

University of Mumbai

PRACTICAL JOURNAL



IT 504

Advanced Computer Networks

SUBMITTED BY

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SEAT NO 1330011

**SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
QUALIFYING M.SC. (IT- CLOUD COMPUTING) PART I SEMESTER I**

EXMAINATION (TWO YEAR) AS PER NEP 2020

2023-2024

DEPARTMENT OF INFORMATION TECHNOLOGY 3RD FLOOR,

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Certificate

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as prescribed by University of Mumbai, during the academic year **2023 - 24**.

Signature

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Signature External Examiner

College Seal: _____

Date:

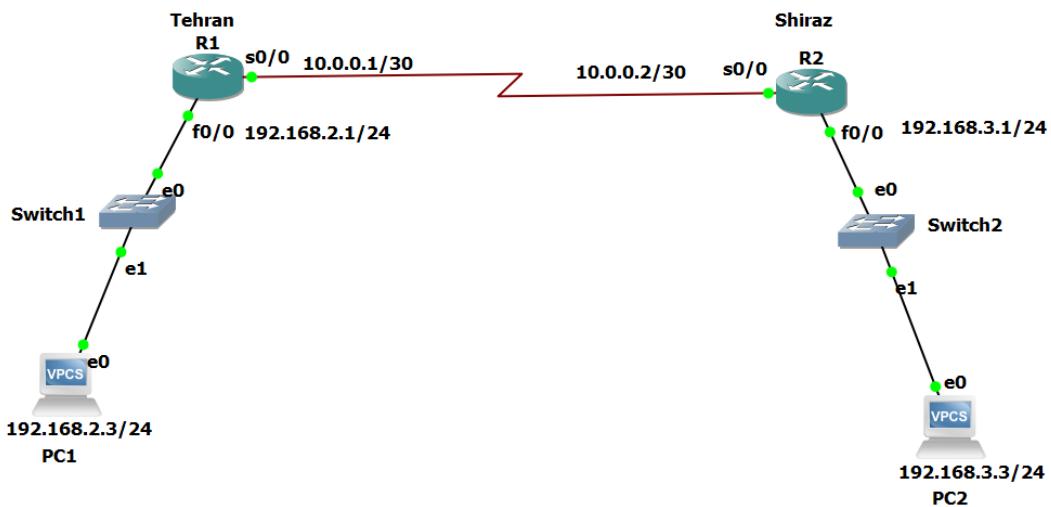
ACN Practical Journal

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Practical 1a: Implement the concept of static routing

Here is the Topology on which we did the experiment



Scenario

Suppose that your company has 2 branches located in Tehran and Shiraz.

As the administrator of the network, you are tasked to connect them so that employees in the two LANs can communicate with each other.

After careful consideration you decided to connect them via static route.

Step1. Configuring interfaces on R1

```

R1(Config)#int fa0/0
R1(Config-if)#ip address 192.168.2.1 255.255.255.0
R1(Config-if)#no shutdown
R1(Config-if)#ex
R1(Config)#int s0/0
R1(Config-if)#ip address 10.0.0.1 255.255.255.0
R1(Config-if)#no shut
R1(Config-if)#clock rate 64000
R1(Config-if)#ex
  
```

```
R1(config)#int f 0/0
R1(config-if)#ip add
R1(config-if)#ip address 192.168.2.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#
*Mar 1 00:02:20.951: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:02:21.951: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
```

```
R1(config)#int s0/0
R1(config-if)#ip addr
R1(config-if)#ip address 10.0.0.1 255.255.255.252
R1(config-if)#no shut
R1(config-if)#clock
R1(config-if)#clock r
R1(config-if)#clock rate 64000
R1(config-if)#ex
```

Step2.Configure interfaces on R2

```
R1(Config)#int s0/0
R1(Config-if)#ip address 10.0.0.2 255.255.255.252
R1(Config-if)#no shut
R1(Config-if)#clock rate
R1(Config-if)#ex
R1(Config)#int fa0/0
R1(Config-if)#ip address 12.168.3.1 255.255.255.0
R1(Config-if)#no shut
R1(Config-if)#ex
```

```
R2(config)#int s 0/0
R2(config-if)#ip addr
R2(config-if)#ip address 10.0.0.2 255.255.255.252
R2(config-if)#no shut
R2(config-if)#clock rate
*Mar 1 00:04:45.227: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
R2(config-if)#clock rate
*Mar 1 00:04:46.231: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R2(config-if)#exit
R2(config)#int f 0/0
R2(config-if)#ip addr
R2(config-if)#ip address 12.168.3.1 255.255.255.0
R2(config-if)#no shut
R2(config-if)# ex
R2(config)#
*Mar 1 00:05:28.943: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:05:29.943: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R2(config)#do sh ip route
```

Step3. show ip route command

```
R1(Config)#do s hip route
```

```
R1(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, Serial0/0
C        192.168.2.0/24 is directly connected, FastEthernet0/0
```

R2(Config)#do s hip route

```
R2(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, Serial0/0
C        192.168.3.0/24 is directly connected, FastEthernet0/0
```

Step4. Configuring static route on R1

R1(Config-if)#ip route 192.168.3.0 255.255.255.0 10.0.0.2

R1(Config-if)#do s hip route

```
R1(config)#ip route 192.168.3.0 255.255.255.0 10.0.0.2
```

```
R1(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, Serial0/0
C        192.168.2.0/24 is directly connected, FastEthernet0/0
S        192.168.3.0/24 [1/0] via 10.0.0.2
```

Step5. Configuring static route on R2

R2(Config)#ip route 192.168.2.0 255.255.255.0 10.0.0.1

R2(Config)#do s hip route

```
R2(config)#ip route 192.168.2.0 255.255.255.0 10.0.0.1
```

```
R2(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, Serial0/0
S        192.168.2.0/24 [1/0] via 10.0.0.1
C        192.168.3.0/24 is directly connected, FastEthernet0/0
```

Step6. Manually set an IP on PC1

PC>1 ip 192.168.2.3/24 192.168.2.1

```
PC1> ip 192.168.2.3/24 192.168.2.1
Checking for duplicate address...
PC1 : 192.168.2.3 255.255.255.0 gateway 192.168.2.1
```

Step7. Manually set an IP on PC2

PC>2 ip 192.168.3.3/24 192.168.3.1

```
PC2> ip 192.168.3.3/24 192.168.3.1
Checking for duplicate address...
PC1 : 192.168.3.3 255.255.255.0 gateway 192.168.3.1
```

Step8. Try to ping each far end network

PC1>ping 192.168.3.3

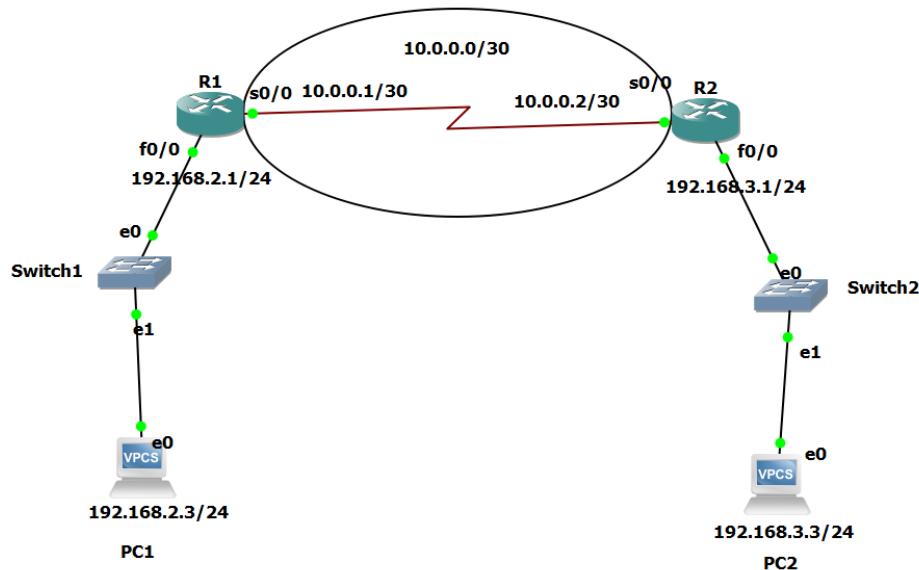
PC2>ping 192.168.3.3

```
PC1> ping 192.168.3.3
192.168.3.3 icmp_seq=1 timeout
84 bytes from 192.168.3.3 icmp_seq=2 ttl=62 time=31.563 ms
84 bytes from 192.168.3.3 icmp_seq=3 ttl=62 time=30.960 ms
84 bytes from 192.168.3.3 icmp_seq=4 ttl=62 time=30.707 ms
84 bytes from 192.168.3.3 icmp_seq=5 ttl=62 time=30.590 ms
```

```
PC2> ping 192.168.2.3
84 bytes from 192.168.2.3 icmp_seq=1 ttl=62 time=31.296 ms
84 bytes from 192.168.2.3 icmp_seq=2 ttl=62 time=30.814 ms
84 bytes from 192.168.2.3 icmp_seq=3 ttl=62 time=31.184 ms
84 bytes from 192.168.2.3 icmp_seq=4 ttl=62 time=30.092 ms
84 bytes from 192.168.2.3 icmp_seq=5 ttl=62 time=31.135 ms
```

Practical1b: Dynamic Routing Protocol (RIP)

Here is the topology used for the experiment



Step1. Configuring interfaces on R1

```
R1# conf t
R1(config)#int s 0/0
R1(config-if)#ip address 10.0.0.1 255.255.255.252
R1(config-if)#no shut
R1(config-if)#ex
R1(config)int f0/0
R1(config-if)#ip address 192.168.2.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
```

```
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int s 0/0
R1(config-if)#ip addr
R1(config-if)#ip address 10.0.0.1 255.255.255.252
R1(config-if)#no shut
R1(config-if)#
*Mar 1 00:04:07.227: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
R1(config-if)#
*Mar 1 00:04:08.231: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R1(config-if)#ex
R1(config)int f 0/0
R1(config-if)#192.168
*Mar 1 00:04:33.999: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to down
R1(config-if)#192.168.2.1 255.255.255.0
^
% Invalid input detected at '^' marker.

R1(config-if)#ip addr 192.168.2.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#
*Mar 1 00:04:55.851: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:04:56.851: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
^
```

Step2. Configure interfaces on R2

```
R1(config)#int s0/0
R1(config-if)#ip address 10.0.0.2 255.255.255.252
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#int fa0/0
R1(config-if)#ip address 192.168.3.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
```

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#int s 0/0
R2(config-if)#ip addr 10.0.0.2 255.255.255.252
R2(config-if)#no shut
R2(config-if)# ex
R2(config)#
*Mar 1 00:04:27.207: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
R2(config)#
*Mar 1 00:04:28.211: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R2(config)#int f 0/0
R2(config-if)#ip addr
R2(config-if)#ip address
% Incomplete command.

R2(config-if)#ip address 192.168.3.1 255.255.255.0
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#
*Mar 1 00:04:51.367: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:04:52.367: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
```

Step3. Manually set an IP on PC1

```
PC>1 ip 192.168.2.3/24 192.168.2.1
```

```
PC1> ip 192.168.2.3/24 192.168.2.1
Checking for duplicate address...
PC1 : 192.168.2.3 255.255.255.0 gateway 192.168.2.1
```

Step4. Manually set an IP on PC2

```
PC>2 ip 192.168.3.3/24 192.168.3.1
```

```
PC2> ip 192.168.3.3/24 192.168.3.1
Checking for duplicate address...
PC1 : 192.168.3.3 255.255.255.0 gateway 192.168.3.1
```

Step5. Configuring static route on R1

```
R1(config)#router rip
R1(config-router)#network 10.0.0.0
```

R1(config-router)#network 192.168.2.0

R1(config-router)#end

R1#conf t

R1(config)#do sh ip route

```
R1(config)#router rip
R1(config-router)#n
R1(config-router)#net
R1(config-router)#network 10.0.0.0
R1(config-router)#ne
R1(config-router)#net
R1(config-router)#network 192.168.2.0
R1(config-router)#end
R1#conf
*Mar 1 00:33:40.311: %SYS-5-CONFIG_I: Configured from console by console
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, Serial0/0
C        192.168.2.0/24 is directly connected, FastEthernet0/0
```

Step6. Configuring static route on R2

R2(config)#router rip

R2(config-router)#network 10.0.0.0

R2(config-router)#network 192.168.3.0

R2(config-router)#ex

R2(config)#do sh ip route

```
R2(config)#router rip
R2(config-router)#net
R2(config-router)#network 10.0.0.0
R2(config-router)#net
R2(config-router)#network 192.168.3.0
R2(config-router)#ex
R2(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, Serial0/0
R        192.168.2.0/24 [120/1] via 10.0.0.1, 00:00:10, Serial0/0
C        192.168.3.0/24 is directly connected, FastEthernet0/0
```

Step7.Ping the end PCs

PC1>ping 192.168.3.3

PC2>ping 192.168.2.3

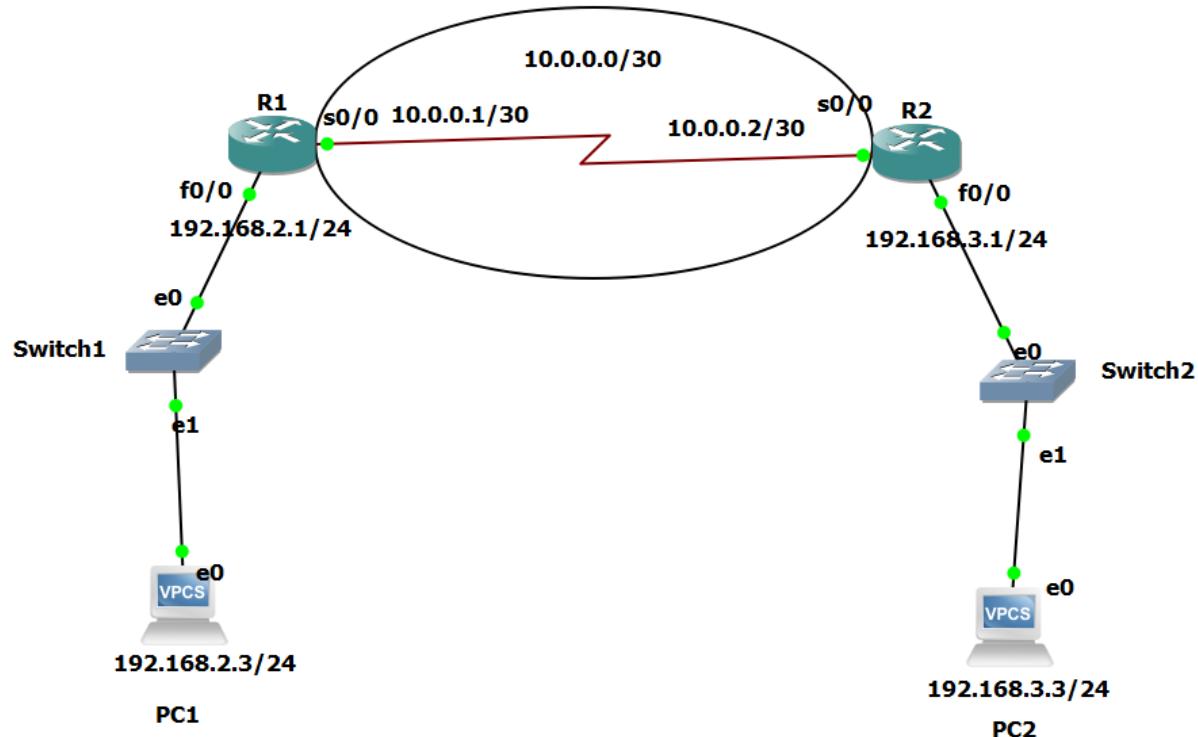
```
PC1> ping 192.168.3.3
192.168.3.3 icmp_seq=1 timeout
84 bytes from 192.168.3.3 icmp_seq=2 ttl=62 time=31.757 ms
84 bytes from 192.168.3.3 icmp_seq=3 ttl=62 time=30.848 ms
84 bytes from 192.168.3.3 icmp_seq=4 ttl=62 time=31.061 ms
84 bytes from 192.168.3.3 icmp_seq=5 ttl=62 time=31.315 ms
```

```
PC2> ping 192.168.2.3
84 bytes from 192.168.2.3 icmp_seq=1 ttl=62 time=31.179 ms
84 bytes from 192.168.2.3 icmp_seq=2 ttl=62 time=30.927 ms
84 bytes from 192.168.2.3 icmp_seq=3 ttl=62 time=30.951 ms
84 bytes from 192.168.2.3 icmp_seq=4 ttl=62 time=31.357 ms
84 bytes from 192.168.2.3 icmp_seq=5 ttl=62 time=31.011 ms
```

Practical 2a: Implement the concept of RIPv1 and RIPv2 routing protocol

RIP v1

Here is the physical topology



Step1. Configuring interfaces on R1

```
R1#conf t
R1(config)#int s0/0
R1(config-if)#ip address 10.0.0.1 255.255.255.252
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#int fa0/0
R1(config-if)#ip address 192.168.2.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
```

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int s 0/0
R1(config-if)#ip addr
R1(config-if)#ip address 10.0.0.1 255.255.255.252
R1(config-if)#no shut
R1(config-if)#
*Mar 1 00:04:07.227: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
R1(config-if)#
*Mar 1 00:04:08.231: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R1(config-if)#ex
R1(config)#int f 0/0
R1(config-if)#192.168
*Mar 1 00:04:33.999: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to down
R1(config-if)#192.168.2.1 255.255.255.0
^
% Invalid input detected at '^' marker.

R1(config-if)#ip addr 192.168.2.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#
*Mar 1 00:04:55.851: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:04:56.851: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
% Incomplete command.
```

Step2.Configure interfaces on R2

```
R2#conf t
R2(config)#int s0/0
R2(config-if)#ip address 10.0.0.2 255.255.255.255
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#int fa0/0
R2(config-if)#ip address 192.168.3.1 255.255.255.0
R2(config-if)#no shut
R2(config-if)#ex
```

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#int s 0/0
R2(config-if)#ip addr 10.0.0.2 255.255.255.252
R2(config-if)#no shut
R2(config-if)#
*Mar 1 00:04:27.207: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
R2(config)#
*Mar 1 00:04:28.211: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R2(config)#int f 0/0
R2(config-if)#ip addr
R2(config-if)#ip address
% Incomplete command.

R2(config-if)#ip address 192.168.3.1 255.255.255.0
R2(config-if)#no shut
R2(config-if)#
R2(config)#
*Mar 1 00:04:51.367: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:04:52.367: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
```

Step3. Manually set an IP on PC1

PC1> 192.168.2.3/24 192.168.2.1

```
PC1> ip 192.168.2.3/24 192.168.2.1
Checking for duplicate address...
PC1 : 192.168.2.3 255.255.255.0 gateway 192.168.2.1
```

Step4. Manually set an IP on PC2

PC2> 192.168.3.3/24 192.168.3.1

```
PC2> ip 192.168.3.3/24 192.168.3.1
Checking for duplicate address...
PC1 : 192.168.3.3 255.255.255.0 gateway 192.168.3.1
```

Step5. Configuring static route on R1

R1(config)#router rip

R1(config-router)#neighbor 10.0.0.0

R1(config-router)#neighbor 192.168.2.0

R1(config-router)#end

R1(config)#do sh ip route

```
R1(config)#router rip
R1(config-router)#n
R1(config-router)#net
R1(config-router)#network 10.0.0.0
R1(config-router)#ne
R1(config-router)#net
R1(config-router)#network 192.168.2.0
R1(config-router)#end
R1#conf
*Mar  1 00:33:40.311: %SYS-5-CONFIG_I: Configured from console by console
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, Serial0/0
C        192.168.2.0/24 is directly connected, FastEthernet0/0
```

Step6. Configuring static route on R2

```
R2(config)#router rip
R2(config-router)#neighbor 10.0.0.0
R2(config-router)#neighbor 192.168.3.0
R2(config-router)#end
R2(config)#do sh ip route
```

```
R2(config)#router rip
R2(config-router)#net
R2(config-router)#network 10.0.0.0
R2(config-router)#net
R2(config-router)#network 192.168.3.0
R2(config-router)#ex
R2(config)#do sh 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

  10.0.0.0/30 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, Serial0/0
R    192.168.2.0/24 [120/1] via 10.0.0.1, 00:00:10, Serial0/0
C    192.168.3.0/24 is directly connected, FastEthernet0/0
```

Step7.Ping the end PCs

PC1> ping 192.168.3.3

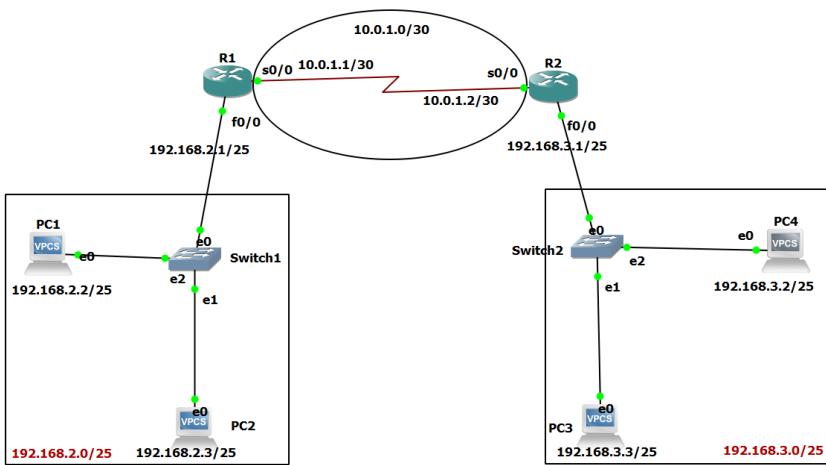
PC2> ping 192.168.2.3

```
PC1> ping 192.168.3.3
192.168.3.3 icmp_seq=1 timeout
84 bytes from 192.168.3.3 icmp_seq=2 ttl=62 time=31.757 ms
84 bytes from 192.168.3.3 icmp_seq=3 ttl=62 time=30.848 ms
84 bytes from 192.168.3.3 icmp_seq=4 ttl=62 time=31.061 ms
84 bytes from 192.168.3.3 icmp_seq=5 ttl=62 time=31.315 ms
```

```
PC2> ping 192.168.2.3
84 bytes from 192.168.2.3 icmp_seq=1 ttl=62 time=31.179 ms
84 bytes from 192.168.2.3 icmp_seq=2 ttl=62 time=30.927 ms
84 bytes from 192.168.2.3 icmp_seq=3 ttl=62 time=30.951 ms
84 bytes from 192.168.2.3 icmp_seq=4 ttl=62 time=31.357 ms
84 bytes from 192.168.2.3 icmp_seq=5 ttl=62 time=31.011 ms
```

RIPv2

Here is the physical topology

**Step1. Configure the router R1**

```
R1#conf t
R1(config)#int s0/0
R1(config-if)#ip address 10.0.1.1 255.255.255.252
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#int fa0/0
R1(config-if)#ip address 192.168.2.1 255.255.255.128
R1(config-if)#no shut
R1(config-if)#ex
R1(config-if)#do sh ip int br
```

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int s0/0
R1(config-if)#ip add
R1(config-if)#ip address 10.0.1.1 255.255.255.252
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#
:Mar 1 00:01:20.079: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
R1(config)#
:Mar 1 00:01:21.083: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R1(config)#
R1(config-if)#int fa0/0
R1(config-if)#ip addr
R1(config-if)#ip address 192.168.2.1 255.255.255.128
:Mar 1 00:01:44.919: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to down
R1(config-if)#ip address 192.168.2.1 255.255.255.128
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#
:Mar 1 00:01:51.819: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
:Mar 1 00:01:52.819: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R1(config)#
:Mar 1 00:02:24.915: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R1(config)#do sh ip int br
Interface          IP-Address      OK? Method Status           Protocol
FastEthernet0/0    192.168.2.1    YES manual up            up
Serial0/0          10.0.1.1      YES manual up            up
FastEthernet0/1    unassigned     YES unset administratively down down
Serial0/1          unassigned     YES unset administratively down down
Serial0/2          unassigned     YES unset administratively down down
Serial0/3          unassigned     YES unset administratively down down
FastEthernet1/0    unassigned     YES unset administratively down down
```

Step2. Configure the Router R2

```
R2#conf t
R2(config)#int s0/0
R2(config-if)#ip address 10.0.1.2 255.255.255.252
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#int fa0/0
R2(config-if)#ip address 192.168.3.1 255.255.255.128
R2(config-if)#no shut
R2(config-if)#ex
R2(config-if)#do sh ip int br
```

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#int s0/0
R2(config-if)#ip addr
R2(config-if)#ip address 10.0.1.2 255.255.255.252
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#
*Mar 1 00:01:40.627: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
*Mar 1 00:01:41.631: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R2(config)#int fo/0
R2(config-if)#ip addr
R2(config-if)#ip address 192.168.3.1 255.255.255.128
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#
*Mar 1 00:02:02.259: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:02:03.259: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R2(config)#do ip sh int br
ip sh int br
^
% Invalid input detected at '^' marker.

