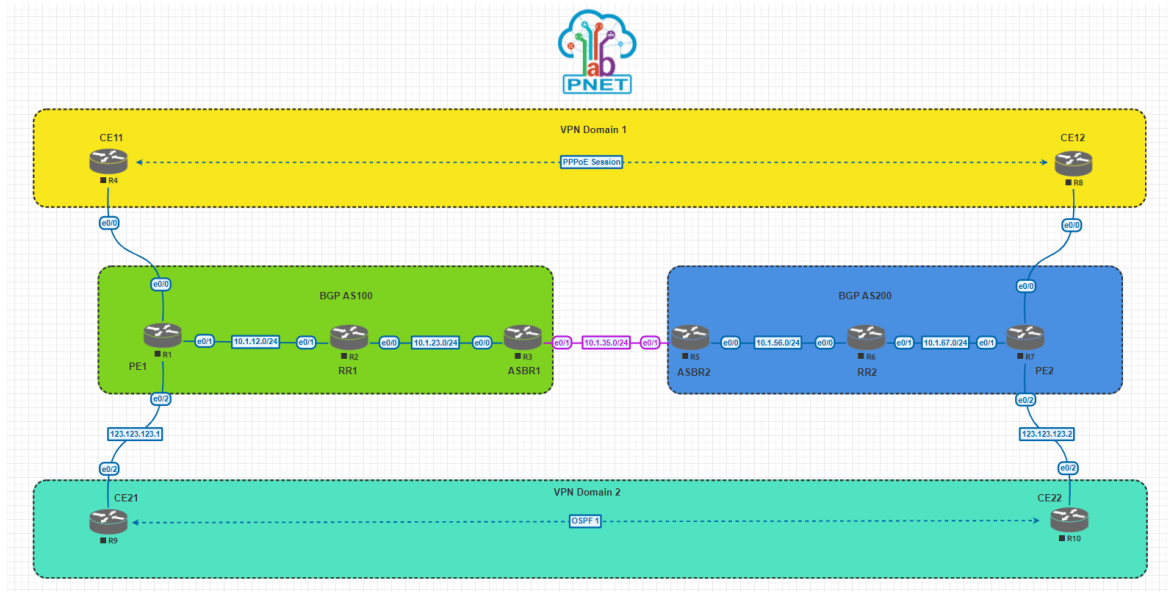


MPLS L2VPN (AtOM) INTER AS

Lab Topology:

Please use the following topology to complete this lab exercise:



Lab Objective:

The objective of this lab exercise is for you to learn and understand how can you configure MPLS VPN Layer 2 at two location in different AS.

Task list:

Task 1: Configure the hostname and IP address for the interface on the router as topo.

Task 2: Configure OSPF domain and MPLS domain in the core of 2 AS.

Task 3: Configure iBGP, eBGP, BGP IPv4 + Label (RFC3107) in 2 AS so that PE1 (R1) and PE2 (R7) router are able to reach each other by labels.

Task 4: Configure AToM (Any Transport over MPLS) in PE1 (R1) and PE2 (R7) to build Layer 2 VPN Services for CE.

Task 5: Configure any routing protocols between CEs in VPN domain2 (In this lab, use OSPF) and configure PPPoE Session between CEs in VPN domain1.

SOLUTION:

Task 1: Configure the hostname and IP address

Customer 1			
Customer 2	<pre> On R9 (CE21) ! interface Loopback0 ip address 9.9.9.9 255.255.255.255 ! interface Ethernet0/0 no ip address ! interface Ethernet0/1 no ip address ! interface Ethernet0/2 ip address 123.123.123.1 255.255.255.0 ! interface Ethernet0/3 no ip address ! </pre>	<pre> On R10 (CE22) ! interface Loopback0 ip address 10.10.10.10 255.255.255.255 ! interface Ethernet0/0 no ip address ! interface Ethernet0/1 no ip address ! interface Ethernet0/2 ip address 123.123.123.2 255.255.255.0 ! interface Ethernet0/3 no ip address ! </pre>	
Core AS100	<pre> On R1 (PE1) ! interface Loopback0 ip address 1.1.1.1 255.255.255.255 ! interface Ethernet0/0 no ip address ! interface Ethernet0/1 ip address 10.1.12.1 255.255.255.0 ! interface Ethernet0/2 no ip address ! interface Ethernet0/3 no ip address ! </pre>	<pre> On R2 (RR1) ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 ip address 10.1.23.2 255.255.255.0 ! interface Ethernet0/1 ip address 10.1.12.2 255.255.255.0 ! interface Ethernet0/2 no ip address ! interface Ethernet0/3 no ip address ! </pre>	<pre> On R3 (ASBR1) ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Ethernet0/0 ip address 10.1.23.3 255.255.255.0 ! interface Ethernet0/1 ip address 10.1.35.3 255.255.255.0 ! interface Ethernet0/2 no ip address ! interface Ethernet0/3 no ip address ! </pre>



Core AS200	On R7 (PE2)	On R6 (RR2)	On R5 (ASBR2)
	!	!	!
	interface Loopback0	interface Loopback0	interface Loopback0
	ip address 7.7.7.7	ip address 6.6.6.6	ip address 5.5.5.5
	255.255.255.255	255.255.255.255	255.255.255.255
	!	!	!
	interface Ethernet0/0	interface Ethernet0/0	interface Ethernet0/0
	no ip address	ip address 10.1.56.6	ip address 10.1.56.5
	!	255.255.255.0	255.255.255.0
	interface Ethernet0/1	!	!
	ip address 10.1.67.7	interface Ethernet0/1	interface Ethernet0/1
	255.255.255.0	ip address 10.1.67.6	ip address 10.1.35.5
	!	255.255.255.0	255.255.255.0
	interface Ethernet0/2	!	!
	no ip address	interface Ethernet0/2	interface Ethernet0/2
	!	no ip address	no ip address
	interface Ethernet0/3	!	!
	no ip address	interface Ethernet0/3	interface Ethernet0/3
	!	no ip address	no ip address
	!	!	!

