Manikandeshwar Manohar,
Student # G01029421
mmanoha3@gmu.edu
Devices Configured:
- *Seattle*
- *Dallas*
- *Atlanta*

Basic Switching
Lab Exercise 6

MPLS-VPN

Table of Contents

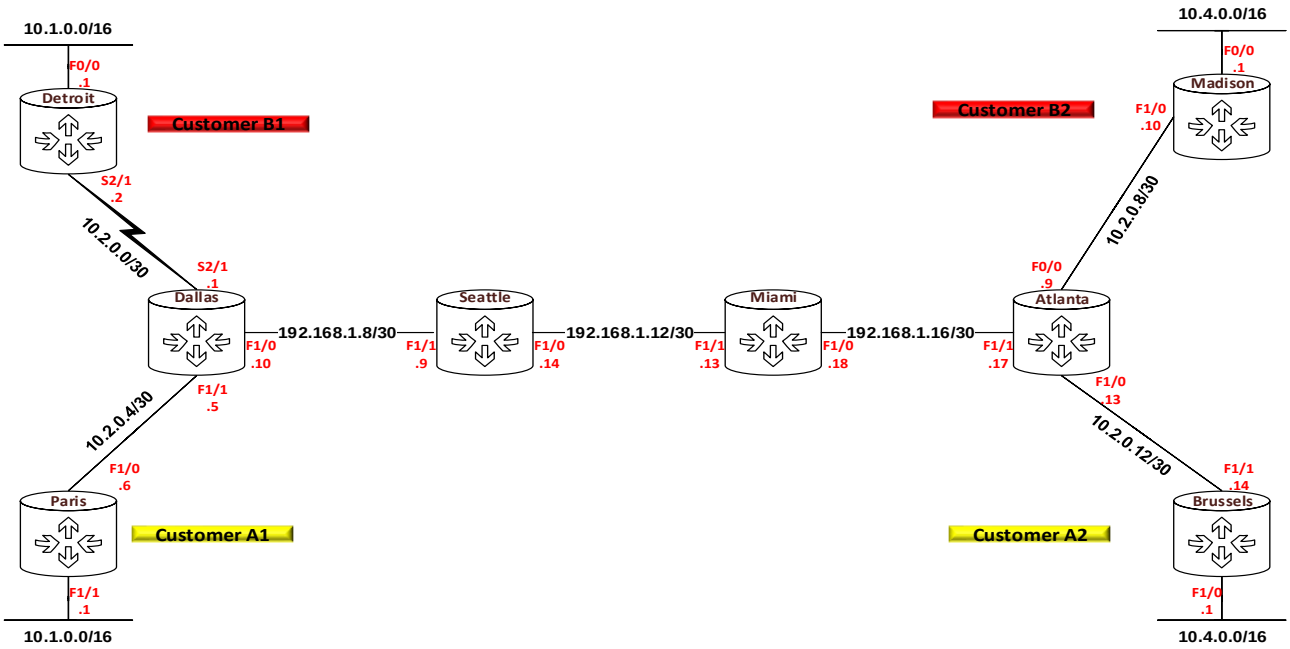
Acknowledgement

I thank George Mason University for providing me this opportunity to do the lab. Also, I appreciate the time taken by my Professor Saeed Agbariah who gave us the lab as a task to express our skills. All credits to the university for giving us this setup to learn.

The topology is shown below and since the configuration of all routers could not be shown selected outputs from Dallas,Seattle and Atlanta are provided. Secure-CRT was used to ssh into the router using a vpn connection between the university and my PC.

1.1 Create the physical network

The physical network link has been established as shown in the below diagram.



The router has been pre-loaded with basic ip configuration as shown in the below table.

Router	Interface IP	Interface IP	Interface IP	Loopback
Atlanta PE1	F1/1 192.168.1.17	F1/0 10.2.0.13	F0/0 10.2.0.9	192.168.1.1/32
Miami P1	F1/0 192.168.1.18	F1/1 192.168.1.13	-	192.168.1.2/32
Seattle P2	F1/1 192.168.1.9	F1/0 192.168.1.14	-	192.168.1.3/32
Dallas PE2	F1/0 192.168.1.10	F1/1 10.2.0.5	S2/1 10.2.0.1	192.168.1.4/32
Paris Customer A1	F1/0 10.2.0.6	F1/1 10.1.0.1	-	192.168.1.20/32
Detroit Customer B1		F0/0 10.1.0.1	S2/1 10.2.0.2	192.168.1.7/32
Brussels Customer A2	F1/1 10.2.0.14	F1/0 10.4.0.1	-	192.168.1.6/32
Madison Customer B2		F0/0 10.4.0.1	F1/0 10.2.0.10	192.168.1.5/32

OSPF has been chosen as the IGP.Also BGP has been configured between PE1 and PE2.

Q1. How many routes are in your routing table?

Sol.) There are totally 9 routes which are reduced due to subnet in the network.There are 4 subnet in the network as we can see from the command below. We use the following command to know about the routes in our routing table:

Show ip route
Show ip route summary

```
Seattle-P2#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
       + - replicated route, % - next hop override

Gateway of last resort is not set

      192.168.1.0/24 is variably subnetted, 9 subnets, 2 masks
O        192.168.1.1/32 [110/3] via 192.168.1.13, 00:06:08, FastEthernet1/0
O        192.168.1.2/32 [110/2] via 192.168.1.13, 00:06:08, FastEthernet1/0
C        192.168.1.3/32 is directly connected, Loopback0
O        192.168.1.4/32 [110/2] via 192.168.1.10, 00:06:18, FastEthernet1/1
C        192.168.1.8/30 is directly connected, FastEthernet1/1
L        192.168.1.9/32 is directly connected, FastEthernet1/1
C        192.168.1.12/30 is directly connected, FastEthernet1/0
L        192.168.1.14/32 is directly connected, FastEthernet1/0
O        192.168.1.16/30 [110/2] via 192.168.1.13, 00:06:08, FastEthernet1/0
Seattle-P2#
```