R2(config)#do sh ip int br
Interface          IP-Address      OK? Method Status        Protocol
FastEthernet0/0    192.168.3.1    YES manual up           up
Serial0/0          10.0.1.2      YES manual up           up
FastEthernet0/1    unassigned     YES unset administratively down down
Serial0/1          unassigned     YES unset administratively down down
```

Step3. Configure the PC1, PC2, PC3, PC4

PC1>ip 192.168.2.2/25 192.168.2.1

PC2>ip 192.168.2.3/25 192.168.2.1

PC3>ip 192.168.3.3/25 192.168.3.1

PC4>ip 192.168.3.2/25 192.168.3.1

```
PC1> ip 192.168.2.2/25 192.168.2.1
Checking for duplicate address...
PC1 : 192.168.2.2 255.255.255.128 gateway 192.168.2.1
```

```
PC2> ip 192.168.2.3/25 192.168.2.1
Checking for duplicate address...
PC1 : 192.168.2.3 255.255.255.128 gateway 192.168.2.1
```

```
PC3> ip 192.168.3.3/25 192.168.3.1
Checking for duplicate address...
PC1 : 192.168.3.3 255.255.255.128 gateway 192.168.3.1
```

```
PC4> ip 192.168.3.2/25 192.168.3.1
Checking for duplicate address...
PC1 : 192.168.3.2 255.255.255.128 gateway 192.168.3.1
```

Step4. Configure the RIP protocol in the R1

R1(config)#router rip

R1(config-router)#version 2

R1(config-router)#neighbor 10.0.1.0

R1(config-router)#neighbor 192.168.2.0

R1(config-router)#ex

```
R1(config)#router rip
R1(config-router)#vers
R1(config-router)#version 2
R1(config-router)#net
R1(config-router)#network
R1(config-router)#network 10.0.1.0
R1(config-router)#net
R1(config-router)#network 192.168.2.0
R1(config-router)#exit
```

Step5.Configure RIP protocol in the R2

```
R2(config)#router rip
R2(config-router)#version 2
R2(config-router)#neighbor 10.0.1.0
R2(config-router)#neighbor 192.168.3.0
R2(config-router)#ex
```

```
R2(config)#router rip
R2(config-router)#version 2
R2(config-router)#net
R2(config-router)#network 10.0.1.0
R2(config-router)#network 192.168.3.0
R2(config-router)#exit
```

Step6. Show IP route command in R1 and R2

```
R1(config)#do s hip route
```

```
R1(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C        10.0.1.0 is directly connected, Serial0/0
      192.168.2.0/25 is subnetted, 1 subnets
C        192.168.2.0 is directly connected, FastEthernet0/0
R        192.168.3.0/24 [120/1] via 10.0.1.2, 00:00:07, Serial0/0
```

```
R2(config)#do sh ip route
```

```
R2(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C          10.0.1.0 is directly connected, Serial0/0
R          192.168.2.0/24 [120/1] via 10.0.1.1, 00:00:17, Serial0/0
          192.168.3.0/25 is subnetted, 1 subnets
C          192.168.3.0 is directly connected, FastEthernet0/0
```

Step7.ping with the end PCs

PC1> ping 192.168.3.2	PC1> ping 192.168.3.3
PC2> ping 192.168.3.3	PC2> ping 192.168.3.2
PC3> ping 192.168.2.3	PC3> ping 192.168.2.2
PC4> ping 192.168.2.3	PC4> ping 192.168.2.2

```
PC1> ping 192.168.3.2
192.168.3.2 icmp_seq=1 timeout
84 bytes from 192.168.3.2 icmp_seq=2 ttl=62 time=30.972 ms
84 bytes from 192.168.3.2 icmp_seq=3 ttl=62 time=31.203 ms
84 bytes from 192.168.3.2 icmp_seq=4 ttl=62 time=31.540 ms
84 bytes from 192.168.3.2 icmp_seq=5 ttl=62 time=31.269 ms

PC1> ping 192.168.3.3
192.168.3.3 icmp_seq=1 timeout
84 bytes from 192.168.3.3 icmp_seq=2 ttl=62 time=30.764 ms
84 bytes from 192.168.3.3 icmp_seq=3 ttl=62 time=30.701 ms
84 bytes from 192.168.3.3 icmp_seq=4 ttl=62 time=30.659 ms
84 bytes from 192.168.3.3 icmp_seq=5 ttl=62 time=31.199 ms
```

```
PC2> ping 192.168.3.3
84 bytes from 192.168.3.3 icmp_seq=1 ttl=62 time=31.148 ms
84 bytes from 192.168.3.3 icmp_seq=2 ttl=62 time=31.654 ms
84 bytes from 192.168.3.3 icmp_seq=3 ttl=62 time=31.288 ms
84 bytes from 192.168.3.3 icmp_seq=4 ttl=62 time=31.300 ms
84 bytes from 192.168.3.3 icmp_seq=5 ttl=62 time=31.690 ms

PC2> ping 192.168.3.2
84 bytes from 192.168.3.2 icmp_seq=1 ttl=62 time=31.043 ms
84 bytes from 192.168.3.2 icmp_seq=2 ttl=62 time=31.432 ms
84 bytes from 192.168.3.2 icmp_seq=3 ttl=62 time=31.760 ms
84 bytes from 192.168.3.2 icmp_seq=4 ttl=62 time=31.730 ms
84 bytes from 192.168.3.2 icmp_seq=5 ttl=62 time=30.290 ms
```

```
PC3> ping 192.168.2.3
84 bytes from 192.168.2.3 icmp_seq=1 ttl=62 time=30.977 ms
84 bytes from 192.168.2.3 icmp_seq=2 ttl=62 time=31.545 ms
84 bytes from 192.168.2.3 icmp_seq=3 ttl=62 time=30.394 ms
84 bytes from 192.168.2.3 icmp_seq=4 ttl=62 time=30.524 ms
84 bytes from 192.168.2.3 icmp_seq=5 ttl=62 time=30.775 ms

PC3> ping 192.168.2.2
Cannot resolve 192.168.2.2

PC3> ping 192.168.2.2
84 bytes from 192.168.2.2 icmp_seq=1 ttl=62 time=30.619 ms
84 bytes from 192.168.2.2 icmp_seq=2 ttl=62 time=31.188 ms
84 bytes from 192.168.2.2 icmp_seq=3 ttl=62 time=31.602 ms
84 bytes from 192.168.2.2 icmp_seq=4 ttl=62 time=32.549 ms
84 bytes from 192.168.2.2 icmp_seq=5 ttl=62 time=30.971 ms
```

```
PC4> ping 192.168.2.3
84 bytes from 192.168.2.3 icmp_seq=1 ttl=62 time=31.234 ms
84 bytes from 192.168.2.3 icmp_seq=2 ttl=62 time=31.438 ms
84 bytes from 192.168.2.3 icmp_seq=3 ttl=62 time=31.548 ms
84 bytes from 192.168.2.3 icmp_seq=4 ttl=62 time=31.593 ms
84 bytes from 192.168.2.3 icmp_seq=5 ttl=62 time=31.287 ms

PC4> ping 192.168.2.2
84 bytes from 192.168.2.2 icmp_seq=1 ttl=62 time=31.594 ms
84 bytes from 192.168.2.2 icmp_seq=2 ttl=62 time=31.895 ms
84 bytes from 192.168.2.2 icmp_seq=3 ttl=62 time=30.996 ms
84 bytes from 192.168.2.2 icmp_seq=4 ttl=62 time=30.980 ms
84 bytes from 192.168.2.2 icmp_seq=5 ttl=62 time=31.051 ms
```

Step8. On Router R2, execute the debug IP rip command to check the RIPv2 configuration and you will see a log as shown in the image below.

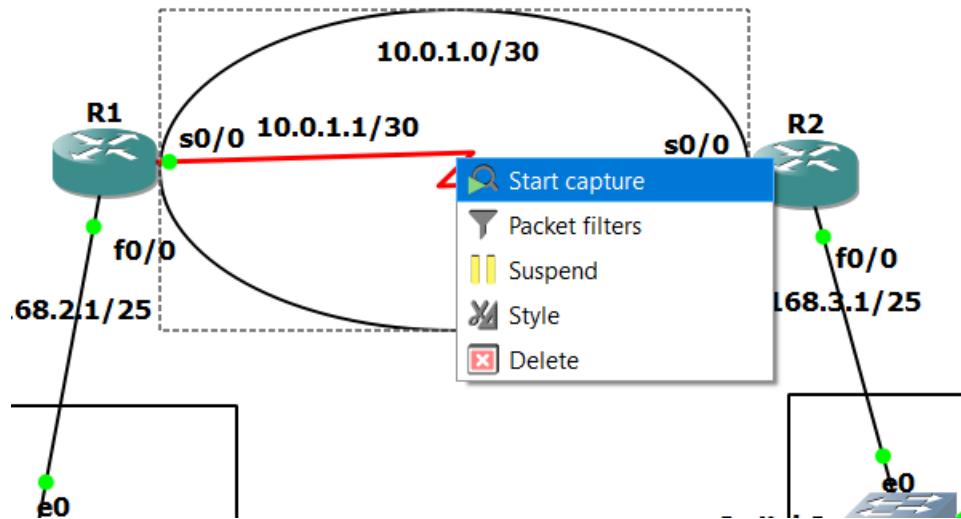
R2(config)#do debug ip rip

```
R2(config)#do debug ip rip
RIP protocol debugging is on
R2(config)#
*Mar 1 00:17:43.371: RIP: sending v2 update to 224.0.0.9 via Serial0/0 (10.0.1.2)
*Mar 1 00:17:43.371: RIP: build update entries
*Mar 1 00:17:43.371: 192.168.3.0/24 via 0.0.0.0, metric 1, tag 0
R2(config)#
*Mar 1 00:17:46.491: RIP: sending v2 update to 224.0.0.9 via FastEthernet0/0 (192.168.3.1)
*Mar 1 00:17:46.491: RIP: build update entries
*Mar 1 00:17:46.491: 10.0.0.0/8 via 0.0.0.0, metric 1, tag 0
*Mar 1 00:17:46.495: 192.168.2.0/24 via 0.0.0.0, metric 2, tag 0
R2(config)#
*Mar 1 00:17:54.767: RIP: received v2 update from 10.0.1.1 on Serial0/0
*Mar 1 00:17:54.767: 192.168.2.0/24 via 0.0.0.0 in 1 hops
R2(config)#
*Mar 1 00:18:12.207: RIP: sending v2 update to 224.0.0.9 via Serial0/0 (10.0.1.2)
*Mar 1 00:18:12.207: RIP: build update entries
*Mar 1 00:18:12.207: 192.168.3.0/24 via 0.0.0.0, metric 1, tag 0
R2(config)#undeb
*Mar 1 00:18:16.267: RIP: sending v2 update to 224.0.0.9 via FastEthernet0/0 (192.168.3.1)
*Mar 1 00:18:16.267: RIP: build update entries
*Mar 1 00:18:16.267: 10.0.0.0/8 via 0.0.0.0, metric 1, tag 0
*Mar 1 00:18:16.267: 192.168.2.0/24 via 0.0.0.0, metric 2, tag 0
R2(config)#undebug ip rip
^
% Invalid input detected at '^' marker.

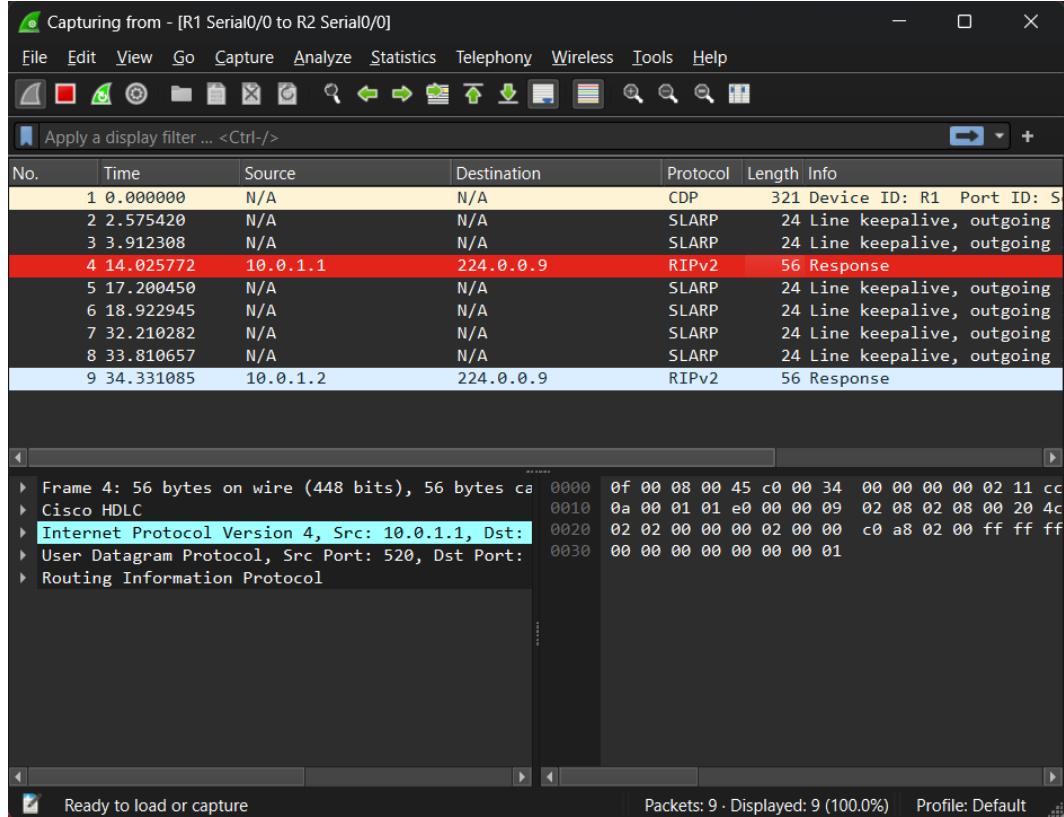
R2(config)#do undebug ip rip
RIP protocol debugging is off
```

Step9. We can use the Wireshark program to verify RIPv2. Start the Wireshark program I in between Serial communication line. We can view the RIP V2 (224.0.0.9) output from the image below.

After clicking on Start capture the next screen opens

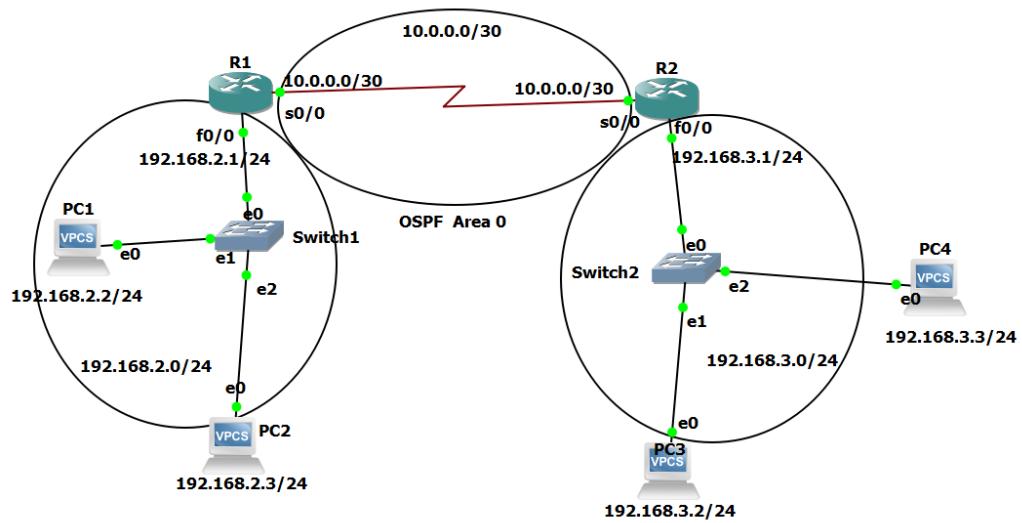


In this screen we can see RIPv2 output on the destination 224.0.0.9



Practical2b: Implementing Dynamic Routing Protocol (OSPF)

Here is the Physical topology



Step 1. Configure the R1

```
R1#conf t
R1(config)#int s0/0
R1(config-if)#ip address 10.0.0.1 255.255.255.252
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#int fa0/0
R1(config-if)#ip address 192.168.2.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
R1(config-if)#do sh ip int br
```

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int s0/0
R1(config-if)#ip addr
R1(config-if)#ip address 10.0.0.1 255.255.255.252
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#int
*Mar 1 00:01:27.499: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
R1(config)#int
*Mar 1 00:01:28.503: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R1(config)#int f 0/0
R1(config-if)#ip addr 192.168.2.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#
*Mar 1 00:01:45.543: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:01:46.543: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R1(config)#
*Mar 1 00:02:04.763: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
```

```
R1(config)#
*Mar 1 00:02:04.763: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R1(config)#
R1(config)# do sh ip int br
Interface          IP-Address      OK? Method Status        Protocol
FastEthernet0/0      192.168.2.1    YES  manual   up
Serial0/0            10.0.0.1       YES  manual   up
```

Step 2. Configure the R2

```
R2#conf t
R2(config)#int s0/0
R2(config-if)#ip address 10.0.0.2 255.255.255.252
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#int fa0/0
R2(config-if)#ip address 192.168.3.1 255.255.255.0
```

```
R2(config-if)#no shut
R2(config-if)#ex
R2(config-if)#do sh ip int br
```

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#int s 0/0
R2(config-if)#ip addr 10.0.0.2 255.255.255.252
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#
*Mar 1 00:01:42.675: %LINK-3-UPDOWN: Interface Serial0/0, changed state to up
R2(config)#int
*Mar 1 00:01:43.679: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up
R2(config)#int f 0/0
R2(config-if)#ip addr 192.168.3.1 255.255.255.0
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#
*Mar 1 00:01:58.327: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:01:59.327: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R2(config)#do sh ip int br
Interface          IP-Address      OK? Method Status        Protocol
FastEthernet0/0    192.168.3.1    YES manual up           up
Serial0/0          10.0.0.2      YES manual up           up
FastEthernet0/1    unassigned     YES unset administratively down down
Serial0/1          unassigned     YES unset administratively down down
Serial0/2          unassigned     YES unset administratively down down
```

Step 3. Configure the PC1, PC2, PC3, PC4

PC1> ip 192.168.2.2/24 192.168.2.1

PC2> ip 192.168.2.3/24 192.168.2.1

PC3> ip 192.168.3.2/24 192.168.3.1

PC4> ip 192.168.3.3/24 192.168.3.1

```
PC1> ip 192.168.2.2/24 192.168.2.1
Checking for duplicate address...
PC1 : 192.168.2.2 255.255.255.0 gateway 192.168.2.1
```

```
PC2> ip 192.168.2.3/24 192.168.2.1
Checking for duplicate address...
PC1 : 192.168.2.3 255.255.255.0 gateway 192.168.2.1
```

```
PC3> ip 192.168.3.2/24 192.168.3.1
Checking for duplicate address...
PC1 : 192.168.3.2 255.255.255.0 gateway 192.168.3.1
```

```
PC4> ip 192.168.3.3/24 192.168.3.1
Checking for duplicate address...
PC1 : 192.168.3.3 255.255.255.0 gateway 192.168.3.1
```

Step 4. Configure the OSPF area 0 on Router R1 and R2

R1

R1(config)#router ospf 10

R1(config-router)#network 192.168.2.0 0.0.0.255 area 0

R1(config-router)#network 10.0.0.0.0.0.3 area 0

R1(config-router)#ex

R1(config)#do sh ip route

```
R1(config)#router ospf 10
R1(config-router)#net
R1(config-router)#network 192.168.2.0 0.0.0.255 area 0
R1(config-router)#network 10.0.0.0 0.0.0.3 area 0
R1(config-router)#exit
R1(config)#
*Mar 1 00:07:20.267: %OSPF-5-ADJCHG: Process 10, Nbr 192.168.3.1 on Serial0/0 from LOADING to FULL, Loading Done
R1(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, Serial0/0
C        192.168.2.0/24 is directly connected, FastEthernet0/0
O        192.168.3.0/24 [110/74] via 10.0.0.2, 00:00:32, Serial0/0
```

R2(config)#router ospf 10

R2(config-router)#network 192.168.3.0 0.0.0.255 area 0

R2(config-router)#network 10.0.0.0.0.0.3 area 0

R2(config-router)#ex

R2(config)#do sh ip route

