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Devices Configured:

- Seattle - Dallas

Atlanta -

Basic Switching Lab Exercise 6

MPLS-VPN

Table of Contents	
ACKNOWLEDGEMENT	01
ANALYSIS	
CONCLUSION	
REFERENCE	

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.



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

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

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

Telnet 1	10 192 -
Seattle-P2#	
0 192.168.1.16/30 [110/2] via 192.168.1.13, 00:06:08, FastEthernet1/0	
L 192.168.1.14/32 is directly connected, FastEthernet1/0	
c 192.168.1.12/30 is directly connected. FastEthernet1/0	
1 192 168.1.9/32 is directly connected, FastEthernet/1	
0 192.108.1.4/32 [110/2] Via 192.108.1.10, 00:06:18, FastEthernet1/1	
C 192.168.1.3/32 is directly connected, Loopback0	
0 192.168.1.2/32 [110/2] via 192.168.1.13, 00:06:08, FastEthernet1/0	
0 192.168.1.1/32 [110/3] via 192.168.1.13, 00:06:08, FastEthernet1/0	
192.168.1.0/24 is variably subnetted, 9 subnets, 2 masks	
Gateway of last resort is not set	
The formation of the fo	
o - ODR, P - periodic downloaded static route, H - NHKP + - replicated route % - pext hop override	
ia - IS-IS inter area, * - candidate default, U - per-user static route	
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2	
E1 - OSPF external type 1, E2 - OSPF external type 2	
D = EIGRP, EX = EIGRP external, 0 = OSPF, IA = OSPF IIIter aleaN1 = OSPF NSSA external type 1. N2 = OSPF NSSA external type 2	
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP	
Seattle-P2#show_ip_route	

Seattle-P2#shou IP routing tab IP routing tab	w ip route su le name is de le maximum-pa	mmary fault (0x0) ths 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 NSSA Externa	4 Inter-area: 1-1: 0 NSSA E	0 External- xternal-2: 0	1: 0 Externa	1-2: 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.

```
Seattle=r2#ping 10.2.0.2
Type escape Sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.0.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
Seattle=r2#ping 10.2.0.6
Type escape sequence to abort.
Seattle=r2#ping 192.168.1.18
Type escape sequence to abort.
Seattle=r2#ping 10.2.0.10
Type escape sequence to abort.
Seat
```

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:

```
allas:

traceroute 192.168.1.1 (loopback of Atlanta)

Dallas-PE2#traceroute 192.168.1.1

Type escape sequence to abort.

Tracing the route to 192.168.1.1

1 192.168.1.9 4 msec 16 msec 16 msec

2 192.168.1.13 12 msec 24 msec 40 msec

3 192.168.1.17 60 msec 48 msec *

Dallas-PE2#
```

In Miami(P1)

In Dallas:

traceroute 192.168.1.4 (loopback of Dallas)

```
Miami-P1#traceroute 192.168.1.4

Type escape sequence to abort.

Tracing the route to 192.168.1.4

1 192.168.1.14 28 msec 36 msec 12 msec

2 192.168.1.10 20 msec 32 msec *

Miami-P1#
```

In Seattle(P2) traceroute 192.168.1.1 (loopback of Atlanta)

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 mp Interface FastEthernet1/0 FastEthernet1/1 Seattle-P2#	ls interface IP Yes (ldp) Yes (ldp)	Tunnel No No	BGP NO NO	Static No No	Operational Yes Yes
Dallas-PE2>en Dallas-PE2#show mp Interface FastEthernet1/0 Dallas-PE2#	ls interface IP Yes (1dp)	Tunnel No	BGP NO	Static No	Operational Yes