Telnet: 10.192.7

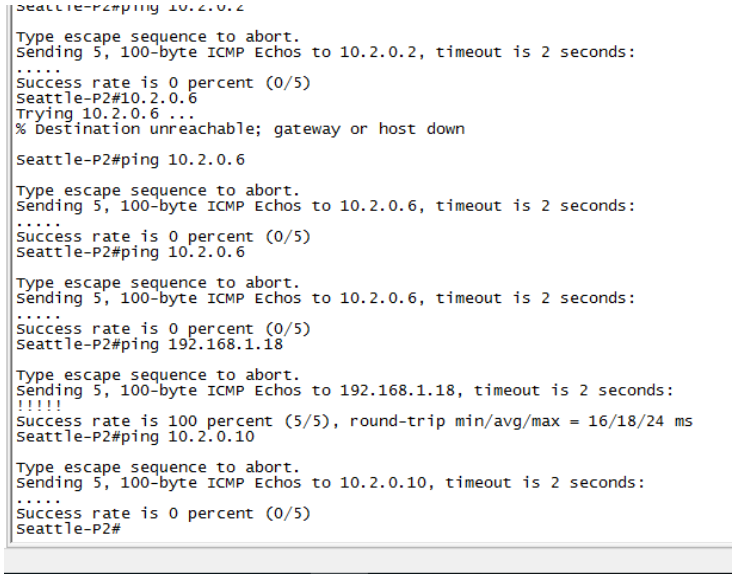
```
Seattle-P2#show ip route summary
IP routing table name is default (0x0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Replicates  Overhead    Memory (bytes)
connected       0           5           0           300         860
static          0           0           0           0           0
ospf 100        0           4           0           240         704
  Intra-area: 4 Inter-area: 0 External-1: 0 External-2: 0
  NSSA External-1: 0 NSSA External-2: 0
internal        1                                               744
Total           1           9           0           540         2308
Seattle-P2#
```

Q2. What type of routes are they?

Sol.) Totally there are 9 routes of which 4 OSPF routes 3 directly connected route and 2 locally connected routes.These are static routes since we configured them.

Q3. Are all IP addresses from figure 1 reachable?

Sol.) No not all the IP address from figure 1 is reachable.

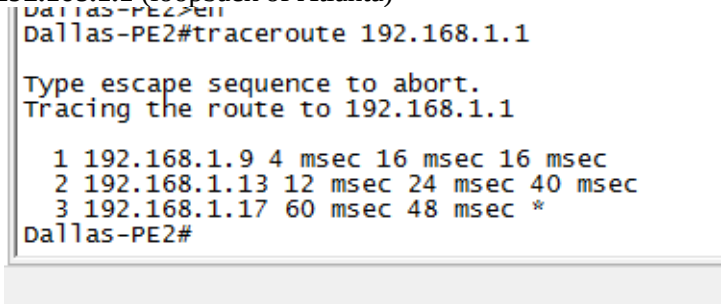


Q4. From PE2 run a traceroute to PE1's loopback address, P1 traceroute to PE2's loopback address and P2 to PE1's loopbackup address. Record your results, are the packets being switched or forwarded?

Sol.) We run the traceroute using the command:

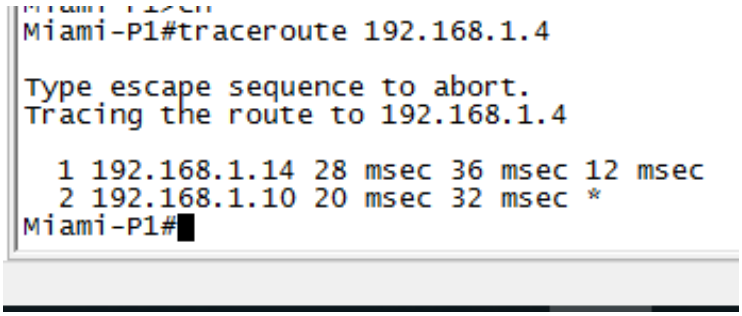
In Dallas:

traceroute 192.168.1.1 (loopback of Atlanta)



In Miami(P1)

traceroute 192.168.1.4 (loopback of Dallas)



In Seattle(P2)

traceroute 192.168.1.1 (loopback of Atlanta)

```
Seattle-P2>en
Seattle-P2#traceroute 192.168.1.1

Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 192.168.1.13 36 msec 28 msec 16 msec
  2 192.168.1.17 40 msec 20 msec *
Seattle-P2#
```

From what we see above we can conclude that the packets are being switched and forwarded. In switching exchange of data takes place in the form of packets from the source to the destination.There are 2 types of packet switching which are connection-oriented and connectionless.the above scenario is a connection-oriented packet switching.

In the above cases 192.168.1.1 192.168.1.4 are the destination from Dallas Seattle and Miami respectively.Hence a switching.

A packet forwarding refers to the transfer of data to the destination via the intermediate links.There are 3 types of packet forwarding.
They are:

- Unicast
- Multicast
- Broadcast

We use Unicast to transfer information in the above scenario.
In above cases 192.168.1.13 192.168.1.17 (Seattle to Atlanta) , 192.168.1.14 192.168.1.10 (Miami to Dallas) and 192.168.1.9 192.168.1.13 192.168.1.13 (Dallas to Atlanta) are all the forwarding medium.

1.2 Enable MPLS

We now are going to enable MPLS on the router.
We enter the following command on all the router:

```
ip cef
mpls label protocol ldp
mpls label range <from table below>
```

Function	Router	Interface	Label Range
PE1	Atlanta	F1/1	100 199
P1	Miami	F1/0 F1/1	200 299
P2	Seattle	F1/0 F1/1	300 399
PE2	Dallas	F1/0	400 499

We also enter "**mpls ip**" under the respective interface shown above.

Q5. Is MPLS running? On which interfaces?

Yes we see that MPLS is running on the interface F1/0 and F1/1 on Seattle. Interface F1/0 on Dallas. We use the command "**show mpls interface**" to view the mpls enable interface

```
Seattle-P2#show mpls interface
Interface              IP           Tunnel   BGP Static Operational
FastEthernet1/0        Yes (ldp)    No       No  No     Yes
FastEthernet1/1        Yes (ldp)    No       No  No     Yes
Seattle-P2#
```

```
Dallas-PE2>en
Dallas-PE2#show mpls interface
Interface              IP           Tunnel   BGP Static Operational
FastEthernet1/0        Yes (ldp)    No       No  No     Yes
Dallas-PE2#
```

Q6. Verify the status of the Label Distribution Protocol (LDP) discovery process? How many neighbors have you discovered? Is the interface transmitting and receiving LDP discovery Hello packets?