Task 2: Configure OSPF domain and MPLS domain in the core

On R1 (PE1)

```
!
interface Ethernet0/1
 ip ospf network point-to-point
 mpls ip
!
router ospf 1
 network 1.1.1.1 0.0.0.0 area 0
 network 10.1.12.0 0.0.0.255 area 0
!
```

On R2 (RR1)

```
!
interface Ethernet0/0
 ip ospf network point-to-point
 mpls ip
!
interface Ethernet0/1
 ip ospf network point-to-point
 mpls ip
!
router ospf 1
 network 2.2.2.2 0.0.0.0 area 0
 network 10.0.0.0 0.255.255.255 area 0
!
```





On R3 (ASBR1)

```
!  
interface Ethernet0/0  
  ip ospf network point-to-point  
  mpls ip  
!  
router ospf 1  
  network 3.3.3.3 0.0.0.0 area 0  
  network 10.1.23.0 0.0.0.255 area 0  
!
```

On R7 (PE2)

```
!  
interface Ethernet0/1  
  ip ospf network point-to-point  
  mpls ip  
!  
router ospf 1  
  network 7.7.7.7 0.0.0.0 area 0  
  network 10.1.67.0 0.0.0.255 area 0  
!
```

On R6 (RR2)

```
!  
interface Ethernet0/0  
  ip ospf network point-to-point  
  mpls ip  
!  
interface Ethernet0/1  
  ip ospf network point-to-point  
  mpls ip  
!  
router ospf 1  
  network 6.6.6.6 0.0.0.0 area 0  
  network 10.1.56.0 0.0.0.255 area 0  
  network 10.1.67.0 0.0.0.255 area 0  
!
```

On R5 (ASBR2)

```
!  
interface Ethernet0/0  
  ip ospf network point-to-point  
  mpls ip  
!
```





```
router ospf 1
 network 5.5.5.5 0.0.0.0 area 0
 network 10.1.56.0 0.0.0.255 area 0
!
```

Verification

On R1 (PE1)

```
PE1#sho ip route
```

Gateway of last resort is not set

```

      1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
      2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 10.1.12.2, 00:08:17, Ethernet0/1
      3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/21] via 10.1.12.2, 00:07:56, Ethernet0/1
      10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C       10.1.12.0/24 is directly connected, Ethernet0/1
L       10.1.12.1/32 is directly connected, Ethernet0/1
O       10.1.23.0/24 [110/20] via 10.1.12.2, 00:08:17, Ethernet0/1

```

```
PE1#sho mpls interfaces
```

Interface	IP	Tunnel	BGP	Static	Operational
Ethernet0/1	Yes (ldp)	No	No	No	Yes

```
PE1#show mpls forwarding-table
```

Local Hop	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next
16	Pop Label	2.2.2.2/32	0		Et0/1	
17	Pop Label	10.1.23.0/24	0		Et0/1	
18	17	3.3.3.3/32	0		Et0/1	

```
PE1#show mpls ldp neighbor
```

```

Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 1.1.1.1:0
TCP connection: 2.2.2.2.60750 - 1.1.1.1.646
State: Oper; Msgs sent/rcvd: 18/19; Downstream
Up time: 00:09:54
LDP discovery sources:
  Ethernet0/1, Src IP addr: 10.1.12.2
Addresses bound to peer LDP Ident:
  10.1.23.2      10.1.12.2      2.2.2.2

```



On R2 (RR1)RR1#**show ip 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 10.1.12.1, 00:10:50, Ethernet0/1
    2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
    3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/11] via 10.1.23.3, 00:10:40, Ethernet0/0
   10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C       10.1.12.0/24 is directly connected, Ethernet0/1
L       10.1.12.2/32 is directly connected, Ethernet0/1
C       10.1.23.0/24 is directly connected, Ethernet0/0
L       10.1.23.2/32 is directly connected, Ethernet0/0\

```

RR1#**show mpls interfaces**

Interface	IP	Tunnel	BGP	Static	Operational
Ethernet0/0	Yes (ldp)	No	No	No	Yes
Ethernet0/1	Yes (ldp)	No	No	No	Yes

RR1#**show mpls forwarding-table**

Local Hop	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next
16	Pop Label	1.1.1.1/32	0		Et0/1	
10.1.12.1						
17	Pop Label	3.3.3.3/32	0		Et0/0	
10.1.23.3						

RR1#**show mpls ldp neighbor**