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

	Capture.pcap						
File	File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help						
Â.	🛛 🔳 🧷 🕲 📙 🐘 🔍 🗢 🗢 🕾 🖗 🕹 🐺 🐻 🚍 🔲 🍳 Q. Q. X. X						
	Apply a display filter <0						
No.	Time	Source	Destination	Protocol	Length Info		
	8 1.600375	ca:06:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.13 (Reply)		
	9 1.953631	ca:08:03:dc:00:1c	CDP/VTP/DTP/PAgP/UDLD	CDP	377 Device ID: Seattle-P2 Port ID: FastEthernet1/0		
	10 2.647249	ca:06:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.13 (Reply)		
	11 2.707895	ca:06:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.13 (Reply)		
	12 2.778551	ca:06:03:dc:00:1d	DEC-MOP-Remote-Console	0x6002	77 DEC DNA Remote Console		
	13 2.788718	ca:06:03:dc:00:1d	CDP/VTP/DTP/PAgP/UDLD	CDP	375 Device ID: Miami-P1 Port ID: FastEthernet1/1		
	14 2.798818	192.168.1.13	224.0.0.2	LDP	76 Hello Message		
	15 2.808939	192.168.1.13	224.0.0.5	OSPF	90 Hello Packet		
	16 2.849242	192.168.1.14	224.0.0.2	LDP	76 Hello Message		
	17 2.859374	ca:08:03:dc:00:1c	Broadcast	ARP	60 Who has 192.168.1.13? Tell 192.168.1.14		
	18 2.930290	ca:08:03:dc:00:1c	CDP/VTP/DTP/PAgP/UDLD	CDP	377 Device ID: Seattle-P2 Port ID: FastEthernet1/0		
	19 2.930399	ca:06:03:dc:00:1d	ca:08:03:dc:00:1c	ARP	60 192.168.1.13 is at ca:06:03:dc:00:1d		
	20 2.970815	192.168.1.13	224.0.0.2	LDP	76 Hello Message		
	21 3.788500	ca:06:03:dc:00:1d	CDP/VTP/DTP/PAgP/UDLD	CDP	375 Device ID: Miami-P1 Port ID: FastEthernet1/1		
	22 4.782632	ca:06:03:dc:00:1d	CDP/VTP/DTP/PAgP/UDLD	CDP	375 Device ID: Miami-P1 Port ID: FastEthernet1/1		
	23 5.166934	ca:08:03:dc:00:1c	ca:08:03:dc:00:1c	LOOP	60 Reply		
İ	24 6.755281	192.168.1.14	224.0.0.2	LDP	76 Hello Message		
>	Frame 16: 76 bytes	on wire (608 bits), 7	76 bytes captured (608 bi	ts)			
>	Ethernet II, Src:	ca:08:03:dc:00:1c (ca:	:08:03:dc:00:1c), Dst: IP	v4mcast 0	2 (01:00:5e:00:00:02)		
>	Internet Protocol	Version 4, Src: 192.16	58.1.14, Dst: 224.0.0.2				
>	User Datagram Prot	ocol, Src Port: 646, D	Ost Port: 646				
~	Label Distribution	Protocol					
1	Version: 1						
	PDU Length: 30						
	LSR ID: 192.168	.1.3					
	Label Space ID:	0					
	✓ Hello Message						
	0 =	U bit: Unknown bit not	: set				
00	00 01 00 5e 00 00	02 ca 08 03 dc 00 1c	: 08 00 45 c0^	E.			
00	10 00 3e 00 00 00	00 01 11 17 37 c0 a8	3 01 0e e0 00 .>	.7			
00	20 00 02 02 86 02	86 00 2a cc 32 00 01	1 00 1e c0 a8*	.2			
00	30 01 03 00 00 01	00 00 14 00 00 00 00	04 00 00 04	•••••			
00-	40 00 0T 00 00 04	010004 c0a80103	• • • • • • • • • • • • • • • • • • • •	••••			
0	∂ Z capture						

