

exit

ip routing

```
DLS1(config)# interface vlan 100
DLS1(config-if)#
*Mar  1 00:36:52.047: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan100, c
hanged state to up
DLS1(config-if)# ip address 172.16.100.1 255.255.255.0
DLS1(config-if)# exit
DLS1(config)# interface vlan 200
DLS1(config-if)#
*Mar  1 00:37:24.907: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan200, c
hanged state to up
DLS1(config-if)# ip address 172.16.200.1 255.255.255.0
DLS1(config-if)# exit
DLS1(config)# ip routing
DLS1(config)#
*Mar  1 00:37:48.983: %IP-4-DUPADDR: Duplicate address 172.16.99.1 on Vlan99, so
urced by c202.07c0.0000
```

Verify the configuration using the show ip route command on DLS1.

DLS1 Console:

show ip route | begin Gateway

```
DLS1# show ip route | begin Gateway
Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 3 subnets
C       172.16.200.0 is directly connected, Vlan200
C       172.16.100.0 is directly connected, Vlan100
C       172.16.99.0 is directly connected, Vlan99
DLS1#
```

Run the following Tcl script on DLS1 to verify full connectivity. If these pings are not successful, troubleshoot.

DLS1 Console:

tclsh

foreach address {

172.16.99.1

172.16.99.101

172.16.99.102

172.16.100.1

172.16.200.1

172.16.100.101

172.16.200.101

} { ping $address }

```
DLS1# tclsh
DLS1(tcl)# foreach address {
+>172.16.99.1
+>172.16.99.101
+>172.16.99.102
+>172.16.100.1
+>172.16.200.1
+>172.16.100.101
+>172.16.200.101
+>} { ping $address }

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.99.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.99.101, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 28/276/1004 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.99.102, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 16/278/1024 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.100.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/4 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.200.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.100.101, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 12/16/20 ms
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.200.101, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 4/14/28 ms
```

Part 2: Configure Cisco IOS IP SLA

Step 1: Configure Cisco IOS IP SLA responders.

Use the ip sla responder command on ALS1 and ALS2 to enable sending and receiving IP SLAs control packets.

ALS1 Console:

ip sla responder

```
ALS1(config)# ip sla responder
```

ALS2 Console:

ip sla responder

```
ALS2(config)# ip sla responder
```

Configure ALS1 and ALS2 as IP SLA responders for UDP jitter using the ip sla responder udp-echo ipaddress command. Specify the IP address of DLS1 VLAN 1 to act as the destination IP address for the reflected UDP traffic on both ALS1 and ALS2. Configure this on both ALS1 and ALS2.

ALS1 Console:

ip sla responder udp-echo ipaddress 172.16.99.101 port 5000

```
ALS1(config)# ip sla responder udp-echo ipaddress 172.16.99.1 port 5000
```

ALS2 Console:

ip sla responder udp-echo ipaddress 172.16.99.102 port 5000

```
ALS2(config)# ip sla responder udp-echo ipaddress 172.16.99.1 port 5000
```

Step 2: Configure the Cisco IOS IP SLA source to measure network performance.

On DLS1, create an IP SLA operation and enter IP SLA configuration mode with the ip sla operation-number command.

DLS1 Console:

ip sla 1

```
DLS1(config)# ip sla 1
DLS1(config-ip-sla)#
```

Configure an IP SLA ICMP echo operation using the icmp-echo command in IP SLA configuration mode. On DLS1, for ICMP echo operation 1, specify the IP address of Host A as the target. For ICMP echo operation 2, specify the IP address of Host B as the target.

DLS1 Console:

icmp-echo 172.16.100.101

exit

ip sla 2

icmp-echo 172.16.200.101

exit

```
DLS1(config-ip-sla)# icmp-echo 172.16.100.101
DLS1(config-ip-sla-echo)#
*Mar  1 01:02:31.423: %IP-4-DUPADDR: Duplicate address 172.16.99.1 on Vlan99, so
urced by c203.1654.0000
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)#
*Mar  1 01:03:01.423: %IP-4-DUPADDR: Duplicate address 172.16.99.1 on Vlan99, so
urced by c203.1654.0000
DLS1(config-ip-sla-echo)# exit
```

To configure an IP SLA UDP jitter operation, use the udp-jitter command in IP SLA configuration mode. For UDP jitter operation 3, specify the destination IP address of the ALS1 VLAN 99 interface as the target. For operation 4, specify the destination IP address of the ALS2 VLAN 99 interface as the target. The IP SLA communication port is 5000 for both operations.

DLS1 Console:

ip sla 3

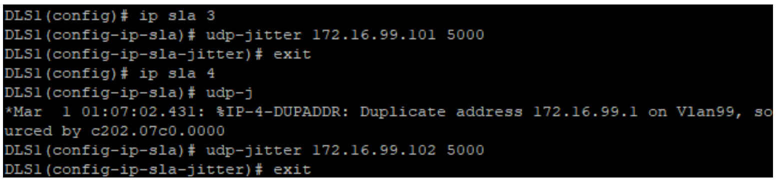
udp-jitter 172.16.99.101 5000

exit

ip sla 4

udp-jitter 172.16.99.102 5000

exit



```
DLS1(config)# ip sla 3
DLS1(config-ip-sla)# udp-jitter 172.16.99.101 5000
DLS1(config-ip-sla-jitter)# exit
DLS1(config)# ip sla 4
DLS1(config-ip-sla)# udp-j
*Mar  1 01:07:02.431: %IP-4-DUPADDR: Duplicate address 172.16.99.1 on Vlan99, so
urced by c202.07c0.0000
DLS1(config-ip-sla)# udp-jitter 172.16.99.102 5000
DLS1(config-ip-sla-jitter)# exit
```

Schedule the IP SLAs operations to run indefinitely beginning immediately using the ip sla schedule global configuration mode command.

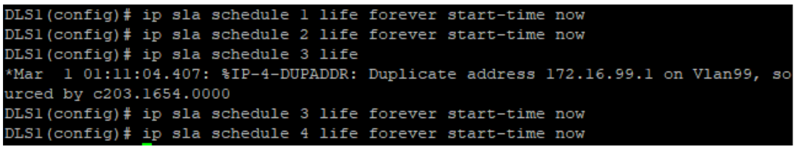
DLS1 Console:

ip sla schedule 1 life forever start-time now

ip sla schedule 2 life forever start-time now

ip sla schedule 3 life forever start-time now

ip sla schedule 4 life forever start-time now



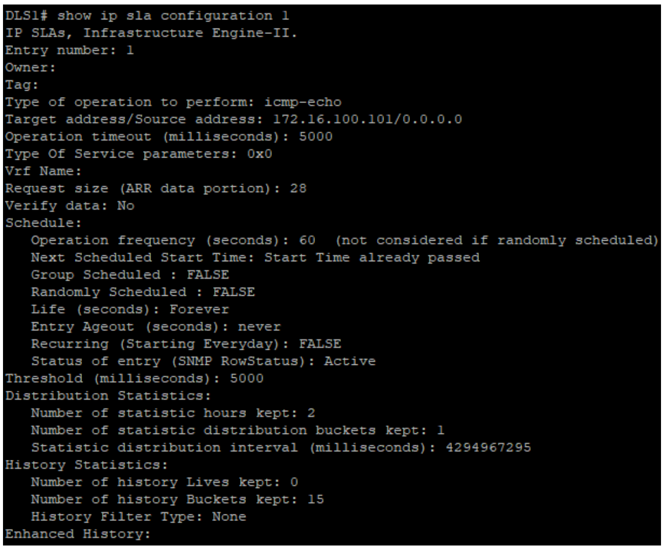
```
DLS1(config)# ip sla schedule 1 life forever start-time now
DLS1(config)# ip sla schedule 2 life forever start-time now
DLS1(config)# ip sla schedule 3 life
*Mar  1 01:11:04.407: %IP-4-DUPADDR: Duplicate address 172.16.99.1 on Vlan99, so
urced by c203.1654.0000
DLS1(config)# ip sla schedule 3 life forever start-time now
DLS1(config)# ip sla schedule 4 life forever start-time now
```

Step 3: Monitor IP SLAs operations.

