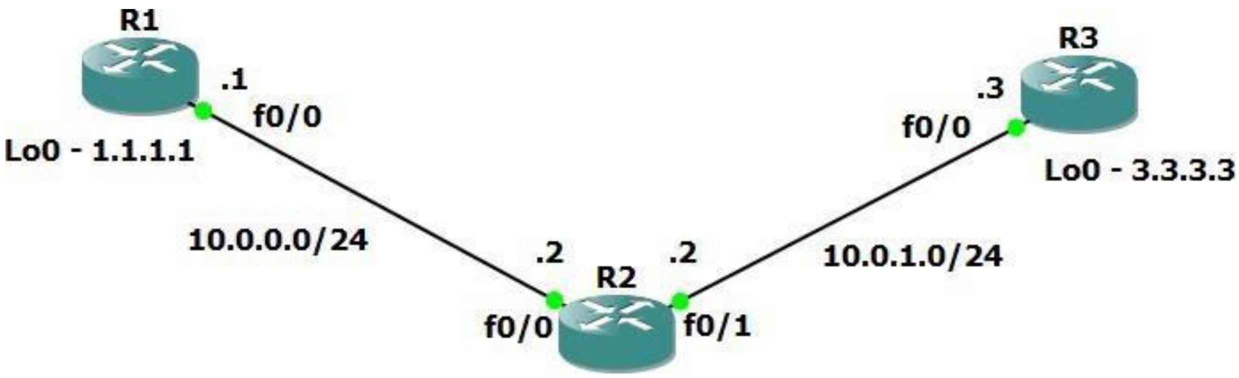
Practical No 8

Aim: Cisco MPLS Configuration

Step 1 – IP addressing of MPLS Core and OSPF

First bring 3 routers into your topology R1, R2, R3 position them as below. We are going to address the routers and configure ospf to ensure loopback to loopback connectivity between R1 and R3




```
R1

hostname

R1intlo0

ipadd1.1.1.1255.255.255.255

ipospf1area0

intf0/0

ipadd10.0.0.1255.255.255.0

no shut

ipospf1area0

R2

hostname

R2intlo0
```

```
ip add 2.2.2.2 255.255.255.255
ip ospf 1 are 0

int f0/0

ip add 10.0.0.2 255.255.255.0

no shut

ip ospf 1 area 0

int f0/1

ip add 10.0.1.2 255.255.255.0

no shut

ip ospf 1 area 0

R3

hostname R3 int lo0

ip add 3.3.3.3 255.255.255.255

ip ospf 1 are 0

int f0/0

ip add 10.0.1.3 255.255.255.0

no shut

ip ospf 1 area 0
```

You should now have full ip connectivity between R1, R2, R3 to verify thiswe need to see if we can ping between the loopbacks of R1 and R3

```
R1#ping3.3.3.3sourcelo0



Typeescapesequencetoabort.

Sending5,100-byteICMPEchosto3.3.3.3,timeoutis2seconds:

Packetsentwithasourceaddressof1.1.1.1

!!!!!

Success rate is 100 percent (5/5), round-
tripmin/avg/max=40/52/64ms

R1#
```

You could show the routing table here, but the fact that you can ping between the loopbacks is verification enough and it is safe to move on.

Step 2 – Configure LDP on all the interfaces in the MPLS Core

In order to run MPLS you need to enable it, there are two ways to do this.