```

Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 2.2.2.2:0
  TCP connection: 1.1.1.1.646 - 2.2.2.2.60750
  State: Oper; Msgs sent/rcvd: 22/22; Downstream
  Up time: 00:12:58
  LDP discovery sources:
    Ethernet0/1, Src IP addr: 10.1.12.1
  Addresses bound to peer LDP Ident:
    10.1.12.1      1.1.1.1
Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 2.2.2.2:0
  TCP connection: 3.3.3.3.48671 - 2.2.2.2.646
  State: Oper; Msgs sent/rcvd: 22/23; Downstream
  Up time: 00:12:48

```

LDP discovery sources:

Ethernet0/0, Src IP addr: 10.1.23.3

Addresses bound to peer LDP Ident:

10.1.23.3 10.1.35.3 3.3.3.3

On R3 (ASBR1)

ASBR1#show ip route

Gateway of last resort is not set

```

    1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/21] via 10.1.23.2, 00:13:30, Ethernet0/0
    2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 10.1.23.2, 00:13:30, Ethernet0/0
    3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
    10.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
O       10.1.12.0/24 [110/20] via 10.1.23.2, 00:13:30, Ethernet0/0
C       10.1.23.0/24 is directly connected, Ethernet0/0
L       10.1.23.3/32 is directly connected, Ethernet0/0
C       10.1.35.0/24 is directly connected, Ethernet0/1
L       10.1.35.3/32 is directly connected, Ethernet0/1

```

ASBR1#show mpls interfaces

Interface	IP	Tunnel	BGP	Static	Operational
Ethernet0/0	Yes (ldp)	No	No	No	Yes

ASBR1#show mpls forwarding-table

Local Hop	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next
16	Pop Label	2.2.2.2/32	0		Et0/0	
17	16	1.1.1.1/32	0		Et0/0	
18	Pop Label	10.1.12.0/24	0		Et0/0	

ASBR1#show mpls forwarding-table

Local Hop	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next
16	Pop Label	2.2.2.2/32	0		Et0/0	
17	16	1.1.1.1/32	0		Et0/0	



```
18          Pop Label  10.1.12.0/24      0          Et0/0
10.1.23.2
```

On R7 (PE2)

PE2#show ip route

Gateway of last resort is not set

```
      5.0.0.0/32 is subnetted, 1 subnets
0       5.5.5.5 [110/21] via 10.1.67.6, 00:36:56, Ethernet0/1
      6.0.0.0/32 is subnetted, 1 subnets
0       6.6.6.6 [110/11] via 10.1.67.6, 00:36:56, Ethernet0/1
      7.0.0.0/32 is subnetted, 1 subnets
C       7.7.7.7 is directly connected, Loopback0
      10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
0       10.1.56.0/24 [110/20] via 10.1.67.6, 00:36:56, Ethernet0/1
C       10.1.67.0/24 is directly connected, Ethernet0/1
L       10.1.67.7/32 is directly connected, Ethernet0/1
```

PE2#show mpls interfaces

Interface	IP	Tunnel	BGP	Static	Operational
Ethernet0/1	Yes (ldp)	No	No	No	Yes

PE2#show mpls forwarding-table

Local Hop	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next Hop
16	Pop Label	6.6.6.6/32	0		Et0/1	
10.1.67.6						
17	16	5.5.5.5/32	0		Et0/1	
10.1.67.6						
18	Pop Label	10.1.56.0/24	0		Et0/1	
10.1.67.6						

PE2#show mpls ldp neighbor

```
Peer LDP Ident: 6.6.6.6:0; Local LDP Ident 7.7.7.7:0
TCP connection: 6.6.6.6.646 - 7.7.7.7.26591
State: Oper; Msgs sent/rcvd: 51/50; Downstream
Up time: 00:37:46
LDP discovery sources:
  Ethernet0/1, Src IP addr: 10.1.67.6
Addresses bound to peer LDP Ident:
  10.1.56.6      10.1.67.6      6.6.6.6
```

On R6 (RR2)

RR2#show ip route

Gateway of last resort is not set



```

5.0.0.0/32 is subnetted, 1 subnets
O      5.5.5.5 [110/11] via 10.1.56.5, 00:39:38, Ethernet0/0
6.0.0.0/32 is subnetted, 1 subnets
C      6.6.6.6 is directly connected, Loopback0
7.0.0.0/32 is subnetted, 1 subnets
O      7.7.7.7 [110/11] via 10.1.67.7, 00:38:22, Ethernet0/1
10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C      10.1.56.0/24 is directly connected, Ethernet0/0
L      10.1.56.6/32 is directly connected, Ethernet0/0
C      10.1.67.0/24 is directly connected, Ethernet0/1
L      10.1.67.6/32 is directly connected, Ethernet0/1

```

RR2#**show mpls interfaces**

Interface	IP	Tunnel	BGP	Static	Operational
Ethernet0/0	Yes (ldp)	No	No	No	Yes
Ethernet0/1	Yes (ldp)	No	No	No	Yes

RR2#**show mpls forwarding-table**

Local Hop	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next
16	Pop Label	5.5.5.5/32	0		Et0/0	
10.1.56.5						
17	Pop Label	7.7.7.7/32	0		Et0/1	
10.1.67.7						

RR2#**show mpls ldp neighbor**