Packet Captured From Dallas

<u> </u>	capture1.pcap					
File	File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help					
		🛅 🔀 🖸 🍳 👄 🔿 🕾 7	🛚 🚛 📃 🔍 Q, Q, Q	¥.		
	oply a display filte	r <ctrl-></ctrl->				
No.	Time	Source	Destination	Protocol	Length Info	
	1 0.00000	0 ca:08:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.9 (Reply)	
	2 0.44358	6 ca:04:03:dc:00:1c	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.10 (Reply)	
	3 0.86024	5 ca:08:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.9 (Reply)	
	4 0.88047	2 ca:08:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.9 (Reply)	
_	5 0.92277	5 192.168.1.9	224.0.0.2	LDP	76 Hello Message	
	6 0.93295	1 ca:08:03:dc:00:1d	DEC-MOP-Remote-Console	0x6002	77 DEC DNA Remote Console	
	7 0.94312	0 ca:08:03:dc:00:1d	CDP/VTP/DTP/PAgP/UDLD	CDP	377 Device ID: Seattle-P2 Port ID: FastEthernet1/1	
	8 0.95387	9 192.168.1.9	224.0.0.5	OSPF	90 Hello Packet	
	9 1.46464	4 ca:04:03:dc:00:1c	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.10 (Replv)	
	10 1.50647	6 ca:04:03:dc:00:1c	Broadcast	ARP	60 Gratuitous ARP for 192,168,1,10 (Reply)	
	11 1.64147	0 ca:04:03:dc:00:1c	DEC-MOP-Remote-Console	0x6002	77 DEC DNA Remote Console	
	12 1.65261	5 ca:04:03:dc:00:1c	CDP/VTP/DTP/PAgP/UDLD	CDP	377 Device ID: Dallas-PE2 Port ID: FastEthernet1/0	
	13 1.66272	6 192.168.1.10	224.0.0.2	LDP	76 Hello Message	
	14 1,69381	1 192.168.1.10	224.0.0.5	OSPF	90 Hello Packet	
	15 1,69393	5 192.168.1.9	224.0.0.2	I DP	76 Hello Message	
	16 1.70404	0 ca:08:03:dc:00:1d	Broadcast	ARP	60 Who has 192.168.1.10? Tell 192.168.1.9	
	17 1.72496	7 ca:04:03:dc:00:1c	ca:08:03:dc:00:1d	ARP	60 192.168.1.10 is at ca:04:03:dc:00:1c	
\ E	nomo 15, 76 l	wtos on wino (60% hits) 7	6 butos contuned (600 bi	+ ~)		
ŚĘ	thernet TT	Spc: ca:08:03:dc:00:1d (ca:	08:03:dc:00:1d) Det: TP	vancast i	22 (01:00:5e:00:00:02)	
(1	nternet Prot	col Version 4 Spc: 192 16	8 1 9 Det: 224 0 0 2	v+iiicast_	52 (01.00.32.00.00.02)	
Ś	leen Datagram	Protocol Src Port: 646	st Port: 646			
ý ľ	abel Distrib	ition Protocol	SC POPC: 040			
	Vencion: 1	101011 11000001				
	PDU Length:	30				
	ISP TD: 101	168 1 3				
	Label Space	TD: 0				
,	Hello Messa	. 10. 0				
	0	. = U bit: Unknown bit not	set			
000			00.00.45 -0	-		
000	0 01 00 5e 6	00 00 02 ca 08 03 dc 00 1d	08 00 45 00	t.		
001	00 00 00 00 00	86 02 86 00 2a cc 37 00 01	00 1e c0 a8 *	7		
003	0 01 03 00 0		04 00 00 04			
004	0 00 0f 00 0	00 04 01 00 04 c0 a8 01 03				
0	7 contract					
	Capure1					