- At each interface enter the **mpls ip** command
- Under the ospf process use the **mpls ldp autoconfig** command

For this tutorial we will be using the second option, so go int the ospf process and enter mpls ldp autoconfig – this will enable mpls label distribution protocol on every interface running ospf under that specific process.

```
R1

routerospf 1

mplsldpautoconfig



R2

routerospf 1
```

```
mplsldpautoconfig



R3

routerospf 1

mplsldpautoconfig
```

You should see log messages coming up showing the LDP neighbors are up.

```
R2#

*Mar1 00:31:53.643: %SYS-5-CONFIG_I: Configured fromconsole

*Mar100:31:54.423:%LDP-5-NBRCHG:LDPNeighbor
1.1.1.1:0 (1) is UPR2#

*Mar100:36:09.951:%LDP-5-NBRCHG:LDPNeighbor
3.3.3.3:0(2)isUP
```

To verify the mpls interfaces the command is very simple – **sh mpls interface**

This is done on R2 and you can see that both interfaces are running mpls and using LDP

```
R2#sh mpls interface

Interface              IP              Tunnel
Operational

FastEthernet0/0        Yes (ldp)       No        Yes

FastEthernet0/1        Yes (ldp)       No        Yes
```

You can also verify the LDP neighbors with the **sh mpls ldp neighbors** command.

```
R2#shmplsldpneigh

     PeerLDPIdent:1.1.1.1:0;LocalLDPIdent2.2.2.2:0TCPconnection:1.1.1.1.646

          -2.2.2.2.37909
```

```
        State:Oper;Msgssent/rcvd:16/17;DownstreamUptim
        e:00:07:46
        LDPdiscoverysources:
          FastEthernet0/0,SrcIPaddr:10.0.0.1Addr
        essesboundtopeerLDPIdent:
          10.0.0.1        1.1.1.1
    PeerLDPIdent:3.3.3.3:0;LocalLDPIdent2.2.2.2:0TCPcon
        nection:3.3.3.3.22155-2.2.2.2.646
        State:Oper;Msgssent/rcvd:12/11;DownstreamUptim
        e:00:03:30
        LDPdiscoverysources:
          FastEthernet0/1,SrcIPaddr:10.0.1.3Addr
        essesboundtopeerLDPIdent:
          10.0.1.3        3.3.3.3
```

One more verification to confirm LDP is running ok is to do a trace between R1 and R3 and verify if you get MPLS Labels show up in the trace.

```
R1#trace3.3.3.3


Type escape sequence to
abort.Tracingtherouteto3.3.3.3


   110.0.0.2[MPLS:Label17Exp0]84msec72msec44msec
   210.0.1.368msec60msec*
```

As you can see the trace to R2 used an MPLS Label in the path, as this is a very small MPLS core only one label was used as R3 was the final hop.

So to review we have now configured IP addresses on the MPLS core, enabled OSPF and full IP connectivity between all routers and finally enabled mpls on all the interfaces in the core and have established ldp neighbors between all routers.

The next step is to configure MP-BGP between R1 and R3

This is when you start to see the layer 3 vpn configuration come to life

Step 3 – MPLS BGP Configuration between R1 and R3

We need to establish a Multi Protocol BGP session between R1 and R3 this is done by configuring the vpnv4 address family as below

```
R1#

routerbgp1

 neighbor3.3.3.3remote-as1

 neighbor 3.3.3.3 update-source Loopback0noauto-summary

 !

 address-family

  vpnv4neighbor3.3.3.3activate


R3#

routerbgp1

 neighbor1.1.1.1remote-as1

 neighbor 1.1.1.1 update-source Loopback0noauto-summary

 !

 address-family

  vpnv4neighbor1.1.1.1activate
```

```
*Mar100:45:01.047:%BGP-5-ADJCHANGE:neighbor1.1.1.1
Up
```

You should see log messages showing the BGP sessions coming up.

To verify the BGP session between R1 and R3 issue the command **sh bgp vpnv4 unicast all summary**

```
R1#shbgpvpnv4unicastallsummary

BGProuteridentifier1.1.1.1,localASnumber1

BGPtableversionis1,mainroutingtableversion1


NeighborOutQ     V     ASMsgRcvdMsgSent       TblVerInQ
Up/Down          State/PfxRcd

3.3.3.3           4      1      218      218          1     0
0 03:17:48          0
```

Router 4 will peer OSPF using process number 2 to a VRF configured on R1. It will use the local site addressing of 223.168.1.0/24.

```
R4

int lo0

ipadd4.4.4.4255.255.255.255

ip ospf 2 area

2intf0/0
```

```
ipadd192.168.1.4255.255.255.0

ip ospf 2 area

2noshut



R1

int f0/1no

shut

ipadd223.168.1.1255.255.255.0
```

Now at this point we have R4 peering to R1 but in the global routing table of R1 which is not what we want.