```
R2(config)#router ospf 10
R2(config-router)#net
R2(config-router)#network 10.0.0.0 0.0.0.3 area 0
R2(config-router)#net
R2(config-router)#network
*Mar 1 00:06:00.247: %OSPF-5-ADJCHG: Process 10, Nbr 192.168.2.1 on Serial0/0 from LOADING to FULL, Loading Done
R2(config-router)#network 192.168.3.0 0.0.0.255 area 0
R2(config-router)#ex
R2(config)#do sh 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

      10.0.0.0/30 is subnetted, 1 subnets

C        10.0.0.0 is directly connected, Serial0/0
O        192.168.2.0/24 [110/74] via 10.0.0.1, 00:00:24, Serial0/0
C        192.168.3.0/24 is directly connected, FastEthernet0/0
R2(config)#[
```

Step 5. Show the ospf neighbor and OSPF database

R1(config)#do sh ip ospf neighbor

```
R1(config)#do sh ip ospf neighbor
Neighbor ID      Pri  State          Dead Time   Address           Interface
192.168.3.1      0    FULL/ -        00:00:30    10.0.0.2       Serial0/0
R1(config)#do sh ip ospf database
              OSPF Router with ID (192.168.2.1) (Process ID 10)
              Router Link States (Area 0)
Link ID          ADV Router     Age      Seq#      Checksum Link count
192.168.2.1      192.168.2.1  103      0x80000003 0x00D4EF 3
192.168.3.1      192.168.3.1  84       0x80000002 0x00B70B 3
```

Step 6. Start the debugging

R1(config)#do debug ip ospf packet

```
R1(config)#do debug ip ospf packet
OSPF packet debugging is on
R1(config)#
*Mar  1 00:10:50.247: OSPF: rcv. v:2 t:1 l:48 rid:192.168.3.1
    aid:0.0.0 chk:654B aut:0 auk: from Serial0/0
R1(config)#
*Mar  1 00:11:00.215: OSPF: rcv. v:2 t:1 l:48 rid:192.168.3.1
    aid:0.0.0 chk:654B aut:0 auk: from Serial0/0
```

Step 7. Ping PC1 to PC4

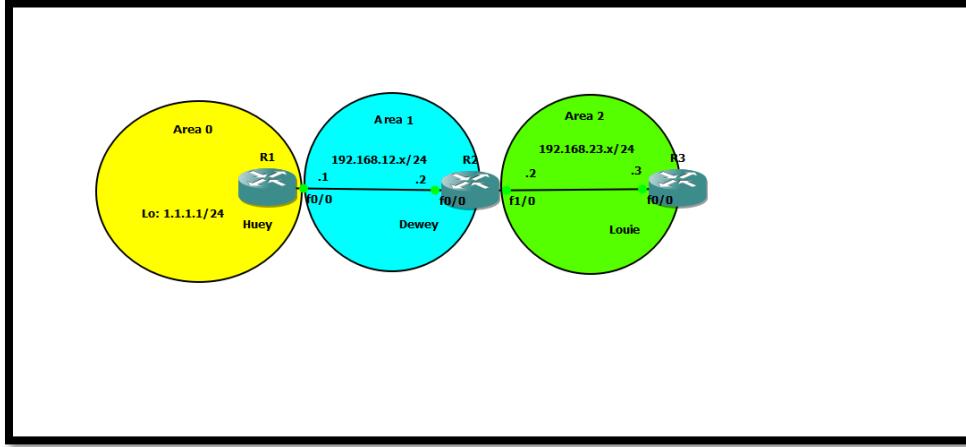
PC1>ping 192.168.3.3

```
PC1> ping 192.168.3.3
192.168.3.3 icmp_seq=1 timeout
84 bytes from 192.168.3.3 icmp_seq=2 ttl=62 time=31.006 ms
84 bytes from 192.168.3.3 icmp_seq=3 ttl=62 time=30.960 ms
84 bytes from 192.168.3.3 icmp_seq=4 ttl=62 time=31.083 ms
84 bytes from 192.168.3.3 icmp_seq=5 ttl=62 time=30.447 ms
```

Step 8. Switch off the Debugging mode

R1(config)#do undebug ip ospf packet

```
R1(config)#do undebug ip ospf packet
*Mar  1 00:11:10.235: OSPF: rcv. v:2 t:1 l:48 rid:192.168.3.1
    aid:0.0.0 chk:654B aut:0 auk: from Serial0/0
R1(config)#do undebug ip ospf packet
OSPF packet debugging is off
```

Practical3a-Implement the concept of OSPF Virtual-Link Configuration

```
R1#conf t  
R1(config)#ip cef  
R1(config)#int la0  
R1(config-if)#ip address 1.1.1.1 255.255.255.0  
R1(config-if)#no shut  
R1(config-if)#ex  
R1(config)#int fa0/0  
R1(config-if)#ip address 192.168.12.1 255.255.255.0  
R1(config-if)#no shut  
R1(config-if)#duplex auto  
R1(config-if)#speed auto  
R1(config-if)#ex
```

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#ip cef
R1(config)#int lo0
R1(config-if)#ip a
*Mar 1 00:00:28.387: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0,
changed state to up
R1(config-if)#ip address 1.1.1.1 255.255.255.0
R1(config-if)#ex
R1(config)#int fa 0/0
R1(config-if)#ip address 192.168.12.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#duplex a
*Mar 1 00:01:52.643: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to
o up
*Mar 1 00:01:53.643: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R1(config-if)#duplex auto
R1(config-if)#speed auto
R1(config-if)#ex
R1(config)#end
R1#sh
```

```
R1#conf t

R2(config)#ip cef

R2(config)#int la0

R2(config-if)#

R2(config-if)#ex

R2(config)#int fa0/0

R2(config-if)#ip address 192.168.12.2 255.255.255.0

R2(config-if)#no shut

R2(config-if)#duplex auto

R2(config-if)#speed auto

R2(config-if)#ex

R2(config)#int fa1/0

R2(config-if)#ip address 192.168.23.2 255.255.255.0

R2(config-if)#no shut

R2(config-if)#duplex auto

R2(config-if)#speed auto

R2(config-if)#ex
```

```

et1/0, changed state to down
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#ip cef
R2(config)int lo0
R2(config-if)#
R2(config-if)#
*Mar 1 00:01:24.799: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0,
  changed state to up
R2(config-if)#ex
R2(config)int fa 0/0
R2(config-if)#ip address 192.168.12.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#duplex
*Mar 1 00:02:03.619: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to
  up
*Mar 1 00:02:04.619: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet
et0/0, changed state to up
R2(config-if)#duplex auto
R2(config-if)#speed auto
R2(config-if)#ex
R2(config)int fa 1/0
R2(config-if)#ip address 192.168.23.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#dup
*Mar 1 00:03:00.359: %LINK-3-UPDOWN: Interface FastEthernet1/0, changed state to
  up
*Mar 1 00:03:01.359: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet
et1/0, changed state to up
R2(config-if)#duplex auto
R2(config-if)#speed auto
R2(config-if)#ex
R2(config)#end
R2#

```

R3#conf t

R3(config)#ip cef

R3(config)#int la0

R3(config-if)#ip address 172.16.0.1 255.255.255.0

R3(config-if)#no shut

R3(config-if)#ex

R3(config)#int la1

R3(config-if)#ip address 172.16.1.1 255.255.255.0

R3(config-if)#no shut

R3(config-if)#ex

R3(config)#int la2

R3(config-if)#ip address 172.16.2.1 255.255.255.0

R3(config-if)#no shut

R3(config-if)#ex

R3(config)#int la3

R3(config-if)#ip address 172.16.3.1 255.255.255.0

R3(config-if)#no shut

R3(config-if)#ex

R3(config)#int fa0/0

```
R3(config-if)#ip address 192.168.23.3 255.255.255.0
```

```
R3(config-if)#no shut
```

```
R3(config-if)#duplex auto
```

```
R3(config-if)#speed auto
```

```
R3(config-if)#ex
```

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#ip cef
R3(config)#int lo0
R3(config-if)#
*Mar 1 00:12:22.627: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0,
` changed state to up
R3(config-if)#ip address 172.16.0.1 255.255.255.0
R3(config-if)#ex
R3(config)#int lo1
R3(config-if)#
*Mar 1 00:13:44.039: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback1,
` changed state to up
R3(config-if)#ip address 172.16.1.1 255.255.255.0
R3(config-if)#ex
R3(config)#int lo2
R3(config-if)#
*Mar 1 00:14:38.963: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback2,
` changed state to up
R3(config-if)#ip address 172.16.2.1 255
% Incomplete command.

R3(config-if)#ip address 172.16.2.1 255.255.255.0
R3(config-if)#ex
R3(config)#int lo3
R3(config-if)#
*Mar 1 00:15:36.067: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback3,
` changed state to up
R3(config-if)#ip address 172.16.3.1 255.255.255.0
R3(config-if)#ex
R3(config-if)#int fa 0/0
R3(config-if)#ip address 192.168.23.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#duplex
*Mar 1 00:16:36.827: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to
o up
*Mar 1 00:16:37.827: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet
0/0, changed state to up
R3(config-if)#duplex auto
R3(config-if)#speed auto
R3(config-if)#ex
R3(config)#end
R3#s
```

Show ip route

```
R1#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

C    192.168.12.0/24 is directly connected, FastEthernet0/0
      1.0.0.0/24 is subnetted, 1 subnets
C          1.1.1.0 is directly connected, Loopback0
R1#
```

```
R2#show ip route
```

```
R2#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    192.168.12.0/24 is directly connected, FastEthernet0/0
C    192.168.23.0/24 is directly connected, FastEthernet1/0
R2#
```

R3#show ip route

```
R3#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

      172.16.0.0/24 is subnetted, 4 subnets
C        172.16.0.0 is directly connected, Loopback0
C        172.16.1.0 is directly connected, Loopback1
C        172.16.2.0 is directly connected, Loopback2
C        172.16.3.0 is directly connected, Loopback3
C    192.168.23.0/24 is directly connected, FastEthernet0/0
R3#
```

R1(config)#router ospf 1

R1(config-router)#network 192.168.12.0 0.0.0.255 area 1

R1(config-router)#network 1.1.1.0 0.0.0.255 area 0

R1(config-router)#ex

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#router ospf 1
R1(config-router)#network 1.1.1.0 0.0.0.255 area 0
R1(config-router)#network 192.168.12.0 0.0.0.255 area 1
R1(config-router)#
*Mar 1 00:20:44.955: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.23.2 on FastEtherne
t0/0 from LOADING to FULL, Loading Done
R1(config-router)#ex
R1(config)#end
R1#d
```

R2(config)#router ospf 1

R2(config-router)#network 192.168.12.0 0.0.0.255 area 1

R2(config-router)#network 192.168.23.0 0.0.0.255 area 2

R2(config-router)#ex

```
R2(config)#router ospf 1
R2(config-router)#network 192.168.12.0 0.0.0.255 area 1
R2(config-router)#
*Mar 1 00:19:11.003: %OSPF-5-ADJCHG: Process 1, Nbr 1.1.1.1 on FastEthernet0/0
from LOADING to FULL, Loading Done
R2(config-router)#network 192.168.23.0 0.0.0.255 area 2
R2(config-router)#
*Mar 1 00:21:22.171: %OSPF-5-ADJCHG: Process 1, Nbr 172.16.3.1 on FastEthernet1
/0 from LOADING to FULL, Loading Done
R2(config-router)#ex
```

R3(config)#router ospf 1

R3(config-router)#network 192.168.23.0 0.0.0.255 area 2

R3(config-router)#ex

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#router ospf 1
R3(config-router)#network 192.168.23.0 0.0.0.255 area 2
R3(config-router)#
*Mar 1 00:29:46.655: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.23.2 on FastEtherne
t0/0 from LOADING to FULL, Loading Done
R3(config-router)#ex
```

R1# Show ip ospf neighbor

```
R1#show ip ospf neighbor
Neighbor ID      Pri   State          Dead Time     Address          Interface
192.168.23.2      1     FULL/BDR      00:00:35     192.168.12.2    FastEthernet0/
0
R1#S
```

R2# Show ip ospf neighbor

```
R2(config)#do show ip ospf neighbor
Neighbor ID      Pri   State          Dead Time     Address          Interface
1.1.1.1          1     FULL/DR       00:00:37     192.168.12.1    FastEthernet0/
0
172.16.3.1        1     FULL/BDR      00:00:37     192.168.23.3    FastEthernet1/
0
```

R3# Show ip ospf neighbor

```
R3(config)#do show ip ospf neighbor
Neighbor ID      Pri   State          Dead Time     Address          Interface
192.168.23.2      1     FULL/DR       00:00:30     192.168.23.2    FastEthernet0/
0
```

Virtual link

R1#conf t

R1(config)#router ospf 1

R1(config-router)#area 1 virtual-link 192.168.23.2

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#router ospf 1
R1(config-router)#area 1 virtual-link 192.168.23.2
R1(config-router)#
*Mar 1 00:31:30.071: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.23.2 on OSPF_VL0 from LOADING to FULL, Loading Done
R1(config-router)#[
```

R2#conf t

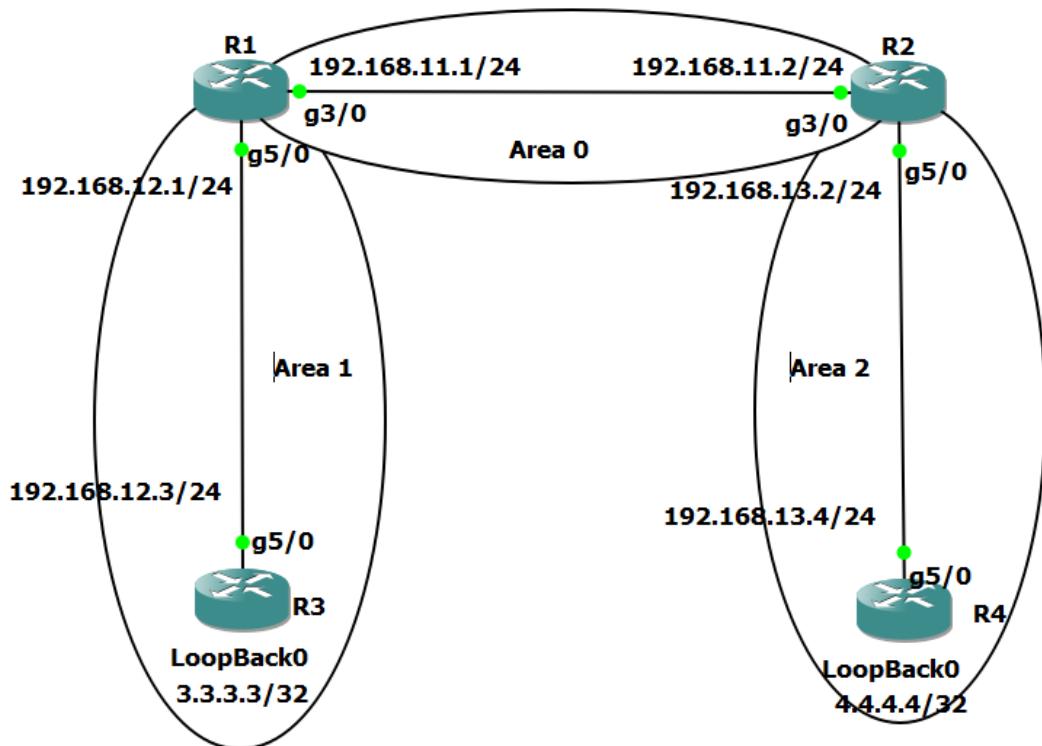
R2(config)#router ospf 1

R2(config-router)#area 1 virtual-link 1.1.1.1

```
R2(config)#router ospf 1
R2(config-router)#area 1 virtual-link 1.1.1.1
R2(config-router)#
*Mar 1 00:29:56.115: %OSPF-5-ADJCHG: Process 1, Nbr 1.1.1.1 on OSPF_VL0 from LOADING to FULL, Loading Done
R2(config-router)#[
```

Practical3b- Implement the concept OSPF Standard Area and Backbone Area

Step 1: do topology according to the image given below:



Step 2: do the initial configuration of the routers R1, R2, R3, R4 as follows:

R1

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int g3/0
R1(config-if)#ip addr 192.168.11.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#
*Feb 19 18:22:04.675: %LINK-3-UPDOWN: Interface GigabitEthernet3/0, changed state to up
*Feb 19 18:22:05.675: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet3/0, changed state to up
R1(config)#int g5/0
R1(config-if)#ip addr 192.168.12.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#
*Feb 19 18:22:27.127: %LINK-3-UPDOWN: Interface GigabitEthernet5/0, changed state to up
*Feb 19 18:22:28.127: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet5/0, changed state to up
```

R2

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#int g3/0
R2(config-if)#ip addr 192.168.11.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#exit
R2(config)#int g5/
*Feb 19 18:24:09.331: %LINK-3-UPDOWN: Interface GigabitEthernet3/0, changed state to up
*Feb 19 18:24:10.331: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet3/0, changed state to up
R2(config)#int g5/0
R2(config-if)#ip addr 192.168.13.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#exit
R2(config)#
*Feb 19 18:24:31.303: %LINK-3-UPDOWN: Interface GigabitEthernet5/0, changed state to up
*Feb 19 18:24:32.303: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet5/0, changed state to up
```

R3

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#int lo0
R3(config)#int loopback 0
R3(config-if)#
*Feb 19 18:25:45.519: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R3(config-if)#ip addr 3.3.3.3 255.255.255.255
R3(config-if)#no shut
R3(config-if)#exit
R3(config)#int g5/0
R3(config-if)#ip addr 192.168.12.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#exit
R3(config)#
*Feb 19 18:27:11.867: %LINK-3-UPDOWN: Interface GigabitEthernet5/0, changed state to up
*Feb 19 18:27:12.867: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet5/0, changed state to up
```

R4

```
R4#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R4(config)#int loop
R4(config)#int loopback 0
R4(config-if)#
*Feb 19 18:27:25.615: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R4(config-if)#ip addr 4.4.4.4 255.255.255.255
R4(config-if)#no shut
R4(config-if)#exit
R4(config)#int g5.0
^
% Invalid input detected at '^' marker.

R4(config)#int g5/0
R4(config-if)#ip addr 192.168.13.4 255.255.255.0
R4(config-if)#no shut
R4(config-if)#exit
R4(config)#
*Feb 19 18:28:05.667: %LINK-3-UPDOWN: Interface GigabitEthernet5/0, changed state to up
*Feb 19 18:28:06.667: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet5/0, changed state to up
```

Step3: Configure the ospf for every router as follows:**R1 and R2 for the backbone area:**

```
R1(config)#router ospf 1
R1(config-router)#net
R1(config-router)#network 192.168.11.0 0.0.0.255 area 0
R1(config-router)#exit
R1(config)#router
*Feb 19 18:29:50.683: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.13.2 on GigabitEthernet3/0 from LOADING to FULL, Loading Done
```

R1(config)#router ospf 1

R1(config-router)#network 192.168.11.0 0.0.0.255 area 0

```
R2(config)#router ospf 1
R2(config-router)#network 192.168.11.0 0.0.0.255 area 0
R2(config-router)#exit
```

R2(config)#router ospf 1

R2(config-router)#network 192.168.11.0 0.0.0.255 area 0

configure R1 and R3 for area 1:

```
R1(config)#router ospf 1
R1(config-router)#network 192.168.12.0 0.0.0.255 area 1
R1(config-router)#exit
R1(config)#
*Feb 19 18:31:25.571: %OSPF-5-ADJCHG: Process 1, Nbr 3.3.3.3 on GigabitEthernet5/0 from LOADING to FULL, Loading Done
```

R1(config)#router ospf 1

R1(config-router)#network 192.168.12.0 0.0.0.255 area 1

```
R3(config)#router ospf 1
R3(config-router)#network 3.3.3.3 0.0.0.0 area 1
R3(config-router)#network 192.168.12.0 0.0.0.255 area 1
R3(config-router)#exit
R3(config)#
*Feb 19 18:31:25.479: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.12.1 on GigabitEthernet5/0 from LOADING to FULL, Loading Done
```

R3(config)#router ospf 1

R3(config-router)#network 192.168.12.0 0.0.0.255 area 1

R3(config-router)#network 3.3.3.3 0.0.0.0 area 1

Configure R2 and R4 for area 2:

```
R2(config)#router ospf 1
R2(config-router)#network 192.168.13.0 0.0.0.255 area 2
R2(config-router)#exit
R2(config)#
*Feb 19 18:32:51.447: %OSPF-5-ADJCHG: Process 1, Nbr 4.4.4.4 on GigabitEthernet5/0 from LOADING to FULL, Loading Done
```

R2(config)#router ospf 1

R2(config-router)#network 192.168.13.0 0.0.0.255 area 2

```
R4(config)#router ospf 1
R4(config-router)#net
R4(config-router)#network 192.168.13.0 0.0.0.255 area 2
R4(config-router)#network 4.4.4.4 0.0.0.0 area 2
R4(config-router)#exit
R4(config)#
*Feb 19 18:32:51.791: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.13.2 on GigabitEthernet5/0 from LOADING to FULL, Loading Done
```

R4(config)#router ospf 1
 R4(config-router)#network 192.168.13.0 0.0.0.255 area 2
 R4(config-router)#network 4.4.4.4 0.0.0.0 area 2

Step 4: Verification of the network

Check the OSPF neighbors:

R1#show ip ospf neighbor

```
R1(config)#do sh ip ospf neighbor

Neighbor ID      Pri  State          Dead Time    Address          Interface
192.168.13.2      1    FULL/DR        00:00:39   192.168.11.2    GigabitEthernet3/0
3.3.3.3          1    FULL/BDR       00:00:32   192.168.12.3    GigabitEthernet5/0
```

R1 has formed a neighbor adjacency with R2 and R3. Let's check R2:

R2#show ip ospf neighbor

```
R2(config)#do sh ip ospf neighbor

Neighbor ID      Pri  State          Dead Time    Address          Interface
192.168.12.1      1    FULL/BDR       00:00:35   192.168.11.1    GigabitEthernet3/0
4.4.4.4          1    FULL/DR        00:00:38   192.168.13.4    GigabitEthernet5/0
```

R2 has formed neighbor adjacencies with R1 and R4. The show ip ospf neighbor command, however, doesn't tell me anything about the areas that are used, So we check it using the **show ip ospf neighbor detail command**

R2#show ip ospf neighbor detail