View the IP SLA configuration for IP SLA 1 on DLS1. The output for IP SLA 2 is similar.

DLS1 Console:

show ip sla configuration 1



```
DLS1# show ip sla configuration 1
IP SLAs, Infrastructure Engine-II.
Entry number: 1
Owner:
Tag:
Type of operation to perform: icmp-echo
Target address/Source address: 172.16.100.101/0.0.0.0
Operation timeout (milliseconds): 5000
Type Of Service parameters: 0x0
Vrf Name:
Request size (ARR data portion): 28
Verify data: No
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): 4294967295
History Statistics:
   Number of history Lives kept: 0
   Number of history Buckets kept: 15
   History Filter Type: None
Enhanced History:
```

View the IP SLA configuration for IP SLA 3 on DLS1. The output for IP SLA 4 is similar.

DLS1 Console:

show ip sla configuration 3

```
DLS1# show ip sla configuration 3
IP SLAs, Infrastructure Engine-II.
Entry number: 3
Owner:
Tag:
Type of operation to perform: udp-jitter
Target address/Source address: 172.16.99.101/0.0.0.0
Target port/Source port: 5000/0
Request size (ARR data portion): 32
Operation timeout (milliseconds): 5000
Packet Interval (milliseconds)/Number of packets: 20/10
Type Of Service parameters: 0x0
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
 --More--
*Mar  1 01:16:36.475: %IP-4-DUPADDR: Duplicate address 172.16.99.1 on Vlan99, so
urced by c203.1654.0000
Threshold (milliseconds): 5000
Distribution Statistics:
   Number of statistic hours kept: 2
   Number of statistic distribution buckets kept: 1
   Statistic distribution interval (milliseconds): 4294967295
Enhanced History:
```

Display global information about Cisco IOS IP SLAs on DLS1.

DLS1 Console:

show ip sla application

```
DLS1# show ip sla application
        IP Service Level Agreements
Version: Round Trip Time MIB 2.2.0, Infrastructure Engine-II
Time of last change in whole IP SLAs: *01:11:25.347 UTC Fri Mar 1 2002
Estimated system max number of entries: 23751

Estimated number of configurable operations: 23747
Number of Entries configured  : 4
Number of active Entries      : 4
Number of pending Entries     : 0
Number of inactive Entries    : 0

        Supported Operation Types
Type of Operation to Perform: dhcp
Type of Operation to Perform: dlsw
Type of Operation to Perform: dns
Type of Operation to Perform: echo
Type of Operation to Perform: frameRelay
Type of Operation to Perform: ftp
Type of Operation to Perform: http
Type of Operation to Perform: icmpJitter
Type of Operation to Perform: jitter
Type of Operation to Perform: lspGroup
Type of Operation to Perform: lspPing
Type of Operation to Perform: lspTrace
Type of Operation to Perform: pathEcho
Type of Operation to Perform: pathJitter
Type of Operation to Perform: rtp
Type of Operation to Perform: slm atm interface
Type of Operation to Perform: slm atm pvc
Type of Operation to Perform: slm controller
Type of Operation to Perform: slm frame-relay interface
Type of Operation to Perform: slm frame-relay pvc
Type of Operation to Perform: slm interface
Type of Operation to Perform: tcpConnect
Type of Operation to Perform: udpEcho
Type of Operation to Perform: voip

IP SLAs low memory water mark: 32434654
```

Display information about Cisco IOS IP SLA responders on ALS1. The ALS2 output is similar.

ALS1 Console:

show ip sla responder

```
ALS1# show ip sla responder
IP SLAs Responder is: Enabled
Number of control message received: 3 Number of errors: 0
Recent sources:
        172.16.99.1 [00:22:13.095 UTC Fri Mar 1 2002]
        172.16.99.1 [00:21:13.067 UTC Fri Mar 1 2002]
        172.16.99.1 [00:20:13.071 UTC Fri Mar 1 2002]
Recent error sources:

udpEcho Responder:
  IP Address              Port
  172.16.99.101           5000
```

Display IP SLA statistics on DLS1 for IP SLA 1. The IP SLA 2 output is similar.

DLS1 Console:

show ip sla statistics 1

```
DLS1# show ip sla statistics 1

Round Trip Time (RTT) for       Index 1
        Latest RTT: 16 milliseconds
Latest operation start time: *01:21:47.331 UTC Fri Mar 1 2002
Latest operation return code: OK
Number of successes: 12
Number of failures: 0
Operation time to live: Forever
```

Display IP SLA statistics on DLS1 for IP SLA 3. The IP SLA 4 output is similar.

DLS1 Console:

show ip sla statistics 3

```
DLS1# show ip sla statistics 3

Round Trip Time (RTT) for       Index 3
        Latest RTT: 62 milliseconds
Latest operation start time: *00:24:32.871 UTC Fri Mar 1 2002
Latest operation return code: OK
RTT Values:
        Number Of RTT: 10               RTT Min/Avg/Max: 14/62/124 milliseconds
Latency one-way time:
        Number of Latency one-way Samples: 0
        Source to Destination Latency one way Min/Avg/Max: 0/0/0 milliseconds
        Destination to Source Latency one way Min/Avg/Max: 0/0/0 milliseconds
Jitter Time:
        Number of SD Jitter Samples: 0
        Number of DS Jitter Samples: 0
        Source to Destination Jitter Min/Avg/Max: 0/0/0 milliseconds
        Destination to Source Jitter Min/Avg/Max: 0/0/0 milliseconds
Packet Loss Values:
        Loss Source to Destination: 0           Loss Destination to Source: 0
        Out Of Sequence: 0      Tail Drop: 10
        Packet Late Arrival: 0  Packet Skipped: 0
Voice Score Values:
        Calculated Planning Impairment Factor (ICPIF): 0
        Mean Opinion Score (MOS): 0
Number of successes: 4
Number of failures: 0
Operation time to live: Forever
```

Disable interface VLAN 99 on ALS1 using the shutdown command.

ALS1 Console:

interface vlan 99

shutdown

```
ALS1(config)# interface vlan 99
ALS1(config-if)# shutdown
```

Allow a few minutes to pass and then issue the show ip sla statistics 3 command on DLS1. The output should look similar to the following.

DLS1 Console:

show ip sla statistics 3

```
DLS1# show ip sla statistics 3

Round Trip Time (RTT) for       Index 3
        Latest RTT: 71 milliseconds
Latest operation start time: *00:25:32.839 UTC Fri Mar 1 2002
Latest operation return code: OK
RTT Values:
        Number Of RTT: 10               RTT Min/Avg/Max: 32/71/120 milliseconds
Latency one-way time:
        Number of Latency one-way Samples: 0
        Source to Destination Latency one way Min/Avg/Max: 0/0/0 milliseconds
        Destination to Source Latency one way Min/Avg/Max: 0/0/0 milliseconds
Jitter Time:
        Number of SD Jitter Samples: 0
        Number of DS Jitter Samples: 0
        Source to Destination Jitter Min/Avg/Max: 0/0/0 milliseconds
        Destination to Source Jitter Min/Avg/Max: 0/0/0 milliseconds
Packet Loss Values:
        Loss Source to Destination: 0           Loss Destination to Source: 0
        Out Of Sequence: 0      Tail Drop: 10
        Packet Late Arrival: 0  Packet Skipped: 0
Voice Score Values:
        Calculated Planning Impairment Factor (ICPIF): 0
        Mean Opinion Score (MOS): 0
Number of successes: 5
Number of failures: 0
Operation time to live: Forever
```

Part 3: Switch Port Analyzer (SPAN) Feature.