We are now going to start using VRF's

What is a VRF in networking?

Virtual routing and forwarding (**VRF**) is a technology included in IP (Internet Protocol) that allows multiple instances of a routing table to co-exist in a router and work together but not interfere with each other.. This increases functionality by allowing network paths to be segmented without using multiple devices.

As an example if R1 was a PE Provider Edge router of an ISP and it had two customers that were both addressed locally with the 223.168.1.0/24 address space it could accommodate both their routing tables in different VRFs – it distinguishes between the two of them using a Route Distinguisher

So back to the topology – we now need to create a VRF on R1 For this mpls tutorial I will

be using VRF RED

```
R1

ip vrf

REDrd4:4

route-targetboth4:4
```

The RD and route-target do not need to be the same – and for a full explanation please read this post on Route Distinguishers
Route Distinguisher vs Route Target before proceeding.

So now we have configured the VRF on R1 we need to move the interface F0/1 into that VRF

```
R1

intf0/1

ipvrfforwardingRED
```

Now notice what happens when you do that – the IP address is removed

```
R1(config-if)#ipvrffo

R1(config-if)#ipvrfforwardingRED

% Interface FastEthernet0/1 IP address
223.168.1.1removedduetoenablingVRFRED
```

You just need to re-apply it

```
R1

intf0/1

ipaddress223.168.1.1255.255.255.0
```

Now if we view the config on R1 int f0/1 you can see the VRF configured.

```
R1
R1#sh run int

f0/1Buildingconfiguration...

Currentconfiguration:119bytes
```

```
interface
 FastEthernet0/1ipvrfforwardingRE
 D
 ipaddress223.168.1.1255.255.255.0
 duplexautospeed
 auto
end
```

Now we can start to look int VRF’s and how they operate – you need to understand now that there are 2 routing tables within R1

- The Global Routing Table
- The Routing Table for VRF RED

If you issue the command **sh ip route** this shows the routes in the global table and you will notice that you do not see 223.168.1.0/24

```
R1#sh ip route

Codes: C - connected, S - static, R - RIP, M - mobile, B
- BGP

   D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF
inter area

   N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2

   E1 - OSPF external type 1, E2 - OSPF external type 2

   i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 -
IS-IS level-2

   ia - IS-IS inter area, * - candidate default, U - per- user static route

   o - ODR, P - periodic downloaded static route



Gateway of last resort is not set
```

```
1.0.0.0/32issubnetted,1subnets

C 1.1.1.1 is directly connected, Loopback02.0.0.0/32issubnetted,1subnets

O 2.2.2.2[110/11]via10.0.0.2,01:03:48,
FastEthernet0/0

   3.0.0.0/32issubnetted,1subnets

O 3.3.3.3[110/21]via10.0.0.2,01:02:29,
FastEthernet0/0

   10.0.0.0/24issubnetted,2subnets

C10.0.0.0isdirectlyconnected,FastEthernet0/0O10.0.1.0[110/20]via10.0.0.2,01:02:39,
FastEthernet0/0R1#
```

If you now issue the command sh ip route vrf red – this will show the routes in the routing table for VRF RED

```
R1#shiproutevrfred

%IProutingtablereddoesnotexist
```