```
R2(config)#do sh ip ospf neighbor detail
Neighbor 192.168.12.1, interface address 192.168.11.1
  In the area 0 via interface GigabitEthernet3/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 192.168.11.2 BDR is 192.168.11.1
  Options is 0x12 in Hello (E-bit, L-bit)
  Options is 0x52 in DBD (E-bit, L-bit, O-bit)
  LLS Options is 0x1 (LR)
  Dead timer due in 00:00:39
  Neighbor is up for 00:05:27
  Index 1/1, retransmission queue length 0, number of retransmission 0
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 0, maximum is 0
  Last retransmission scan time is 0 msec, maximum is 0 msec
Neighbor 4.4.4.4, interface address 192.168.13.4
  In the area 2 via interface GigabitEthernet5/0
  Neighbor priority is 1, State is FULL, 6 state changes
  DR is 192.168.13.4 BDR is 192.168.13.2
  Options is 0x12 in Hello (E-bit, L-bit)
  Options is 0x52 in DBD (E-bit, L-bit, O-bit)
  LLS Options is 0x1 (LR)
  Dead timer due in 00:00:32
  Neighbor is up for 00:01:51
  Index 1/2, retransmission queue length 0, number of retransmission 0
  First 0x0(0)/0x0(0) Next 0x0(0)/0x0(0)
  Last retransmission scan length is 0, maximum is 0
  Last retransmission scan time is 0 msec, maximum is 0 msec
```

Above you can see that interface GigabitEthernet0/1 is in area 0 and interface GigabitEthernet0/2 is in area 2. Another good command to find area information is show ip protocols:

R2#show ip protocols

```
R2(config)#do sh ip protocols
*** IP Routing is NSF aware ***

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.13.2
  It is an area border router
  Number of areas in this router is 2. 2 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.11.0 0.0.0.255 area 0
    192.168.13.0 0.0.0.255 area 2
  Routing Information Sources:
    Gateway        Distance      Last Update
    4.4.4.4          110          00:02:30
    192.168.12.1     110          00:02:40
  Distance: (default is 110)
```

Above you can see which networks belong to which area:

Network 192.168.11.0 in area 0.

Network 192.168.13.0 in area 2.

Check the routing tables:

R1#show ip route ospf

```
R1(config)#do sh ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.3 [110/2] via 192.168.12.3, 00:04:24, GigabitEthernet5/0
      4.0.0.0/32 is subnetted, 1 subnets
O IA    4.4.4.4 [110/3] via 192.168.11.2, 00:03:01, GigabitEthernet3/0
O IA    192.168.13.0/24 [110/2] via 192.168.11.2, 00:03:01, GigabitEthernet3/0
```

Above we see three OSPF entries. The first one is for 3.3.3.3/32, the loopback interface of R3. It shows up with an O since this is an intra-area route. R1 has also learned about 4.4.4.4/32 and 192.168.24.0/24. These two entries show up as O IA since they are inter-area routes.

R2 has a similar output:

R2#show ip route ospf

```
R2(config)#do sh ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
O IA    3.3.3.3 [110/3] via 192.168.11.1, 00:03:27, GigabitEthernet3/0
      4.0.0.0/32 is subnetted, 1 subnets
O        4.4.4.4 [110/2] via 192.168.13.4, 00:03:17, GigabitEthernet5/0
O IA    192.168.12.0/24 [110/2] via 192.168.11.1, 00:03:27, GigabitEthernet3/0
```

Above we see that R2 has learned about 3.3.3.3/32 and 192.168.13.0/24 which are inter-area routes.

4.4.4.4/32 is an intra-area route. Let's check R3:

R3#show ip route ospf

```
R3(config)#do sh ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      4.0.0.0/32 is subnetted, 1 subnets
O IA    4.4.4.4 [110/4] via 192.168.12.1, 00:03:23, GigabitEthernet5/0
O IA    192.168.11.0/24 [110/2] via 192.168.12.1, 00:04:43, GigabitEthernet5/0
O IA    192.168.13.0/24 [110/3] via 192.168.12.1, 00:03:23, GigabitEthernet5/0
```

Everything that R3 has learned is from another area, that's why we only see inter-area routes here. **The same thing applies to R4:**

R4#show ip route ospf

```
R4(config)#do sh ip route ospf
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISPs
      + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
O IA      3.3.3.3 [110/4] via 192.168.13.2, 00:03:27, GigabitEthernet5/0
O IA 192.168.11.0/24 [110/2] via 192.168.13.2, 00:03:27, GigabitEthernet5/0
O IA 192.168.12.0/24 [110/3] via 192.168.13.2, 00:03:27, GigabitEthernet5/0
O IA 192.168.13.0/24 [110/1] via 192.168.13.2, 00:03:27, GigabitEthernet5/0
```

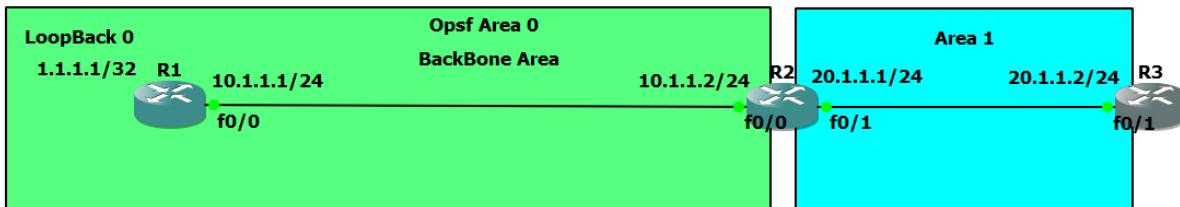
Just to be sure, let's try a quick ping between R3 and R4 to prove that our multi-area OSPF configuration is working:

R3#ping 4.4.4.4 source 3.3.3.3

```
R3(config)#do ping 4.4.4.4 source 3.3.3.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds:
Packet sent with a source address of 3.3.3.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 88/90/92 ms
```

Practical3c- Implement the concept OSPF Stub and Totally Stubby Area

Step 1: Create the physical topology in GNS3 as shown in the image below :



Step 2: Configure the IPv4 address on the physical interface on the routers :

On R1 :

```
R1(config)#int f0/0
R1(config-if)#ip
R1(config-if)#ip addr
R1(config-if)#ip address 10.1.1.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#exit
```

R1(config)#interface FastEthernet0/0

R1(config-if)#ip address 10.1.1.1 255.255.255.0

On R2 :

```
R2(config)#int f0/0
R2(config-if)#ip addr
R2(config-if)#ip address 10.1.1.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#exit
```

R2(config)#interface FastEthernet0/0

R2(config-if)#ip address 10.1.1.2 255.255.255.0

```
R2(config)#int f0/1
R2(config-if)#ip addr
R2(config-if)#ip address 20.1.1.1 255.255.255.0
R2(config-if)#no shut
R2(config-if)#exit
```

R2(config-if)#interface FastEthernet1/0

R2(config-if)#ip address 20.1.1.1 255.255.255.0

On R3 :

```
R3(config)#int f0/1
R3(config-if)#ip addr
R3(config-if)#ip address
R3(config-if)#ip address 20.1.1.2 255.255.255.0
R3(config-if)#no shut
R3(config-if)#exit
```

R3(config)#interface FastEthernet1/0

R3(config-if)#ip address 20.1.1.2 255.255.255.0

Step 3: Configure a loopback interface on R1 with an IPv4 address :

R1(config)#interface Loopback0

R1(config-if)#ip address 1.1.1.1 255.255.255.255

```
R1(config)#int loo
R1(config)#int loopback 0
R1(config-if)#ip addre
*Mar  1 00:00:49.523: %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)#no shut
R1(config-if)#exit
```

Step 4: Configuring the OSPF process on all three routers with the command router OSPF <process-id> :

```
R1(config)#router ospf 1
```

```
R1(config-if)#exit
```

R1(config)#router ospf 1

R1(config-router)#exit

```
R2(config)#router ospf 1
```

```
R2(config-router)#exit
```

R2(config)#router ospf 1

R2(config-router)#exit

```
R3(config)#router ospf 1
```

```
R3(config-router)#exit
```

R3(config)#router ospf 1

R3(config-router)#exit

Step 5: Enabling OSPF on the interfaces with the interface level sub-command IP OSPF <process-id> area <area-id> :

```
R1(config)#int loopback 0
R1(config-if)#ip ospf 1 area 0
R1(config-if)#
*Mar 1 00:10:22.455: %OSPF-5-ADJCHG: Process 1, Nbr 20.1.1.1 on FastEthernet0/0 from LOADING to FULL, Loading Done
R1(config-if)#int f0/0
R1(config-if)#ip ospf 1 area 0
R1(config-if)#no shut
```

R1(config)#interface FastEthernet0/0

R1(config-if)#ip ospf 1 area 0

R1(config)#interface Loopback0

R1(config-if)#ip ospf 1 area 0

```
R2(config)#int f0/0
R2(config-if)#ip ospf 1 area 0
R2(config-if)#no shut
R2(config-if)#exit
R2(config)#
*Mar 1 00:08:32.391: %OSPF-5-ADJCHG: Process 1, Nbr 1.1.1.1 on FastEthernet0/0 from LOADING to FULL, Loading Done
R2(config)#int f0/1
R2(config-if)#ip ospf 1 area 1
R2(config-if)#no shut
R2(config-if)#exit
R2(config)#
*Mar 1 00:10:49.687: %OSPF-5-ADJCHG: Process 1, Nbr 20.1.1.2 on FastEthernet0/1 from LOADING to FULL, Loading Done
```

R2(config)#interface FastEthernet0/0

R2(config-if)#ip ospf 1 area 0

R2(config-if)#interface FastEthernet1/0

R2(config-if)#ip ospf 1 area 1

```
R3(config)#int f0/1
R3(config-if)#ip ospf 1 area 1
R3(config-if)#no shut
R3(config-if)#exit
R3(config)#
*Mar 1 00:10:19.735: %OSPF-5-ADJCHG: Process 1, Nbr 20.1.1.1 on FastEthernet0/1 from LOADING to FULL, Loading Done
```

R3(config)#interface FastEthernet1/0

R3(config-if)#ip ospf 1 area 1

Step 6: Configuring area 2 as a stub area with the router sub-command area <area-id> stub

```
R2(config)#router ospf 1
R2(config-router)#area 1 stub
R2(config-router)#
*Mar 1 00:11:59.735: %OSPF-5-ADJCHG: Process 1, Nbr 20.1.1.2 on FastEthernet0/1 from FULL to DOWN, Neighbor Down: Adjacency forced to reset
R2(config-router)#exit
R2(config)#
*Mar 1 00:12:30.367: %OSPF-5-ADJCHG: Process 1, Nbr 20.1.1.2 on FastEthernet0/1 from LOADING to FULL, Loading Done
```

R2(config)#router ospf 1

R2(config-router)#area 1 stub

R2(config-router)#exit

```
R3(config)#router ospf 1
R3(config-router)#area 1 stub
R3(config-router)#
*Mar 1 00:11:59.971: %OSPF-5-ADJCHG: Process 1, Nbr 20.1.1.1 on FastEthernet0/1 from FULL to DOWN, Neighbor Down: Adjacency forced to reset
*Mar 1 00:12:00.415: %OSPF-5-ADJCHG: Process 1, Nbr 20.1.1.1 on FastEthernet0/1 from LOADING to FULL, Loading Done
```

R3(config-router)#exit

R3(config)#router ospf 1

R3(config-router)#area 1 stub

R3(config-router)#exit

Step 7: Verifying OSPF configuration on the routers :

R1#show ip protocol

```
R1(config)#do show ip protocol
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 1.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    Routing on Interfaces Configured Explicitly (Area 0):
      Loopback0
      FastEthernet0/0
      Reference bandwidth unit is 100 mbps
      Routing Information Sources:
        Gateway          Distance      Last Update
        20.1.1.1           110          00:03:11
        Distance: (default is 110)
```

R2#show ip protocol

```
R2(config)#do show ip protocol
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 20.1.1.1
  It is an area border router
  Number of areas in this router is 2. 1 normal 1 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    Routing on Interfaces Configured Explicitly (Area 0):
      FastEthernet0/0
    Routing on Interfaces Configured Explicitly (Area 1):
      FastEthernet0/1
  Reference bandwidth unit is 100 mbps
  Routing Information Sources:
    Gateway          Distance      Last Update
    1.1.1.1           110          00:01:07
  Distance: (default is 110)
```

R3#show ip protocol

```
R3(config)#do show ip protocol
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 20.1.1.2
  Number of areas in this router is 1. 0 normal 1 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    Routing on Interfaces Configured Explicitly (Area 1):
      FastEthernet0/1
  Reference bandwidth unit is 100 mbps
  Routing Information Sources:
    Gateway          Distance      Last Update
    20.1.1.1          110          00:00:39
  Distance: (default is 110)
```

Step 8: Checking the IPv4 routing table on the routers and seeing OSPF route entry :

R1#show ip route

```
R1(config)#do 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
      20.0.0.0/24 is subnetted, 1 subnets
O  IA    20.1.1.0 [110/20] via 10.1.1.2, 00:04:21, FastEthernet0/0
        10.0.0.0/24 is subnetted, 1 subnets
C        10.1.1.0 is directly connected, FastEthernet0/0
```

R2#show ip route

```
R2(config)#do 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

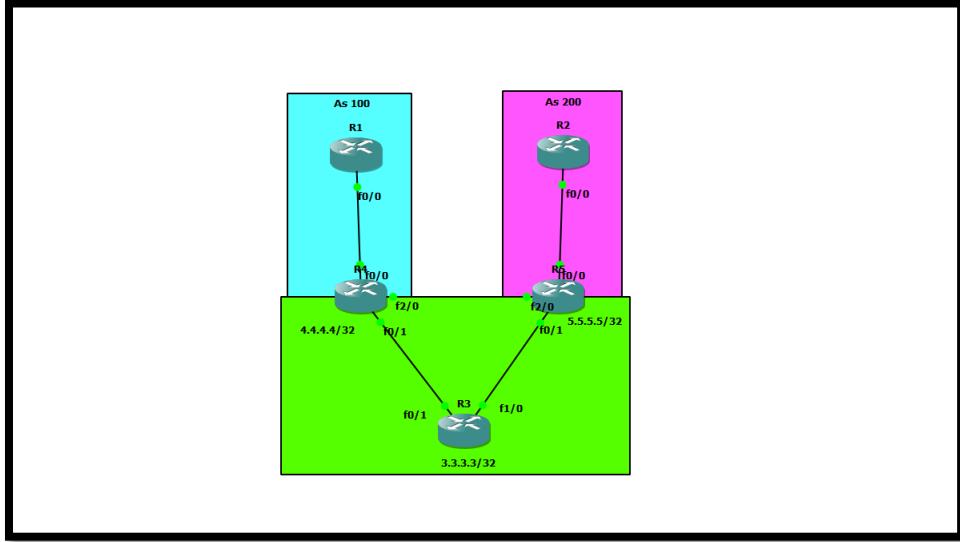
  1.0.0.0/32 is subnetted, 1 subnets
O   1.1.1.1 [110/11] via 10.1.1.1, 00:02:47, FastEthernet0/0
  20.0.0.0/24 is subnetted, 1 subnets
C     20.1.1.0 is directly connected, FastEthernet0/1
  10.0.0.0/24 is subnetted, 1 subnets
C     10.1.1.0 is directly connected, FastEthernet0/0
```

R3#show ip route

```
R3(config)#do 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 20.1.1.1 to network 0.0.0.0

  1.0.0.0/32 is subnetted, 1 subnets
O IA   1.1.1.1 [110/21] via 20.1.1.1, 00:02:18, FastEthernet0/1
  20.0.0.0/24 is subnetted, 1 subnets
C     20.1.1.0 is directly connected, FastEthernet0/1
  10.0.0.0/24 is subnetted, 1 subnets
O IA   10.1.1.0 [110/20] via 20.1.1.1, 00:02:18, FastEthernet0/1
O*IA 0.0.0.0/0 [110/11] via 20.1.1.1, 00:02:18, FastEthernet0/1
```

Practical 4a-Implement the concept of BGP routing protocol

Ip configuration

```
R1#conf t  
R1(config)#int fa0/0  
R1(config-if)#ip address 192.168.14.2 255.255.255.0  
R1(config-if)#no shut  
R1(config-if)#ex  
R1(config)#int Loopback11  
R1(config-if)#ip address 11.11.11.11 255.255.255.255  
R1(config-if)#no shut  
R1(config-if)#ex
```

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int fa0/0
R1(config-if)#ip address 192.168.14.2 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#
*Dec 12 11:33:11.779: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Dec 12 11:33:12.779: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R1(config-if)#ex
R1(config)#interface Loopback1
R1(config-if)#
*Dec 12 11:34:11.595: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback1, changed state to up
R1(config-if)#ip address 11.11.11.11 255.255.255.255
R1(config-if)#no shutdown
R1(config-if)#ex
R1(config)#end
R1#
```

R2#conf t

```
R2(config)#int fa0/0
R2(config-if)#ip address 192.168.25.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#int Loopback22
R2(config-if)#ip address 22.22.22.22 255.255.255.252
R2(config-if)#no shut
R2(config-if)#ex
```

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#int fa0/0
R2(config-if)#ip address 192.168
% Incomplete command.

R2(config-if)#ip address 192.168.25.2 255.255.255.0
R2(config-if)#no shutdown
R2(config-if)#
*Dec 12 11:36:10.003: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Dec 12 11:36:11.003: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R2(config-if)#ex
R2(config)#interface Loopback 22
R2(config-if)#ip
*Dec 12 11:36:37.895: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback22, changed state to up
R2(config-if)#ip address 22.22.22.22 255.255.255.252
R2(config-if)#no shutdown
R2(config-if)#ex
R2(config)#end
R2#
*Dec 12 11:59:23.655: %SYS-5-CONFIG_I: Configured from console by console
exit
```

R3#conf t

R3(config)#int fa0/1

```
R3(config-if)#ip address 192.168.34.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#ex
R3#conf t
R3(config)#int fa1/0
R3(config-if)#ip address 192.168.35.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#ex
R3(config)#int Loopback0
R3(config-if)#ip address 3.3.3.3 255.255.255.255
R3(config-if)#no shut
R3(config-if)#ex
R3(config)#router ospf 1
R3(config-router)#network 3.3.3.3 0.0.0.0 area 0
R3(config-router)#network 192.168.34.0 0.0.0.255 area 0
R3(config-router)#network 192.168.35.0 0.0.0.255 area 0
R3(config-router)#no shut
R3(config-router)#ex
```

```

INITIATIVELY DOWN
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#int fa0/1
R3(config-if)#ip address 192.168.34.3 255.255.255.0
R3(config-if)#no shutdown
R3(config-if)#ex
R3(config)#
*Dec 12 11:39:47.211: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Dec 12 11:39:48.211: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R3(config)#int fal/0
R3(config-if)#ip address 192.168.35.3 255.255.255.0
R3(config-if)#no shutdown
R3(config-if)#ex
R3(config)#
*Dec 12 11:40:37.847: %LINK-3-UPDOWN: Interface FastEthernet1/0, changed state to up
*Dec 12 11:40:38.847: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet1/0, changed state to up
R3(config)#interface Loopback0
R3(config-if)#
*Dec 12 11:40:56.467: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R3(config-if)#ip address 3
% Incomplete command.

R3(config-if)#ip address 3.3.3.3 255.255.255.255
R3(config-if)#no shutdown
R3(config-if)#ex
R3(config)#router ospf 1
R3(config-router)#network 3.3.3.3 0.0.0.0 area 0
^
% Invalid input detected at '^' marker.

R3(config-router)#network 3.3.3.3 0.0.0.0 area 0
R3(config-router)#network 192.168.34.0 0.0.0.255 area 0
R3(config-router)#network 192.168.35.0 0.0.0.255 area 0
R3(config-router)#no shutdown
R3(config-router)#ex
R3(config)#
*Dec 12 11:48:53.507: %OSPF-5-ADJCHG: Process 1, Nbr 4.4.4.4 on FastEthernet0/1 from LOADING to FULL, Loading Done
R3(config)#
*Dec 12 11:57:38.343: %OSPF-5-ADJCHG: Process 1, Nbr 5.5.5.5 on FastEthernet1/0 from LOADING to FULL, Loading Done
R3(config)#end
R3#sh

```

R4#conf t

R4(config)#int fa0/0

R4(config-if)#ip address 192.168.14.4 255.255.255.0

R4(config-if)#no shut

R4(config-if)#ex

R4#conf t

R4(config)#int fa2/0

R4(config-if)#ip address 192.168.45.3 255.255.255.0

R4(config-if)#no shut

R4(config-if)#ex

R4(config)#int fa01

R4(config-if)#ip address 192.168.34.4 255.255.255.0

```
R4(config-if)#no shut
R4(config-if)#ex
R4(config)#int Loopback0
R4(config-if)#ip address 4.4.4.4 255.255.255.255
R4(config-if)#no shut
R4(config-if)#ex
R4(config)#router ospf 1
R4(config-router)#network 4.4.4.4 0.0.0.0 area 0
R4(config-router)#network 192.168.34.0 0.0.0.255 area 0
R4(config-router)#network 192.168.45.0 0.0.0.255 area 0
R4(config-router)#no shut
R4(config-router)#ex
```

```

Administrative down
R4#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R4(config)#int fa0/0
R4(config-if)#ip address 192.168.14.4 255.255.255.0
R4(config-if)#no shutdown
R4(config-if)#exit
R4(config)#
*Dec 12 11:45:06.255: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Dec 12 11:45:07.255: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R4(config)#int fa2/0
R4(config-if)#ip address 192.168.45.4 255.255.255.0
R4(config-if)#no shutdown
R4(config-if)#exit
R4(config)#
*Dec 12 11:45:51.287: %LINK-3-UPDOWN: Interface FastEthernet2/0, changed state to up
*Dec 12 11:45:52.287: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/0, changed state to up
R4(config)#int fa0/1
R4(config-if)#ip address 192.168.34.4 255.255.255.0
R4(config-if)#no shutdown
R4(config-if)#
*Dec 12 11:46:40.515: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Dec 12 11:46:41.515: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R4(config-if)#exit
R4(config)#interface Loopback0
R4(config-if)#
*Dec 12 11:46:57.339: %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)#no shutdown
R4(config-if)#exit
R4(config)#router ospf 1
R4(config-router)#network 4.4.4.0
% Incomplete command.

R4(config-router)#network 4.4.4.0 0.0.0.0 area 0
R4(config-router)#network 192.168.34.0 0
% Incomplete command.

