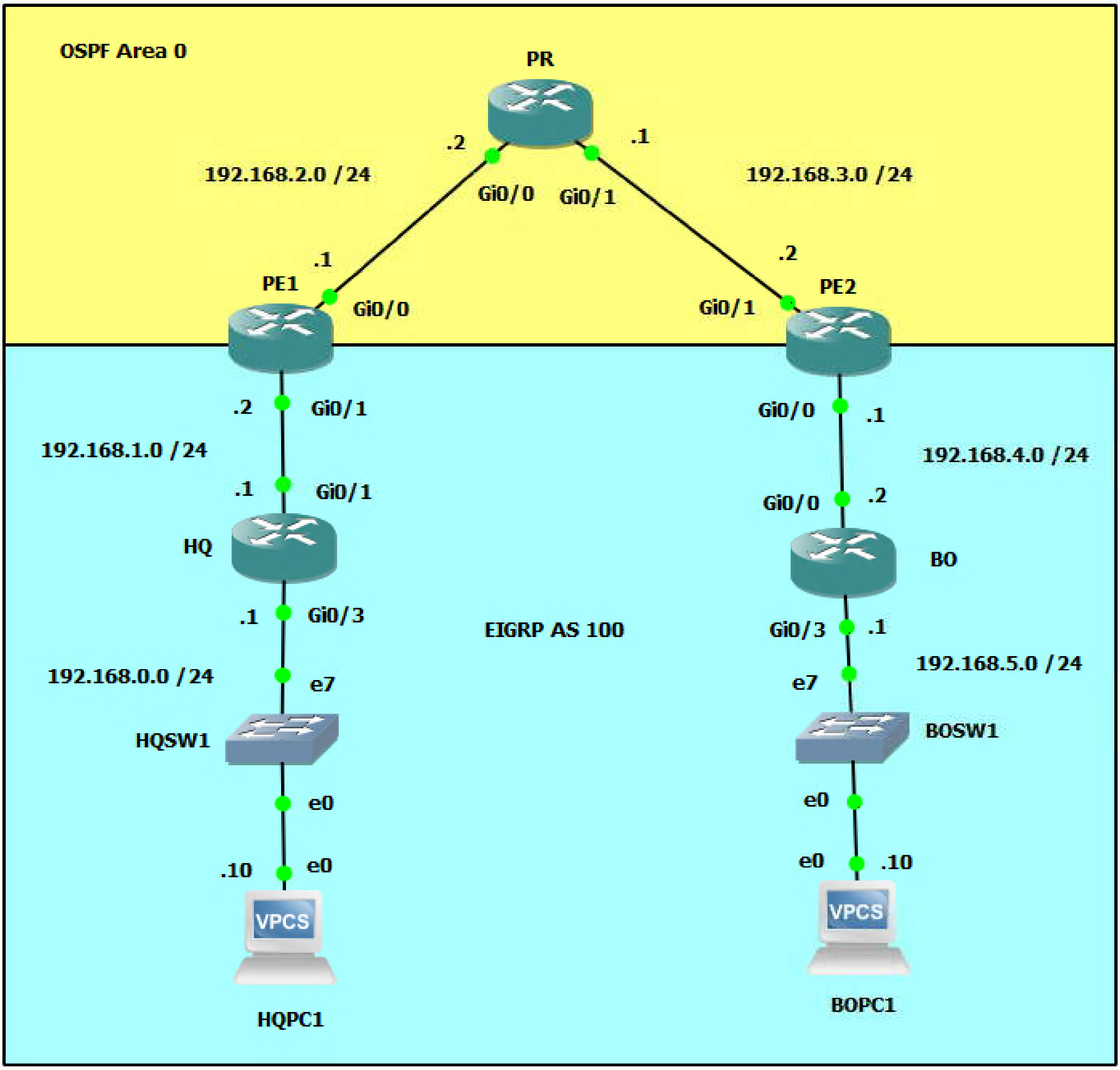
Cisco IOS Basic MPLS VPN

Network Topology



What is MPLS?