NOTE: The VRF name is case sensitive!

```
R1#shiproutevrfRED



RoutingTable:RED

Codes:C-connected,S-static,R - RIP,M-mobile,B
-BGP

  D- EIGRP,EX- EIGRPexternal,O-OSPF,IA-OSPF
interarea

  N1 - OSPF NSSA external type 1, N2 - OSPF NSSA externaltype2
```

```
 E1-OSPFexternaltype1,E2-OSPFexternaltype2

 i- IS-IS,su - IS-ISsummary,L1-IS-ISlevel-1,L2-
IS-IS level-2

 ia - IS-IS inter area, * - candidate default, U - per-userstaticroute

 o-ODR,P -periodicdownloadedstaticroute



Gatewayoflastresortisnotset



C223.168.1.0/24isdirectlyconnected,FastEthernet0/1R1#
```

We just need to enable OSPF on this interface and get the loopback address for R4 in the VRF RED routing table before proceeding.

```
R1

 intf0/1

 ipospf2area2
```

You should see a log message showing the OSPF neighbor come up

```
R1(config-if)#

             *Mar101:12:54.323:%OSPF-5-ADJCHG:Process2,Nbr
4.4.4.4

             onFastEthernet0/1fromLOADINGtoFULL,LoadingDone
```

If we now check the routes in the VRF RED routing table you should see 4.4.4.4 in there as well.

```
R1#shiproutevrfRED



RoutingTable:RED
 Codes: C - connected, S - static, R - RIP, M - mobile,B-BGP
```

```
 D- EIGRP,EX- EIGRPexternal,O-OSPF,IA-OSPF
interarea

 N1 - OSPF NSSA external type 1, N2 - OSPF NSSA externaltype2

 E1-OSPFexternaltype1,E2-OSPFexternaltype2

 i- IS-IS,su - IS-ISsummary,L1-IS-ISlevel-1,L2-
IS-IS level-2

 ia - IS-IS inter area, * - candidate default, U - per-userstaticroute

 o-ODR,P -periodicdownloadedstaticroute



Gatewayoflastresortisnotset



4.0.0.0/32issubnetted,1subnets

 O4.4.4.4[110/11]via223.168.1.4,00:00:22,
FastEthernet0/1

 C223.168.1.0/24isdirectlyconnected,FastEthernet0/1R1#
```

We now need to repeat this process for R3 & R6

Router 6 will peer OSPF using process number 2 to a VRF configured on R3. It will use the local site addressing of 223.168.2.0/24.

```
R6

int lo0

ipadd6.6.6.6255.255.255.255

ip ospf 2 area

2intf0/0

ipadd223.168.2.6255.255.255.0

ipospf2area2
```

```
no shut



R3

int f0/1no

shut

ipadd223.168.2.3255.255.255.0
```

We also need to configure a VRF onto R3 as well.

```
R3

ip vrf

REDrd4:4

route-targetboth4:4
```

So now we have configured the VRF on R3 we need to move the interface F0/1 into that VRF

```
R3

intf0/1

ipvrfforwardingRED
```

Now notice what happens when you do that – the IP address is removed

```
R3(config-if)#ipvrfforwardingRED

% Interface FastEthernet0/1 IP address
223.168.2.1removedduetoenablingVRFRED
```

You just need to re-apply it

```
R3
intf0/1
ip address 223.168.2.1255.255.255.0
```

Now if we view the config on R3 int f0/1 you can see the VRF configured.

```
R3#sh run int

f0/1Buildingconfiguration...



Currentconfiguration:119bytes

!

interface

FastEthernet0/1ipvrfforwardingRED

ip address 223.168.2.1255.255.255.0

duplex

autospeed

autoend
```

Finally, we just need to enable OSPF on that interface and verify the routes are in the RED routing table.

```
R3

intf0/1

ipospf2area2
```

Check the routes in vrf RED

```
R3

R3#shiproutevrfRED
RoutingTable:RED

Codes:C-connected,S-static,R-RIP,M-mobile,B
-BGP
Gatewayoflastresortisnotset
```