Sol.) To verify the status of the MPLS enable interface we use the command

show mpls ldp neighbor

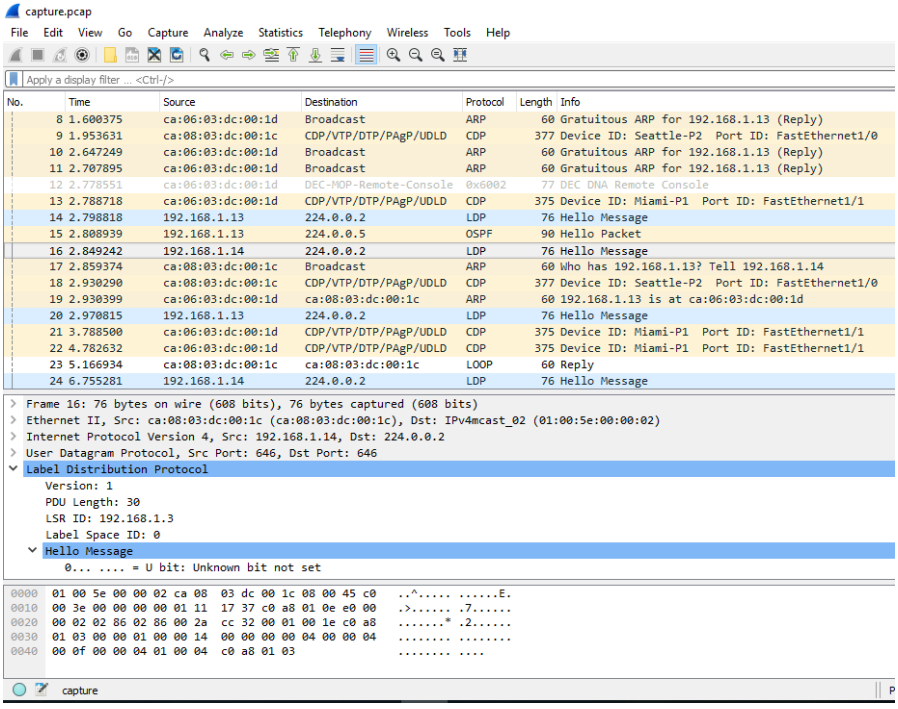
From the figure below we see that in Seattle has discovered 2 neighbor while Dallas has one neighbor

```
Seattle-P2#
Seattle-P2#show mpls ldp discovery
 Local LDP Identifier:
    192.168.1.3:0
    Discovery Sources:
    Interfaces:
        FastEthernet1/0 (ldp): xmit/recv
            LDP Id: 192.168.1.2:0
        FastEthernet1/1 (ldp): xmit/recv
            LDP Id: 192.168.1.4:0
Seattle-P2#
```

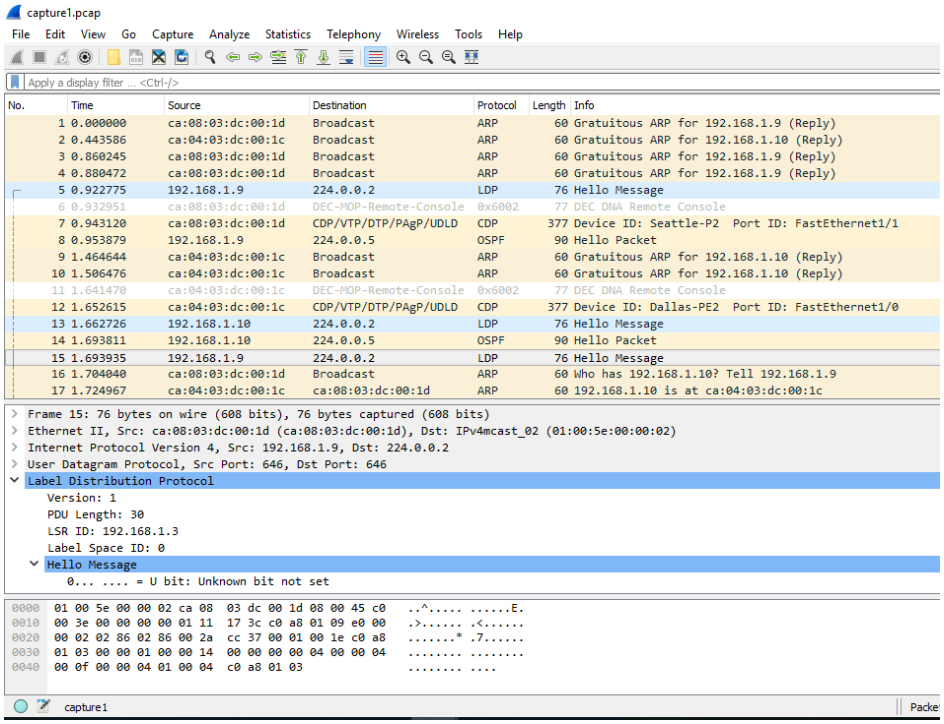
```
Dallas-PE2#show mpls ldp discovery
 Local LDP Identifier:
    192.168.1.4:0
    Discovery Sources:
    Interfaces:
        FastEthernet1/0 (ldp): xmit/recv
            LDP Id: 192.168.1.3:0
Dallas-PE2#
```

We see from the below figure that Hello packets are sent .

Packet captured from Seattle



Packet Captured From Dallas



Q7.How many LDP neighbors do you have? Who are they?