Multiprotocol Label Switching (MPLS) is a type of data-carrying technique for high-performance telecommunications networks. It directs data from one network node to the next based on short path labels rather than long network addresses, avoiding complex lookups in a routing table. MPLS can provide better performance, security, and service-level agreements (SLAs) for data traffic. The MPLS protocol is used to create virtual private networks (VPNs) and traffic engineering (TE) networks. It is often used in service provider networks, but can also be used in enterprise networks. MPLS can be used to forward packets using labels, rather than routing them based on their IP addresses. This allows for faster forwarding decisions, because the label can be looked up quickly in a table. MPLS also allows for the creation of virtual links, which can be used to connect different networks together, even if they use different routing protocols.

Multiprotocol Label Switching (MPLS) can be used to create Virtual Private Networks (VPNs). A VPN is a private network that uses a public network (such as the Internet) to connect remote sites or users together. MPLS VPNs use MPLS labels to forward packets between sites, instead of routing them based on their IP addresses. This allows for more efficient and secure communications, as well as the ability to create different virtual networks for different customers or applications.

MPLS VPNs can be configured in different ways, such as:

- MPLS Layer 3 VPNs, which use MPLS to forward packets between sites based on their IP addresses. This allows for the creation of virtual networks that use the same IP addresses as the underlying public network.
- MPLS Layer 2 VPNs, which use MPLS to forward packets between sites based on their MAC addresses. This allows for the creation of virtual networks that use different MAC addresses than the underlying public network.

In both cases, MPLS VPNs use a technique called "VPN label" to identify the different VPNs and forward the packets to the correct destination. MPLS VPNs can also use security features such as encryption, to ensure that the data cannot be intercepted or tampered with while in transit.

MPLS VPNs are widely used by service providers to offer VPN services to their customers. They can also be used in enterprise networks to connect remote sites or branch offices together securely. It's also a good choice for interconnecting multiple sites of a large enterprise as it can provide high performance and better security compared to traditional VPN technologies.

MPLS vs SD-WAN

Multiprotocol Label Switching (MPLS) and Software-Defined WAN (SD-WAN) are both technologies used to connect remote sites or users together, but they have some key differences:

- MPLS is a type of data-carrying technique that directs data from one network node to the next based on short path labels rather than long network addresses. It is primarily used by service providers to offer VPN services to their customers and can also be used in enterprise networks to connect remote sites or branch offices together.
- SD-WAN, on the other hand, is a software-based approach to managing WAN connections. It allows for the use of multiple types of connections (such as broadband, cellular, or MPLS) and automatically chooses the best one for each application or user based on factors such as cost, quality, or security. SD-WAN also allows for better visibility and control over network traffic, as well as the ability to easily add or remove sites from the

network.

- MPLS is typically more expensive than SD-WAN, but it offers better security, QoS and SLAs. On the other hand, SD-WAN is more flexible and cost-effective, but it may not provide the same level of security and performance as MPLS.
- MPLS is a more traditional approach that has been used for more than two decades while SD-WAN is a newer technology that uses software to manage network connections.
- MPLS is a Layer 3 technology while SD-WAN is a Layer 4-7 technology.

In summary, MPLS is a proven and reliable technology that is well-suited for organizations that require high levels of security and Quality of Service (QoS), while SD-WAN is a cost-effective and flexible option that is well-suited for organizations that need to connect multiple sites or users together in a dynamic way.

Configure the Interface Settings on All Routers and PCs (including Loopback Interfaces on Routers)

```
HQ>enable
HQ#configure terminal
HQ(config)#interface gigabitEthernet g0/1
HQ(config-if)#ip address 192.168.1.1 255.255.255.0
HQ(config-if)#no shutdown
HQ(config)#interface gigabitEthernet g0/3
HQ(config-if)#ip address 192.168.0.1 255.255.255.0
HQ(config-if)#no shutdown
HQ(config-if)#exit
HQ(config)#interface loopback 0
HQ(config-if)#ip address 1.1.1.1 255.255.255.0
HQ(config-if)#end

PE1>enable
PE1#configure terminal
PE1(config)#interface gigabitEthernet g0/0
PE1(config-if)#ip address 192.168.2.1 255.255.255.0
PE1(config-if)#no shutdown
PE1(config)#interface gigabitEthernet g0/1
PE1(config-if)#ip address 192.168.1.2 255.255.255.0
PE1(config-if)#no shutdown
PE1(config-if)#exit
PE1(config)#interface loopback 0
PE1(config-if)#ip address 2.2.2.2 255.255.255.0
PE1(config-if)#end

PR>enable
PR#configure terminal
PR(config)#interface gigabitEthernet g0/0
```