Step 1: Configure Remote SPAN (RSPAN).

Create the RSPAN VLAN on DLS1 using the VLAN 300 command from global configuration mode.

DLS1 Console:

vlan 300

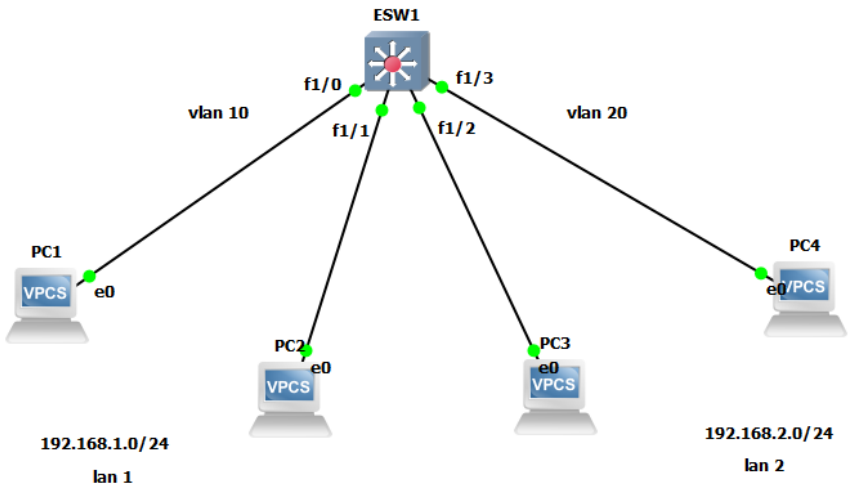
name REMOTE_SPAN

remote-span

Practical 7

Aim:- Inter-VLAN Routing.

Topology:-



Configuration for PC1:

ip 192.168.1.1/24

```
PC1> ip 192.168.1.1/24
Checking for duplicate address...
PC1 : 192.168.1.1 255.255.255.0
```

Configuration for PC2:

ip 192.168.1.2/24

```
PC2> ip 192.168.1.2/24
Checking for duplicate address...
PC1 : 192.168.1.2 255.255.255.0
```

Configuration for PC3:

ip 192.168.2.1/24

```
PC3> ip 192.168.2.1
Checking for duplicate address...
PC1 : 192.168.2.1 255.255.255.0
```

Configuration for PC4:

ip 192.168.2.2/24

```
PC4> ip 192.168.2.2/24
Checking for duplicate address...
PC1 : 192.168.2.2 255.255.255.0
```

Configuration for EtherSwitch:

vlan database

vlan 10

vlan 20

```
ESW1# vlan database
ESW1(vlan)# vlan 10
VLAN 10 added:
    Name: VLAN0010
ESW1(vlan)# vlan 20
VLAN 20 added:
    Name: VLAN0020
```

show vlan-switch

```
ESW1# show vlan-switch

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa1/0, Fa1/1, Fa1/2, Fa1/3
                                                Fa1/4, Fa1/5, Fa1/6, Fa1/7
                                                Fa1/8, Fa1/9, Fa1/10, Fa1/11
                                                Fa1/12, Fa1/13, Fa1/14, Fa1/15
10   VLAN0010                         active
20   VLAN0020                         active
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
1    enet  100001     1500  -      -      -        -    -        1002   1003
10   enet  100010     1500  -      -      -        -    -        0      0
20   enet  100020     1500  -      -      -        -    -        0      0
1002 fddi  101002     1500  -      -      -        -    -        1      1003
1003 tr    101003     1500  1005   0      -        -    srb      1      1002
1004 fdnet 101004     1500  -      -      1        ibm  -        0      0
1005 trnet 101005     1500  -      -      1        ibm  -        0      0
```

interface f1/0

switchport mode access

switchport access vlan 10

exit

interface f1/1

switchport mode access

switchport access vlan 10

exit

interface f1/2

switchport mode access

switchport access vlan 20

exit

interface f1/3

switchport mode access

switchport access vlan 20

exit

```
ESW1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
ESW1(config)# interface f1/0
ESW1(config-if)# switchport mode access
ESW1(config-if)# switchport access vlan 10
ESW1(config-if)#
ESW1(config-if)# exit
ESW1(config)# interface f1/1
ESW1(config-if)# switchport mode access
ESW1(config-if)# switchport access vlan 10
ESW1(config-if)#
ESW1(config-if)# exit
ESW1(config)# interface f1/2
ESW1(config-if)# switchport mode access
ESW1(config-if)# switchport access vlan 20
ESW1(config-if)#
ESW1(config-if)# exit
ESW1(config)# interface f1/3
ESW1(config-if)# switchport mode access
ESW1(config-if)# switchport access vlan 20
ESW1(config-if)#
ESW1(config-if)# exit
```

show vlan-switch

```
ESW1# show vlan-switch

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa1/4, Fa1/5, Fa1/6, Fa1/7
                                                Fa1/8, Fa1/9, Fa1/10, Fa1/11
                                                Fa1/12, Fa1/13, Fa1/14, Fa1/15
10   VLAN0010                         active    Fa1/0, Fa1/1
20   VLAN0020                         active    Fa1/2, Fa1/3
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
1    enet  100001     1500  -      -      -        -    -        1002   1003
10   enet  100010     1500  -      -      -        -    -        0      0
20   enet  100020     1500  -      -      -        -    -        0      0
1002 fddi  101002     1500  -      -      -        -    -        1      1003
1003 tr    101003     1500  1005   0      -        -    srb      1      1002
1004 fdnet 101004     1500  -      -      1        ibm  -        0      0
1005 trnet 101005     1500  -      -      1        ibm  -        0      0
```

PC1 Console:

ping 192.168.1.2

```
PC1> ping 192.168.1.2
84 bytes from 192.168.1.2 icmp_seq=1 ttl=64 time=3.230 ms
84 bytes from 192.168.1.2 icmp_seq=2 ttl=64 time=3.126 ms
84 bytes from 192.168.1.2 icmp_seq=3 ttl=64 time=3.061 ms
84 bytes from 192.168.1.2 icmp_seq=4 ttl=64 time=3.010 ms
84 bytes from 192.168.1.2 icmp_seq=5 ttl=64 time=3.125 ms
```

ping 192.168.2.2

```
PC1> ping 192.168.2.1
No gateway found
```

show ip

```
PC1> show ip

NAME        : PC1[1]
IP/MASK     : 192.168.1.1/24
GATEWAY     : 0.0.0.0
DNS         :
MAC         : 00:50:79:66:68:00
LPORT       : 10016
RHOST:PORT  : 127.0.0.1:10017
MTU:        : 1500
```

Since there is no gateway, we will create gateway in all PC's.