```

Peer LDP Ident: 5.5.5.5:0; Local LDP Ident 6.6.6.6:0
TCP connection: 5.5.5.5.646 - 6.6.6.6.38239
State: Oper; Msgs sent/rcvd: 53/55; Downstream
Up time: 00:40:25
LDP discovery sources:
  Ethernet0/0, Src IP addr: 10.1.56.5
Addresses bound to peer LDP Ident:
  10.1.56.5      10.1.35.5      5.5.5.5
Peer LDP Ident: 7.7.7.7:0; Local LDP Ident 6.6.6.6:0
TCP connection: 7.7.7.7.26591 - 6.6.6.6.646
State: Oper; Msgs sent/rcvd: 52/52; Downstream
Up time: 00:39:11
LDP discovery sources:
  Ethernet0/1, Src IP addr: 10.1.67.7
Addresses bound to peer LDP Ident:
  7.7.7.7      10.1.67.7

```

On R5 (ASBR2)ASBR2#**show ip route**

Gateway of last resort is not set

```

      5.0.0.0/32 is subnetted, 1 subnets
C       5.5.5.5 is directly connected, Loopback0
      6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/11] via 10.1.56.6, 00:41:21, Ethernet0/0
      7.0.0.0/32 is subnetted, 1 subnets
O       7.7.7.7 [110/21] via 10.1.56.6, 00:39:59, Ethernet0/0
      10.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
C       10.1.35.0/24 is directly connected, Ethernet0/1
L       10.1.35.5/32 is directly connected, Ethernet0/1
C       10.1.56.0/24 is directly connected, Ethernet0/0
L       10.1.56.5/32 is directly connected, Ethernet0/0
O       10.1.67.0/24 [110/20] via 10.1.56.6, 00:41:21, Ethernet0/0

```

ASBR2#**show mpls interfaces**

Interface	IP	Tunnel	BGP	Static	Operational
Ethernet0/0	Yes (ldp)	No	No	No	Yes

ASBR2#**show mpls forwarding-table**

Local Hop	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next
16	Pop Label	6.6.6.6/32	0		Et0/0	
17	Pop Label	10.1.67.0/24	0		Et0/0	
18	17	7.7.7.7/32	0		Et0/0	

ASBR2#**show mpls ldp neighbor**

```

Peer LDP Ident: 6.6.6.6:0; Local LDP Ident 5.5.5.5:0
TCP connection: 6.6.6.6.38239 - 5.5.5.5.646
State: Oper; Msgs sent/rcvd: 57/55; Downstream
Up time: 00:42:17
LDP discovery sources:
  Ethernet0/0, Src IP addr: 10.1.56.6
Addresses bound to peer LDP Ident:
  10.1.56.6      10.1.67.6      6.6.6.6

```



Task 3: Configure iBGP, eBGP, BGP IPv4 + Label (RFC3107) in 2 AS so that PE_1 (R1) and PE_2 (R7) router are able to reach each other by labels.

On R1 (PE1)

```
!  
router bgp 100  
  bgp log-neighbor-changes  
  neighbor 2.2.2.2 remote-as 100  
  neighbor 2.2.2.2 update-source Loopback0  
!  
address-family ipv4  
  neighbor 2.2.2.2 activate  
  neighbor 2.2.2.2 send-label  
exit-address-family
```

!
// When you issue the **neighbor send-label** command on both BPG routers, the routers advertise to each other that they can then send MPLS labels with the routes. If the routers successfully negotiate their ability to send MPLS labels, the routers add MPLS labels to all outgoing BGP updates.

On R2(RR1)

```
!  
router bgp 100  
  bgp log-neighbor-changes  
  neighbor 1.1.1.1 remote-as 100  
  neighbor 1.1.1.1 update-source Loopback0  
  neighbor 3.3.3.3 remote-as 100  
  neighbor 3.3.3.3 update-source Loopback0  
!  
address-family ipv4  
  neighbor 1.1.1.1 activate  
  neighbor 1.1.1.1 route-reflector-client  
  neighbor 1.1.1.1 send-label  
  neighbor 3.3.3.3 activate  
  neighbor 3.3.3.3 route-reflector-client  
  neighbor 3.3.3.3 send-label  
exit-address-family  
!
```

On R3(ASBR1)

```
!  
router bgp 100  
  bgp log-neighbor-changes  
  neighbor 2.2.2.2 remote-as 100  
  neighbor 2.2.2.2 update-source Loopback0  
  neighbor 10.1.35.5 remote-as 200 //eBGP with ASBR2 in AS200
```





```
!  
address-family ipv4  
  redistribute ospf 1  
  neighbor 2.2.2.2 activate  
  neighbor 2.2.2.2 next-hop-self //Next-hop changed to ASBR1  
  neighbor 2.2.2.2 send-label  
  neighbor 10.1.35.5 activate  
  neighbor 10.1.35.5 send-label  
exit-address-family  
!
```

On R7(PE2)

```
!  
router bgp 200  
  bgp log-neighbor-changes  
  neighbor 6.6.6.6 remote-as 200  
  neighbor 6.6.6.6 update-source Loopback0  
!  
address-family ipv4  
  neighbor 6.6.6.6 activate  
  neighbor 6.6.6.6 send-label  
exit-address-family  
!
```

On R6(RR2)