PR(config-if)#ip address 192.168.2.2 255.255.255.0
PR(config-if)#no shutdown
PR(config)#interface gigabitEthernet g0/1
PR(config-if)#ip address 192.168.3.1 255.255.255.0
PR(config-if)#no shutdown
PR(config-if)#exit
PR(config)#interface loopback 0
PR(config-if)#ip address 3.3.3.3 255.255.255.0
PR(config-if)#end

PE2>enable
PE2#configure terminal
PE2(config)#interface gigabitEthernet g0/0
PE2(config-if)#ip address 192.168.4.1 255.255.255.0
PE2(config-if)#no shutdown
PE2(config)#interface gigabitEthernet g0/1
PE2(config-if)#ip address 192.168.3.2 255.255.255.0
PE2(config-if)#no shutdown
PE2(config-if)#exit
PE2(config)#interface loopback 0
PE2(config-if)#ip address 4.4.4.4 255.255.255.0
PE2(config-if)#end

BO>enable
BO#configure terminal
BO(config)#interface gigabitEthernet g0/0
BO(config-if)#ip address 192.168.4.2 255.255.255.0
BO(config-if)#no shutdown
BO(config-if)#interface gigabitEthernet g0/3
BO(config-if)#ip address 192.168.5.1 255.255.255.0
BO(config-if)#no shutdown
BO(config-if)#exit
BO(config)#interface loopback 0
BO(config-if)#ip address 5.5.5.5 255.255.255.0
BO(config-if)#end

HQPC1>ip 192.168.0.10/24 192.168.0.1

BOPC1>ip 192.168.5.10/24 192.168.5.1

Setup OSPF Topology for the Provider Edge Routers (PE1 and PE2) and Provider Backbone Router (PR)

PE1>enable
PE1#configure terminal

PE1(config)#router ospf 1
PE1(config-router)#network 192.168.2.0 0.0.0.255 area 0
PE1(config-router)#network 2.2.2.0 0.0.0.255 area 0
PE1(config-router)#passive-interface gigabitEthernet 0/1

PR>enable
PR#configure terminal
PR(config)#router ospf 1
PR(config-router)#network 192.168.2.0 0.0.0.255 area 0
PR(config-router)#network 192.168.3.0 0.0.0.255 area 0
PR(config-router)#network 3.3.3.0 0.0.0.255 area 0

PE2>enable
PE2#configure terminal
PE2(config)#router ospf 1
PE2(config-router)#network 192.168.3.0 0.0.0.255 area 0
PE2(config-router)#network 4.4.4.0 0.0.0.255 area 0
PE2(config-router)#passive-interface gigabitEthernet 0/0

Setup MPLS on the Provider Router Interfaces DO NOT Include the Interfaces Facing the Customer Routers (HQ and BO) on PE1 and PE2

PE1>enable
PE1#configure terminal
PE1(config)#interface gigabitEthernet 0/0
PE1(config-if)#mpls ip

PR>enable
PR#configure terminal
PR(config)#interface gigabitEthernet 0/0
PR(config-if)#mpls ip
PR(config)#interface gigabitEthernet 0/1
PR(config-if)#mpls ip

PE2>enable
PE2#configure terminal
PE2(config)#interface gigabitEthernet 0/1
PE2(config-if)#mpls ip

*You should see a message on the console about the LDP Neighbor switching to a status of UP.

Now let's take a look at the Loopback interfaces by entering the command **show mpls forwarding-table**.

```
PE1#show mpls forwarding-table
Local      Outgoing    Prefix           Bytes Label   Outgoing   Next Hop
Label      Label       or Tunnel Id     Switched      interface
16         No Label    3.3.3.3/32       0             Gi0/0      192.168.2.2
17         17          4.4.4.4/32       0             Gi0/0      192.168.2.2
18         Pop Label   192.168.3.0/24   0             Gi0/0      192.168.2.2
```

The mask shown on the Loopback interfaces is reporting incorrect so we need to fix this.