We see that we have 6 neighbor in Seattle and 3 neighbor in Dallas.We have configured Seattle Dallas Miami and Atlanta for MPLS.In Seattle It is Dallas and Miami (including the loopback address).In Dallas it is Seattle ip address including the loopback address. We use the command

Show mpls ldp neighbor

```
Seattle-P2#show mpl
*Dec  1 13:26:18.983: %SYS-5-CONFIG_I: Configured from console by consoles ldp neighbor
    Peer LDP Ident: 192.168.1.4:0; Local LDP Ident 192.168.1.3:0
        TCP connection: 192.168.1.4.21586 - 192.168.1.3.646
        State: Oper; Msgs sent/rcvd: 23/26; Downstream
        Up time: 00:12:16
        LDP discovery sources:
          FastEthernet1/1, Src IP addr: 192.168.1.10
        Addresses bound to peer LDP Ident:
          192.168.1.10    192.168.1.4     10.2.0.5        10.2.0.1
    Peer LDP Ident: 192.168.1.2:0; Local LDP Ident 192.168.1.3:0
        TCP connection: 192.168.1.2.646 - 192.168.1.3.28703
        State: Oper; Msgs sent/rcvd: 24/24; Downstream
        Up time: 00:12:06
        LDP discovery sources:
          FastEthernet1/0, Src IP addr: 192.168.1.13
        Addresses bound to peer LDP Ident:
          192.168.1.18    192.168.1.2     192.168.1.13
```

```
Dallas-PE2#show mpls ldp neighbor
    Peer LDP Ident: 192.168.1.3:0; Local LDP Ident 192.168.1.4:0
        TCP connection: 192.168.1.3.646 - 192.168.1.4.21586
        State: Oper; Msgs sent/rcvd: 25/23; Downstream
        Up time: 00:11:37
        LDP discovery sources:
          FastEthernet1/0, Src IP addr: 192.168.1.9
        Addresses bound to peer LDP Ident:
          192.168.1.14    192.168.1.3     192.168.1.9
```

Section 2 MPLS VPNs

1.3 Configure RIP

We shall now configure RIP between the PE router and the CE router.it is used to propagate between the customers CE router.

By default the CE router has been configured.On the PE router we enter the following command.

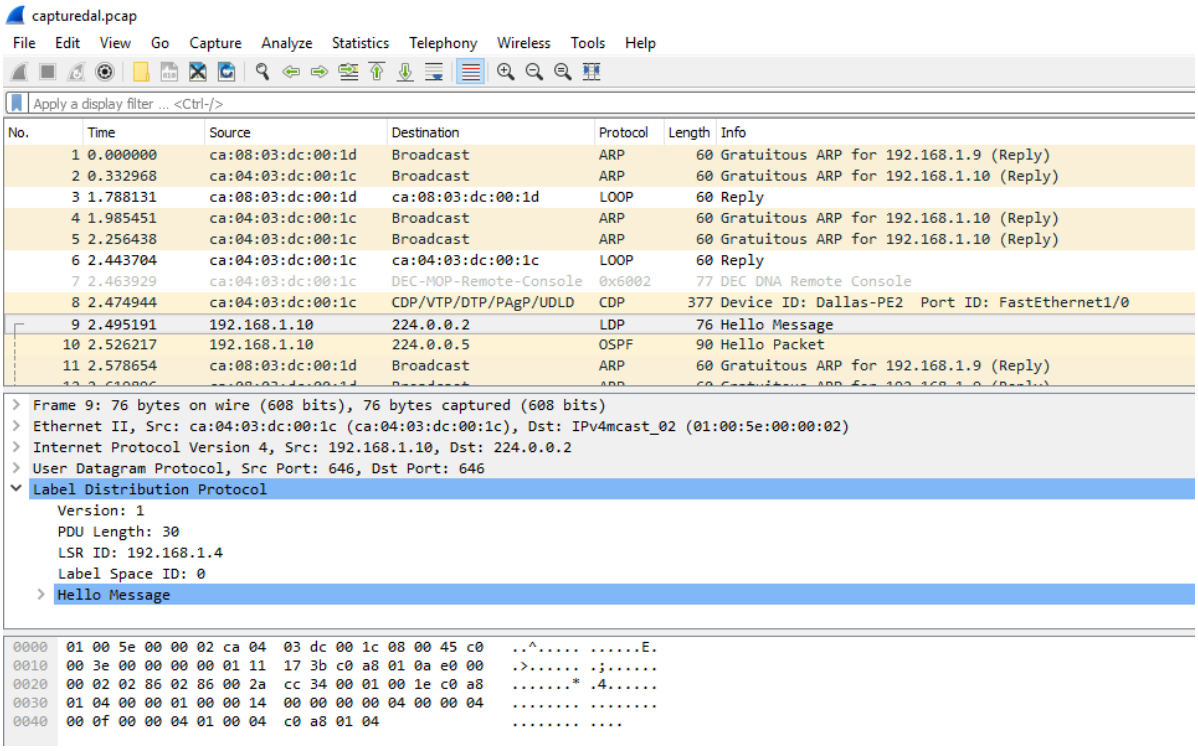
Q8. Check PE1's and PE2's routing table, do you have entry for 10.X.0.0/16? Record the routes

Sol.) We see that the routes have been added onto the routing table.Some of the example are

```
Atlanta-PE1#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
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 5 subnets, 3 masks
C        10.2.0.8/30 is directly connected, FastEthernet0/0
L        10.2.0.9/32 is directly connected, FastEthernet0/0
C        10.2.0.12/30 is directly connected, FastEthernet1/0
L        10.2.0.13/32 is directly connected, FastEthernet1/0
R        10.4.0.0/16 [120/1] via 10.2.0.14, 00:00:12, FastEthernet1/0
                     [120/1] via 10.2.0.10, 00:00:26, FastEthernet0/0
      192.168.1.0/24 is variably subnetted, 8 subnets, 2 masks
C        192.168.1.1/32 is directly connected, Loopback0
O        192.168.1.2/32 [110/2] via 192.168.1.18, 00:10:34, FastEthernet1/1
O        192.168.1.3/32 [110/3] via 192.168.1.18, 00:10:34, FastEthernet1/1
O        192.168.1.4/32 [110/4] via 192.168.1.18, 00:10:34, FastEthernet1/1
O        192.168.1.8/30 [110/3] via 192.168.1.18, 00:10:34, FastEthernet1/1
O        192.168.1.12/30 [110/2] via 192.168.1.18, 00:10:34, FastEthernet1/1
C        192.168.1.16/30 is directly connected, FastEthernet1/1
L        192.168.1.17/32 is directly connected, FastEthernet1/1
```