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: 192.168.1.2.646 - 192.168.1.3:0
TCP connection: 192.168.1.2
ddresses 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: 192.168.1.3.046 - 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:
    192.168.1.4 192.168.1.3 192.168.1.9
```

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-FL# Atlanta-FEL#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 NI - 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 over route, H - NHRP
	Gateway of last resort is not set
Ш	10.0.0.0(0 is used blue subsets of 5 subsets 2 mode
Ш	10.0.0/8 is variably subnetted, 5 subnets, 3 masks
Ш	c 10.2.0.8/30 is directly connected, FastEthernet0/0
Ш	L 10.2.0.9/32 is directly connected, FastEthernett/(
Ш	c 10.2.0.12/30 is directly connected, FastEthernet1/0
Ш	L 10.2.0.13/32 is directly connected, FastEtherhet1/0
Ш	R 10.4.0.0/10 [120/1] Via 10.2.0.14, 00:00:12, FastEthernet1/0
Ш	102 168 1 0/24 is variably subnatiad 8 subnatial Parks
Ш	192.100.1.0/24 is valiably subjected, o subjects, 2 masks
Ш	0 192.100.1.1/32 13 directly connected, coopdacko
Ш	0 = 192.100.1.2/32 [110/2] via 192.100.1.10, 00.10.34, FastEthermet1/1
Ш	0 = 192.100.1.3/32 [110/3] via 192.100.1.10, 00.10.34, FastEthermeti/1
	0 192 168 1 8/30 [110/3] via 192 168 1 18 00.10.34 EastEthernet1/1
	0 192 168 1 12/30 [110/2] via 192 168 1 18 00:10:34 EastEthernet1/1
	c 192 168 1 16/30 is directly connected EastEthernet1/1
	1 192 168 1.17/32 is directly connected, FastEthernet1/1
11	Atlanta DELL

<pre>Ualias-rtz# Dallas-PE2#show ip route Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D = GRAP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF 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, * - Caandidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP + - replicated route, * - next hop override</pre>
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
0 192.168.1.1/32 [110/4] Via 192.168.1.9, 00:09:09, FastEthernet1/0
0 192.108.1.2/32 [110/3] Via 192.108.1.9, 00:09:09, FastEthernet1/0
c 192.168.1.4/32 is directly connected. Loophack0
C 192.168.1.8/30 is directly connected. FastEthernet1/0
L 192.168.1.10/32 is directly connected, FastEthernet1/0
0 192.168.1.12/30 [110/2] via 192.168.1.9, 00:09:19, FastEthernet1/0
0 192.168.1.16/30 [110/3] via 192.168.1.9, 00:09:09, FastEthernet1/0

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

🚄 capturedal.pcap

File	e Edit	View Go	Capture Analyze Statistics	s Telephony Wireless Too	ols Help	
		(🕘 📘 🛅	🗙 🛅 । ९ 🗢 🔿 警 👔	👲 📃 📃 @, Q, Q, I		