PE1(config)#interface loopback 0
PE1(config-if)#ip ospf network point-to-point

PR(config)#interface loopback 0
PR(config-if)#ip ospf network point-to-point

PE2(config)#interface loopback 0
PE2(config-if)#ip ospf network point-to-point

Check the MPLS forwarding-table again to see if the mask is correct on the Loopback

```
PE1#show mpls forwarding-table
Local      Outgoing    Prefix           Bytes Label   Outgoing   Next Hop
Label      Label       or Tunnel Id     Switched      interface
18         Pop Label   192.168.3.0/24   0             Gi0/0      192.168.2.2
19         Pop Label   3.3.3.0/24       0             Gi0/0      192.168.2.2
20         19          4.4.4.0/24       0             Gi0/0      192.168.2.2
```

Looks good. the loopback interfaces now have the correct subnet mask of /24

One more thing let's manually force the router-id for mpls to be the Loopback interface IP.

PE1(config)#mpls ldp router-id loopback 0

PR(config)#mpls ldp router-id loopback 0

PE2(config)#mpls ldp router-id loopback 0

Setup Virtual Routing and Forwarding (VRF) for the Customer

PE1>enable
PE1#configure terminal
PE1(config)#ip vrf CUSTOMER
PE1(config-vrf)#rd 100:1
PE1(config-vrf)#route-target both 1:100
PE1(config-vrf)#exit
PE1(config)#interface gigabitEthernet 0/1
PE1(config-if)#ip vrf forwarding CUSTOMER

After setting the vrf on the interface the IP address will be removed and you will have to re-configure it.

```
PE1(config-if)#ip vrf forwarding CUSTOMER
% Interface GigabitEthernet0/1 IPv4 disabled and address(es) removed due to enabling VRF CUSTOMER
PE1(config-if)#
```

PE1(config-if)#ip address 192.168.1.2 255.255.255.0

Now setup the VRF on router PE2 the same way.

PE2>enable
PE2#configure terminal
PE2(config)#ip vrf CUSTOMER
PE2(config-vrf)#rd 100:1
PE2(config-vrf)#route-target both 1:100
PE2(config-vrf)#exit
PE2(config)#interface gigabitEthernet 0/0
PE2(config-if)#ip vrf forwarding CUSTOMER

And don't forget to re-enter the IP configuration for the interface after.

PE2(config-if)ip address 192.168.4.1 255.255.255.0

After setting up the VRF you will not be able to ping the interface on the HQ router (192.168.1.1). This is because just using a regular ping without designating the VRF will use the global routing table instead of the virtual routing table for the CUSTOMER VRF. Instead, you have to designate the VRF in the ping command as follows **ping vrf CUSTOMER 192.168.1.1**

```
PE1#ping 192.168.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
PE1#ping vrf CUSTOMER 192.168.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 3/5/7 ms
```

Configure Dynamic Routing Protocols

EIGRP

HQ>enable
HQ#configure terminal
HQ(config)#router eigrp 100
HQ(config-router)#network 192.168.0.0
HQ(config-router)#network 192.168.1.0
HQ(config-router)#network 1.1.1.0

HQ(config-router)#no auto-summary

BO>enable
BO#configure terminal
BO(config)#router eigrp 100
BO(config-router)#network 192.168.4.0
BO(config-router)#network 192.168.5.0
BO(config-router)#network 5.5.5.0
BO(config-router)#no auto-summary

PE1>enable
PE1#configure terminal
PE1(config)#router eigrp1
PE1(config-router)#address-family ipv4 vrf CUSTOMER
PE1(config-router-af)#autonomous-system 100
PE1(config-router-af)#network 192.168.1.0
PE1(config-router-af)#no auto-summary

You should see the EIGRP adjacency message popup

```
*Jan 18 22:53:20.177: %DUAL-5-NBRCHANGE: EIGRP-IPv4 100: Neighbor 192.168.1.1 (GigabitEthernet0/1) is up: new adjacency
```

PE2>enable
PE2#configure terminal
PE2(config)#router eigrp1
PE2(config-router)#address-family ipv4 vrf CUSTOMER
PE2(config-router-af)#autonomous-system 100
PE2(config-router-af)#network 192.168.4.0
PE2(config-router-af)#no auto-summary

In order to show the EIGRP neighbors from the Provider Edge Routers (PE1 and PE2) keep in mind you have to include the vrf in the command **show ip eigrp vrf CUSTOMER neighbors.**

```
PE2#show ip eigrp vrf CUSTOMER neighbors
EIGRP-IPv4 Neighbors for AS(100) VRF(CUSTOMER)
H   Address                 Interface              Hold Uptime   SRTT   RTO  Q  Seq
                                                   (sec)         (ms)       Cnt Num
0   192.168.4.2             Gi0/0                    12 00:00:33    4   100  0  2
```