R4(config-router)#network 192.168.34.0 0.0.0.255 area 0
R4(config-router)#
*Dec 12 11:48:53.291: %OSPF-5-ADJCHG: Process 1, Nbr 3.3.3.3 on FastEthernet0/1 from LOADING to FULL, Loading Done
R4(config-router)#network 192.168.45.0 0.0.0.255 area 0
R4(config-router)#no shutdown
R4(config-router)#exit
R4(config)#
*Dec 12 11:58:03.803: %OSPF-5-ADJCHG: Process 1, Nbr 5.5.5.5 on FastEthernet2/0 from LOADING to FULL, Loading Done
R4(config)#end
R4#
*Dec 12 11:58:44.307: %SYS-5-CONFIG_I: Configured from console by console

```

R5#conf t

R5(config)#int fa0/0

R5(config-if)#ip address 192.168.25.5 255.255.255.0

R5(config-if)#no shut

R5(config-if)#exit

R5#conf t

R5(config)#int fa2/0

R5(config-if)#ip address 192.168.45.5 255.255.255.0

R5(config-if)#no shut

R5(config-if)#exit

R5(config)#int fa0/1

```
R5(config-if)#ip address 192.168.35.5 255.255.255.0
R5(config-if)#no shut
R5(config-if)#ex
R5(config)#int Loopback0
R5(config-if)#ip address 5.5.5.5 255.255.255.255
R5(config-if)#no shut
R5(config-if)#ex
R5(config)#router ospf 1
R5(config-router)#network 5.5.5.5 0.0.0.0 area 0
R5(config-router)#network 192.168.35.0 0.0.0.255 area 0
R5(config-router)#network 192.168.45.0 0.0.0.255 area 0
R5(config-router)#no shut
R5(config-router)#ex
```

```

R5#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R5(config)#int fa0/0
R5(config-if)#ip address 192.168.25.5 255.255.255.0
R5(config-if)#no shutdown
R5(config-if)#exit
R5(config-if)#exit
*Dec 12 11:51:59.511: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to
o up
*Dec 12 11:51:30.511: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet
eth0/0, changed state to up
R5(config-if)#exit
R5(config)#int fa2/0
R5(config-if)#ip address 192.168.45.5 255.255.255.0
R5(config-if)#no shutdown
R5(config-if)#exit
^
% Invalid input detected at '^' marker.

R5(config-if)#
*Dec 12 11:52:18.211: %LINK-3-UPDOWN: Interface FastEthernet2/0, changed state to
o up
*Dec 12 11:52:19.211: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet
eth2/0, changed state to up
R5(config-if)#exit
R5(config-if)#int fa0/1
R5(config-if)#ip address 192.168.35.5 255.255.255.0
R5(config-if)#no shutdown
R5(config-if)#
*Dec 12 11:53:07.471: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to
o up
*Dec 12 11:53:08.471: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet
eth0/1, changed state to up
R5(config-if)#interface Loopback0
R5(config-if)#
*Dec 12 11:53:25.379: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0,
changed state to up
R5(config-if)##.5.5.5 255.255.255.255
^
% Invalid input detected at '^' marker.

R5(config-if)#ip address 5.5.5.5 255.255.255.255
R5(config-if)#no shutdown
R5(config-if)#exit
R5(config)#router ospf 1
R5(config-router)#network 5.5.5.0 0.0.0.0 area 0
R5(config-router)#network 192.168.35.0 0.0.0.255 area 0
R5(config-router)#netw
*Dec 12 11:57:38.163: %OSPF-5-ADJCHG: Process 1, Nbr 3.3.3.3 on FastEthernet0/1
from LOADIN to FULL, Loading Done
R5(config-router)#network 192.168.45.0 0.0.0.255 area 0
R5(config-router)#exit
R5(config)#
*Dec 12 11:58:03.055: %OSPF-5-ADJCHG: Process 1, Nbr 4.4.4.4 on FastEthernet2/0
from LOADIN to FULL, Loading Done
R5(config)#
*Dec 12 11:58:10.755: %SYS-5-CONFIG_I: Configured from console by console

```

Show ip route

R1#show ip route

```
R1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      11.0.0.0/32 is subnetted, 1 subnets
C          11.11.11.11 is directly connected, Loopback11
      192.168.14.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.14.0/24 is directly connected, FastEthernet0/0
L          192.168.14.2/32 is directly connected, FastEthernet0/0
R1#conf t
```

R2#show ip route

```
R2#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      22.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C          22.22.22.20/30 is directly connected, Loopback22
L          22.22.22.22/32 is directly connected, Loopback22
      192.168.25.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.25.0/24 is directly connected, FastEthernet0/0
L          192.168.25.2/32 is directly connected, FastEthernet0/0
R2#
```

R3#show ip route

```
R3#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
C          3.3.3.3 is directly connected, Loopback0
      4.0.0.0/32 is subnetted, 1 subnets
O          4.4.4.4 [110/2] via 192.168.34.4, 00:10:13, FastEthernet0/1
      5.0.0.0/32 is subnetted, 1 subnets
O          5.5.5.5 [110/2] via 192.168.35.5, 00:01:28, FastEthernet1/0
      192.168.34.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.34.0/24 is directly connected, FastEthernet0/1
L          192.168.34.3/32 is directly connected, FastEthernet0/1
      192.168.35.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.35.0/24 is directly connected, FastEthernet1/0
L          192.168.35.3/32 is directly connected, FastEthernet1/0
O          192.168.45.0/24 [110/2] via 192.168.35.5, 00:00:54, FastEthernet1/0
                  [110/2] via 192.168.34.4, 00:09:43, FastEthernet0/1
R3#
```

R4#show ip route

```
R4#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

  3.0.0.0/32 is subnetted, 1 subnets
O     3.3.3.3 [110/2] via 192.168.34.3, 00:09:54, FastEthernet0/1
  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     5.5.5.5 [110/2] via 192.168.45.5, 00:00:44, FastEthernet2/0
      192.168.14.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.14.0/24 is directly connected, FastEthernet0/0
L       192.168.14.4/32 is directly connected, FastEthernet0/0
      192.168.34.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.34.0/24 is directly connected, FastEthernet0/1
L       192.168.34.4/32 is directly connected, FastEthernet0/1
O     192.168.35.0/24 [110/2] via 192.168.45.5, 00:00:44, FastEthernet2/0
      [110/2] via 192.168.34.3, 00:09:54, FastEthernet0/1
      192.168.45.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.45.0/24 is directly connected, FastEthernet2/0
L       192.168.45.4/32 is directly connected, FastEthernet2/0
R4#
```

R5#show ip route

```
R5#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

  3.0.0.0/32 is subnetted, 1 subnets
O     3.3.3.3 [110/2] via 192.168.35.3, 00:00:36, FastEthernet0/1
  4.0.0.0/32 is subnetted, 1 subnets
O     4.4.4.4 [110/2] via 192.168.45.4, 00:00:11, FastEthernet2/0
  5.0.0.0/32 is subnetted, 1 subnets
C     5.5.5.5 is directly connected, Loopback0
      192.168.25.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.25.0/24 is directly connected, FastEthernet0/0
L       192.168.25.5/32 is directly connected, FastEthernet0/0
O     192.168.34.0/24 [110/2] via 192.168.45.4, 00:00:11, FastEthernet2/0
      [110/2] via 192.168.35.3, 00:00:36, FastEthernet0/1
      192.168.35.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.35.0/24 is directly connected, FastEthernet0/1
L       192.168.35.5/32 is directly connected, FastEthernet0/1
      192.168.45.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.45.0/24 is directly connected, FastEthernet2/0
L       192.168.45.5/32 is directly connected, FastEthernet2/0
R5#
```

EBGP Configuration

R1(config)#router bgp 100

R1(config-router)#network 11.11.11.0 mask 255.255.255.255

R1(config-router)#neighbor 192.168.14.4 remote-as 300

R1(config-router)#end

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#router bgp 100
R1(config-router)#network 11.11.11.0 mask 255.255.255.255
R1(config-router)#neighbor 192.168.14.4 remote-as 300
R1(config-router)#
*Dec 12 12:08:07.627: %BGP-5-ADJCHANGE: neighbor 192.168.14.4 Up
R1(config-router)#end
R1#sh
*Dec 12 12:29:43.515: %SYS-5-CONFIG_I: Configured from console by console
R1#
```

R2(config)#router bgp 200

R2(config-router)#network 22.22.22.22.0 mask 255.255.255.255

R2(config-router)#neighbor 192.168.25.5 remote-as 300

R2(config-router)#end

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#router bgp 200
R2(config-router)#network 22.22.22.0 mask 255.255.255.255
R2(config-router)#neighbor 192.168.25.5 remote-as 300
R2(config-router)#
*Dec 12 12:17:22.675: %BGP-5-ADJCHANGE: neighbor 192.168.25.5 Up
R2(config-router)#end
R2#sh
*Dec 12 12:29:25.035: %SYS-5-CONFIG_I: Configured from console by console
```

R4(config)#router bgp 300

R4(config-router)#neighbor 192.168.14.2 remote-as 100

R4(config-router)#end

```
R4#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R4(config)#router bgp 300
R4(config-router)#neighbor 192.168.14.2 remote-as 100
R4(config-router)#
*Dec 12 12:08:07.375: %BGP-5-ADJCHANGE: neighbor 192.168.14.2 Up
R4(config-router)#ex
```

R5(config)#router bgp 300

R5(config-router)#neighbor 192.168.25.2 remote-as 200

R5(config-router)#end

```
R5#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R5(config)#router bgp 300
R5(config-router)#neighbor 192.168.25.2 remote-as 200
R5(config-router)#ex
```

IBGP Configuration

R3(config)#router bgp 300

R3(config-router)#neighbor 4.4.4.4 remote-as 300

```
R3(config-router)#neighbor 4.4.4.4 update-source Loopback0
R3(config-router)#neighbor 5.5.5.5 remote-as 300
R3(config-router)#neighbor 5.5.5.5 update-source Loopback0
R3(config-router)#end
```

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#router bgp 300
R3(config-router)#neighbor 4.4.4.4 remote-as 300
R3(config-router)#neighbor 4.4.4.4 upa
*Dec 12 12:20:52.767: %BGP-5-ADJCHANGE: neighbor 4.4.4.4 Up
R3(config-router)#neighbor 4.4.4.4 update-source Loopback0
R3(config-router)#neighbor 5.5.5.5 remote-as 300
R3(config-router)#neighbor 5.5.5.5 up
*Dec 12 12:21:46.975: %BGP-5-ADJCHANGE: neighbor 5.5.5.5 Up
R3(config-router)#neighbor 5.5.5.5 update-source Loopback0
R3(config-router)#end
```

```
R4(config)#router bgp 300
R4(config-router)#neighbor 3.3.3.3 remote-as 300
R4(config-router)#neighbor 3.3.3.3 update-source Loopback0
R4(config-router)#neighbor 5.5.5.5 remote-as 300
R4(config-router)#neighbor 5.5.5.5 update-source Loopback0
R4(config-router)#end
```

```
R4(config)#router bgp 300
R4(config-router)#neighbor 3.3.3.3 remote-as 300
R4(config-router)#neighbor 3.3.3.3 update-source Loopback0
R4(config-router)#neighbor 5.5.5.5 remote-as 300
R4(config-router)#neighbor 5.5.5.5 update-source Loopback0
R4(config-router)#
*Dec 12 12:18:34.223: %BGP-5-ADJCHANGE: neighbor 5.5.5.5 Up
R4(config-router)#
*Dec 12 12:20:52.471: %BGP-5-ADJCHANGE: neighbor 3.3.3.3 Up
R4(config-router)#end
```

```
R4(config)#router bgp 300
R4(config-router)#neighbor 4.4.4.4 remote-as 300
R4(config-router)#neighbor 4.4.4.4 update-source Loopback0
R4(config-router)#neighbor 3.3.3.3 remote-as 300
R4(config-router)#neighbor 3.3.3.3 update-source Loopback0
R4(config-router)#end
```

```
R5(config)#router bgp 300
R5(config-router)#neighbor 4.4.4.4 remote-as 300
R5(config-router)#neighbor 4.4.4.4
*Dec 12 12:18:34.287: %BGP-5-ADJCHANGE: neighbor 4.4.4.4 Up
R5(config-router)#neighbor 4.4.4.4 update-source Loopback0
R5(config-router)#neighbor 3.3.3.3 remote-as 300
R5(config-router)#neighbor 3.3.3.3 update-source Loopback0
R5(config-router)#
*Dec 12 12:21:46.739: %BGP-5-ADJCHANGE: neighbor 3.3.3.3 Up
R5(config-router)#end
R5#
```

Show BGP Neighbor

R1#show bgp neighbor

```
R1#show bgp neighbor
BGP neighbor is 192.168.14.4,  remote AS 300, external link
  BGP version 4, remote router ID 4.4.4.4
  BGP state = Established, up for 00:21:45
  Last read 00:00:29, last write 00:00:15, hold time is 180, keepalive interval is 60 seconds
  Neighbor sessions:
    1 active, is not multisession capable (disabled)
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
    Enhanced Refresh Capability: advertised and received
    Multisession Capability:
      Stateful switchover support enabled: NO for session 1
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

              Sent      Rcvd
  Opens:          1          1
  Notifications:  0          0
  Updates:        1          1
  Keepalives:     26         25
  Route Refresh:  0          0
  Total:          28         27

Default minimum time between advertisement runs is 30 seconds
```

R2#show bgp neighbor

```
R2#show bgp neighbor
BGP neighbor is 192.168.25.5,  remote AS 300, external link
  BGP version 4, remote router ID 5.5.5.5
  BGP state = Established, up for 00:12:09
  Last read 00:00:32, last write 00:00:22, hold time is 180, keepalive interval is 60 seconds
  Neighbor sessions:
    1 active, is not multisession capable (disabled)
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
    Enhanced Refresh Capability: advertised and received
    Multisession Capability:
      Stateful switchover support enabled: NO for session 1
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

              Sent      Rcvd
  Opens:          1          1
  Notifications:  0          0
  Updates:        1          1
  Keepalives:     15         15
  Route Refresh:  0          0
  Total:          17         17

Default minimum time between advertisement runs is 30 seconds
```

R3#show bgp neighbor

```
R3#show bgp neighbor
BGP neighbor is 4.4.4.4, remote AS 300, internal link
BGP version 4, remote router ID 4.4.4.4
BGP state = Established, up for 00:08:20
Last read 00:00:12, last write 00:00:30, hold time is 180, keepalive interval is 60 seconds
Neighbor sessions:
  1 active, is not multisession capable (disabled)
Neighbor capabilities:
  Route refresh: advertised and received(new)
  Four-octets ASN Capability: advertised and received
  Address family IPv4 Unicast: advertised and received
  Enhanced Refresh Capability: advertised and received
  Multisession Capability:
    Stateful switchover support enabled: NO for session 1
Message statistics:
  InQ depth is 0
  OutQ depth is 0

          Sent      Rcvd
  Opens:        1        1
  Notifications: 0        0
  Updates:      1        0
  Keepalives:   11       10
  Route Refresh: 0        0
  Total:        13       11
Default minimum time between advertisement runs is 0 seconds
```

R4#show bgp neighbor

```
R4#show bgp neighbor
BGP neighbor is 3.3.3.3, remote AS 300, internal link
BGP version 4, remote router ID 3.3.3.3
BGP state = Established, up for 00:07:59
Last read 00:00:09, last write 00:00:41, hold time is 180, keepalive interval is 60 seconds
Neighbor sessions:
  1 active, is not multisession capable (disabled)
Neighbor capabilities:
  Route refresh: advertised and received(new)
  Four-octets ASN Capability: advertised and received
  Address family IPv4 Unicast: advertised and received
  Enhanced Refresh Capability: advertised and received
  Multisession Capability:
    Stateful switchover support enabled: NO for session 1
Message statistics:
  InQ depth is 0
  OutQ depth is 0

          Sent      Rcvd
  Opens:        1        1
  Notifications: 0        0
  Updates:      0        1
  Keepalives:   9        11
  Route Refresh: 0        0
  Total:        10       13
Default minimum time between advertisement runs is 0 seconds
```

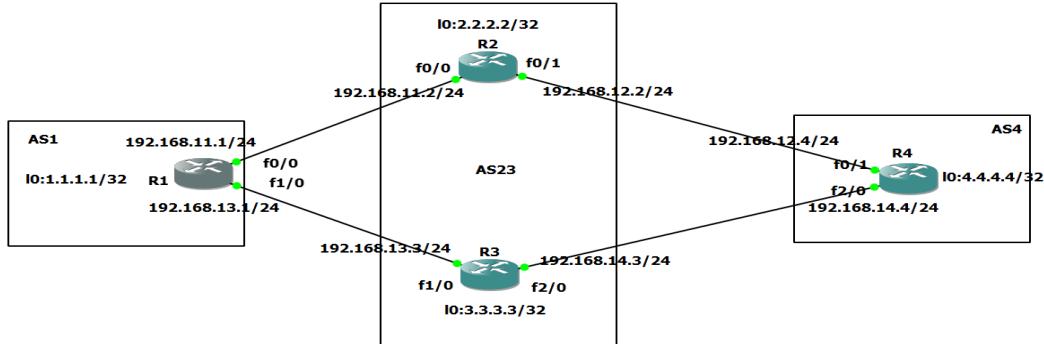
R5#show bgp neighbor

```
R5#show bgp neighbors
BGP neighbor is 3.3.3.3, remote AS 300, internal link
BGP version 4, remote router ID 3.3.3.3
BGP state = Established, up for 00:05:55
Last read 00:00:22, last write 00:00:43, hold time is 180, keepalive interval is 60 seconds
Neighbor sessions:
  1 active, is not multisession capable (disabled)
Neighbor capabilities:
  Route refresh: advertised and received(new)
  Four-octets ASN Capability: advertised and received
  Address family IPv4 Unicast: advertised and received
  Enhanced Refresh Capability: advertised and received
  Multisession Capability:
    Stateful switchover support enabled: NO for session 1
Message statistics:
  InQ depth is 0
  OutQ depth is 0

          Sent      Rcvd
  Opens:        1        1
  Notifications: 0        0
  Updates:      0        0
  Keepalives:   7        7
  Route Refresh: 0        0
  Total:        8        8
Default minimum time between advertisement runs is 0 seconds
```

Practical 4b- Implement the concept of BGP Path Attributes – MED

Step 1: do the topology as below image



Step 2: do the necessary router configuration for R1, R2, R3, R4 as follows

R1

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#
R1(config)#int loop
R1(config)#int loopback 0
R1(config-if)#ip addr
*Mar 1 00:00:28.719: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R1(config-if)#ip addr 1.1.1.1 255.255.255.255
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#int f 0/0
R1(config-if)#ip addr 192.168.11.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#exit
^
% Invalid input detected at '^' marker.

R1(config-if)#exit
*Mar 1 00:01:07.723: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:01:08.723: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R1(config-if)#exit
R1(config)#int f1/0
R1(config-if)#ip addr 192.168.13.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#
*Mar 1 00:01:27.375: %LINK-3-UPDOWN: Interface FastEthernet1/0, changed state to up
*Mar 1 00:01:28.375: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet1/0, changed state to up
```

R2

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#
R2(config)#int loop
R2(config)#int loopback 0
R2(config-if)#ip addr 22
*Mar 1 00:00:51.027: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R2(config-if)#ip addr 2.2.2.2 255.255.255.255
R2(config-if)#no shut
R2(config-if)#exit
R2(config)#int f0/0
R2(config-if)#ip addr 192.168.11.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#exit
R2(config)#
*Mar 1 00:01:17.795: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Mar 1 00:01:18.795: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R2(config)#int f0/1
R2(config-if)#ip addr 192.168.12.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#exit
R2(config)#
*Mar 1 00:01:38.191: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Mar 1 00:01:39.191: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
```

R3

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#int lo0
R3(config)#int loopback 0
R3(config-if)#ipa
*Mar 1 00:01:20.499: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R3(config-if)#ip addr 3.3.3.3 255.255.255.255
R3(config-if)#no shut
R3(config-if)#exit
R3(config)#int f1/0
R3(config-if)#ip addr 192.168.13.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#exit
R3(config)#int
*Mar 1 00:02:15.043: %LINK-3-UPDOWN: Interface FastEthernet1/0, changed state to up
*Mar 1 00:02:16.043: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet1/0, changed state to up
R3(config)#int f2/0
R3(config-if)#ip addr 192.168.14.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#exit
R3(config)#
*Mar 1 00:02:40.827: %LINK-3-UPDOWN: Interface FastEthernet2/0, changed state to up
*Mar 1 00:02:41.827: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/0, changed state to up
```

R4

```
R4#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R4(config)#int loop
R4(config)#int loopback 0
R4(config-if)#ip addr 1
*Mar 1 00:02:02.331: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R4(config-if)#ip addr 4.4.4.4 255.255.255.0
R4(config-if)#ip add 4.4.4.4 255.255.255.255
R4(config-if)#no shut
R4(config-if)#exit
^
% Invalid input detected at '^' marker.