	Apply a	display filter <c< td=""><td>trl-/></td><td></td><td></td><td></td></c<>	trl-/>			
No.		Time	Source	Destination	Protocol Leng	th Info
	1	0.000000	ca:08:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.9 (Reply)
	2	0.332968	ca:04:03:dc:00:1c	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.10 (Reply)
	3	1.788131	ca:08:03:dc:00:1d	ca:08:03:dc:00:1d	LOOP	60 Reply
	4	1.985451	ca:04:03:dc:00:1c	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.10 (Reply)
	5	2.256438	ca:04:03:dc:00:1c	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.10 (Reply)
	6	2.443704	ca:04:03:dc:00:1c	ca:04:03:dc:00:1c	LOOP	60 Reply
	7	2.463929	ca:04:03:dc:00:1c	DEC-MOP-Remote-Console	0x6002	77 DEC DNA Remote Console
	8	2.474944	ca:04:03:dc:00:1c	CDP/VTP/DTP/PAgP/UDLD	CDP 3	77 Device ID: Dallas-PE2 Port ID: FastEthernet1/0
_	9	2.495191	192.168.1.10	224.0.0.2	LDP	76 Hello Message
	10	2.526217	192.168.1.10	224.0.0.5	OSPF	90 Hello Packet
	11	2.578654	ca:08:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 192.168.1.9 (Reply)
	10	2 610806		Decederat	100	CO Castuitana ADD faa 100 100 1 0 (Daalu)
>	Frame	9: 76 bytes (on wire (608 bits), 76	bytes captured (608 bits	5)	
>	Etherr	net II, Src: (ca:04:03:dc:00:1c (ca:0	04:03:dc:00:1c), Dst: IP	/4mcast_02 (0	01:00:5e:00:00:02)
>	Interr	net Protocol \	Version 4, Src: 192.168	3.1.10, Dst: 224.0.0.2		
>	User [Datagram Proto	ocol, Src Port: 646, Ds	t Port: 646		
~	Label	Distribution	Protocol			
	Ver	sion: 1				
	PDL	J Length: 30				
	LSF	ID: 192.168	.1.4			
	Lab	el Space ID:	0			
	> He]	llo Message				
000	ao o 1	00 5e 00 00	02 ca 04 03 dc 00 1c	08 00 45 c0^	E.	
001	10 00) 3e 00 00 00	00 01 11 17 3b c0 a8	01 0a e0 00 .>	.;	
002	20 00	02 02 86 02	86 00 2a cc 34 00 01	00 1e c0 a8*	.4	
003	30 01	04 00 00 01	00 00 14 00 00 00 00	04 00 00 04		
004	+0 06	0 0T 00 00 04	01 00 04 C0 a8 01 04			

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

<u> </u>	capture4.pcap					
File	File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help					
	# I I I I I I I I I I I I I I I I I I I					
No.	Time	Source	Destination	Protocol	Length Info	
	1 0.000000	ca:02:03:dc:00:1c	Broadcast	ARP	60 Gratuitous ARP for 10.2.0.13 (Reply)	
	2 0.301116	ca:03:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 10.2.0.14 (Reply)	
	3 0.793638	ca:02:03:dc:00:1c	Broadcast	ARP	60 Gratuitous ARP for 10.2.0.13 (Reply)	
	4 0.976269	ca:02:03:dc:00:1c	Broadcast	ARP	60 Gratuitous ARP for 10.2.0.13 (Reply)	
	5 0.996540	ca:03:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 10.2.0.14 (Reply)	