We can also check the routing tables from the Provider routers, but again remember to include the correct VRF designation. **show ip route vrf CUSTOMER**

```
PE1#show ip route vrf CUSTOMER

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

Gateway of last resort is not set

      1.0.0.0/24 is subnetted, 1 subnets
D        1.1.1.0 [90/130816] via 192.168.1.1, 00:02:30, GigabitEthernet0/1
D     192.168.0.0/24 [90/3072] via 192.168.1.1, 00:02:30, GigabitEthernet0/1
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1
L        192.168.1.2/32 is directly connected, GigabitEthernet0/1
```

As can be seen above the PE1 Provide Edge Router has learned about the Loopback interface IP of the HQ router as well as the LAN network of 192.168.0.0 And notice that I can ping HQPC1 from the gigabitEthernet 0/1 interface of PE1 but not gigabitEthernet 0/0

```
PE1#ping vrf CUSTOMER 192.168.0.10 source gigabitEthernet 0/1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.10, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/4 ms
PE1#ping vrf CUSTOMER 192.168.0.10 source gigabitEthernet 0/0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.10, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
.....
Success rate is 0 percent (0/5)
```

This is as expected because the 0/1 interface is participating in the VRF and knows about the virtual routing table pointing to HQ while the 0/0 interface is not part of the VRF.

iBGP (Internal)

PE1>enable
PE1#configure terminal
PE1(config)#router bgp 1
PE1(config-router)#neighbor 4.4.4.4 remote-as 1
PE1(config-router)#neighbor 4.4.4.4 update-source loopback 0

PE2>enable
PE2#configure terminal
PE2(config)#router bgp 1
PE2(config-router)#neighbor 2.2.2.2 remote-as 1
PE2(config-router)#neighbor 2.2.2.2 update-source loopback 0

You should see the BGP neighbor messages on PE1 and PE2 like below.

```
*Jan 18 21:05:25.001: %BGP-5-ADJCHANGE: neighbor 4.4.4.4 Up
```

```
*Jan 18 21:05:25.101: %BGP-5-ADJCHANGE: neighbor 2.2.2.2 Up
```

Now that we have BGP routing configured we still need to configure the address family and ensure that we are sending communities. In Cisco BGP (Border Gateway Protocol) configuration, the "send-community" command is used to configure the sending of community attributes to other BGP peers. Community attributes are used to group routes together and apply a common set of policies to them. The "send-community" command can be used to specify whether or not to send the standard, extended, or both types of community attributes to BGP peers. The command can also be used to specify whether or not to send the community attributes in both the outbound and inbound directions.

PE1(config)#router bgp 1
PE1(config-router)#address-family vpnv4
PE1(config-router-af)#neighbor 4.4.4.4 activate
PE1(config-router-af)#neighbor 4.4.4.4 send-community both

PE2(config)#router bgp 1
PE2(config-router)#address-family vpnv4
PE2(config-router-af)#neighbor 2.2.2.2 activate
PE2(config-router-af)#neighbor 2.2.2.2 send-community both

Redistribute Protocols

BGP into EIGRP

PE1#configure terminal
PE1(config)#router eigrp 1
PE1(config-router)#address-family ipv4 vrf CUSTOMER
PE1(config-router-af)#redistribute bgp 1 metric 1500 4000 200 10 1500

PE2#configure terminal
PE2(config)#router eigrp 1
PE2(config-router)#address-family ipv4 vrf CUSTOMER
PE2(config-router-af)#redistribute bgp 1 metric 1500 4000 200 10 1500

EIGRP into BGP

PE1#configure terminal
PE1(config)#router bgp 1
PE1(config-router)#address-family ipv4 vrf CUSTOMER
PE1(config-router-af)#redistribute eigrp 100

PE2#configure terminal
PE2(config)#router bgp 1
PE2(config-router)#address-family ipv4 vrf CUSTOMER
PE2(config-router-af)#redistribute eigrp 100