```
!  
router bgp 200  
  bgp log-neighbor-changes  
  neighbor 5.5.5.5 remote-as 200  
  neighbor 5.5.5.5 update-source Loopback0  
  neighbor 7.7.7.7 remote-as 200  
  neighbor 7.7.7.7 update-source Loopback0  
!  
address-family ipv4  
  neighbor 5.5.5.5 activate  
  neighbor 5.5.5.5 route-reflector-client  
  neighbor 5.5.5.5 send-label  
  neighbor 7.7.7.7 activate  
  neighbor 7.7.7.7 route-reflector-client  
  neighbor 7.7.7.7 send-label  
exit-address-family  
!
```



**On R5(ASBR2)**

```

!
router bgp 200
  bgp log-neighbor-changes
  neighbor 6.6.6.6 remote-as 200
  neighbor 6.6.6.6 update-source Loopback0
  neighbor 10.1.35.3 remote-as 100
!
address-family ipv4
  network 5.5.5.5 mask 255.255.255.255
  network 6.6.6.6 mask 255.255.255.255
  network 7.7.7.7 mask 255.255.255.255
  redistribute ospf 1
  neighbor 6.6.6.6 activate
  neighbor 6.6.6.6 next-hop-self //Next-hop changed to ASBR2
  neighbor 6.6.6.6 send-label
  neighbor 10.1.35.3 activate
  neighbor 10.1.35.3 send-label
exit-address-family
!

```

After configure send-label between 2 ASBR, the following logs will automatically appear :

```
%BGP_LMM-6-AUTOGEN1: The mpls bgp forwarding command has been
configured on interface: Ethernet0/1
```

And new configuration on interface Ethernet0/1 :

```

!
interface Ethernet0/1
  ip address 10.1.35.3 255.255.255.0
  mpls bgp forwarding
end
!

```

// A node should understand if it can send/accept labeled packet over any interface. When LDP is used as label distribution protocol, enabling "mpls ip" will not only enable LDP (Control plane), but also allows the LSR to send/accept labeled packet over the interface. In case of Inter-AS Option B, BGP is used as label distribution protocol between ASBRs. So the command "mpls bgp forwarding" enables ASBR to send/accept labeled packet over the configured interface (which is towards the other ASBR).

Verification**On R1 (PE1)**

```
PE1#show ip bgp summary | begin Neighbor
```

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ
Up/Down	State/PfxRcd						
2.2.2.2	4	100	31	24	11	0	0
00:19:10	10						



PE1#show ip bgp

Network	Next Hop	Metric	LocPrf	Weight	Path
r>i 1.1.1.1/32	3.3.3.3	21	100	0	?
r>i 2.2.2.2/32	3.3.3.3	11	100	0	?
r>i 3.3.3.3/32	3.3.3.3	0	100	0	?
*>i 5.5.5.5/32	3.3.3.3	0	100	0	200 i
*>i 6.6.6.6/32	3.3.3.3	11	100	0	200 i
*>i 7.7.7.7/32	3.3.3.3	21	100	0	200 i
r>i 10.1.12.0/24	3.3.3.3	20	100	0	?
r>i 10.1.23.0/24	3.3.3.3	0	100	0	?
*>i 10.1.56.0/24	3.3.3.3	0	100	0	200 ?
*>i 10.1.67.0/24	3.3.3.3	20	100	0	200 ?

PE1#show ip bgp labels

Network	Next Hop	In label/Out label
1.1.1.1/32	3.3.3.3	nolabel/17
2.2.2.2/32	3.3.3.3	nolabel/16
3.3.3.3/32	3.3.3.3	nolabel/imp-null
5.5.5.5/32	3.3.3.3	nolabel/20
6.6.6.6/32	3.3.3.3	nolabel/21
7.7.7.7/32	3.3.3.3	nolabel/22
10.1.12.0/24	3.3.3.3	nolabel/18
10.1.23.0/24	3.3.3.3	nolabel/imp-null
10.1.56.0/24	3.3.3.3	nolabel/23
10.1.67.0/24	3.3.3.3	nolabel/24

PE1#show ip route bgp

Gateway of last resort is not set