	6 1.048575	10.2.0.13	224.0.0.9	RIPv2	66 Request	
	7 1.078987	ca:03:03:dc:00:1d	Broadcast	ARP	60 Gratuitous ARP for 10.2.0.14 (Reply)	
	8 1.109232	ca:02:03:dc:00:1c	DEC-MOP-Remote-Console	0x6002	77 DEC DNA Remote Console	
	9 1.119398	ca:02:03:dc:00:1c	CDP/VTP/DTP/PAgP/UDLD	CDP	378 Device ID: Atlanta-PE1 Port ID: FastEthernet1/0	
	10 1.173015	ca:03:03:dc:00:1d	DEC-MOP-Remote-Console	0x6002	77 DEC DNA Remote Console	
	11 1.184606	ca:03:03:dc:00:1d	CDP/VTP/DTP/PAgP/UDLD	CDP	378 Device ID: Brussels-A2 Port ID: FastEthernet1/1	
	12 2.119555	ca:02:03:dc:00:1c	CDP/VTP/DTP/PAgP/UDLD	CDP	378 Device ID: Atlanta-PE1 Port ID: FastEthernet1/0	
	13 2.190274	ca:03:03:dc:00:1d	CDP/VTP/DTP/PAgP/UDLD	CDP	378 Device ID: Brussels-A2 Port ID: FastEthernet1/1	
	14 3.055667	10.2.0.13	224.0.0.9	RIPv2	66 Response	
	15 3.126135	ca:02:03:dc:00:1c	CDP/VTP/DTP/PAgP/UDLD	CDP	378 Device ID: Atlanta-PE1 Port ID: FastEthernet1/0	
	16 3.196782	ca:03:03:dc:00:1d	CDP/VTP/DTP/PAgP/UDLD	CDP	378 Device ID: Brussels-A2 Port ID: FastEthernet1/1	
	17 5.846072	ca:02:03:dc:00:1c	ca:02:03:dc:00:1c	LOOP	60 Reply	
> 1	Frame 14: 66 bytes	on wire (528 bits), 6	6 bytes captured (528 bi	ts)		
> 1	Ethernet II, Src: c	a:02:03:dc:00:1c (ca:	02:03:dc:00:1c), Dst: IP	v4mcast_	09 (01:00:5e:00:00:09)	
>	Internet Protocol V	ersion 4, Src: 10.2.0	.13, Dst: 224.0.0.9			
> (User Datagram Proto	col, Src Port: 520, D	st Port: 520			
\sim	Routing Information	Protocol				
	Command: Respons	e (2)				
	Version: RIPv2 (2)				
	> IP Address: 10.2	.0.8, Metric: 1				
000	0 01 00 5e 00 00	09 ca 02 03 dc 00 1c	08 00 45 c0^			
001	0 00 34 00 00 00	00 02 11 cd e1 0a 02	00 0d e0 00 .4			
002	00 09 02 08 02	08 00 20 05 7a 02 02	00 00 00 02	.z		
003	00 00 0a 02 00	08 ff ff ff fc 00 00	00 00 00 00			
004	00 01					

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-PEI#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
pallas-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 bg 100 Dallas-PE2(config)frouter-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 receivedIf Dallas-PE2(config-router-af)#neighbor 192.168.1.1 send-community-both % Invalid input detected at 'A' marker. Dallas-PE2(config-router-af)#neighbor 192.168.1.1 send-community both Dallas-PE2(config-router-af)# *Dec 3 14:12:36.397: %BGP-3-NOTIFICATION: received from neighbor 192.168.1.1 active 2/8 (no supported AFI/SAFI) 3 bytes 000180 (timer *Pec 3 14:14:36.305: %BGP-5-ADJCHANGE: neighbor 192.168.1.1 session 2 Up

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