Verify Configuration

HQPC1>ping 192.168.5.10

```
HQPC1> ping 192.168.5.10

84 bytes from 192.168.5.10 icmp_seq=1 ttl=59 time=4.542 ms
84 bytes from 192.168.5.10 icmp_seq=2 ttl=59 time=7.510 ms
84 bytes from 192.168.5.10 icmp_seq=3 ttl=59 time=4.656 ms
84 bytes from 192.168.5.10 icmp_seq=4 ttl=59 time=3.695 ms
84 bytes from 192.168.5.10 icmp_seq=5 ttl=59 time=5.240 ms
```

BOPC1>ping 192.168.0.10

```
BOPC1> ping 192.168.0.10

84 bytes from 192.168.0.10 icmp_seq=1 ttl=59 time=4.893 ms
84 bytes from 192.168.0.10 icmp_seq=2 ttl=59 time=12.834 ms
84 bytes from 192.168.0.10 icmp_seq=3 ttl=59 time=5.206 ms
84 bytes from 192.168.0.10 icmp_seq=4 ttl=59 time=6.227 ms
84 bytes from 192.168.0.10 icmp_seq=5 ttl=59 time=4.335 ms
```

HQ# show ip eigrp topology

```
HQ#show ip eigrp topology
EIGRP-IPv4 Topology Table for AS(100)/ID(1.1.1.1)
Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 5.5.5.0/24, 1 successors, FD is 131072
        via 192.168.1.2 (131072/130816), GigabitEthernet0/1
P 192.168.0.0/24, 1 successors, FD is 2816
        via Connected, GigabitEthernet0/3
P 192.168.1.0/24, 1 successors, FD is 2816
        via Connected, GigabitEthernet0/1
P 192.168.4.0/24, 1 successors, FD is 3072
        via 192.168.1.2 (3072/2816), GigabitEthernet0/1
P 192.168.5.0/24, 1 successors, FD is 3328
        via 192.168.1.2 (3328/3072), GigabitEthernet0/1
P 1.1.1.0/24, 1 successors, FD is 128256
        via Connected, Loopback0
```

HQ#show ip route

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

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
      5.0.0.0/24 is subnetted, 1 subnets
D        5.5.5.0 [90/131072] via 192.168.1.2, 01:25:27, GigabitEthernet0/1
      192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.0.0/24 is directly connected, GigabitEthernet0/3
L        192.168.0.1/32 is directly connected, GigabitEthernet0/3
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1
L        192.168.1.1/32 is directly connected, GigabitEthernet0/1
D     192.168.4.0/24 [90/3072] via 192.168.1.2, 01:25:27, GigabitEthernet0/1
D     192.168.5.0/24 [90/3328] via 192.168.1.2, 01:25:27, GigabitEthernet0/1
```

PE1#show ip vrf

```
PE1#show ip vrf
  Name                             Default RD            Interfaces
  CUSTOMER                         100:1                 Gi0/1
```

PE1#show ip vrf interfaces

```
PE1#show ip vrf interfaces
Interface              IP-Address      VRF                              Protocol
Gi0/1                  192.168.1.2     CUSTOMER                         up
```

PE1#show ip route vrf CUSTOMER

```
PE1#show ip route vrf CUSTOMER

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

Gateway of last resort is not set

      1.0.0.0/24 is subnetted, 1 subnets
D        1.1.1.0 [90/130816] via 192.168.1.1, 01:41:08, GigabitEthernet0/1
      5.0.0.0/24 is subnetted, 1 subnets
B        5.5.5.0 [200/130816] via 4.4.4.4, 01:28:10
D     192.168.0.0/24 [90/3072] via 192.168.1.1, 01:41:08, GigabitEthernet0/1
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/1
L        192.168.1.2/32 is directly connected, GigabitEthernet0/1
B     192.168.4.0/24 [200/0] via 4.4.4.4, 01:28:10
B     192.168.5.0/24 [200/3072] via 4.4.4.4, 01:28:10
```

PE1#traceroute vrf CUSTOMER 192.168.5.10

```
PE1#traceroute vrf CUSTOMER 192.168.5.10
Type escape sequence to abort.
Tracing the route to 192.168.5.10
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.2.2 [MPLS: Labels 19/21 Exp 0] 6 msec 5 msec 4 msec
  2 192.168.4.1 [MPLS: Label 21 Exp 0] 4 msec 3 msec 4 msec
  3 192.168.4.2 9 msec 6 msec 3 msec
  4 192.168.5.10 7 msec 7 msec 4 msec
```

PE1#show mpls interfaces