ip 192.168.1.1/24 192.168.1.254

show ip

```
PC1> ip 192.168.1.1/24 192.168.1.254
Checking for duplicate address...
PC1 : 192.168.1.1 255.255.255.0 gateway 192.168.1.254

PC1> show ip

NAME        : PC1[1]
IP/MASK     : 192.168.1.1/24
GATEWAY     : 192.168.1.254
DNS         :
MAC         : 00:50:79:66:68:00
LPORT       : 10016
RHOST:PORT  : 127.0.0.1:10017
MTU:        : 1500
```

```
PC2> ip 192.168.1.2/24 192.168.1.254
Checking for duplicate address...
PC1 : 192.168.1.2 255.255.255.0 gateway 192.168.1.254

PC2> show ip

NAME        : PC2[1]
IP/MASK     : 192.168.1.2/24
GATEWAY     : 192.168.1.254
DNS         :
MAC         : 00:50:79:66:68:01
LPORT       : 10018
RHOST:PORT  : 127.0.0.1:10019
MTU:        : 1500
```

```
PC3> ip 192.168.2.1/24 192.168.2.254
Checking for duplicate address...
PC1 : 192.168.2.1 255.255.255.0 gateway 192.168.2.254

PC3> show ip

NAME        : PC3[1]
IP/MASK     : 192.168.2.1/24
GATEWAY     : 192.168.2.254
DNS         :
MAC         : 00:50:79:66:68:02
LPORT       : 10020
RHOST:PORT  : 127.0.0.1:10021
MTU:        : 1500
```

```
PC4> ip 192.168.2.2/24 192.168.2.254
Checking for duplicate address...
PC1 : 192.168.2.2 255.255.255.0 gateway 192.168.2.254

PC4> show ip

NAME        : PC4[1]
IP/MASK     : 192.168.2.2/24
GATEWAY     : 192.168.2.254
DNS         :
MAC         : 00:50:79:66:68:03
LPORT       : 10022
RHOST:PORT  : 127.0.0.1:10023
MTU:        : 1500
```

Configuration for EhterSwitch:

interface vlan 10

ip address 192.168.1.254 255.255.255.0

no shutdown

exit

interface vlan 20

ip address 192.168.2.254 255.255.255.0

no shutdown

exit

```
ESW1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
ESW1(config)# interface vlan 10
ESW1(config-if)#
*Mar  1 00:34:48.479: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan10, ch
anged state to up
ESW1(config-if)# ip address 192.168.1.254 255.255.255.0
ESW1(config-if)# no shutdown
ESW1(config-if)# exit
ESW1(config)#
ESW1(config)# interface vlan 20
ESW1(config-if)#
*Mar  1 00:35:46.427: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan20, ch
anged state to up
ESW1(config-if)# ip address 192.168.2.254 255.255.255.0
ESW1(config-if)# no shutdown
ESW1(config-if)# exit
```

show ip route

```
ESW1# show ip route
Default gateway is not set

Host               Gateway           Last Use    Total Uses  Interface
ICMP redirect cache is empty
```

ip routing

```
ESW1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
ESW1(config)# ip routing
ESW1(config)# end
ESW1#
*Mar  1 00:39:56.903: %SYS-5-CONFIG_I: Configured from console by console
```

show ip route

```
ESW1# show ip route
Codes: 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

Gateway of last resort is not set

C    192.168.1.0/24 is directly connected, Vlan10
C    192.168.2.0/24 is directly connected, Vlan20
```

Now since gateway is created we will ping again and check whether it is successful or not.

PC1 Console:

ping 192.168.2.1

```
PC1> ping 192.168.2.1
192.168.2.1 icmp_seq=1 timeout
84 bytes from 192.168.2.1 icmp_seq=2 ttl=63 time=31.685 ms
84 bytes from 192.168.2.1 icmp_seq=3 ttl=63 time=31.593 ms
84 bytes from 192.168.2.1 icmp_seq=4 ttl=63 time=31.341 ms
84 bytes from 192.168.2.1 icmp_seq=5 ttl=63 time=32.058 ms

PC1> ping 192.168.2.2
192.168.2.2 icmp_seq=1 timeout
84 bytes from 192.168.2.2 icmp_seq=2 ttl=63 time=32.201 ms
84 bytes from 192.168.2.2 icmp_seq=3 ttl=63 time=31.589 ms
84 bytes from 192.168.2.2 icmp_seq=4 ttl=63 time=31.551 ms
84 bytes from 192.168.2.2 icmp_seq=5 ttl=63 time=31.751 ms
```

PC4 Console:

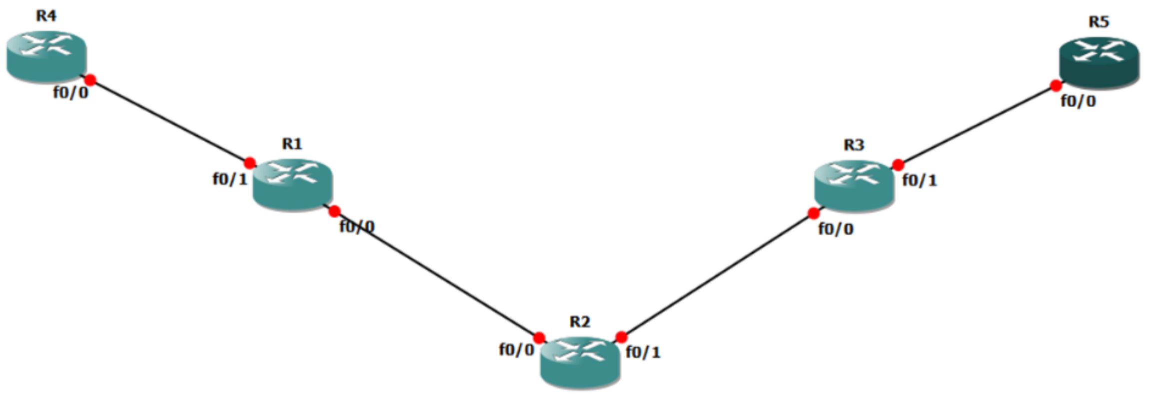
ping 192.168.1.1

```
PC4> ping 192.168.1.1
84 bytes from 192.168.1.1 icmp_seq=1 ttl=63 time=31.835 ms
84 bytes from 192.168.1.1 icmp_seq=2 ttl=63 time=31.564 ms
84 bytes from 192.168.1.1 icmp_seq=3 ttl=63 time=31.684 ms
84 bytes from 192.168.1.1 icmp_seq=4 ttl=63 time=31.315 ms
84 bytes from 192.168.1.1 icmp_seq=5 ttl=63 time=31.545 ms

PC4> ping 192.168.1.2
192.168.1.2 icmp_seq=1 timeout
84 bytes from 192.168.1.2 icmp_seq=2 ttl=63 time=31.758 ms
84 bytes from 192.168.1.2 icmp_seq=3 ttl=63 time=31.651 ms
84 bytes from 192.168.1.2 icmp_seq=4 ttl=63 time=31.550 ms
84 bytes from 192.168.1.2 icmp_seq=5 ttl=63 time=31.816 ms
```

Practical 8

Aim:- Simulating MPLS

Topology:-



Router R1 Console

interface Loopback0

ip address 1.1.1.1 255.255.255.255

ip ospf 1 area 0

exit

interface f0/0

ip address 10.0.0.1 255.255.255.0

no shutdown

ip ospf 1 area

exit

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# interface Loopback0
R1(config-if)#
*Apr  5 20:54:51.639: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R1(config-if)# ip address 1.1.1.1 255.255.255.255
R1(config-if)# ip ospf 1 area 0
R1(config-if)# exit
R1(config)# interface f0/0
R1(config-if)# ip address 10.0.0.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)#
*Apr  5 20:56:20.671: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
R1(config-if)#
*Apr  5 20:56:20.671: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/0 Physical Port Administrative State Down
*Apr  5 20:56:21.671: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R1(config-if)# ip ospf 1 area 0
R1(config-if)#
*Apr  5 21:03:03.675: %OSPF-5-ADJCHG: Process 1, Nbr 2.2.2.2 on FastEthernet0/0 from LOADING to FULL, Loading
Done
R1(config-if)# exit
```

Router R2 Console

interface Loopback0

ip address 2.2.2.2 255.255.255.255

ip ospf 1 area 0

exit

interface f0/0

ip address 10.0.0.2 255.255.255.0

no shutdown

ip ospf 1 area 0

exit

interface f0/1

ip address 10.0.1.2 255.255.255.0

no shutdown

ip ospf 1 area 0

exit