```

      5.0.0.0/32 is subnetted, 1 subnets
B       5.5.5.5 [200/0] via 3.3.3.3, 00:16:02
      6.0.0.0/32 is subnetted, 1 subnets
B       6.6.6.6 [200/11] via 3.3.3.3, 00:16:02
      7.0.0.0/32 is subnetted, 1 subnets
B       7.7.7.7 [200/21] via 3.3.3.3, 00:16:02
      10.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
B       10.1.56.0/24 [200/0] via 3.3.3.3, 00:15:32
B       10.1.67.0/24 [200/20] via 3.3.3.3, 00:15:32

```

PE1#show ip cef 7.7.7.7

7.7.7.7/32

nexthop 10.1.12.2 Ethernet0/1 label 17 22

//Now, PE1 could use 2 labels to reach to PE2. Label 22 is BGP-LU labels. And label 17 is LDP label use to reach ASBR1.



PE1#ping 7.7.7.7 source 10

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 7.7.7.7, timeout is 2 seconds:

Packet sent with a source address of 1.1.1.1

!!!!

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

On R3 (ASBR1)

ASBR1#show ip bgp summary | begin Neighbor

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ
Up/Down	State/PfxRcd						
2.2.2.2	4	100	40	39	11	0	0
00:26:52	0						
10.1.35.5	4	200	31	31	11	0	0
00:21:54	5						

ASBR1#show ip bgp

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 1.1.1.1/32	10.1.23.2	21		32768	?
*> 2.2.2.2/32	10.1.23.2	11		32768	?
*> 3.3.3.3/32	0.0.0.0	0		32768	?
*> 5.5.5.5/32	10.1.35.5	0		0	200 i
*> 6.6.6.6/32	10.1.35.5	11		0	200 i
*> 7.7.7.7/32	10.1.35.5	21		0	200 i
*> 10.1.12.0/24	10.1.23.2	20		32768	?
*> 10.1.23.0/24	0.0.0.0	0		32768	?
*> 10.1.56.0/24	10.1.35.5	0		0	200 ?
*> 10.1.67.0/24	10.1.35.5	20		0	200 ?

ASBR1#show ip bgp labels

Network	Next Hop	In label/Out label
1.1.1.1/32	10.1.23.2	17/nolabel
2.2.2.2/32	10.1.23.2	16/nolabel
3.3.3.3/32	0.0.0.0	imp-null/nolabel
5.5.5.5/32	10.1.35.5	20/imp-null
6.6.6.6/32	10.1.35.5	21/16
7.7.7.7/32	10.1.35.5	22/18
10.1.12.0/24	10.1.23.2	18/nolabel
10.1.23.0/24	0.0.0.0	imp-null/nolabel
10.1.56.0/24	10.1.35.5	23/imp-null
10.1.67.0/24	10.1.35.5	24/17



ASBR1#show ip route bgp

Gateway of last resort is not set

```

      5.0.0.0/32 is subnetted, 1 subnets
B       5.5.5.5 [20/0] via 10.1.35.5, 00:23:48
      6.0.0.0/32 is subnetted, 1 subnets
B       6.6.6.6 [20/11] via 10.1.35.5, 00:23:48
      7.0.0.0/32 is subnetted, 1 subnets
B       7.7.7.7 [20/21] via 10.1.35.5, 00:23:48
    10.0.0.0/8 is variably subnetted, 8 subnets, 2 masks
B       10.1.56.0/24 [20/0] via 10.1.35.5, 00:23:17
B       10.1.67.0/24 [20/20] via 10.1.35.5, 00:23:17

```

On R5 (ASBR2)

ASBR2#show ip bgp summary | begin Neighbor

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ
Up/Down	State/PfxRcd						
6.6.6.6	4	200	40	40	11	0	0
00:25:54	0						
10.1.35.3	4	100	36	36	11	0	0
00:25:56	5						

ASBR2#show ip bgp

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 1.1.1.1/32	10.1.35.3	21		0	100 ?
*> 2.2.2.2/32	10.1.35.3	11		0	100 ?
*> 3.3.3.3/32	10.1.35.3	0		0	100 ?
*> 5.5.5.5/32	0.0.0.0	0		32768	i
*> 6.6.6.6/32	10.1.56.6	11		32768	i
*> 7.7.7.7/32	10.1.56.6	21		32768	i
*> 10.1.12.0/24	10.1.35.3	20		0	100 ?
*> 10.1.23.0/24	10.1.35.3	0		0	100 ?
*> 10.1.56.0/24	0.0.0.0	0		32768	?
*> 10.1.67.0/24	10.1.56.6	20		32768	?

ASBR2#show ip bgp labels

Network	Next Hop	In label/Out label
1.1.1.1/32	10.1.35.3	20/17
2.2.2.2/32	10.1.35.3	21/16
3.3.3.3/32	10.1.35.3	22/imp-null
5.5.5.5/32	0.0.0.0	imp-null/nolabel

```

6.6.6.6/32      10.1.56.6      16/nolabel
7.7.7.7/32      10.1.56.6      18/nolabel
10.1.12.0/24    10.1.35.3      24/18
10.1.23.0/24    10.1.35.3      23/imp-null
10.1.56.0/24    0.0.0.0        imp-null/nolabel
10.1.67.0/24    10.1.56.6      17/nolabel

```

ASBR2#show ip route bgp

Gateway of last resort is not set