R4(config-if)#exit
R4(config)#int f0/1
R4(config-if)#ip addr 192.168.12.4 255.255.255.0
R4(config-if)#no shut
R4(config-if)#exit
R4(config)#
*Mar 1 00:02:40.959: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Mar 1 00:02:41.959: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R4(config)#int f2/0
R4(config-if)#ip addr 192.168.14.4 255.255.255.0
R4(config-if)#no shut
R4(config-if)#exit
R4(config)#
*Mar 1 00:03:00.167: %LINK-3-UPDOWN: Interface FastEthernet2/0, changed state to up
*Mar 1 00:03:01.167: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/0, changed state to up
```

R1 Interface Configuration:

R1(config)#do show ip int brief

FastEthernet0/0	192.168.11.1	YES	manual	up	up
Serial0/0	unassigned	YES	unset	administratively	down down
FastEthernet0/1	unassigned	YES	unset	administratively	down down
Serial0/1	unassigned	YES	unset	administratively	down down
Serial0/2	unassigned	YES	unset	administratively	down down
Serial0/3	unassigned	YES	unset	administratively	down down
FastEthernet1/0	192.168.13.1	YES	manual	up	up

Loopback0	1.1.1.1	YES	manual	up	up
-----------	---------	-----	--------	----	----

R2 Interface Configuration:

R2(config)#do show ip int brief

FastEthernet0/0	192.168.11.2	YES	manual	up	up
Serial0/0	unassigned	YES	unset	administratively	down down
FastEthernet0/1	192.168.12.2	YES	manual	up	up

Vlan12	unassigned	YES unset	up	down
Loopback0	2.2.2.2	YES manual	up	up

R3 Interface Configuration:

R3(config)#do show ip int br

FastEthernet1/0	192.168.13.3	YES manual	up	up
FastEthernet2/0	192.168.14.3	YES manual	up	up
Vlan1	unassigned	YES unset	up	down
Loopback0	3.3.3.3	YES manual	up	up

R4 Interface Configuration:

R4(config)#do show ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	unassigned	YES	unset	administratively down	down
Serial0/0	unassigned	YES	unset	administratively down	down
FastEthernet0/1	192.168.12.4	YES	manual	up	up
Loopback0	4.4.4.4	YES	manual	up	up

Step 3: configure BGP in all the routers**R1 BGP Configuration:**

```
R1(config)#router bgp 1
R1(config-router)#nei
R1(config-router)#neighbor 192.168.11.2 remote
R1(config-router)#neighbor 192.168.11.2 remote-as 23
R1(config-router)#neighbor 192.168.13.3 remote-as 23
R1(config-router)#redistribute con
R1(config-router)#redistribute connected
R1(config-router)#exit
R1(config)#
*Mar  1 00:08:56.491: %BGP-5-ADJCHANGE: neighbor 192.168.13.3 Up
R1(config)#
*Mar  1 00:09:35.735: %BGP-5-ADJCHANGE: neighbor 192.168.11.2 Up
```

R2 BGP Configuration:

```
R2(config)#router bgp 23
R2(config-router)#neigh
R2(config-router)#neighbor 192.168.11.1 remote
R2(config-router)#neighbor 192.168.11.1 remote-as 1
R2(config-router)#neighbor 192.168.12.4 remote-as 4
R2(config-router)#redist
R2(config-router)#redistribute
*Mar  1 00:08:23.867: %BGP-5-ADJCHANGE: neighbor 192.168.12.4 Up
R2(config-router)#redistribute conn
R2(config-router)#redistribute connected
R2(config-router)#exit
R2(config)#
*Mar  1 00:08:41.679: %BGP-5-ADJCHANGE: neighbor 192.168.11.1 Up
```

R3 BGP Configuration:

```
R3(config)#router bgp 23
R3(config-router)#reigh
R3(config-router)#neigh
R3(config-router)#neighbor 192.168.13.1 remote
R3(config-router)#neighbor 192.168.13.1 remote-as 1
R3(config-router)#neighbor 192.168.14.4 remote-as 4
R3(config-router)#redis
R3(config-router)#redistribute con
R3(config-router)#redistribute connected
R3(config-router)#exit
R3(config)#
*Mar  1 00:07:17.979: %BGP-5-ADJCHANGE: neighbor 192.168.13.1 Up
*Mar  1 00:07:18.603: %BGP-5-ADJCHANGE: neighbor 192.168.14.4 Up
```

R4 BGP Configuration:

```
R4(config)#router bgp 4
R4(config-router)#neight
R4(config-router)#neigh
R4(config-router)#neighbor 192.168.12.2 remot
R4(config-router)#neighbor 192.168.12.2 remote-as 23
R4(config-router)#neighbor 192.168.14.3 remote-as 23
R4(config-router)#redis
R4(config-router)#redistribute conn
R4(config-router)#redistribute connected
R4(config-router)#exit
R4(config)#
*Mar  1 00:06:44.807: %BGP-5-ADJCHANGE: neighbor 192.168.14.3 Up
R4(config)#
*Mar  1 00:07:05.615: %BGP-5-ADJCHANGE: neighbor 192.168.12.2 Up
```

From the below R1 BGP table, we can see that the R1 prefers the path through R3 (Next Hop IP as 192.168.13.3) to reach the Network 4.4.4.4/32.

Symbol ">" in-front of the network indicates the best path (router prefers to use this path to send the traffic)

```
R1(config)#do sh ip bgp
BGP table version is 10, 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
*> 1.1.1.1/32        0.0.0.0             0       32768 ?
*> 2.2.2.2/32        192.168.11.2         0       0 23 ?
*> 3.3.3.3/32        192.168.13.3         0       0 23 ?
*  4.4.4.4/32        192.168.11.2           0       0 23 4 ?
*>                   192.168.13.3           0       0 23 4 ?
*  192.168.11.0      192.168.11.2           0       0 23 ?
*>                   0.0.0.0             0       32768 ?
*> 192.168.12.0      192.168.11.2           0       0 23 ?
*                   192.168.13.3           0       0 23 4 ?
*  192.168.13.0      192.168.13.3           0       0 23 ?
*>                   0.0.0.0             0       32768 ?
*  192.168.14.0      192.168.11.2           0       0 23 4 ?
*>                   192.168.13.3           0       0 23 ?
```

Now, our task to change the path through R2 to reach the Network 4.4.4.4/32.

Step4: Create route-map MED-TEST

Here, I have created a route-map named as MED-TEST. Next, I have used the command "match ip address 1" to match the access-list 1, and then if it matches I have set the Metric (MED) value as 500. I have created a second permit statement for the same route-map AS-PATH-TEST.

Creating a Route-Map:

```
R3(config)#route-map MED-TEST permit
R3(config-route-map)#match ip address 1
R3(config-route-map)#set m
R3(config-route-map)#set met
R3(config-route-map)#set metric 500
R3(config-route-map)#exit
R3(config)#route-m
R3(config)#route-map MED-
R3(config)#route-map MED-TEST permit 20
R3(config-route-map)#exit
R3(config)#do sh route-map
route-map MED-TEST, permit, sequence 10
  Match clauses:
    ip address (access-lists): 1
  Set clauses:
    metric 500
  Policy routing matches: 0 packets, 0 bytes
route-map MED-TEST, permit, sequence 20
  Match clauses:
  Set clauses:
  Policy routing matches: 0 packets, 0 bytes
R3(config)#acc
R3(config)#access-list 1 permit host 4.4.4.4
R3(config)#exit
```

R3#conf terminal

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

```
R3(config)#
R3(config)#route-map MED-TEST permit
R3(config-route-map)#match ip address 1
R3(config-route-map)#set metric 500
R3(config-route-map)#exi
R3(config)#route-map MED-TEST permit 20
R3(config-route-map)#end
R3#
```

You can also view the created c-map using the below command:

R3#show route-map

```
R3(config)#do sh route-map
route-map MED-TEST, permit, sequence 10
  Match clauses:
    ip address (access-lists): 1
  Set clauses:
    metric 500
  Policy routing matches: 0 packets, 0 bytes
route-map MED-TEST, permit, sequence 20
  Match clauses:
  Set clauses:
  Policy routing matches: 0 packets, 0 bytes
```

Next create a access-list as below:

```
R3(config)#access-list 1 permit host 4.4.4.4
R3(config)#exit
```

You can view configured access-list using the below command,

R3#show access-lists

```
R3#sh access-lists
Standard IP access list 1
  10 permit 4.4.4.4
```

Applying the created route-map to bgp configuration.

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#router bgp 23
R3(config-router)#neigh
R3(config-router)#neighbor 192.168.13.1 route-map MED-TEST out
R3(config-router)#exit
R3(config)#
```

Here, we have mapped the route-map MED-TEST as "OUT" to the neighbor R1 (192.168.13.1). so that it will advertise the configured Metric value (value: 500) its neighbor.

You need to clear the BGP session to take the newly applied configuration to take effect.

In-order to clear the bgp session, use the command "clear ip bgp * soft in"

```
R1(config)#do clear ip bgp * soft in
R1(config)#do sh ip bgp
BGP table version is 11, 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
*> 1.1.1.1/32        0.0.0.0             0        32768 ?
*> 2.2.2.2/32        192.168.11.2         0        0 23 ?
*> 3.3.3.3/32        192.168.13.3         0        0 23 ?
*> 4.4.4.4/32        192.168.11.2         0        0 23 4 ?
*   192.168.13.3     192.168.13.3         500      0 23 4 ?
*  192.168.11.0     192.168.11.2         0        0 23 ?
*> 0.0.0.0             0.0.0.0             0        32768 ?
*> 192.168.12.0     192.168.11.2         0        0 23 ?
*   192.168.13.3     192.168.13.3         0        0 23 4 ?
*> 192.168.13.0     192.168.13.3         0        0 23 ?
*> 0.0.0.0             0.0.0.0             0        32768 ?
*  192.168.14.0     192.168.11.2         0        0 23 4 ?
*> 192.168.13.3     192.168.13.3         0        0 23 ?

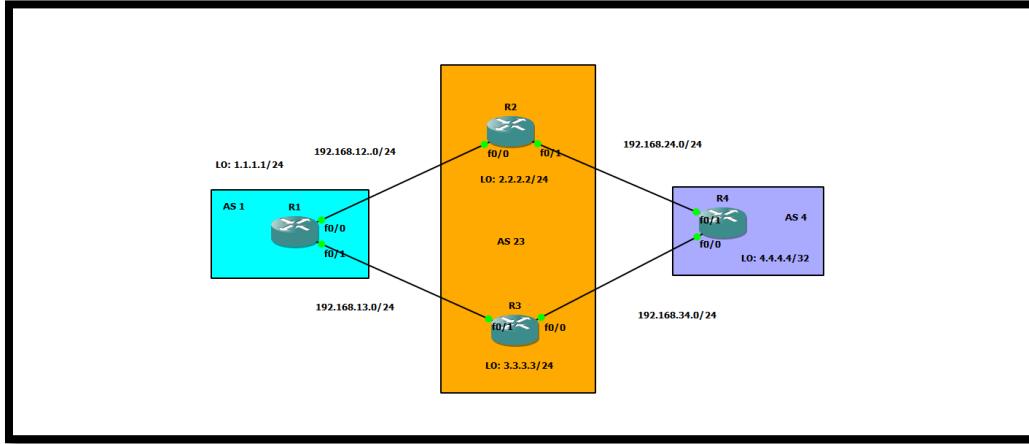
R1(config)#
```

You can see that,

The metric for the neighbor 192.168.13.3 (R3 router) has now changed to 500.

Best path changed to R2 (Next hop 192.168.12.2) as the metric has been changed.

Practical 4c-Implement the concept of BGP AS Path Attribute



Ip configuration

R1 Interface Information:

```
R1#conf t
R1(config)#int fa0/0
R1(config-if)#ip address 192.168.2.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
R1#conf t
R1(config)#int fa0/1
R1(config-if)#ip address 192.168.13.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
R1(config)#int Loopback0
R1(config-if)#ip address 1.1.1.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#ex
```

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int fa0/0
R1(config-if)#ip address 192.168.2.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#ex
R1(config)#
*Dec 13 15:06:06.227: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Dec 13 15:06:07.227: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R1(config)#int fa0/1
R1(config-if)#ip address 192.168.13.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#ex
R1(config)#
*Dec 13 15:06:56.863: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Dec 13 15:06:57.863: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R1(config)#interface Loopback0
R1(config-if)#
*Dec 13 15:07:19.075: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R1(config-if)#ip address 1.1.1.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#end
```

R2 Interface Information:

```
R2#conf t
R2(config)#int fa0/0
R2(config-if)#ip address 192.168.12.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#ex
R2#conf t
R2(config)#int fa0/1
R2(config-if)#ip address 192.168.24.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#ex
R2(config)#int Loopback0
R2(config-if)#ip address 2.2.2.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#ex
```

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2 (config)#int fa0/0
R2 (config-if)#ip address 192.168.12.2 255.255.255.0
R2 (config-if)#no shutdown
R2 (config-if)#ex
R2 (config)#
*Dec 13 15:12:00.823: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Dec 13 15:12:01.823: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R2 (config)#int fa0/1
R2 (config-if)#ip address 192.168.24.2 255.255.255.0
R2 (config-if)#no shutdown
R2 (config-if)#ex
R2 (config)#
*Dec 13 15:12:39.803: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Dec 13 15:12:40.803: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R2 (config)#interface Loopback0
R2 (config-if)#i
*Dec 13 15:12:52.755: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R2 (config-if)#ip address 2.2.2.2 255.255.255.0
R2 (config-if)#no shutdown
R2 (config-if)#ex
R2 (config)#end
```

R3 Interface Information:

```
R3#conf t
R3(config)#int fa0/0
R3(config-if)#ip address 192.168.13.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#ex

R3#conf t
R3(config)#int fa0/1
R3(config-if)#ip address 192.168.34.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#ex

R3(config)#int Loopback0
R3(config-if)#ip address 3.3.3.3 255.255.255.0
R3(config-if)#no shut
R3(config-if)#ex
```

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#int fa0/0
R3(config-if)#ip address 192.168.13.3 255.255.255.0
R3(config-if)#no shutdown
R3(config-if)#ex
R3(config)#int
*Dec 13 15:15:33.255: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Dec 13 15:15:34.255: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R3(config)#int fa0/1
R3(config-if)#ip address 192.168.34.3 255.255.255.0
R3(config-if)#no shutdown
R3(config-if)#ex
R3(config)#
*Dec 13 15:16:10.931: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Dec 13 15:16:11.931: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R3(config)#interface Loopback0
R3(config-if)#ip a
*Dec 13 15:16:29.203: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
R3(config-if)#ip address 3.3.3.3 255.255.255.0
R3(config-if)#no shutdown
R3(config-if)#ex
R3(config)#end
```

R4 Interface Information:

R4#conf t

R4(config)#int fa0/0

R4(config-if)#ip address 192.168.24.4 255.255.255.0

R4(config-if)#no shut

R4(config-if)#ex

R4#conf t

R4(config)#int fa0/1

R4(config-if)#ip address 192.168.34.4 255.255.255.0

R4(config-if)#no shut

R4(config-if)#ex

R4(config)#int Loopback0

R4(config-if)#ip address 4.4.4.4 255.255.255.252

R4(config-if)#no shut

R4(config-if)#ex

Show ip route

R1#show ip route

```
R1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      1.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        1.1.1.0/24 is directly connected, Loopback0
L        1.1.1.1/32 is directly connected, Loopback0
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.2.0/24 is directly connected, FastEthernet0/0
L        192.168.2.1/32 is directly connected, FastEthernet0/0
      192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.13.0/24 is directly connected, FastEthernet0/1
L        192.168.13.1/32 is directly connected, FastEthernet0/1
```

R2#show ip route

```
R2#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      2.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        2.2.2.0/24 is directly connected, Loopback0
L        2.2.2.2/32 is directly connected, Loopback0
      192.168.12.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.12.0/24 is directly connected, FastEthernet0/0
L        192.168.12.2/32 is directly connected, FastEthernet0/0
      192.168.24.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.24.0/24 is directly connected, FastEthernet0/1
L        192.168.24.2/32 is directly connected, FastEthernet0/1
```

R3#show ip route

```
R3#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      3.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        3.3.3.0/24 is directly connected, Loopback0
L        3.3.3.3/32 is directly connected, Loopback0
      192.168.13.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.13.0/24 is directly connected, FastEthernet0/0
L        192.168.13.3/32 is directly connected, FastEthernet0/0
      192.168.34.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.34.0/24 is directly connected, FastEthernet0/1
L        192.168.34.3/32 is directly connected, FastEthernet0/1
```

R4#show ip route

```
R4#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

  192.168.24.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.24.0/24 is directly connected, FastEthernet0/0
L        192.168.24.4/32 is directly connected, FastEthernet0/0
  192.168.34.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.34.0/24 is directly connected, FastEthernet0/1
L        192.168.34.4/32 is directly connected, FastEthernet0/1

```

Show ip int brief

R1#show ip int brief

```
R1#show ip int brief
Interface          IP-Address      OK? Method Status           Protocol
FastEthernet0/0    192.168.2.1    YES manual up            up
FastEthernet0/1    192.168.13.1   YES manual up            up
FastEthernet1/0    unassigned     YES unset administratively down down
FastEthernet2/0    unassigned     YES unset administratively down down
FastEthernet2/1    unassigned     YES unset administratively down down
Serial4/0          unassigned     YES unset administratively down down
Serial4/1          unassigned     YES unset administratively down down
Serial4/2          unassigned     YES unset administratively down down
Serial4/3          unassigned     YES unset administratively down down
Serial4/4          unassigned     YES unset administratively down down
Serial4/5          unassigned     YES unset administratively down down
Serial4/6          unassigned     YES unset administratively down down
Serial4/7          unassigned     YES unset administratively down down
Serial5/0          unassigned     YES unset administratively down down
Serial5/1          unassigned     YES unset administratively down down
Serial5/2          unassigned     YES unset administratively down down
Serial5/3          unassigned     YES unset administratively down down
Ethernet6/0        unassigned     YES unset administratively down down
Ethernet6/1        unassigned     YES unset administratively down down
Ethernet6/2        unassigned     YES unset administratively down down
Ethernet6/3        unassigned     YES unset administratively down down
Ethernet6/4        unassigned     YES unset administratively down down
Ethernet6/5        unassigned     YES unset administratively down down
Ethernet6/6        unassigned     YES unset administratively down down
Ethernet6/7        unassigned     YES unset administratively down down
Loopback0          1.1.1.1       YES manual up            up
```

R2#show ip int brief

```
R2#show ip int brief
Interface          IP-Address      OK? Method Status           Protocol
FastEthernet0/0    192.168.12.2   YES manual up            up
FastEthernet0/1    192.168.24.2   YES manual up            up
FastEthernet1/0    unassigned     YES unset administratively down down
FastEthernet2/0    unassigned     YES unset administratively down down
FastEthernet2/1    unassigned     YES unset administratively down down
Serial4/0          unassigned     YES unset administratively down down
Serial4/1          unassigned     YES unset administratively down down
Serial4/2          unassigned     YES unset administratively down down
Serial4/3          unassigned     YES unset administratively down down
Serial4/4          unassigned     YES unset administratively down down
Serial4/5          unassigned     YES unset administratively down down
Serial4/6          unassigned     YES unset administratively down down
Serial4/7          unassigned     YES unset administratively down down
Serial5/0          unassigned     YES unset administratively down down
Serial5/1          unassigned     YES unset administratively down down
Serial5/2          unassigned     YES unset administratively down down
Serial5/3          unassigned     YES unset administratively down down
Ethernet6/0        unassigned     YES unset administratively down down
Ethernet6/1        unassigned     YES unset administratively down down
Ethernet6/2        unassigned     YES unset administratively down down
Ethernet6/3        unassigned     YES unset administratively down down
Ethernet6/4        unassigned     YES unset administratively down down
Ethernet6/5        unassigned     YES unset administratively down down
Ethernet6/6        unassigned     YES unset administratively down down
Ethernet6/7        unassigned     YES unset administratively down down
Loopback0          2.2.2.2       YES manual up            up
```

R3#show ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.13.3	YES	manual	up	up
FastEthernet0/1	192.168.34.3	YES	manual	up	up
FastEthernet1/0	unassigned	YES	unset	administratively down	down
FastEthernet2/0	unassigned	YES	unset	administratively down	down
FastEthernet2/1	unassigned	YES	unset	administratively down	down
Serial4/0	unassigned	YES	unset	administratively down	down
Serial4/1	unassigned	YES	unset	administratively down	down
Serial4/2	unassigned	YES	unset	administratively down	down
Serial4/3	unassigned	YES	unset	administratively down	down
Serial4/4	unassigned	YES	unset	administratively down	down
Serial4/5	unassigned	YES	unset	administratively down	down
Serial4/6	unassigned	YES	unset	administratively down	down
Serial4/7	unassigned	YES	unset	administratively down	down
Serial5/0	unassigned	YES	unset	administratively down	down
Serial5/1	unassigned	YES	unset	administratively down	down
Serial5/2	unassigned	YES	unset	administratively down	down
Serial5/3	unassigned	YES	unset	administratively down	down
Ethernet6/0	unassigned	YES	unset	administratively down	down
Ethernet6/1	unassigned	YES	unset	administratively down	down
Ethernet6/2	unassigned	YES	unset	administratively down	down
Ethernet6/3	unassigned	YES	unset	administratively down	down
Ethernet6/4	unassigned	YES	unset	administratively down	down
Ethernet6/5	unassigned	YES	unset	administratively down	down
Ethernet6/6	unassigned	YES	unset	administratively down	down
Ethernet6/7	unassigned	YES	unset	administratively down	down
Loopback0	3.3.3.3	YES	manual	up	up

R4#show ip int brief

Interface	IP-Address	OK?	Method	Status	Protocol
FastEthernet0/0	192.168.24.4	YES	manual	up	up
FastEthernet0/1	192.168.34.4	YES	manual	up	up
FastEthernet1/0	unassigned	YES	unset	administratively down	down
FastEthernet2/0	unassigned	YES	unset	administratively down	down
FastEthernet2/1	unassigned	YES	unset	administratively down	down
Serial4/0	unassigned	YES	unset	administratively down	down
Serial4/1	unassigned	YES	unset	administratively down	down
Serial4/2	unassigned	YES	unset	administratively down	down
Serial4/3	unassigned	YES	unset	administratively down	down
Serial4/4	unassigned	YES	unset	administratively down	down
Serial4/5	unassigned	YES	unset	administratively down	down
Serial4/6	unassigned	YES	unset	administratively down	down
Serial4/7	unassigned	YES	unset	administratively down	down
Serial5/0	unassigned	YES	unset	administratively down	down
Serial5/1	unassigned	YES	unset	administratively down	down
Serial5/2	unassigned	YES	unset	administratively down	down
Serial5/3	unassigned	YES	unset	administratively down	down
Ethernet6/0	unassigned	YES	unset	administratively down	down
Ethernet6/1	unassigned	YES	unset	administratively down	down
Ethernet6/2	unassigned	YES	unset	administratively down	down
Ethernet6/3	unassigned	YES	unset	administratively down	down
Ethernet6/4	unassigned	YES	unset	administratively down	down
Ethernet6/5	unassigned	YES	unset	administratively down	down
Ethernet6/6	unassigned	YES	unset	administratively down	down
Ethernet6/7	unassigned	YES	unset	administratively down	down
Loopback0	unassigned	YES	unset	up	up

BGP Configuration

R1(config)#router bgp 1

R1(config-router)#neighbor 192.168.12.2 remote-as 23

R1(config-router)#neighbor 192.168.13.3 remote-as 23

R1(config-router)#redistribute connected

R1(config-router)#end

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#router bgp 1
R1(config-router)#neighbor 192.168.12
% Incomplete command.

R1(config-router)#neighbor 192.168.12.2 remote-as 23
R1(config-router)#neighbor 192.168.13.3 remote-as 23
R1(config-router)#redistribute connected
R1(config-router)#end
R1#
*Dec 13 15:23:10.283: %SYS-5-CONFIG_I: Configured from console by console
```

R2(config)#router bgp 23

R2(config-router)#neighbor 192.168.2.1 remote-as 1

R2(config-router)#neighbor 192.168.34.4 remote-as 4

R2(config-router)#redistribute connected

R2(config-router)#end

```
R2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#router bgp 23
R2(config-router)#neighbor 192.168.2.1 remote-as 1
R2(config-router)#neighbor 192.168.24.4 remote-as 4
R2(config-router)#redistribute connected
R2(config-router)#end
R2#
```

R3(config)#router bgp 23

R3(config-router)#neighbor 192.168.13.1 remote-as 1

R3(config-router)#neighbor 192.168.34.4 remote-as 4

R3(config-router)#redistribute connected

R3(config-router)#end

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#router bgp 23
R3(config-router)#neighbor 192.168.13.1 remote-as 1
R3(config-router)#neighbor 192.168.34.4 remote-as 4
R3(config-router)#redistribute connected
R3(config-router)#end
R3#
```

R4(config)#router bgp 4

R4(config-router)#neighbor 192.168.24.2 remote-as 23

R4(config-router)#neighbor 192.168.34.3 remote-as 23

R4(config-router)#redistribute connected

R4(config-router)#end

```
R4#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R4(config)#router bgp 4
R4(config-router)#neighbor 192.168.24.2 remote-as 23
R4(config-router)#neighbor 192.168.34.3 remote-as 23
R4(config-router)#redistribute connected
R4(config-router)#end
R4#
```

Creating a route map

```
R3(config)#route-map MED-TEST permit
R3(config-router-map)#match ip address 1
R3(config-router-map)#set metric 500
R3(config-router-map)#ex
R3(config)#route-map MED-TEST permit 20
R3(config-router-map)#end
```

```
Dec 13 15:29:47.211: %SYS-5-CONFIG_I: Configured from console by console
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#route-map MED-TEST permit
R3(config-route-map)#match ip address 1
R3(config-route-map)#set metric 500
R3(config-route-map)#ex
R3(config)#route-map MED-TEST permit 20
R3(config-route-map)#end
R3#
*Dec 13 15:29:47.211: %SYS-5-CONFIG_I: Configured from console by console
```

R3#show route-map

```
R3#show route-map
route-map MED-TEST, permit, sequence 10
 Match clauses:
   ip address (access-lists): 1
 Set clauses:
   metric 500
 Policy routing matches: 0 packets, 0 bytes
route-map MED-TEST, permit, sequence 20
 Match clauses:
 Set clauses:
 Policy routing matches: 0 packets, 0 bytes
```

Creating a access list

R3#conf t

R3(config)#access-list 1 permit host 4.4.4.4

R3(config)#end

R3#show access-list

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#access-list 1 permit host 4.4.4.4
R3(config)#end
R3#
*Dec 13 15:30:51.959: %SYS-5-CONFIG_I: Configured from console by console
R3#show access-list
Standard IP access list 1
 10 permit 4.4.4.4
```

Applying the created route-map to bgp configuration.