```
*Dec 3 14:12:35.157: %BGP-3-NOTIFICATION: sent to neighbor 192.168.1.4 passive 2/8 (no supported AFI/SAFI) 3 bytes 000180
Atlanta-PE1×en
Atlanta-PE1*conf t
Enter configuration commands, one per line. End with CNTL/Z.
Atlanta-PE1(config-router bgp 100
Atlanta-PE1(config-router-af)#neighbor 192.168.1.4 activate
Atlanta-PE1(config-router-af)#neighbor 192.168.1.4 session 2 Up next-hop self
% Invalid input detected at 'A' marker.
Atlanta-PE1(config-router-af)#neighbor 192.168.1.4 next-hop-self
Atlanta-PE1(config-router-af)#neighbor 192.168.1.4 send-community_both
% Invalid input detected at 'A' marker.
Atlanta-PE1(config-router-af)#neighbor 192.168.1.4 send-community both
Atlanta-PE1(conf
```

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/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#
```

10.2.0.2
10.2.0.2
10.2.0.2
10.2.0.2
10.2.0.2
1111

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*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 Atlanta

✔ 10.192.78.13 ✔ Atlanta ✔ Dallas 🛛 🛕 Detroit 🛕 Paris	🔥 Madison 🛕 Brussels 🛕 Seattle 🛕 Miam	i
Dallas-PE2(config)#show ip bgp vpn v4 all		
% Invalid input detected at '^' marker.		
ballas-PE2(Sconfig)#exi ballas-PE2#Show 'DeC 5 00:27:57,675: %SYS-5-CONFIG_I: Confi % Type 'show ?' for a list of subcommands ballas-PE2#Show ip bgy vprv4 all BGP table version is 13, local router ID is status codes: s suppressed, d damped, h hist or RIB-failure, S Stale, m mult origin codes: i - IGP, e - EGP, ? - incomple	igured from console by conso 192.168.1.4 .ory, * valid, > best, i - interna ripath, b backup-path, x best-exte te	l, rnal
Network Next Hop fault for Vrf *> 10.1.0.0/16 100:1 (default for Vrf *> 10.1.0.0/16 10.2.0.6 *>10.2.0.4/30 0.0.0 *>10.2.0.12/30 192.168.1.1 *>10.4.0.0/16 192.168.1.1 Route Distinguisher: 100:2 (default for Vrf *> 10.1.0.0/16 0.2.0.2 *>10.2.0.8/30 0.22.168.1.1 *>10.4.0.0/16 192.168.1.1 Dallas-PE2#	<pre>-ic LocPrf Weight Path VPW_A) 22768 ? 1 327768 ? 1 100 0 ? 1 100 0 ? VPN_B) 22768 ? 0 100 22768 ? 0 100 0 ? 1 100 0 ? 1 100 0 ? </pre>	
Atlanta-PEI>en Atlanta-PEI#Show ip bgp vpnv4 all GGP table version is 13, local router ID is Status codes: s suppressed, d damped, h his origin codes: i - IGE e = FGE ? - incomp	; 192.168.1.1 story, " valid, > best, i - intern ltipath, b backup-path, x best-ext	al, ernal

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**

Dallas-PEZ>en					
Dallas-PE2#show ip) bgp vpnv4 all i	label			
Network	Next Hop	In label/Out label			
Route Distinguishe	er: 100:1 (VPN_A))			
10.1.0.0/16	10.2.0.6	406/nolabel			
10.2.0.4/30	0.0.0.0	407/nolabel(VPN_A)			
10.2.0.12/30	192.168.1.1	nolabel/106			
10.4.0.0/16	192.168.1.1	nolabel/107			
Route Distinguisher: 100:2 (VPN_B)					
10.1.0.0/16	10.2.0.2	408/nolabel			
10.2.0.0/30	0.0.0.0	409/nolabel(VPN_B)			
10.2.0.8/30	192.168.1.1	nolabel/108			
10.4.0.0/16	192.168.1.1	nolabel/109			
Dallas-PE2#					
. –					

In Atlanta

1	/		<u>+</u>	
	Atlanta-PE1#show ip	bgp vpnv4 all	label	
	Network	Next Hop	In label/Out label	
	Route Distinguisher	: 100:1 (VPN_A)		
	10.1.0.0/16	192.168.1.4	nolabel/406	
	10.2.0.4/30	192.168.1.4	nolabel/407	
	10.2.0.12/30	0.0.0.0	106/nolabel(VPN_A)	
	10.4.0.0/16	10.2.0.14	107/nolabel	
	Route Distinguisher	: 100:2 (VPN_B)		
	10.1.0.0/16	192.168.1.4	nolabel/408	
	10.2.0.0/30	192.168.1.4	nolabel/409	
	10.2.0.8/30	0.0.0.0	108/nolabel(VPN_B)	
	10.4.0.0/16	10.2.0.10	109/nolabel	
	Atlanta-PE1#			
4	,			

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, 0 - OSPF, IA - OSPF inter area
N1 - OSPF NSA external type 1, N2 - OSPF 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
0 192.168.1.2/32 [110/2] via 192.168.1.13, 01:27:46, FastEthernet1/0
0 192.168.1.2/32 [110/2] via 192.168.1.13, 01:27:56, FastEthernet1/1
C 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 192.168.1.14/32 is directly connected, FastEthernet1/1
L 192.168.1.14/32 is directly connected, FastEthernet1/0
L 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#



PEI -> PI IN OUT Ext Label Label 192.168.1 700 303 14 P, -> P2 IN OUT EXT LABEL LABEL 192.165. 100 204 1.18 P2 -> PE2 TNLABEL ACTION OUT (300 is initially 100 POP 10.2.0. 13 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