```

      1.0.0.0/32 is subnetted, 1 subnets
B       1.1.1.1 [20/21] via 10.1.35.3, 00:28:41
      2.0.0.0/32 is subnetted, 1 subnets
B       2.2.2.2 [20/11] via 10.1.35.3, 00:28:41
      3.0.0.0/32 is subnetted, 1 subnets
B       3.3.3.3 [20/0] via 10.1.35.3, 00:28:41
      10.0.0.0/8 is variably subnetted, 8 subnets, 2 masks
B       10.1.12.0/24 [20/20] via 10.1.35.3, 00:28:41
B       10.1.23.0/24 [20/0] via 10.1.35.3, 00:28:41

```

On R7 (PE2)

PE2#show ip bgp summary | begin Neighbor

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ
Up/Down	State/PfxRcd						
6.6.6.6	4	200	49	42	11	0	0
00:35:25	10						

PE2#show ip bgp

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i 1.1.1.1/32	5.5.5.5	21	100	0	100 ?
*>i 2.2.2.2/32	5.5.5.5	11	100	0	100 ?
*>i 3.3.3.3/32	5.5.5.5	0	100	0	100 ?
r>i 5.5.5.5/32	5.5.5.5	0	100	0	i
r>i 6.6.6.6/32	5.5.5.5	11	100	0	i
r>i 7.7.7.7/32	5.5.5.5	21	100	0	i
*>i 10.1.12.0/24	5.5.5.5	20	100	0	100 ?
*>i 10.1.23.0/24	5.5.5.5	0	100	0	100 ?
r>i 10.1.56.0/24	5.5.5.5	0	100	0	?
r>i 10.1.67.0/24	5.5.5.5	20	100	0	?

PE2#show ip bgp labels

Network	Next Hop	In label/Out label
1.1.1.1/32	5.5.5.5	nolabel/20
2.2.2.2/32	5.5.5.5	nolabel/21
3.3.3.3/32	5.5.5.5	nolabel/22

5.5.5.5/32	5.5.5.5	nolabel/imp-null
6.6.6.6/32	5.5.5.5	nolabel/16
7.7.7.7/32	5.5.5.5	nolabel/18
10.1.12.0/24	5.5.5.5	nolabel/24
10.1.23.0/24	5.5.5.5	nolabel/23
10.1.56.0/24	5.5.5.5	nolabel/imp-null
10.1.67.0/24	5.5.5.5	nolabel/17

PE2#show ip route bgp

Gateway of last resort is not set

```

      1.0.0.0/32 is subnetted, 1 subnets
B       1.1.1.1 [200/21] via 5.5.5.5, 00:33:37
      2.0.0.0/32 is subnetted, 1 subnets
B       2.2.2.2 [200/11] via 5.5.5.5, 00:33:37
      3.0.0.0/32 is subnetted, 1 subnets
B       3.3.3.3 [200/0] via 5.5.5.5, 00:33:37
      10.0.0.0/8 is variably subnetted, 5 subnets, 2 masks
B       10.1.12.0/24 [200/20] via 5.5.5.5, 00:33:37
B       10.1.23.0/24 [200/0] via 5.5.5.5, 00:33:37

```

PE2#show ip cef 1.1.1.1

```

1.1.1.1/32
  nexthop 10.1.67.6 Ethernet0/1 label 16 20

```

PE2#ping 1.1.1.1 source 10

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:

Packet sent with a source address of 7.7.7.7

!!!!

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

// So PE1 and PE2 now could reachability each other.

Task 4: Configure AToM (Any Transport over MPLS) in PE1 (R1) and PE2 (R7) to build Layer 2 VPN Services for CE.

On R1 (PE1)

!

interface Ethernet0/0

no ip address

no keepalive

xconnect 7.7.7.7 100 encapsulation mpls sequencing both

!

interface Ethernet0/2

no ip address



```
no keepalive
xconnect 7.7.7.7 10 encapsulation mpls sequencing both
!
```

On R7 (PE2)

```
!
interface Ethernet0/0
no ip address
no keepalive
xconnect 1.1.1.1 100 encapsulation mpls sequencing both
!
interface Ethernet0/2
no ip address
no keepalive
xconnect 1.1.1.1 10 encapsulation mpls sequencing both
!
```

After configuration, the following log will automatically appear :

%LDP-5-NBRCHG: LDP Neighbor 7.7.7.7:0 (2) is UP

%LDP-5-NBRCHG: LDP Neighbor 1.1.1.1:0 (2) is UP

1 Targeted LDP Session has been established between 2 PE.

Verification

On R1 (PE1)

PE1#**show mpls ldp neighbor**

Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 1.1.1.1:0

TCP connection: 2.2.2.2.60750 - 1.1.1.1.646

State: Oper; Msgs sent/rcvd: 140/139; Downstream

Up time: 01:55:24

LDP discovery sources:

Ethernet0/1, Src IP addr: 10.1.12.2

Addresses bound to peer LDP Ident:

10.1.23.2 10.1.12.2 2.2.2.2

Peer LDP Ident: 7.7.7.7:0; Local LDP Ident 1.1.1.1:0

TCP connection: 7.7.7.7.25803 - 1.1.1.1.646

State: Oper; Msgs sent/rcvd: 14/15; Downstream

Up time: 00:04:11

LDP discovery sources:

Targeted Hello 1.1.1.1 -> 7.7.7.7, active, passive

Addresses bound to peer LDP Ident:

7.7.7.7 10.1.67.7

PE2#**show mpls ldp neighbor**

Peer LDP Ident: 6.6.6.6:0; Local LDP Ident 7.7.7.7:0

TCP connection: 6.6.6.6.646 - 7.7.7.7.26591

State: Oper; Msgs sent/rcvd: 132/131; Downstream

Up time: 01:48:06





```

LDP discovery sources:
  Ethernet0/1, Src IP addr: 10.1.67.6
Addresses bound to peer LDP Ident:
  10.1.56.6      10.1.67.6      6.6.6.6
Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 7.7.7.7:0
TCP connection: 1.1.1.1.646 - 7.7.7.7.25803
State: Oper; Msgs sent/rcvd: 15/15; Downstream
Up time: 00:04:54
LDP discovery sources:
  Targeted Hello 7.7.7.7 -> 1.1.1.1, active, passive
Addresses bound to peer LDP Ident:
  10.1.12.1      1.1.1.1

```

PE1#show mpls l2transport vc

Local intf Status	Local circuit	Dest address	VC ID
Et0/2 UP	Ethernet	7.7.7.7	10
Et0/0 UP	Ethernet	7.7.7.7	100

PE2#show mpls l2transport vc

Local intf Status	Local circuit	Dest address	VC ID
Et0/2 UP	Ethernet	1.1.1.1	10
Et0/0 UP	Ethernet	1.1.1.1	100

PE1#show mpls forwarding-table

Local Hop	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next
16	Pop Label	2.2.2.2/32	0	Et0/1	
10.1.12.2					
17	Pop Label	10.1.23.0/24	0	Et0/1	
10.1.12.2					
18	17	3.3.3.3/32	0	Et0/1	
10.1.12.2					