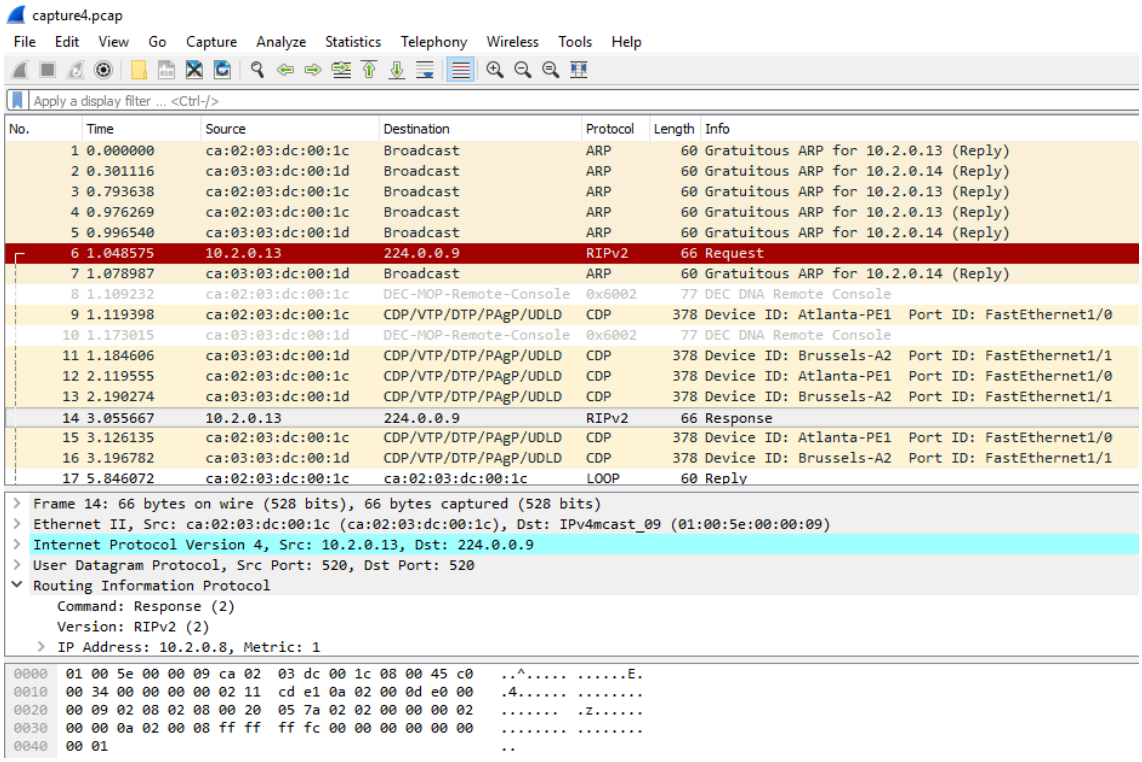
```
Dallas-PE2#
Dallas-PE2#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external 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
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 5 subnets, 3 masks
R        10.1.0.0/16 [120/1] via 10.2.0.6, 00:00:25, FastEthernet1/1
                     [120/1] via 10.2.0.2, 00:00:16, Serial2/1
C        10.2.0.0/30 is directly connected, Serial2/1
L        10.2.0.1/32 is directly connected, Serial2/1
C        10.2.0.4/30 is directly connected, FastEthernet1/1
L        10.2.0.5/32 is directly connected, FastEthernet1/1
      192.168.1.0/24 is variably subnetted, 8 subnets, 2 masks
O        192.168.1.1/32 [110/4] via 192.168.1.9, 00:09:09, FastEthernet1/0
O        192.168.1.2/32 [110/3] via 192.168.1.9, 00:09:09, FastEthernet1/0
O        192.168.1.3/32 [110/2] via 192.168.1.9, 00:09:19, FastEthernet1/0
C        192.168.1.4/32 is directly connected, Loopback0
C        192.168.1.8/30 is directly connected, FastEthernet1/0
L        192.168.1.10/32 is directly connected, FastEthernet1/0
O        192.168.1.12/30 [110/2] via 192.168.1.9, 00:09:19, FastEthernet1/0
O        192.168.1.16/30 [110/3] via 192.168.1.9, 00:09:09, FastEthernet1/0
```

An example of the route captured in Dallas on interface fa1/1



```
```

An example of the route captured in Atlanta on interface fa1/0



Q9. From PE1 traceroute to 10.4.0.1, from PE2 traceroute 10.1.0.1, explain what you see, is that a good or a bad thing, why?

Sol.) We see the following when we try to traceroute the ip address.

```
Atlanta-PE1#traceroute 10.4.0.1

Type escape sequence to abort.
Tracing the route to 10.4.0.1

  1 10.2.0.10 16 msec
    10.2.0.14 56 msec
    10.2.0.10 36 msec
```

```
Dallas-PE2#traceroute 10.1.0.1

Type escape sequence to abort.
Tracing the route to 10.1.0.1

  1 10.2.0.2 16 msec
    10.2.0.6 24 msec
    10.2.0.2 32 msec
```

We see that we are able to trace the address route of 10.4.0.1 & 10.1.0.1 from Atlanta and Dallas.This is not a good thing since the packets have to travel through the same network.This wastes a lot of time and also consumes a lot of bandwidth.

Q10. From PE1 ping 10.4.0.1, from PE2 ping 10.1.0.1, which router is responding to your pings? Explain?

Sol.) We see that both the router are pinging back.This is because we have enabled RIP on the router and when the broadcast message has been sent and received , the router gets to know the address and hence it is capable of transmitting the pings.

```
Atlanta-PE1#ping 10.4.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.4.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/16/20 ms
Atlanta-PE1#ping 10.1.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.0.1, timeout is 2 seconds:
..
```

```
Dallas-PE2#ping 10.1.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.1.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 12/16/20 ms
Dallas-PE2#
```

1.4 Configure MP-BGP for MPLS VPN

We shall now configure MP-BGP for MPLS VPN
On the PE2(Dallas) router we enter the following command.