```
R2# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)# interface Loopback0
R2(config-if)# ip add
*Apr  5 21:01:44.131: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R2(config-if)# ip address 2.2.2.2 255.255.255.255
R2(config-if)# ip ospf 1 area 0
R2(config-if)# exit
R2(config)# interface f0/0
R2(config-if)# ip address 10.0.0.2 255.255.255.0
R2(config-if)# no shutdown
R2(config-if)# ip
*Apr  5 21:02:40.411: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
R2(config-if)# ip
*Apr  5 21:02:40.411: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/0 Physical Port Administrative State Down
*Apr  5 21:02:41.411: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R2(config-if)# ip ospf 1 area 0
R2(config-if)# exit
R2(config)# interface f0/1
R2(config-if)# ip address 10.
*Apr  5 21:03:03.523: %OSPF-5-ADJCHG: Process 1, Nbr 1.1.1.1 on FastEthernet0/0 from LOADING to FULL, Loading
Done
R2(config-if)# ip address 10.0.1.2 255.255.255.0
R2(config-if)# no shutdown
R2(config-if)#
*Apr  5 21:03:30.123: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
R2(config-if)#
*Apr  5 21:03:30.123: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/1 Physical Port Administrative State Down
*Apr  5 21:03:31.123: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R2(config-if)# ip ospf 1 area 0
R2(config-if)# exit
```

Router R3 Console

interface Loopback0

ip address 3.3.3.3 255.255.255.255

ip ospf 1 area 0

exit

interface f0/0

ip address 10.0.1.3 255.255.255.0

no shutdown

ip ospf 1 area 0

exit

```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# interface Loopback0
R3(config-if)#
*Apr  5 21:06:51.615: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R3(config-if)# ip address 3.3.3.3 255.255.255.255
R3(config-if)# ip ospf 1 area 0
R3(config-if)# exit
R3(config)# interface f0/0
R3(config-if)# ip address 10.0.1.3 255.255.255.0
R3(config-if)# no shutdown
R3(config-if)#
*Apr  5 21:08:03.647: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
R3(config-if)#
*Apr  5 21:08:03.647: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/0 Physical Port Administrative State Down
*Apr  5 21:08:04.647: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R3(config-if)# ip ospf 1 area 0
R3(config-if)# exit
```

Router R1 Console

ping 3.3.3.3 source Loopback0

```
R1# ping 3.3.3.3 source Loopback0

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 1.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/72/112 ms
```

router ospf 1

mpls ldp autoconfig

```
R1(config)# router ospf 1
R1(config-router)# mpls ldp autoconfig
R1(config-router)#
*Apr  5 21:13:30.759: %LDP-5-NBRCHG: LDP Neighbor 2.2.2.2:0 (1) is UP
```

Router R3 Console

router ospf 1

mpls ldp autoconfig

```
R3(config)# router ospf 1
R3(config-router)# mpls ldp autoconfig
R3(config-router)#
*Apr  5 21:14:48.471: %LDP-5-NBRCHG: LDP Neighbor 2.2.2.2:0 (1) is UP
```

Router R2 Console

router ospf 1

mpls ldp autoconfig

```
R2(config)# router ospf 1
R2(config-router)# mpls ldp autoconfig
R2(config-router)#
*Apr  5 21:13:30.583: %LDP-5-NBRCHG: LDP Neighbor 1.1.1.1:0 (1) is UP
R2(config-router)#
*Apr  5 21:14:48.307: %LDP-5-NBRCHG: LDP Neighbor 3.3.3.3:0 (2) is UP
```

show mpls interface

```
R2# show mpls interface
Interface              IP            Tunnel   Operational
FastEthernet0/0        Yes (ldp)     No       Yes
FastEthernet0/1        Yes (ldp)     No       Yes
```

show mpls ldp neighbor

```
R2# show 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 - 2.2.2.2.24503
        State: Oper; Msgs sent/rcvd: 16/16; Downstream
        Up time: 00:07:03
        LDP discovery sources:
          FastEthernet0/0, 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: 3.3.3.3.19432 - 2.2.2.2.646
        State: Oper; Msgs sent/rcvd: 14/14; Downstream
        Up time: 00:05:46
        LDP discovery sources:
          FastEthernet0/1, Src IP addr: 10.0.1.3
        Addresses bound to peer LDP Ident:
          10.0.1.3        3.3.3.3
```

Router R1 Console

trace 3.3.3.3

```
R1# trace 3.3.3.3

Type escape sequence to abort.
Tracing the route to 3.3.3.3

  1 10.0.0.2 [MPLS: Label 17 Exp 0] 80 msec 76 msec 104 msec
  2 10.0.1.3 96 msec 60 msec 64 msec
```

Router R1 Console

router bgp 1

neighbor 3.3.3.3 remote-as 1

neighbor 3.3.3.3 update-source Loopback0

no auto-summary

address-family vpnv4

neighbor 3.3.3.3 activate

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# router bgp 1
R1(config-router)# neighbor 3.3.3.3 remote-as 1
R1(config-router)# neighbor 3.3.3.3 update-source Loopback0
R1(config-router)# no auto-summary
R1(config-router)# !
R1(config-router)# address-family vpnv4
R1(config-router-af)# neighbor 3.3.3.3 activate
```

Router R3 Console

router bgp 1

neighbor 1.1.1.1 remote-as 1

neighbor 1.1.1.1 update-source Loopback0

no auto-summary

address-family vpnv4

neighbor 1.1.1.1 activate

```
R3(config)# router ospf 1
R3(config-router)# mpls ldp autoconfig
R3(config-router)#
*Apr  5 21:14:48.471: %LDP-5-NBRCHG: LDP Neighbor 2.2.2.2:0 (1) is UP
R3(config-router)#exit
R3(config)#
R3(config)# router bgp 1
R3(config-router)# neighbor 1.1.1.1 remote-as 1
R3(config-router)# neighbor 1.1.1.1 update-s
*Apr  5 21:33:17.519: %BGP-5-ADJCHANGE: neighbor 1.1.1.1 Up
R3(config-router)# neighbor 1.1.1.1 update-source Loopback0
R3(config-router)# address-family vpnv4
R3(config-router-af)# neighbor 1.1.1.1 activate
```

Router R1 Console

show bgp vpnv4 unicast all summary

```
R1# show bgp vpnv4 unicast all summary
BGP router identifier 1.1.1.1, local AS number 1
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     1      10      10        1    0    0 00:02:12        0
```

Router R4 Console

interface Loopback0

ip address 4.4.4.4 255.255.255.255

ip ospf 2 area 2

exit

interface f0/0

ip address 192.168.1.4 255.255.255.0

ip ospf 2 area 2

no shutdown

```
R4# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R4(config)# interface Loopback0
R4(config-if)#
*Apr  5 22:37:47.667: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R4(config-if)# ip address 4.4.4.4 255.255.255.255
R4(config-if)# ip ospf 2 area 2
R4(config-if)# exit
R4(config)# interface f0/0
R4(config-if)# ip address 192.168.1.4 255.255.255.0
R4(config-if)# ip ospf 2 area 2
R4(config-if)# no shutdown
```