```

19      No Label   12ckt(1)      0      Et0/0
point2point
20      No Label   12ckt(2)      6182    Et0/2
point2point

```

PE2#**show mpls forwarding-table**

Local Hop	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next
16 10.1.67.6	Pop Label	6.6.6.6/32	0		Et0/1	
17 10.1.67.6	16	5.5.5.5/32	0		Et0/1	
18 10.1.67.6	Pop Label	10.1.56.0/24	0		Et0/1	
19 point2point	No Label	12ckt(1)	5597		Et0/0	
20 point2point	No Label	12ckt(2)	5720		Et0/2	

Task 5: Configure any routing protocols between CEs in VPN domain2 (In this lab, use OSPF) and configure PPPoE Session between CEs in VPN domain1.

On R4 (CE11)

```

!
interface Ethernet0/0
 no ip address
 pppoe enable group global
 pppoe-client dial-pool-number 1
!
interface Dialer1
 mtu 1492
 ip address negotiated
 encapsulation ppp
 dialer pool 1
 ppp pap sent-username customer password 0 cisco
!

```

// Configure CE11 as a PPPoE client, using PAP for authentication with username : customer, password : cisco





On R8 (CE12)

```
!  
username customer password 0 cisco  
!  
bba-group pppoe global  
  virtual-template 1  
!  
interface Ethernet0/0  
  no ip address  
  pppoe enable group global  
!  
interface Virtual-Template1  
  mtu 1492  
  ip address 10.1.48.8 255.255.255.0  
  peer default ip address pool CLIENT  
  ppp authentication pap callin  
!  
ip local pool CLIENT 10.1.48.4  
!  
//Configure CE12 as a PPPoE Server, using IP 10.1.48.8 for PPPoE  
Client.
```

On R9 (CE21)

```
!  
interface Loopback0  
  ip address 9.9.9.9 255.255.255.255  
!  
interface Ethernet0/2  
  ip address 123.123.123.1 255.255.255.0  
!  
router ospf 1  
  network 9.9.9.9 0.0.0.0 area 0  
  network 123.123.123.0 0.0.0.255 area 0  
!
```

On R10 (CE22)

```
!  
interface Loopback0  
  ip address 10.10.10.10 255.255.255.255  
!  
interface Ethernet0/2
```





```

ip address 123.123.123.2 255.255.255.0
!
router ospf 1
 network 10.10.10.10 0.0.0.0 area 0
 network 123.123.123.0 0.0.0.255 area 0
!

```

Verification

CE11#show ip interface brief | exclude assign

Interface	IP-Address	OK?	Method	Status
Dialer1	10.1.48.4	YES	IPCP	up

CE12#show pppoe session interface ethernet 0/0

```

1 session in LOCALLY_TERMINATED (PTA) State
1 session total

```

Uniq ID	PPPoE	RemMAC	Port	VT	VA
State					
	SID	LocMAC			VA-st
Type					
1	1	aabb.cc00.8e00	Et0/0	1	Vi1.1
PTA		aabb.cc00.9200			UP

CE12#show ppp all

Interface/ID	OPEN+	Nego*	Fail-	Stage	Peer Address	Peer Name
Vi1.1	LCP+	PAP+	IPCP+	LocalT	10.1.48.4	customer

CE1#ping 10.1.48.8

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 10.1.48.8, timeout is 2 seconds:

!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/3 ms

CE21#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address
Interface				
10.10.10.10	1	FULL/DR	00:00:32	123.123.123.2
Ethernet0/2				





```
CE22#show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address
Interface				
9.9.9.9	1	FULL/BDR	00:00:30	123.123.123.1
Ethernet0/2				

```
CE21#show ip route ospf
```

```
Gateway of last resort is not set
```

```
10.0.0.0/32 is subnetted, 1 subnets
0      10.10.10.10 [110/11] via 123.123.123.2, 00:10:50, Ethernet0/2
```

```
CE22#show ip route ospf
```

```
Gateway of last resort is not set
```

```
9.0.0.0/32 is subnetted, 1 subnets
0      9.9.9.9 [110/11] via 123.123.123.1, 00:10:23, Ethernet0/2
```

```
CE21#ping 10.10.10.10 source 10
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 10.10.10.10, timeout is 2 seconds:
```

```
Packet sent with a source address of 9.9.9.9
```

```
!!!!!!
```

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

```
CE22#ping 9.9.9.9 source 10
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 9.9.9.9, timeout is 2 seconds:
```

```
Packet sent with a source address of 10.10.10.10
```

```
!!!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/3 ms
```

Congratulation! Now All CE in 2 domain L2VPN could reachability each other!