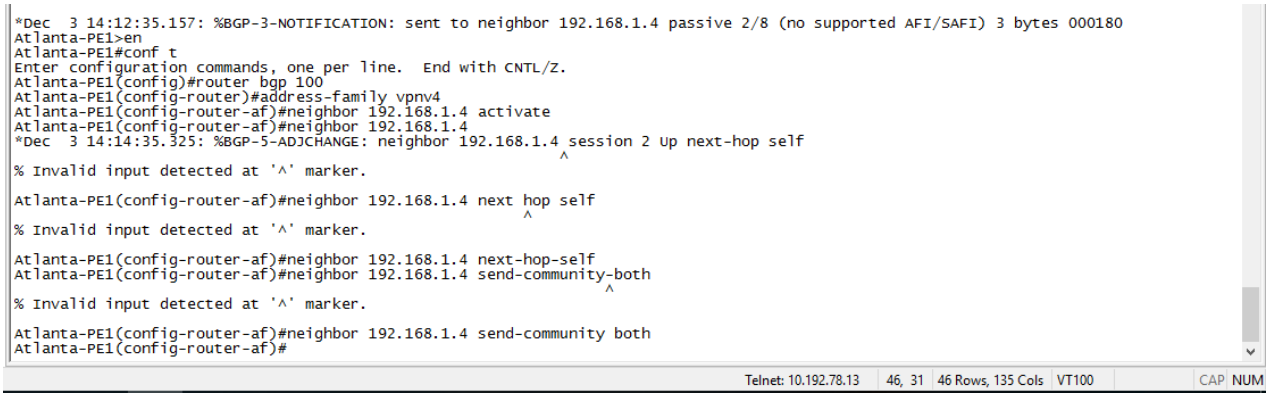
config t
router bgp 100
address-family vpnv4
neighbor 192.168.1.1 activate
neighbor 192.168.1.1 next-hop-self
neighbor 192.168.1.1 send-community both

```
Dallas-PE2>en
Dallas-PE2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Dallas-PE2(config)#router bgp 100
Dallas-PE2(config-router)#address-family vpnv4
Dallas-PE2(config-router-af)#neighbor 192.168.1.1 activate
Dallas-PE2(config-router-af)#neighbor 192.168.1.1 next-hop-se
*Dec  3 14:12:36.141: %BGP_SESSION-5-ADJCHANGE: neighbor 192.168.1.1 VPNv4 Unicast topology base removed from session  BGP Notification
 receivedlf
Dallas-PE2(config-router-af)#neighbor 192.168.1.1 send-community-both
                                                                  ^
% Invalid input detected at '^' marker.

Dallas-PE2(config-router-af)#neighbor 192.168.1.1 send-community both
Dallas-PE2(config-router-af)#
*Dec  3 14:13:36.397: %BGP-3-NOTIFICATION: received from neighbor 192.168.1.1 active 2/8 (no supported AFI/SAFI) 3 bytes 000180 (timer
expired)
*Dec  3 14:14:36.305: %BGP-5-ADJCHANGE: neighbor 192.168.1.1 session 2 Up
```

Telnet: 10.192.78.13 | 46, 75 | 46 Rows, 135 Cols | VT100 | CAP NUM

and on the PE1 the following:

config t
router bgp 100
address-family vpnv4
neighbor 192.168.1.4 activate
neighbor 192.168.1.4 next-hop-self
neighbor 192.168.1.4 send-community both



1.5 Configure VRF for each customer

VRF is virtual routing and forwarding table.We shall now configure VRF on the routers as following.

On the PE1 and PE2 routers, configure the VRFs as follows:

```
config t
 ip vrf VPN_A
  rd 100:1
  route-target export 100:1
  route-target import 100:1
  exit

 ip vrf VPN_B
  rd 100:2
  route-target export 100:2
  route-target import 100:2
```

1.6 Routing for the VRFs

Instead of configuring RIP globally, we will configure RIP under each of the VRFs.

Step 1- remove the previous RIP configuration from PE1 and PE2 only, enter the following commands:

Config t
no router rip

Step 2 - Enable RIP under both VPN_A and VPN_B, complete the following on PE1 and PE2 routers

```
router rip
 version 2
 !
 address-family ipv4 vrf VPN_A
 version 2
 redistribute bgp 100 metric transparent
 network 10.2.0.0
 no auto-summary
 exit-address-family

!
 address-family ipv4 vrf VPN_B
 version 2
 redistribute bgp 100 metric transparent
```

```
 network 10.2.0.0
 no auto-summary
 exit-address-family
```

Step 3- Redistribute the RIP learned routes into BGP. Configure the following on PE1 and PE2:

```
router bgp 100

address-family ipv4 vrf VPN_A
 redistribute rip
 no synchronization
 no auto-summary
 exit-address-family
!
address-family ipv4 vrf VPN_B
 redistribute rip
 no synchronization
 no auto-summary
 exit-address-family
```

Step 4- Enable vrf forwarding under the interfaces, configure the following on PE1 (Atlanta) only:

```
Config t

interface FastEthernet0/0
ip vrf forwarding VPN_B
 ip address 10.2.0.9 255.255.255.252

!
interface FastEthernet1/0
 ip vrf forwarding VPN_A
 ip address 10.2.0.13 255.255.255.252

 end
```

Step 5- Enable vrf forwarding under the interfaces, Configure the following on PE2 (Dallas) only:

```
Config t
!
interface FastEthernet1/1
 ip vrf forwarding VPN_A
 ip address 10.2.0.5 255.255.255.252
 !
interface s2/1
 ip vrf forwarding VPN_B
 ip address 10.2.0.1 255.255.255.252
!
end
```

Q11.Ping from the Detroit CE to Brussels CE, ping the LAN interface connected to fastethernet 1/0, does it work? Why or Why not?

Sol.) NO we are not able to ping from Detroit to Brussels.Since they belong to a different VPN we cannot ping from Detroit to Brussels.For reference I have attached the icmp debug below along with another interface.

```
Detroit-B1>en
Detroit-B1#ping 10.4.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.4.0.1, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
Detroit-B1#
```

Another Interface

```
Detroit-B1#ping 10.2.0.14

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.0.14, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
Detroit-B1#
```

ICMP DEBUG -ENABLED ON MADISON AND BRUSSELS

When we type the ping command on Detroit we get the following reply only from Madison and Not Brussels

```
Detroit-B1#ping 10.4.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.4.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/92/100 ms
Detroit-B1#
```

```
Brussels-A2>en
Brussels-A2#debug ip icmp
ICMP packet debugging is on
Brussels-A2#debug ip icmp ?
  <cr>

Brussels-A2#
```

```
Madison-B2>en
Madison-B2#debug ip icmp
ICMP packet debugging is on
Madison-B2#
*Mar  1 02:06:39.791: ICMP: echo reply sent, src 10.4.0.1, dst 10.2.0.2
*Mar  1 02:06:39.899: ICMP: echo reply sent, src 10.4.0.1, dst 10.2.0.2
*Mar  1 02:06:40.003: ICMP: echo reply sent, src 10.4.0.1, dst 10.2.0.2
*Mar  1 02:06:40.107: ICMP: echo reply sent, src 10.4.0.1, dst 10.2.0.2
*Mar  1 02:06:40.207: ICMP: echo reply sent, src 10.4.0.1, dst 10.2.0.2
```

Q12.) Ping From Detroit CE to Madison CE, ping the LAN interface connected to fastethernet 0/0, does it work? Why or Why not?