Router R1 Console

interface f0/1

ip address 192.168.1.1 255.255.255.0

no shutdown

```
R1(config)# interface f0/1
R1(config-if)# ip address 192.168.1.1 255.255.255.0
R1(config-if)# no shutdown
```

Router R1 Console

ip vrf RED

rd 4:4

route-target both 4:4

```
R1(config)# ip vrf RED
R1(config-vrf)# rd 4:4
R1(config-vrf)# route-target both 4:4
R1(config-vrf)# exit
```

interface f0/1

ip vrf forwarding RED

```
R1(config)# interface f0/1
R1(config-if)# ip vrf forwarding RED
% Interface FastEthernet0/1 IP address 192.168.1.1 removed due to enabling VRF RED
```

interface f0/1

ip address 192.168.1.1 255.255.255.0

no shutdown

```
R1(config-if)# interface f0/1
R1(config-if)# ip address 192.168.1.1 255.255.255.0
R1(config-if)# no shutdown
```

show run interface f0/1

```
R1# show run interface f0/1
Building configuration...

Current configuration : 119 bytes
!
interface FastEthernet0/1
 ip vrf forwarding RED
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
end
```

show ip route

```
R1# show ip route
Codes: 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

Gateway of last resort is not set

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/2] via 10.0.0.2, 00:46:24, FastEthernet0/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/3] via 10.0.0.2, 00:46:24, FastEthernet0/0
     10.0.0.0/24 is subnetted, 2 subnets
C       10.0.0.0 is directly connected, FastEthernet0/0
O       10.0.1.0 [110/2] via 10.0.0.2, 00:46:24, FastEthernet0/0
```

show ip route vrf RED

```
R1# show ip route vrf RED

Routing Table: RED
Codes: 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

Gateway of last resort is not set

C    192.168.1.0/24 is directly connected, FastEthernet0/1
```

int f0/1

ip ospf 2 area 2

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# interface f0/1
R1(config-if)# ip ospf 2 area 2
R1(config-if)#
*Apr  5 21:58:12.735: %OSPF-5-ADJCHG: Process 2, Nbr 4.4.4.4 on FastEthernet0/1 from LOADING to FULL, Loading
Done
```

show ip route vrf RED

```
R1# show ip route vrf RED

Routing Table: RED
Codes: 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

Gateway of last resort is not set

     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/2] via 192.168.1.4, 00:01:17, FastEthernet0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/1
```

Router R5 Console

interface Loopback0

ip address 5.5.5.5 255.255.255.255

ip ospf 2 area 2

exit

interface f0/0

ip address 192.168.2.5 255.255.255.0

ip ospf 2 area 2

no shutdown

```
R5# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R5(config)# interface Loopback0
R5(config-if)#
*Apr  5 22:55:55.071: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R5(config-if)# ip address 5.5.5.5 255.255.255.255
R5(config-if)# ip ospf 2 area 2
R5(config-if)# exit
R5(config)# interface f0/0
R5(config-if)# ip address 192.168.2.5 255.255.255.0
R5(config-if)# ip ospf 2 area 2
R5(config-if)# no shutdown
```

Router R3 Console

interface f0/1

ip address 192.168.2.3 255.255.255.0

no shutdown

```
R3(config)# interface f0/1
R3(config-if)# ip address 192.168.2.3 255.255.255.0
R3(config-if)# no shutdown
```

ip vrf RED

rd 4:4

route-target both 4:4

```
R3(config)# ip vrf RED
R3(config-vrf)# rd 4:4
R3(config-vrf)# route-target both 4:4
R3(config-vrf)# exit
```

interface f0/1

ip vrf forwarding RED

```
R3(config)# interface f0/1
R3(config-if)# ip vrf forwarding RED
% Interface FastEthernet0/1 IP address 192.168.2.3 removed due to enabling VRF RED
```

interface f0/1

ip address 192.168.2.3 255.255.255.0

no shutdown

```
R3(config)# interface f0/1
R3(config-if)# ip address 192.168.2.3 255.255.255.0
R3(config-if)# no shutdown
R3(config-if)# exit
```

show run interface f0/1

```
R3# show run interface f0/1
Building configuration...

Current configuration : 119 bytes
!
interface FastEthernet0/1
 ip vrf forwarding RED
 ip address 192.168.2.3 255.255.255.0
 duplex auto
 speed auto
end
```

interface f0/1

ip ospf 2 area 2

```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# interface f0/1
R3(config-if)# ip ospf 2 area 2
```

show ip route vrf RED

```
R3# show ip route vrf RED

Routing Table: RED
Codes: 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

Gateway of last resort is not set

     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/2] via 192.168.2.5, 00:00:46, FastEthernet0/1
C    192.168.2.0/24 is directly connected, FastEthernet0/1
```

Router R4 Console

show ip route

```
R4# show ip route
Codes: 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

Gateway of last resort is not set

     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
```

Router R1 Console

show ip route

```
R1# show ip route
Codes: 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

Gateway of last resort is not set

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/2] via 10.0.0.2, 01:07:22, FastEthernet0/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/3] via 10.0.0.2, 01:07:22, FastEthernet0/0
     10.0.0.0/24 is subnetted, 2 subnets
C       10.0.0.0 is directly connected, FastEthernet0/0
O       10.0.1.0 [110/2] via 10.0.0.2, 01:07:22, FastEthernet0/0
```

show ip route vrf RED

```
R1# show ip route vrf RED

Routing Table: RED
Codes: 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

Gateway of last resort is not set

     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/2] via 192.168.1.4, 00:18:57, FastEthernet0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/1
```

router bgp 1

address-family ipv4 vrf RED

redistribute ospf 2

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# router bgp 1
R1(config-router)# address-family ipv4 vrf RED
R1(config-router-af)# redistribute ospf 2
```

Router R3 Console

router bgp 1

address-family ipv4 vrf RED

redistribute ospf 2

```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# router bgp 1
R3(config-router)# address-family ipv4 vrf RED
R3(config-router-af)# redistribute ospf 2
```

Router R1 Console

show ip bgp vpnv4 vrf RED

```
R1# show ip bgp vpnv4 vrf RED
BGP table version is 9, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 4:4 (default for vrf RED)
*> 4.4.4.4/32       192.168.1.4              2         32768 ?
*>i5.5.5.5/32       3.3.3.3                  2    100      0 ?
*> 192.168.1.0      0.0.0.0                  0         32768 ?
*>i192.168.2.0      3.3.3.3                  0    100      0 ?
```

Router R3 Console

show ip bgp vpnv4 vrf RED

```
R3# show ip bgp vpnv4 vrf RED
BGP table version is 9, 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
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 4:4 (default for vrf RED)
*>i4.4.4.4/32       1.1.1.1                  2    100      0 ?
*> 5.5.5.5/32       192.168.2.5              2         32768 ?
*>i192.168.1.0      1.1.1.1                  0    100      0 ?
*> 192.168.2.0      0.0.0.0                  0         32768 ?
```

Router R1 Console

router ospf 2

redistribute bgp 1 subnets

```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# router ospf 2
R1(config-router)# redistribute bgp 1 subnets
```

Router R3 Console

router ospf 2

redistribute bgp 1 subnets

```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# router ospf 2
R3(config-router)# redistribute bgp 1 subnets
```