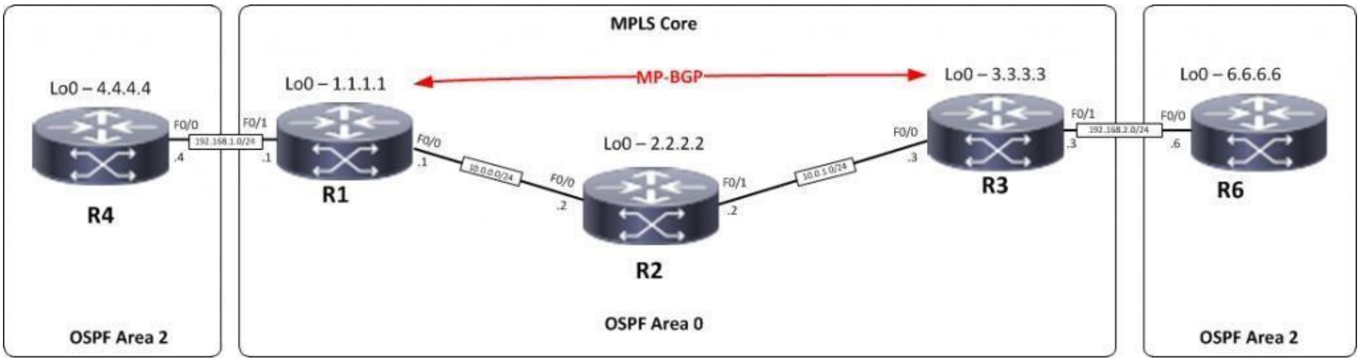
```
     6.0.0.0/32issubnetted,1subnets

O       6.6.6.6[110/11]via 223.168.2.6,00:02:44,
FastEthernet0/1

C    223.168.2.0/24isdirectlyconnected,
FastEthernet0/1

R3#
```

Ok so we have come a long way now let's review the current situation. We now have this setup



R1,R2,R3 form the MPLS Core and are running OSPF with all loopbacks running a /32 address and all have full connectivity. R1 and R3 are peering with MP-BGP. LDP is enabled on all the internal interfaces. The external interfaces of the MPLS core have been placed into a VRF called RED and then a site router has been joined to that VRF on each side of the MPLS core – (These represent a small office)

The final step to get full connectivity across the MPLS core is to redistribute the routes in OSPF on R1 and R3 into MP-BGP and MP-BGP into OSPF, this is what we are going to do now.

We need to redistribute the OSPF routes from R4 into BGP in the VRF on R1, the OSPF routes from R6 into MP-BGP in the VRF on R3 and then the routes in MP-BGP in R1 and R3 back out to OSPF

Before we start lets do some verifications

Check the routes on R4

```
R4#shiproute

4.0.0.0/32issubnetted,1subnets

C 4.4.4.4isdirectlyconnected,Loopback0
```

```
C223.168.1.0/24isdirectlyconnected,FastEthernet0/0
```

As expected we have the local interface and the loopback address.

When we are done we want to see 6.6.6.6 in there so we can ping across the MPLS

Check the routes on R1

```
R1#shiproute

1.0.0.0/32issubnetted,1subnets

C1.1.1.1isdirectlyconnected,Loopback02.0.0.0/32issubnette
 d,1subnets

O 2.2.2.2[110/11]via10.0.0.2,00:01:04,
FastEthernet0/0

 3.0.0.0/32issubnetted,1subnets

O 3.3.3.3[110/21]via10.0.0.2,00:00:54,
FastEthernet0/0

 10.0.0.0/24issubnetted,2subnets

C10.0.0.0isdirectlyconnected,FastEthernet0/0O10.0.1.0[110/20]via10

.0.0.2,00:00:54,
FastEthernet0/0
```

Remember we have a VRF configured on this router so this command will

show routes in the global routing table (the MPLS Core) and it will not show the 223.168.1.0/24 route as that is in VRF RED – to see that we run the following command.

```
R1#shiproutevrfRED
RoutingTable:RED
4.0.0.0/32issubnetted,1subnets
```

```
O 4.4.4.4[110/11]via192.168.1.4,00:02:32,
FastEthernet0/1

C223.168.1.0/24isdirectlyconnected,FastEthernet0/1
```