Sol.) Yes we are able to ping from Detroit to Madison. We are able to do so because both the customers belong to the same VPN and hence we can be able to ping them.

```
Detroit-B1#ping 10.4.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.4.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 84/92/100 ms
Detroit-B1#
```

Q13. **Ping from Paris CE to Brussels CE, ping the LAN interface connected to fastethernet 1/0, does it work? Why or Why not?**

Sol.) Yes we are able to ping from Paris to Brussels. We are able to do so because both the customers belong to the same VPN and hence we can be able to ping them.

```
Paris-A1>en
Paris-A1#ping 10.4.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.4.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 72/97/128 ms
Paris-A1#
```

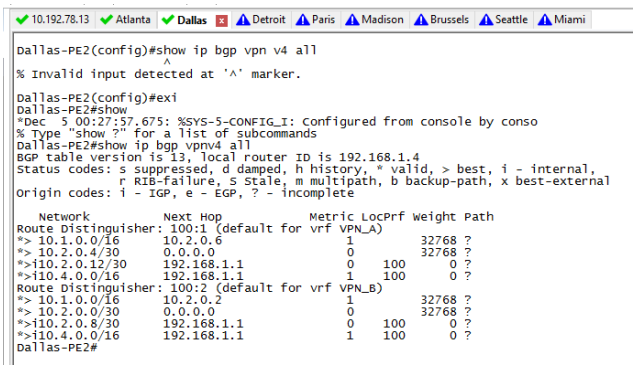
Q14. Check the PE routers VPNv4 routing tables, do you see overlapping networks, why or why not?

Sol.) We use the command

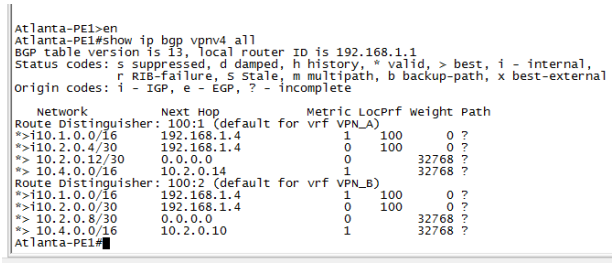
Show ip bgp vpnv4 all

We see that it the address 10.4.0.0 and 10.1.0.0 are overlapping networks. This is so because Paris and Detroit both use the network 10.1.0.0 while Madison and Brussels use 10.4.0.0 as there network for their respective customer.Hence we see that they overlap.

In **Dallas**



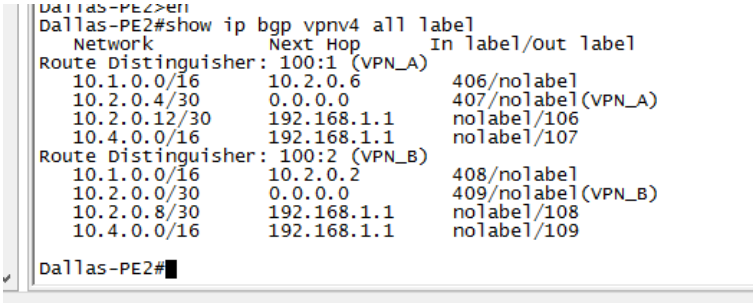
In **Atlanta**



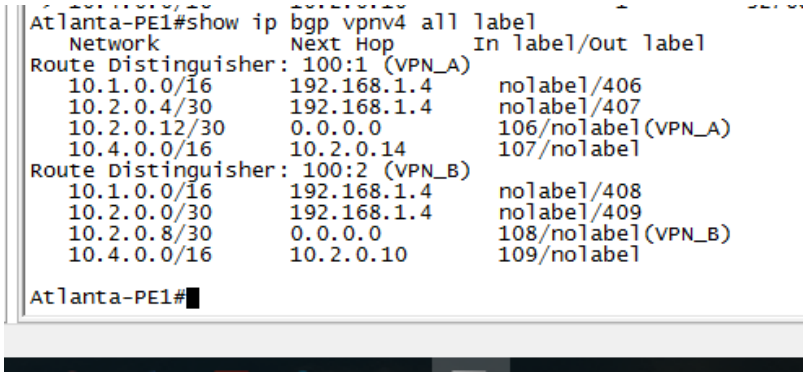
Q15. Type "show ip bgp vpnv4 all labels" on the PE routers, what type of labels is being assigned to 10.4.0.0/16 and 10.1.0.0/16?

Sol.) We see that the following label has been assigned to the address 10.4.0.0/16 & 10.1.0.0/16

In **Dallas**



In **Atlanta**



Q16.How has the routing table of the P routers changed from Section 1?

Sol.) There is no change in the routing table as far as the P router (here Seattle) is considred.
This is because the main function of the P router is just like in any other MPLS enable router which is to look at the label and forward the packet.It uses LFIB to process the packet

```
Seattle-P2#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
       + - replicated route, % - next hop override

Gateway of last resort is not set

      192.168.1.0/24 is variably subnetted, 9 subnets, 2 masks
O        192.168.1.1/32 [110/3] via 192.168.1.13, 01:27:46, FastEthernet1/0
O        192.168.1.2/32 [110/2] via 192.168.1.13, 01:27:46, FastEthernet1/0
C        192.168.1.3/32 is directly connected, Loopback0
O        192.168.1.4/32 [110/2] via 192.168.1.10, 01:27:56, FastEthernet1/1
C        192.168.1.8/30 is directly connected, FastEthernet1/1
L        192.168.1.9/32 is directly connected, FastEthernet1/1
C        192.168.1.12/30 is directly connected, FastEthernet1/0
L        192.168.1.14/32 is directly connected, FastEthernet1/0
O        192.168.1.16/30 [110/2] via 192.168.1.13, 01:27:46, FastEthernet1/0
Seattle-P2#
```

Q17. Traceroute from Detroit CE to Madison CE, explain what you see?