Router R4 Console

show ip route

```
R4# show ip route
Codes: 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

Gateway of last resort is not set

     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
     5.0.0.0/32 is subnetted, 1 subnets
O IA    5.5.5.5 [110/3] via 192.168.1.1, 00:02:04, FastEthernet0/0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
O IA 192.168.2.0/24 [110/2] via 192.168.1.1, 00:02:04, FastEthernet0/0
```

Router R5 Console

show ip route

```
R5# show ip route
Codes: 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

Gateway of last resort is not set

     4.0.0.0/32 is subnetted, 1 subnets
O IA    4.4.4.4 [110/3] via 192.168.2.3, 00:02:05, FastEthernet0/0
     5.0.0.0/32 is subnetted, 1 subnets
C       5.5.5.5 is directly connected, Loopback0
O IA 192.168.1.0/24 [110/2] via 192.168.2.3, 00:02:05, FastEthernet0/0
C    192.168.2.0/24 is directly connected, FastEthernet0/0
```

Router R4 Console

ping 5.5.5.5

```
R4# ping 5.5.5.5

Type 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 = 300/341/424 ms
```

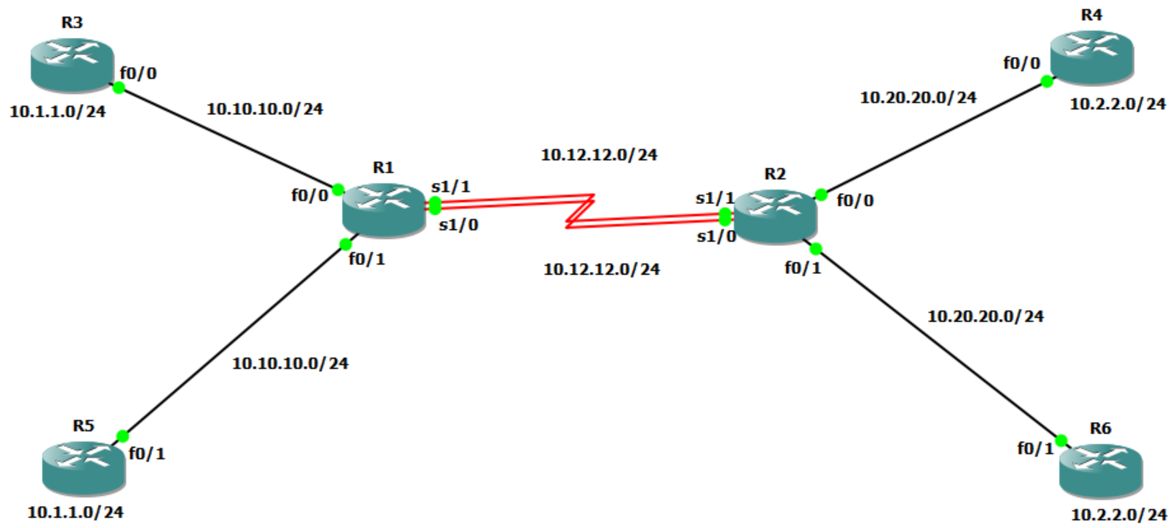
trace 5.5.5.5

```
R4# trace 5.5.5.5

Type escape sequence to abort.
Tracing the route to 5.5.5.5

  1 192.168.1.1 124 msec 156 msec 80 msec
  2 10.0.0.2 200 msec 348 msec 248 msec
  3 192.168.2.3 236 msec 232 msec 328 msec
  4 192.168.2.5 328 msec 296 msec 376 msec
```

Practical 9

Aim:- Simulating Virtual Routing and Forwarding (VRF)

Topology:-



Step 1:- Prepare the routers for the lab.

Cable the network as shown in the topology diagram. Erase the startup configuration and reload each router to clear previous configurations.

Step 2:- Configure Virtual Routing and Forwarding.

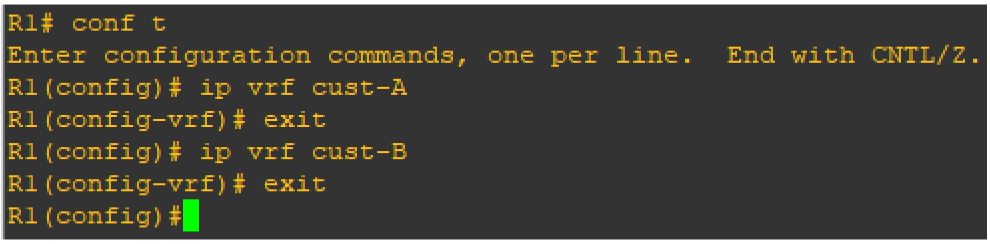
Router R1 Console

ip vrf cust-A

exit

ip vrf cust-B

exit


```
R1# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)# ip vrf cust-A
R1(config-vrf)# exit
R1(config)# ip vrf cust-B
R1(config-vrf)# exit
R1(config)#
```

Step 3:- Configure interface addresses.

interface f0/0

ip vrf forwarding cust-A

ip address 10.10.10.1 255.255.255.0

no shutdown

exit

interface S1/1

ip vrf forwarding cust-A

ip address 10.12.12.1 255.255.255.0

no shutdown

exit

interface f0/1

ip vrf forwarding cust-B

ip address 10.10.10.1 255.255.255.0

no shutdown

exit

interface S1/0

ip vrf forwarding cust-B

ip address 10.12.12.1 255.255.255.0

no shutdown

exit

```
R1(config)# interface f0/0
R1(config-if)# ip vrf forwarding cust-A
R1(config-if)# ip address 10.10.10.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)#
*Mar 28 18:10:47.195: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
R1(config-if)#
*Mar 28 18:10:47.195: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/0 Physical Port Administrative State Down
*Mar 28 18:10:48.195: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R1(config-if)#exit
R1(config)# interface S1/1
R1(config-if)# ip vrf forwarding cust-A
R1(config-if)# ip address 10.12.12.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)#
*Mar 28 18:12:03.055: %LINK-3-UPDOWN: Interface Serial1/1, changed state to up
R1(config-if)#
*Mar 28 18:12:03.055: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/1 Physical Port Administrative State Down
R1(config-if)#
*Mar 28 18:12:04.059: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to up
R1(config-if)#exit
R1(config)# interface f0/1
R1(config-if)# ip vrf forwarding
*Mar 28 18:12:27.267: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/1, changed state to down
R1(config-if)# ip vrf forwarding cust-B
R1(config-if)# ip address 10.10.10.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)#
*Mar 28 18:13:14.659: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
R1(config-if)#
*Mar 28 18:13:14.659: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/1 Physical Port Administrative State Down
*Mar 28 18:13:15.659: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R1(config-if)#exit
R1(config)# interface S1/0
R1(config-if)# ip vrf forwarding cust-B
R1(config-if)# ip address 10.12.12.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)#
*Mar 28 18:14:23.423: %LINK-3-UPDOWN: Interface Serial1/0, changed state to up
R1(config-if)#
*Mar 28 18:14:23.423: %ENTITY_ALARM-6-INFO: CLEAR INFO Se1/0 Physical Port Administrative State Down
R1(config-if)#
*Mar 28 18:14:24.427: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial1/0, changed state to up
R1(config-if)#exit
```