R3#conf t

R3(config)#router bgp 23

R3(config)#neighbor 192.168.13.1 route-map MED-TEST out

R3(config)#end

R3#show ip bgp

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#router bgp 23
R3(config-router)#neighbor 192.168.13.1 route-map MED-TEST out
R3(config-router)#end
R3#
*Dec 13 15:32:00.543: %SYS-5-CONFIG_I: Configured from console by console
R3#show ip bgp
BGP table version is 4, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

      Network          Next Hop            Metric LocPrf Weight Path
*>  3.3.3.0/24        0.0.0.0            0       32768 ?
*>  192.168.13.0     0.0.0.0            0       32768 ?
*>  192.168.34.0     0.0.0.0            0       32768 ?
```

R1#show ip bgp

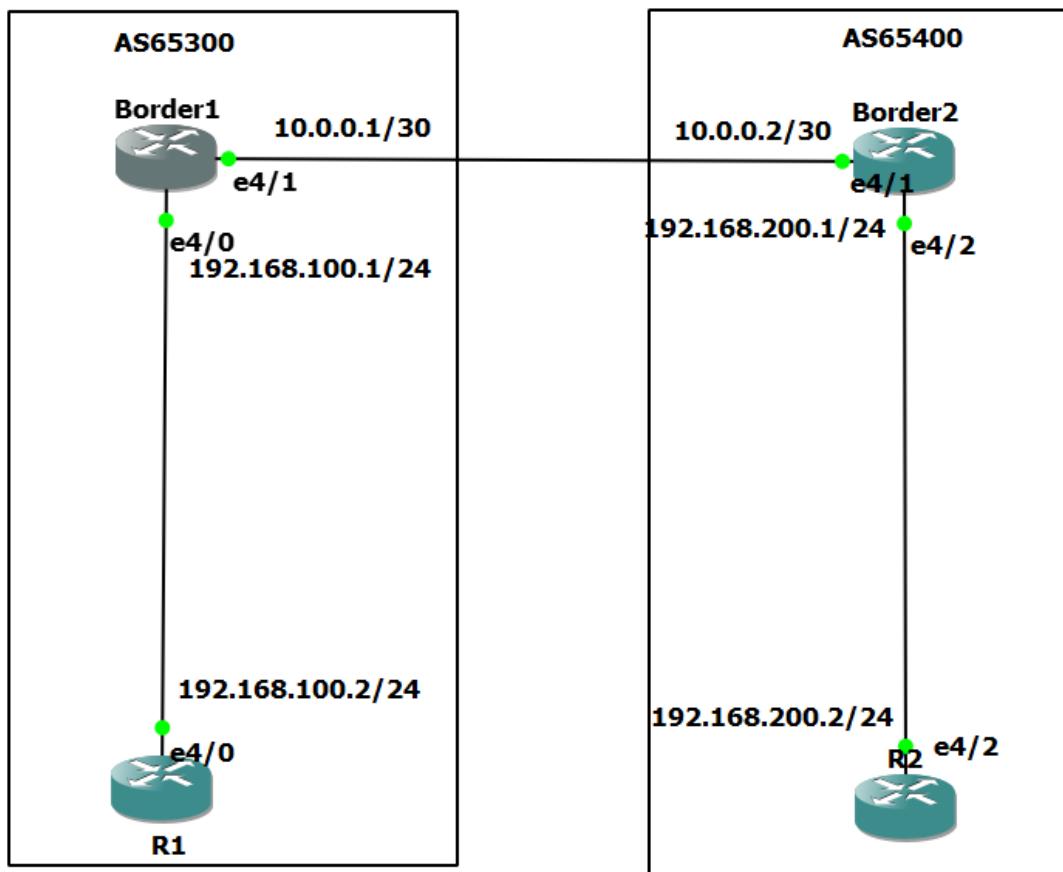
```
R1#clear ip bgp * soft in
R1#show ip bgp
BGP table version is 4, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

      Network          Next Hop            Metric LocPrf Weight Path
* >  1.1.1.0/24      0.0.0.0                 0        32768 ?
* >  192.168.2.0    0.0.0.0                 0        32768 ?
* >  192.168.13.0   0.0.0.0                 0        32768 ?

R1#
```

Practical 4d-

Practical 4e- configure Internal BGP(IBGP) and External BGP(EBGP)



As you can see, router R1 with BORDER_1 and R2 with BORDER_2 are IBGP neighbors. BORDER_1 with BORDER_2 are EBGP neighbors and they belong to different AS.

After configure IP addresses in the interfaces, you need to configure BGP. The configuration of BGP start with router bgp AS which enters you to BGP configuration mode.

The next step is configure bgp neighbors with neighbor (ip-address | peer-group-name) remote-as AS command. I will set neighbors based on ip address in this lab. Use the command network network-number (mask network-mask) (route-map map-tag) to tell the router what to advertise.

Now, let's return to our lab. Below you can see configurations according to my topology and command described above.

ROUTER – R1

```
R1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int e4/0
R1(config-if)#ip addr 192.168.100.2 255.255.255.0
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#
*Feb 19 21:05:47.387: %LINK-3-UPDOWN: Interface Ethernet4/0, changed state to up
*Feb 19 21:05:48.387: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet4/0, changed state to up
R1(config)#router bgp 65300
R1(config-router)#neighbor 192.168.100.1 remote
R1(config-router)#neighbor 192.168.100.1 remote-as 65300
R1(config-router)#exig
^
% Invalid input detected at '^' marker.

R1(config-router)#exit
```

R1(config) # interface Ethernet0/0

R1(config) # ip address 192.168.100.2 255.255.255.0

R1(config) # no shutdown

R1(config) # router bgp 65300

R1(config)# neighbor 192.168.100.1 remote-as 65300

ROUTER - BORDER_1

```
Border1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Border1(config)#int e4/1
Border1(config-if)#ip addr 10.0.0.1 255.255.255.252
Border1(config-if)#no shut
Border1(config-if)#exit
Border1(config)#int
*Feb 19 21:19:04.863: %LINK-3-UPDOWN: Interface Ethernet4/1, changed state to up
*Feb 19 21:19:05.863: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet4/1, changed state to up
Border1(config)#int e4/0
Border1(config-if)#ip addr 192.168.100.1 255.255.255.0
Border1(config-if)#no shut
Border1(config-if)#exit
Border1(config)#
*Feb 19 21:19:29.059: %LINK-3-UPDOWN: Interface Ethernet4/0, changed state to up
*Feb 19 21:19:30.059: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet4/0, changed state to up
Border1(config)#router bgp 65300
```

```
Border1(config-router)#neigh
Border1(config-router)#neighbor 192.168.100.2 remote
Border1(config-router)#neighbor 192.168.100.2 remote-as 65300
Border1(config-router)#neighbor 192.168.100.2 re
*Feb 19 21:21:07.947: %BGP-5-ADJCHANGE: neighbor 192.168.100.2 Up
```

```
Border1(config-router)#network 192.168.100.0 mask 255.255.255.0
Border1(config-router)#exit
Border1(config)#router bgp 65300
Border1(config-router)#neigh
Border1(config-router)#neighbor 10.0.0.2 remote
Border1(config-router)#neighbor 10.0.0.2 remote-as 65400
Border1(config-router)#exit
```

BORDER_1(config) # interface Ethernet0/0
 BORDER_1(config) # ip address 10.0.0.1 255.255.255.252
 BORDER_1(config) # no shutdown
 BORDER_1(config) # interface Ethernet0/1
 BORDER_1(config) # ip address 192.168.0.1 255.255.255.0
 BORDER_1(config) # no shutdown
 BORDER_1(config) # router bgp 65300
 BORDER_1(config)# neighbor 10.0.0.2 remote-as 65400
 BORDER_1(config)# neighbor 192.168.0.2 remote-as 65300
 BORDER_1(config)# network 192.168.0.0 mask 255.255.255.0

ROUTER - BORDER_2

```
Border2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Border2(config)#int e4/1
Border2(config-if)#ip addr 10.0.0.2 255.255.255.252
Border2(config-if)#no shut
Border2(config-if)#exit
^
% Invalid input detected at '^' marker.

Border2(config-if)#exit
*Feb 19 21:19:52.535: %LINK-3-UPDOWN: Interface Ethernet4/1, changed state to up
*Feb 19 21:19:53.535: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet4/1, changed state to up
Border2(config-if)#exit
Border2(config)#int e4/2
Border2(config-if)#ip addr 192.168.200.1 255.255.255.0
Border2(config-if)#no shut
Border2(config-if)#exit
Border2(config)#
*Feb 19 21:20:30.267: %LINK-3-UPDOWN: Interface Ethernet4/2, changed state to up
*Feb 19 21:20:31.267: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet4/2, changed state to up
Border2(config)#router bgp 65400
```

```

Border2(config-router)#neigh
Border2(config-router)#neighbor 192.168.200.2 remote
Border2(config-router)#neighbor 192.168.200.2 remote-as 65400
Border2(config-router)#
*Feb 19 21:25:39.271: %BGP-5-ADJCHANGE: neighbor 192.168.200.2 Up
Border2(config-router)#net
Border2(config-router)#network 192.168.200.0 mask 255.255.255.0
Border2(config-router)#neighb
Border2(config-router)#neighbor 10.0.0.1 remote
Border2(config-router)#neighbor 10.0.0.1 remote-as 65300
Border2(config-router)#exit
Border2(config)#
*Feb 19 21:26:11.483: %BGP-5-ADJCHANGE: neighbor 10.0.0.1 Up

```

BORDER_2(config) # interface Ethernet0/0
 BORDER_2(config) # ip address 10.0.0.2 255.255.255.252
 BORDER_2(config) # no shutdown
 BORDER_2(config) # interface Ethernet0/1
 BORDER_2(config) # ip address 192.168.100.1 255.255.255.0
 BORDER_2(config) # no shutdown
 BORDER_2(config) # router bgp 65400
 BORDER_2(config) # neighbor 10.0.0.1 remote-as 65300
 BORDER_2(config) # neighbor 192.168.100.2 remote-as 65400
 BORDER_2(config) # network 192.168.100.0 mask 255.255.255.0

ROUTER - R2

```

R2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#int e4/0
R2(config-if)#exit
R2(config)#int e4/2
R2(config-if)#ip addr 192.168.200.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#exit
R2(config)#
*Feb 19 21:11:24.783: %LINK-3-UPDOWN: Interface Ethernet4/2, changed state to up
*Feb 19 21:11:25.783: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet4/2, changed state to up
R2(config)#router bgp 65400
R2(config-router)#neighbor
R2(config-router)#neighbor 192.168.200.1 remote
R2(config-router)#neighbor 192.168.200.1 remote-as 65400
R2(config-router)#exit

```

R2(config) # interface Ethernet0/0
 R2(config) # ip address 192.168.100.2 255.255.255.0
 R2(config) # no shutdown
 R2(config) # router bgp 65400
 R2(config) # neighbor 192.168.100.1 remote-as 65400

If you use the mask in network command then the network in routing table must match network from this command. Also note that you can advertise any network that resides in routing table and is not necessary to be directly connected.

You can use few tools to verify bgp status:

- 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, m multipath, b backup-path, f RT-Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

      Network          Next Hop            Metric LocPrf Weight Path
  *-> 192.168.100.0    0.0.0.0                  0        32768  i
  *-> 192.168.200.0   10.0.0.2                  0          0 65400  i
Border1(config)#
```

- show ip bgp summary;

```
Border1(config)#do sh ip bgp summary
BGP router identifier 192.168.100.1, local AS number 65300
BGP table version is 3, main routing table version 3
2 network entries using 288 bytes of memory
2 path entries using 160 bytes of memory
2/2 BGP path/bestpath attribute entries using 272 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 744 total bytes of memory
BGP activity 2/0 prefixes, 2/0 paths, scan interval 60 secs

Neighbor      V      AS MsgRcvd MsgSent     TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.0.2      4      65400    39    42        3      0    0 00:31:08      1
102.168.100.2 4      65400    0      0        1      0    0 never      Idle
192.168.100.2 4      65300    44    45        3      0    0 00:36:11      0
Border1(config)#
```

You can see that we have two neighbors with BORDER_1, one internal and one external. Let's see the results on R1:

R1#show ip route

```
R1(config)#do sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      192.168.100.0/24 is variably subnetted, 2 subnets, 2 masks
C          192.168.100.0/24 is directly connected, Ethernet4/0
L          192.168.100.2/32 is directly connected, Ethernet4/0
```

Wow...! But as you can see on R1 we don't have external route to network 192.168.100.0/24. This is because BORDER_2, which is an external router, routing updates sent have address 10.0.0.2 as source ip

address, but in this case R1 doesn't have any idea how to get 10.0.0.0 network. BGP on router R1 doesn't put in routing table a route to 192.168.100.0/24. To overcome this we have to add on router BORDER_1 this command: neighbor 192.168.0.2 next-hop-self, this command will change source ip address of routing updates sent to router R1 (will change to its e0/1 ip address). You need to put the command inside router bgp AS configuration.

BORDER_1(config-router)#neighbor 192.168.100.2 next-hop-self

```
Border1(config)#router bgp 65300
Border1(config-router)#neighbor 102.168.100.2 remote-as 65300  next-hop-self
^
% Invalid input detected at '^' marker.

Border1(config-router)#neighbor 102.168.100.2 remote-as 65300
Border1(config-router)#neighbor 102.168.100.2 next-ho
Border1(config-router)#neighbor 102.168.100.2 next-hop-se
Border1(config-router)#neighbor 102.168.100.2 next-hop-self
Border1(config-router)#exit
```

You need to do the same on router BORDER_2 to change update source to neighbor R1.

BORDER_2(config-router)#neighbor 192.168.200.2 next-hop-self

```
Border2(config)#router bgp 65400
Border2(config-router)#neigh
Border2(config-router)#neigh
Border2(config-router)#neighbor
% Incomplete command.

Border2(config-router)#neighbor 192.168.200.2 remote-
Border2(config-router)#neighbor 192.168.200.2 remote-as 65400
Border2(config-router)#neighbor 192.168.200.2 next
Border2(config-router)#neighbor 192.168.200.2 next-hop-sel
Border2(config-router)#neighbor 192.168.200.2 next-hop-self
Border2(config-router)#exit
```

So, let's see again routing table on router R1

R1#show ip route

```
R1(config)#do sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override

Gateway of last resort is not set

      192.168.100.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.100.0/24 is directly connected, Ethernet4/0
L        192.168.100.2/32 is directly connected, Ethernet4/0
```

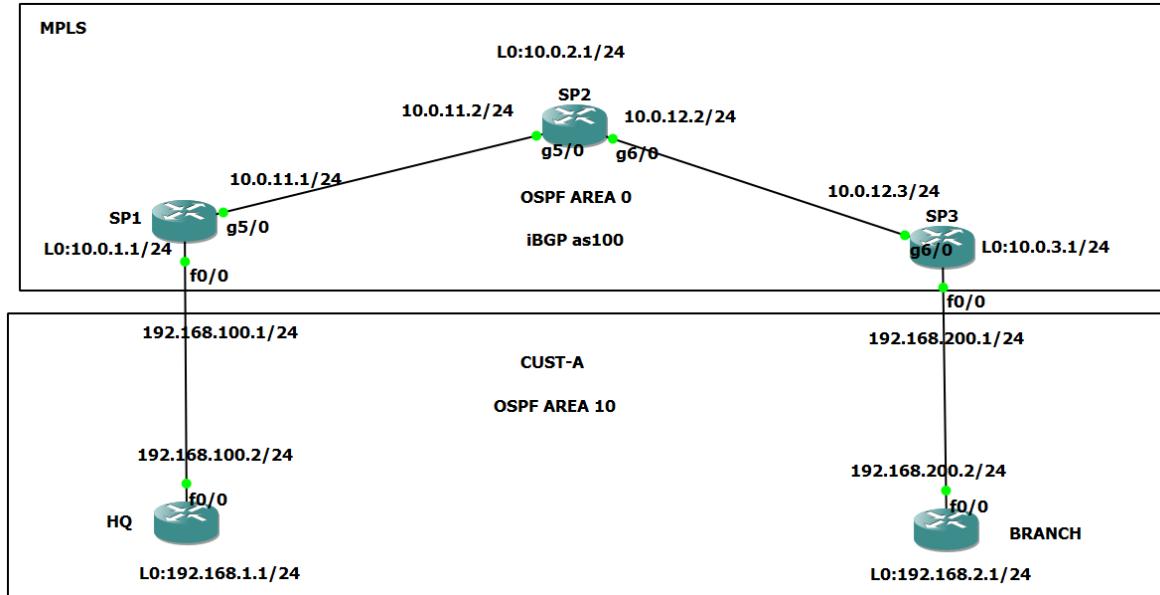
Then, ping from R1 to R2

R1#ping 192.168.100.2

```
R1(config)#do ping 192.168.100.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.100.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/3/8 ms
R1(config)#[
```

Practical 6a- Implementing MPLS VPNs

Here is the Topology on which we did the experiment



Step1 Router Config

```

SP1#conf t
SP1(config)#int Loopback 0
SP1(config-if)#ip address 10.0.1.1 255.255.255.0
SP1(config-if)#no shut
SP1(config-if)#ex
SP1(config)#int g5/0
SP1(config-if)#ip address 10.0.11.1 255.255.255.0
SP1(config-if)#no shut
SP1(config-if)#ex
SP1(config)#int fa0/0
SP1(config-if)#ip address 192.168.100.1 255.255.255.0
SP1(config-if)#no shut
SP1(config-if)#ex
    
```

```

SP1(config)#int loop
SP1(config)#int loopback 0
SP1(config-if)#ip
*Feb 21 01:06:16.731: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
SP1(config-if)#ip addr 10.0.1.1 255.255.255.0
SP1(config-if)#no shut
SP1(config-if)#int g5/0
SP1(config-if)#ip addr 10.0.11.1 255.255.255.0
SP1(config-if)#no shut
SP1(config-if)#
*Feb 21 01:06:54.103: %LINK-3-UPDOWN: Interface GigabitEthernet5/0, changed state to up
*Feb 21 01:06:55.103: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet5/0, changed state to up
SP1(config-if)#int f0/0
SP1(config-if)#ip addr 192.168.100.1 255.255.255.0
SP1(config-if)#no shut
SP1(config-if)#
*Feb 21 01:07:18.819: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Feb 21 01:07:19.819: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up

```

SP2#conf t

```

SP2(config)#int Loopback 0
SP2(config-if)#ip address 10.0.2.1 255.255.255.0
SP2(config-if)#no shut
SP2(config-if)#ex
SP2(config)#int g5/0
SP2(config-if)#ip address 10.0.11.2 255.255.255.0
SP2(config-if)#no shut
SP2(config-if)#ex
SP2(config)#int g6/0
SP2(config-if)#ip address 10.0.12.2 255.255.255.0
SP2(config-if)#no shut
SP2(config-if)#ex

```

```

SP2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
SP2(config)#int loop
SP2(config)#int loopback 0
SP2(config-if)#
*Feb 21 01:07:36.035: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
SP2(config-if)#ip addr 10.0.2.1 255.255.255.0
SP2(config-if)#no shut
SP2(config-if)#int g5/0
SP2(config-if)#ip addr 10.0.11.2 255.255.255.0
SP2(config-if)#no shut
SP2(config-if)#
*Feb 21 01:08:14.671: %LINK-3-UPDOWN: Interface GigabitEthernet5/0, changed state to up
*Feb 21 01:08:15.671: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet5/0, changed state to up
SP2(config-if)#int g6/0
SP2(config-if)#ip addr 10.0.12.2 255.255.255.0
SP2(config-if)#no shut
SP2(config-if)#
*Feb 21 01:08:35.947: %LINK-3-UPDOWN: Interface GigabitEthernet6/0, changed state to up
*Feb 21 01:08:36.947: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet6/0, changed state to up
SP2(config-if)#
SP2(config-if)#

```

```

SP3#conf t
SP3(config)#int Loopback 0
SP3(config-if)#ip address 10.0.3.1 255.255.255.0
SP3(config-if)#no shut
SP3(config-if)#ex
SP3(config)#int g6/0
SP3(config-if)#ip address 10.0.12.3 255.255.255.0
SP3(config-if)#no shut
SP3(config-if)#ex
SP3(config)#int fa0/0
SP3(config-if)#ip address 192.168.200.1 255.255.255.0
SP3(config-if)#no shut
SP3(config-if)#ex