```
PE1#show mpls interfaces
Interface              IP            Tunnel   BGP Static Operational
GigabitEthernet0/0     Yes (ldp)     No       No  No     Yes
```

PE1#show mpls forwarding-table

```
PE1#show mpls forwarding-table
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
16         No Label   1.1.1.0/24[V]    0             Gi0/1      192.168.1.1
17         No Label   192.168.0.0/24[V]   \
                                       6886          Gi0/1      192.168.1.1
18         Pop Label  192.168.3.0/24   0             Gi0/0      192.168.2.2
19         Pop Label  3.3.3.0/24       0             Gi0/0      192.168.2.2
20         19         4.4.4.0/24       0             Gi0/0      192.168.2.2
21         No Label   192.168.1.0/24[V]   \
                                       6072          aggregate/CUSTOMER
```

PE1#show mpls ldp bindings

```
PE1#show mpls ldp bindings
  lib entry: 2.2.2.0/24, rev 2
        local binding:  label: imp-null
        remote binding: lsr: 3.3.3.3:0, label: 18
  lib entry: 3.3.3.0/24, rev 15
        local binding:  label: 19
        remote binding: lsr: 3.3.3.3:0, label: imp-null
  lib entry: 4.4.4.0/24, rev 17
        local binding:  label: 20
        remote binding: lsr: 3.3.3.3:0, label: 19
  lib entry: 192.168.2.0/24, rev 10
        local binding:  label: imp-null
        remote binding: lsr: 3.3.3.3:0, label: imp-null
  lib entry: 192.168.3.0/24, rev 12
        local binding:  label: 18
        remote binding: lsr: 3.3.3.3:0, label: imp-null
```

PE1#show mpls ldp neighbor

```
PE1#show mpls ldp neighbor
    Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 2.2.2.2:0
        TCP connection: 3.3.3.3.56393 - 2.2.2.2.646
        State: Oper; Msgs sent/rcvd: 161/159; Downstream
        Up time: 02:05:44
        LDP discovery sources:
          GigabitEthernet0/0, Src IP addr: 192.168.2.2
        Addresses bound to peer LDP Ident:
          192.168.2.2     192.168.3.1     3.3.3.3
```

PE1#show bgp vpnv4 unicast all summary

```
PE1#show bgp vpnv4 unicast all summary
BGP router identifier 2.2.2.2, local AS number 1
BGP table version is 10, main routing table version 10
6 network entries using 936 bytes of memory
6 path entries using 504 bytes of memory
6/6 BGP path/bestpath attribute entries using 1008 bytes of memory
6 BGP extended community entries using 1500 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 3948 total bytes of memory
BGP activity 6/0 prefixes, 6/0 paths, scan interval 60 secs

Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
4.4.4.4         4            1     114     114       10    0    0 01:37:35        3
```

PE1#show bgp vpnv4 unicast all neighbor 4.4.4.4 advertised-routes

```
PE1#show bgp vpnv4 unicast all neighbor 4.4.4.4 advertised-routes
BGP table version is 10, local router ID is 2.2.2.2
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,
              t secondary path,
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 CUSTOMER)
 *>   1.1.1.0/24       192.168.1.1         130816         32768 ?
 *>   192.168.0.0      192.168.1.1           3072         32768 ?
 *>   192.168.1.0      0.0.0.0                  0         32768 ?

Total number of prefixes 3
```

PE1#show bgp vpnv4 unicast all neighbor 4.4.4.4 routes

```
PE1#show bgp vpnv4 unicast all neighbor 4.4.4.4 routes
BGP table version is 10, local router ID is 2.2.2.2
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,
              t secondary path,
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 CUSTOMER)
 *>i  5.5.5.0/24       4.4.4.4             130816    100      0 ?
 *>i  192.168.4.0      4.4.4.4                  0    100      0 ?
 *>i  192.168.5.0      4.4.4.4               3072    100      0 ?

Total number of prefixes 3
```

Reference for Commands

GNS3 File

basic mpls.gns3

Revision #9
Created 18 January 2023 16:00:08 by Glen Taylor
Updated 24 January 2023 22:45:52 by Glen Taylor