Router R2 Console

ip vrf cust-A

exit

ip vrf cust-B

exit

interface f0/0

ip vrf forwarding cust-A

ip address 10.20.20.2 255.255.255.0

no shutdown

exit

interface S1/1

ip vrf forwarding cust-A

ip address 10.12.12.2 255.255.255.0

no shutdown

exit

interface f0/1

ip vrf forwarding cust-B

ip address 10.20.20.2 255.255.255.0

no shutdown

exit

interface S1/0

ip vrf forwarding cust-B

ip address 10.12.12.2 255.255.255.0

no shutdown

exit

Router R3 Console

interface Loopback0

ip address 10.1.1.3 255.255.255.0

no shutdown

exit

interface f0/0

ip address 10.10.10.3 255.255.255.0

no shutdown

exit

```
R3# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)# interface Loopback0
R3(config-if)# ip
*Mar 28 18:24:35.023: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R3(config-if)# ip address 10.1.1.3 255.255.255.0
R3(config-if)# no shutdown
R3(config-if)# exit
R3(config)# interface f0/0
R3(config-if)# ip address 10.10.10.3 255.255.255.0
R3(config-if)# no shutdown
R3(config-if)#
*Mar 28 18:25:46.595: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
R3(config-if)#
*Mar 28 18:25:46.595: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/0 Physical Port Administrative State Down
*Mar 28 18:25:47.595: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R3(config-if)# exit
```

router eigrp 100

no auto

net 10.0.0.0

```
R3(config)# router eigrp 100
R3(config-router)# no auto
R3(config-router)# net 10.0.0.0
```

Router R4 Console

interface Loopback0

ip address 10.2.2.4 255.255.255.0

no shutdown

exit

interface f0/0

ip address 10.20.20.4 255.255.255.0

no shutdown

exit

```
R4# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R4(config)# interface Loopback0
R4(config-if)# i
*Mar 28 18:27:18.747: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R4(config-if)# ip address 10.2.2.4 255.255.255.0
R4(config-if)# no shutdown
R4(config-if)# interface f0/0
R4(config-if)# ip address 10.20.20.4 255.255.255.0
R4(config-if)# no shutdown
R4(config-if)#
*Mar 28 18:28:23.295: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
R4(config-if)#
*Mar 28 18:28:23.295: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/0 Physical Port Administrative State Down
*Mar 28 18:28:24.295: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R4(config-if)# exit
```

router eigrp 100

no auto

net 10.0.0.0

```
R4(config)# router eigrp 100
R4(config-router)# no auto
R4(config-router)# net 10.0.0.0
```

Router R5 Console

interface Loopback0

ip address 10.1.1.5 255.255.255.0

no shutdown

exit

interface f0/1

ip address 10.10.10.5 255.255.255.0

no shutdown

exit

```
R5# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R5(config)# interface Loopback0
R5(config-if)# ip
*Mar 28 18:29:39.127: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R5(config-if)# ip address 10.1.1.5 255.255.255.0
R5(config-if)# no shutdown
R5(config-if)# exit
R5(config)# interface f0/1
R5(config-if)# ip address 10.10.10.5 255.255.255.0
R5(config-if)# no shutdown
R5(config-if)#
*Mar 28 18:30:38.619: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
R5(config-if)#
*Mar 28 18:30:38.619: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/1 Physical Port Administrative State Down
*Mar 28 18:30:39.619: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R5(config-if)# exit
```

router eigrp 100

no auto

net 10.0.0.0

```
R5(config)# router eigrp 100
R5(config-router)# no auto
R5(config-router)# net 10.0.0.0
```

Router R6 Console

interface Loopback0

ip address 10.2.2.6 255.255.255.0

no shutdown

exit

interface f0/1

ip address 10.20.20.6 255.255.255.0

no shutdown

exit

```
R6# conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R6(config)# interface Loopback0
R6(config-if)#
*Mar 28 18:31:54.039: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R6(config-if)# ip address 10.2.2.6 255.255.255.0
R6(config-if)# no shutdown
R6(config-if)# exit
R6(config)# interface f0/1
R6(config-if)# ip address 10.20.20.6 255.255.255.0
R6(config-if)# no shutdown
R6(config-if)#
*Mar 28 18:33:21.979: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
R6(config-if)#
*Mar 28 18:33:21.979: %ENTITY_ALARM-6-INFO: CLEAR INFO Fa0/1 Physical Port Administrative State Down
*Mar 28 18:33:22.979: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R6(config-if)# exit
```

router eigrp 100

no auto

net 10.0.0.0

```
R6(config)# router eigrp 100
R6(config-router)# no auto
R6(config-router)# net 10.0.0.0
```

Router R1 Console

router eigrp 1

address-family ipv4 vrf cust-A

autonomous-system 100

no auto

network 10.0.0.0

exit

address-family ipv4 vrf cust-B

autonomous-system 100

no auto

network 10.0.0.0

exit

```
R1(config)# router eigrp 1
R1(config-router)# address-family ipv4 vrf cust-A
*Mar 28 18:45:31.451: %CDP-4-DUPLEX_MISMATCH: duplex mismatch discovered on FastEthernet0/0 (not half duplex),
 with R3 FastEthernet0/0 (half duplex).
R1(config-router)# address-family ipv4 vrf cust-A
R1(config-router-af)# autonomous-system 100
R1(config-router-af)# no auto
R1(config-router-af)# network 10.0.0.0
R1(config-router-af)#
*Mar 28 18:46:29.223: %DUAL-5-NBRCHANGE: IP-EIGRP(1) 100: Neighbor 10.10.10.3 (FastEthernet0/0) is up: new adj
acency
R1(config-router-af)#
*Mar 28 18:46:31.403: %CDP-4-DUPLEX_MISMATCH: duplex mismatch discovered on FastEthernet0/0 (not half duplex),
 with R3 FastEthernet0/0 (half duplex).
R1(config-router-af)# exit
R1(config-router)# address-family ipv4 vrf cust-B
R1(config-router-af)# autonomous-system 100
R1(config-router-af)# no auto
R1(config-router-af)# network 10.0.0.0
```

Router R1 Console

show ip route

Note:- Since we have configured virtual routing and forwarding it will not display the connections.

```
R1# show ip route
Codes: 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

Gateway of last resort is not set
```

To check the routes we have to write the following command.

show ip route vrf cust-A

Note:- Now it will display all the connections.

```
R1# show ip route vrf cust-A

Routing Table: cust-A
Codes: 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

Gateway of last resort is not set

     10.0.0.0/24 is subnetted, 5 subnets
D       10.20.20.0 [90/2172416] via 10.12.12.2, 00:02:21, Serial1/1
C       10.12.12.0 is directly connected, Serial1/1
C       10.10.10.0 is directly connected, FastEthernet0/0
D       10.2.2.0 [90/2300416] via 10.12.12.2, 00:02:19, Serial1/1
D       10.1.1.0 [90/156160] via 10.10.10.3, 00:08:00, FastEthernet0/0
```

Since we have configured virtual routing and forwarding on R1 and R2, to ping we have to write the following command.

ping vrf cust-A 10.1.1.3

```
R1# ping vrf cust-A 10.1.1.3

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/87/128 ms
R1#
*Mar 28 18:59:31.715: %CDP-4-DUPLEX_MISMATCH: duplex mismatch discovered on FastEthernet0/0 (not half duplex),
 with R3 FastEthernet0/0 (half duplex).
R1# ping vrf cust-B 10.1.1.5

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.1.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/108/152 ms
```

Router R2 Console

router eigrp 1

address-family ipv4 vrf cust-A

autonomous-system 100

no auto

network 10.0.0.0

exit

address-family ipv4 vrf cust-B

autonomous-system 100

no auto

network 10.0.0.0

exit

Router R3 Console

Since we have not configured virtual routing and forwarding on R3,R4,R5 and R6, to ping we simply have to write the following command.

ping 10.2.2.4

```
R3# ping 10.2.2.4

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.2.4, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 264/352/404 ms
```

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