```

```

SP3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
SP3(config)#int loop
SP3(config)#int loopback 0
SP3(config-if)#
*Feb 21 01:08:53.603: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
SP3(config-if)#ip addr 10.0.3.1 255.255.255.0
SP3(config-if)#no shut
SP3(config-if)#int g6/0
SP3(config-if)#ip addr 10.0.12.3 255.255.255.0
SP3(config-if)#no shut
SP3(config-if)#int
*Feb 21 01:09:32.327: %LINK-3-UPDOWN: Interface GigabitEthernet6/0, changed state to up
*Feb 21 01:09:33.327: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet6/0, changed state to up
SP3(config-if)#int f0/0
SP3(config-if)#ip addr 192.168.200.1
% Incomplete command.

SP3(config-if)#ip addr 192.168.200.1 255.255.255.0
SP3(config-if)#no shut
SP3(config-if)#exit

```

```

HQ#conf t
HQ(config)#int Loopback 0
HQ(config-if)#ip address 192.168.1.1 255.255.255.0
HQ(config-if)#no shut
HQ(config-if)#ex
HQ(config)#int fa0/0
HQ(config-if)#ip address 192.168.100.2 255.255.255.0

```

```
HQ(config-if)#no shut
```

```
HQ(config-if)#ex
```

```
HQ#conf t
Enter configuration commands, one per line. End with CNTL/Z.
HQ(config)#int loop 0
HQ(config-if)#ip
*Feb 21 01:10:29.299: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
HQ(config-if)#ip addr 192.168.1.1 255.255.255.0
HQ(config-if)#no shut
HQ(config-if)#int f0/0
HQ(config-if)#ip addr 192.168.100.2 255.255.255.0
HQ(config-if)#no shut
HQ(config-if)#exit
HQ(config)#
*Feb 21 01:10:43.559: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Feb 21 01:10:44.559: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
```

```
BRANCH#conf t
```

```
BRANCH(config)#int Loopback 0
```

```
BRANCH(config-if)#ip address 192.168.2.1 255.255.255.0
```

```
BRANCH(config-if)#no shut
```

```
BRANCH(config-if)#ex
```

```
BRANCH(config)#int fa0/0
```

```
BRANCH(config-if)#ip address 192.168.200.2 255.255.255.0
```

```
BRANCH(config-if)#no shut
```

```
BRANCH(config-if)#ex
```

```
BRANCH#conf t
Enter configuration commands, one per line. End with CNTL/Z.
BRANCH(config)#int loop 0
BRANCH(config-if)#ip
*Feb 21 01:10:54.763: %LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to up
BRANCH(config-if)#ip addr 192.168.2.1 255.255.255.0
BRANCH(config-if)#no shut
BRANCH(config-if)#int f0/0
BRANCH(config-if)#ip addr 192.168.200.2 255.255.255.0
BRANCH(config-if)#no shut
BRANCH(config-if)#exit
BRANCH(config)#
*Feb 21 01:11:32.043: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Feb 21 01:11:33.043: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
```

Step 2 Ospf Configuration

```
SP1(config)#router ospf 1
```

```
SP1(config-if)#network 10.0.1.0 0.0.0.255 area 0
```

```
SP1(config-if)#network 10.0.11.0 0.0.0.255 area 0
```

```
SP1(config-if)#ex
```

```
SP1(config-if)#router ospf 1
SP1(config-router)#net
SP1(config-router)#network 10.0.1.0 0.0.0.255 area 0
SP1(config-router)#network 10.0.11.0 0.0.0.255 area 0
SP1(config-router)#exit
SP1(config)#
*Feb 21 01:13:17.271: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.2.1 on GigabitEthernet5/0 from LOADING to FULL, Loading Done
```

```
SP2(config)#router ospf 1
SP2(config-if)#network 10.0.2.0 0.0.0.255 area 0
SP2(config-if)#network 10.0.11.0 0.0.0.255 area 0
SP2(config-if)#network 10.0.12.0 0.0.0.255 area 0
SP2(config-if)#ex
```

```
SP2(config)#router ospf 1
SP2(config-router)#net
SP2(config-router)#network 10.0.2.0 0.0.0.255 area 0
SP2(config-router)#network 10.0.11.0 0.0.0.255 area 0
SP2(config-router)#network 10.0.12.0 0.0.0.255 area 0
SP2(config-router)#exit
SP2(config)#
*Feb 21 01:13:17.231: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.1.1 on GigabitEthernet5/0 from LOADING to FULL, Loading Done
SP2(config)#
*Feb 21 01:14:11.231: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.3.1 on GigabitEthernet6/0 from LOADING to FULL, Loading Done
```

```
SP3(config)#router ospf 1
SP3(config-if)#network 10.0.3.0 0.0.0.255 area 0
SP3(config-if)#network 10.0.12.0 0.0.0.255 area 0
SP3(config-if)#ex
```

```
SP3(config)#router ospf 1
SP3(config-router)#net
SP3(config-router)#network 10.0.3.0 0.0.0.255 area 0
SP3(config-router)#network 10.0.12.0 0.0.0.255 area 0
SP3(config-router)#exit
```

For Checking the config

```
SP2(config)#do show ip ospf neighbor
```

```
SP2(config)#do sh ip ospf neighbor
Neighbor ID      Pri   State          Dead Time    Address          Interface
10.0.3.1          1     FULL/BDR       00:00:30    10.0.12.3      GigabitEthernet6/0
10.0.1.1          1     FULL/BDR       00:00:38    10.0.11.1      GigabitEthernet5/0
SP2(config)#

```

Step3- do the MPLS config

```
SP1(config)#mpls ldp
```

```
SP1(config-if)#mpls ldp router-id loopback 0 force
```

```
SP1(config)#int g5/0
```

```
SP1(config-if)#mpls ip
```

SP1(config-if)#no shut

SP1(config-if)#ex

```
SP1(config)#mpls ldp ro
SP1(config)#mpls ldp router-id loo
SP1(config)#mpls ldp router-id loopback 0 for
SP1(config)#mpls ldp router-id loopback 0 force
SP1(config)#int g5/0
SP1(config-if)#mpls ip
SP1(config-if)#no shut
SP1(config-if)#exit
SP1(config)#
*Feb 21 01:15:45.351: %LDP-5-NBRCHG: LDP Neighbor 10.0.2.1:0 (1) is UP
```

SP2(config)#mpls ldp

SP2(config)#mpls ldp router-id loopback 0 force

SP2(config)#int g5/0

SP2(config-if)#mpls ip

SP2(config-if)#no shut

SP2(config-if)#ex

SP2(config)#mpls ldp

SP2(config)#mpls ldp router-id loopback 0 force

SP2(config)#int g5/0

SP2(config-if)#mpls ip

SP2(config-if)#no shut

SP2(config-if)#ex

```
SP2(config)#mpls ld
SP2(config)#mpls ldp rout
SP2(config)#mpls ldp router-id loop
SP2(config)#mpls ldp router-id loopback 0 for
SP2(config)#mpls ldp router-id loopback 0 force
SP2(config)#int g5/0
SP2(config-if)#mpls ip
SP2(config-if)#
*Feb 21 01:15:45.259: %LDP-5-NBRCHG: LDP Neighbor 10.0.1.1:0 (1) is UP
SP2(config-if)#no shut
SP2(config-if)#exit
SP2(config)#mpls ldp ro
SP2(config)#mpls ldp router-id loo
SP2(config)#mpls ldp router-id loopback 0 for
SP2(config)#mpls ldp router-id loopback 0 force
SP2(config)#int g6/0
SP2(config-if)#mpls ip
SP2(config-if)#no shut
SP2(config-if)#exit
SP2(config)#
*Feb 21 01:16:57.703: %LDP-5-NBRCHG: LDP Neighbor 10.0.3.1:0 (2) is UP
```

```

SP3(config)#mpls ldp
SP3(config)#mpls ldp router-id loopback 0 force
SP3(config)#int g5/0
SP3(config-if)#mpls ip
SP3(config-if)#no shut
SP3(config-if)#ex

```

```

SP3(config)#mpls ldp ro
SP3(config)#mpls ldp router-id lo
SP3(config)#mpls ldp router-id loo
SP3(config)#mpls ldp router-id loopback 0 for
SP3(config)#mpls ldp router-id loopback 0 force
SP3(config)#int g6/0
SP3(config-if)#mpls ip
SP3(config-if)#no shut
SP3(config-if)#ex

```

SP2(config)#do sh mpls ldp neighbor

```

SP2(config)#do sh mpls ldp neighbor
Peer LDP Ident: 10.0.1.1:0; Local LDP Ident 10.0.2.1:0
    TCP connection: 10.0.1.1.646 - 10.0.2.1.33855
    State: Oper; Msgs sent/rcvd: 9/10; Downstream
    Up time: 00:01:30
    LDP discovery sources:
        GigabitEthernet5/0, Src IP addr: 10.0.11.1
        Addresses bound to peer LDP Ident:
            192.168.100.1 10.0.11.1 10.0.1.1
Peer LDP Ident: 10.0.3.1:0; Local LDP Ident 10.0.2.1:0
    TCP connection: 10.0.3.1.41521 - 10.0.2.1.646
    State: Oper; Msgs sent/rcvd: 8/9; Downstream
    Up time: 00:00:18
    LDP discovery sources:
        GigabitEthernet6/0, Src IP addr: 10.0.12.3
        Addresses bound to peer LDP Ident:
            192.168.200.1 10.0.12.3 10.0.3.1

```

Step4 config the vrf CUST-A

```

SP1(config)#ip vrf CUST-A
SP1(config-vrf)#rd 100:1
SP1(config-vrf)#route-target export 1:100
SP1(config-vrf)#route-target import 1:100
SP1(config-vrf)#no shut
SP1(config-vrf )#ex

```

```

SP1`^o
SP1(config)#ip vrf CUST-A
SP1(config-vrf)#rd 100:1
SP1(config-vrf)#route
SP1(config-vrf)#route-
SP1(config-vrf)#route-t
SP1(config-vrf)#route-target ex
SP1(config-vrf)#route-target export 1:100
SP1(config-vrf)#rout
SP1(config-vrf)#route-ta
SP1(config-vrf)#route-target imp
SP1(config-vrf)#route-target import 1:100
SP1(config-vrf)#no shut
^
% Invalid input detected at '^' marker.

SP1(config-vrf)#
SP1(config-vrf)#exit

```

```

SP3(config)#ip vrf CUST-A
SP3(config-vrf)#rd 100:1
SP3(config-vrf)#route-target export 1:100
SP3(config-vrf)#route-target import 1:100
SP3(config-vrf)#no shut
SP3(config-vrf )#ex
SP3(config)#int fa0/0
SP3(config-if)#ip vrf forwarding CUST-A
SP3(config-if)#ip address 192.168.200.1 255.255.255.0
SP3(config-if)#no shut
SP3(config-if)#ex

```

```

SP3(config)#ip vrf CUST-A
SP3(config-vrf)#rd 100:1
SP3(config-vrf)#route-targ
SP3(config-vrf)#route-target export 1:100
SP3(config-vrf)#route
SP3(config-vrf)#route-tar
SP3(config-vrf)#route-target impor
SP3(config-vrf)#route-target import 1:100
SP3(config-vrf)#
SP3(config-vrf)#exit
SP3(config)#
SP3(config)#int f0/0
SP3(config-if)#ip vrf forw
SP3(config-if)#ip vrf forwarding CUST-A
% Interface FastEthernet0/0 IPv4 disabled and address(es) removed due to enabling VRF CUST-A
SP3(config-if)#ip addr
SP3(config-if)#ip address 192.168.200.1 255.255.255.0
SP3(config-if)#no shut
SP3(config-if)#exit

```

For Checking the vrf

SP1(config)#do ping vrf CUST-A 192.168.100.2

```
SP1(config)#do ping vrf CUST-A 192.168.100.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.100.2, timeout is 2 seconds:
!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 20/26/32 ms
```

Step 5 Customer routing

HQ(config)#router ospf 1

HQ(config-router)#log-adjacency-changes

HQ(config-router)#network 192.168.1.0 0.0.0.255 area 10

HQ(config-router)#network 192.168.100.0 0.0.0.255 area 10

HQ(config-router)#exit

```
HQ(config)#router ospf 1
HQ(config-router)#log
HQ(config-router)#log-adjacency-changes
HQ(config-router)#net
HQ(config-router)#network 192.168.1.0 0.0.0.255 area 10
HQ(config-router)#network 192.168.100.0 0.0.0.255 area 10
HQ(config-router)#exit
HQ(config)#
*Feb 21 01:25:11.591: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.100.1 on FastEthernet0/0 from LOADING to FULL, Loading Done
```

BRANCH(config)#router ospf 1

BRANCH(config-router)#log-adjacency-changes

BRANCH(config-router)#network 192.168.2.0 0.0.0.255 area 10

BRANCH(config-router)#network 192.168.200.0 0.0.0.255 area 10

BRANCH(config-router)#exit

```
BRANCH(config)#router ospf 1
BRANCH(config-router)#log
BRANCH(config-router)#log-adjacency-changes
BRANCH(config-router)#net
BRANCH(config-router)#network 192.168.2.0 0.0.0.255 area 10
BRANCH(config-router)#network 192.168.200.0 0.0.0.255 area 10
BRANCH(config-router)#exit
BRANCH(config)#
*Feb 21 01:25:53.587: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.200.1 on FastEthernet0/0 from LOADING to FULL, Loading Done
```

SP1(config)#router ospf 10 VRF CUST-A

SP1(config-router)#network 192.168.100.0 0.0.0.255 area 10

SP1(config-router)#exit

```
SP1(config)#router ospf 10 vrf CUST-A
SP1(config-router)#net
SP1(config-router)#network 192.168.100.0 0.0.0.255 area 10
SP1(config-router)#
*Feb 21 01:25:10.927: %OSPF-5-ADJCHG: Process 10, Nbr 192.168.1.1 on FastEthernet0/0 from LOADING to FULL, Loading Done
```

```
SP3(config)#router ospf 10 VRF CUST-A
```

```
SP3(config-router)#network 192.168.200.0 0.0.0.255 area 10
```

```
SP3(config-router)#exit
```

```
SP3(config)#router ospf 10 vrf CUST-A
SP3(config-router)#network 192.168.200.0 0.0.0.255 area 10
SP3(config-router)#exit
*Feb 21 01:53:023: %OSPF-5-ADJCHG: Process 10, Nbr 192.168.2.1 on FastEthernet0/0 from LOADING to FULL, Loading Done
SP3(config-router)#exit
```

```
SP1(config)#do sh ip ospf neighbor
```

```
SP1(config)#do sh ip ospf neighbor

Neighbor ID      Pri  State          Dead Time    Address          Interface
10.0.2.1          1    FULL/DR       00:00:39    10.0.11.2      GigabitEthernet5/0
192.168.1.1        1    FULL/DR       00:00:32    192.168.100.2   FastEthernet0/0
SP1(config)#do sh ip route vrf CUST-A

Routing Table: CUST-A
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LIS
      + - replicated route, % - next hop override
```

```
Gateway of last resort is not set

      192.168.1.0/32 is subnetted, 1 subnets
O      192.168.1.1 [110/2] via 192.168.100.2, 00:01:43, FastEthernet0/0
      192.168.100.0/24 is variably subnetted, 2 subnets, 2 masks
C      192.168.100.0/24 is directly connected, FastEthernet0/0
L      192.168.100.1/32 is directly connected, FastEthernet0/0
SP1(config)*
```

Step6 BGP

```
SP1(config)#router bgp 100
```

```
SP1(config-router)#neighbor 10.0.3.1 remote-as 100
```

```
SP1(config-router)#neighbor 10.0.3.1 update-source Loopback 0
```

```
SP1(config-router)#exit
```

```
SP1(config-if)#do sh ip bgp summary
```

```

SP1(config)#router bgp 100
SP1(config-router)#neighbor 10.0.3.1 remote-as 100
SP1(config-router)#neighbor 10.0.3.1 update-source loopback 0
SP1(config-router)#exit
SP1(config)#
*Feb 21 01:30:33.727: %BGP-5-ADJCHANGE: neighbor 10.0.3.1 Up
SP1(config)#
SP1(config)#
SP1(config)#
SP1(config)#do sh ip bgp sum
SP1(config)#do sh ip bgp summary
BGP router identifier 10.0.1.1, local AS number 100
BGP table version is 1, main routing table version 1

Neighbor      V      AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.3.1      4      100     4       4        1      0    0  00:00:27      0

```

```

SP1(config)#router bgp 100
SP1(config-router)#neighbor 10.0.1.1 remote-as 100
SP1(config-router)#neighbor 10.0.1.1 update-source Loopback 0
SP1(config-router)#exit
SP1(config-if)#do sh ip bgp summary

```

```

SP3(config)#router bgp 100
SP3(config-router)#neighbor 10.0.1.1 remote
SP3(config-router)#neighbor 10.0.1.1 remote-as 100
SP3(config-router)#nei
SP3(config-router)#neighbor
*Feb 21 01:30:33.839: %BGP-5-ADJCHANGE: neighbor 10.0.1.1 Up
SP3(config-router)#neighbor 10.0.1.1 up
SP3(config-router)#neighbor 10.0.1.1 update-source loo
SP3(config-router)#neighbor 10.0.1.1 update-source loopback 0
SP3(config-router)#exit

```

```

SP1(config)#router bgp 100
SP1(config-router)#address-family vpnv4
SP1(config-router)#neighbor 10.0.3.1 activate
SP1(config-router)#exit

```

```

SP1(config)#router bgp 100
SP1(config-router)#add
SP1(config-router)#address-family v
SP1(config-router)#address-family vpnv4
SP1(config-router-af)#neigh
SP1(config-router-af)#neighbor 10.0.3.1 ac
SP1(config-router-af)#neighbor 10.0.3.1 activate
SP1(config-router-af)#neighbor 10.0.3.1 act
*Feb 21 01:31:53.511: %BGP-5-NBR_RESET: Neighbor 10.0.3.1 reset (Capability changed)
*Feb 21 01:31:53.519: %BGP-5-ADJCHANGE: neighbor 10.0.3.1 Down Capability changed
*Feb 21 01:31:53.523: %BGP_SESSION-5-ADJCHANGE: neighbor 10.0.3.1 IPv4 Unicast topology base removed from session Capability changed

```

```

SP1(config)#do sh ip bp summary

```

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
10.0.3.1	4	100	4	4	1	0	0	00:00:27	0

```
SP3(config)#router bgp 100
SP3(config-router)#address-family vpng4
SP3(config-router)#neighbor 10.0.1.1 activate
SP3(config-router)#exit
```

```
SP3(config)#router bgp 100
SP3(config-router)#ad
SP3(config-router)#address-family vp
SP3(config-router)#address-family vpng4
SP3(config-router-af)#nei
SP3(config-router-af)#neighbor 10.0.1.1 ac
SP3(config-router-af)#neighbor 10.0.1.1 activate
```

```
SP1(config)#router ospf 10 vrf CUST-A
SP1(config-router)#redistribute bgp 100 subnets
SP1(config)#router bgp 100
SP1(config-router)#address-family vpng4 vrf CUST-A
SP1(config-router)#redistribute ospf 10 vrf CUST-A
SP1(config-router)#exit
SP1(config-router)#exit-address-family
```

```
SP1(config)#router ospf 10 vrf CUST-A
SP1(config-router)#red
SP1(config-router)#redistribute bgp 100 su
SP1(config-router)#redistribute bgp 100 subnets
SP1(config-router)#exit
SP1(config)#router bgp 100
SP1(config-router)#addre
SP1(config-router)#address-family ipv4 vrf CUST-A
SP1(config-router-af)#redis
SP1(config-router-af)#redistribute os
SP1(config-router-af)#redistribute ospf 10 vrf CUST-A
SP1(config-router-af)#ext
*Feb 21 01:39:17.403: %BGP-4-VPN4NH_MASK: Nexthop 10.0.1.1 may not be reachable from neighbor 10.0.3.1 - not /32 mask
SP1(config-router-af)#exit
SP1(config-router-af)#exit-address-family
SP1(config-router)#exit
```

```
SP3(config)#router ospf 10 vrf CUST-A
SP3(config-router)#redistribute bgp 100 subnets
SP3(config)#router bgp 100
SP3(config-router)#address-family vpng4 vrf CUST-A
SP3(config-router)#redistribute ospf 10 vrf CUST-A
SP3(config-router)#exit
SP3(config-router)#exit-address-family
```

```
SP3(config)#router ospf 10 vrf CUST-A
SP3(config-router)#redis
SP3(config-router)#redistribute bgp 100 sub
SP3(config-router)#redistribute bgp 100 subnets
SP3(config-router)#exit
SP3(config)#router bgp 100
SP3(config-router)#addr
SP3(config-router)#add
SP3(config-router)#address-family ipv4 vrf CUST-A
SP3(config-router-af)#redis
SP3(config-router-af)#redistribute ospf 10 vrf CUST-A
SP3(config-router-af)#exit
SP3(config-router-af)#exit-address-family
SP3(config-router)#[
```

SP1(config)#do sh ip bgp vpnv4 all

```
SP3(config)#do sh ip bgp vpnv4 all
BGP table version is 5, local router ID is 10.0.3.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
               x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

      Network          Next Hop           Metric LocPrf Weight Path
Route Distinguisher: 100:1 (default for vrf CUST-A)
  *i 192.168.1.1/32  10.0.1.1                  2    100      0 ?
  *i 192.168.100.0   10.0.1.1                  0    100      0 ?
```

SP1(config)#do sh ip route vrf CUST-A

```
SP1(config)#do sh ip route vrf CUST-A

Routing Table: CUST-A
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LIS
      + - replicated route, % - next hop override

Gateway of last resort is not set

      192.168.1.0/32 is subnetted, 1 subnets
O         192.168.1.1 [110/2] via 192.168.100.2, 00:26:55, FastEthernet0/0
      192.168.100.0/24 is variably subnetted, 2 subnets, 2 masks
C         192.168.100.0/24 is directly connected, FastEthernet0/0
L         192.168.100.1/32 is directly connected, FastEthernet0/0
```

SP1(config)#do sh ip route

```
SP1(config)#do sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LIS
      + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C         10.0.1.1/32 is directly connected, Loopback0
O         10.0.2.1/32 [110/2] via 10.0.11.2, 00:47:01, GigabitEthernet5/0
O         10.0.3.1/32 [110/3] via 10.0.11.2, 00:45:57, GigabitEthernet5/0
C         10.0.11.0/24 is directly connected, GigabitEthernet5/0
L         10.0.11.1/32 is directly connected, GigabitEthernet5/0
O         10.0.12.0/24 [110/2] via 10.0.11.2, 00:47:01, GigabitEthernet5/0
```