Sol.)

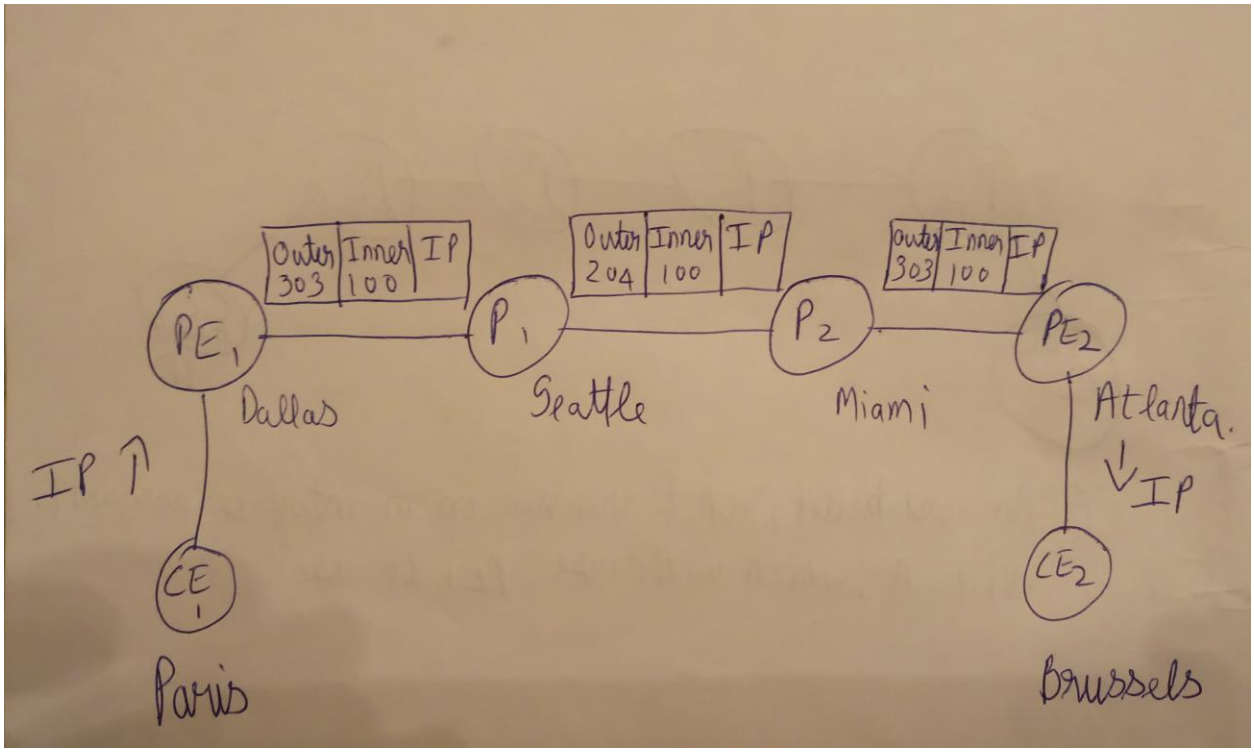
```
Detroit-B1>traceroute 10.2.0.10

Type escape sequence to abort.
Tracing the route to 10.2.0.10

  1 10.2.0.1 20 msec 8 msec 12 msec
  2 192.168.1.9 [MPLS: Labels 303/108 Exp 0] 76 msec 76 msec 76 msec
  3 192.168.1.13 [MPLS: Labels 204/108 Exp 0] 76 msec 88 msec 76 msec
  4 10.2.0.9 76 msec 96 msec 76 msec
  5 10.2.0.10 112 msec 88 msec *
Detroit-B1>
```

From the traceroute we find that the route has gone through initially from 10.2.0.1 to 192.168.1.9 in which an MPLS label is used for VPN to forward the packet to 192.168.1.13 in which another label is used to again forward the packet.At the receiver it we see that the PE router uses the extra label to deliver the packet.

Q18.) Based on the information you gathered from the previous questions, draw the packets (labeled or unlabeled) as they move from Cust-A1 to Cust-A2 or from Cust-B1 to Cust-B2

Sol.)

```
Paris-A1>en
Paris-A1#traceroute 10.2.0.14

Type escape sequence to abort.
Tracing the route to 10.2.0.14

  1 10.2.0.5 12 msec 20 msec 20 msec
  2 192.168.1.9 [MPLS: Labels 303/100 Exp 0] 68 msec 80 msec 76 msec
  3 192.168.1.13 [MPLS: Labels 204/100 Exp 0] 76 msec 72 msec 76 msec
  4 10.2.0.13 76 msec 76 msec 76 msec
  5 10.2.0.14 80 msec 96 msec *
Paris-A1#
```


Outer 303
Inner 100
IP
Outer 204
Inner 100
IP
outer 303
Inner 100
IP
PE1
P1
P2
PE2
Dallas
Seattle
Miami
Atlanta.
IP
IP
CE1
CE2
Paris
Brussels

$PE_1 \rightarrow P_1$

IN Label	OUT Label	Ext
~~100~~	303	192.168.1.14

$P_1 \rightarrow P_2$

IN LABEL	OUT LABEL	EXT
100	204	192.168.1.18

$P_2 \rightarrow PE_2$

IN LABEL	ACTION	OUT
~~300~~	POP	10.2.0.13

(300 is initially POPed out)

II. CONCLUSION

From this Lab we learned about the different concept of MPLS which is used to route MPLS data through the router. MPLS uses labeling to transmit data from one end to another.In this lab I learnt about MPLS VPN.MPLS VPN is very much useful when compared to normal MPLS as it saves much time while transmitting data and also helps when similar network exist in the same network. MPLS-VPN (Virtual private Network) allows several networks to transparently inter-connect through a service provider's network.

III. REFERENCE

MPLS VPN
http://www.ciscopress.com/articles/article.asp?p=1081501&seqNum=4

Configuring MPLS VPN with RIP on Customer Side
http://www.cisco.com/c/en/us/support/docs/multiprotocol-label-switching-mpls/mpls/13732-mpls-vpn-rip.html#debugandshow

Troubleshooting MPLS VPN
http://www.cisco.com/c/en/us/support/docs/multiprotocol-label-switching-mpls/mpls/13734-mpls-vpn-tsh.html