Here you can see Routing Table: RED is shown and the routes to R4 are
now visible with 4.4.4.4 being in OSPF. So we need

to do the following;

- Redistribute OSPF into MP-BGP on R1
- Redistribute MP-BGP into OSPF on R1
- Redistribute OSPF into MP-BGP on R3
- Redistribute MP-BGP into OSPF on R3

Redistribute OSPF into MP-BGP on R1

```
R1

routerbgp1

address-family ipv4 vrf

REDredistributeospf2
```

Redistribute OSPF into MP-BGP on R3

```
R3

routerbgp1

address-family ipv4 vrf

REDredistributeospf2
```

This has enabled redistribution of the OSPF routes into BGP. We can check
the routes from R4 and R6 are now showing in the BGP table for their VRF with this command

sh ip bgp vpnv4 vrf RED

```
R1#shipbgpvpnv4vrfRED

BGPtableversionis9,localrouterIDis1.1.1.1

Statuscodes:ssuppressed,ddamped,hhistory,*valid,>best,
```

```
r RIB-failure, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network Next Hop Metric LocPrf Weight Path

Route Distinguisher: 4:4 (default for vrf RED)
*> 4.4.4.4/32 223.168.1.4 11 32768 ?

*>i6.6.6.6/32 3.3.3.3 11          100 0     ?

*> 223.168.1.0 0.0.0.0 0             32768  ?

*>i223.168.2.0 3.3.3.3 0          100 0     ?
```

Here we can see that 4.4.4.4 is now in the BGP table in VRF RED on
R1 with a next hop of 223.168.1.4 (R4) and also 6.6.6.6 is in there as well with a next hop of 3.3.3.3 (which is the loopback of R3 – showing that it is going over the MPLS and R1 is not in the picture)

The same should be true on R3

```
R3#sh ip bgp vpnv4 vrf RED

BGP table version is 9, local router ID is 3.3.3.3

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,

r RIB-failure, S Stale

Origin codes: i - IGP, e - EGP, ? - incomplete

Network Next Hop Metric LocPrf Weight Path Route Distinguisher: 4:4 (default for vrf RED)
  *>i4.4.4.4/32 1.1.1.1 11 100 0 ?

*> 6.6.6.6/32 223.168.2.6 11 32768 ?

*>i223.168.1.0 1.1.1.1 0 100 0 ?
```

```
*>223.168.2.00.0.0.0032768?
```

Which it is! 6.6.6.6 is now in the BGP table in VRF RED on R3 with a next

hop of 223.168.2.6 (R6) and also 4.4.4 is in there as well with a next hop of 1.1.1.1 (which is the loopback of R1 – showing that it is going over the MPLS and R2 is not in the picture)
The final step is to get the routes that have come across the MPLS back into OSPF and then we can get end to end connectivity

If all has worked we should be now able to ping 6.6.6.6 from R4

```
R1
routerospf2redistributebgp1subnets

R3

routerospf2redistributebgp1subnets
```

Before we do let’s see what the routing table looks like on R4

```
R4#shiproute

4.0.0.0/32issubnetted,1subnets

C

   4.4.4.4isdirectlyconnected,Loopba

   ck06.0.0.0/32issubnetted,1subnets

O IA6.6.6.6[110/21] via 223.168.1.1,00:01:31,
FastEthernet0/0
```

```
O E2223.168.2.0/24[110/1]via223.168.1.1,00:01:31,
FastEthernet0/0
```

Great we have 6.6.6.6 in there

Also check the routing table on R6

```
R6#shiproute



4.0.0.0/32issubnetted,1subnets

O  IA4.4.4.4[110/21]via225.168.2.1,00:01:22,
FastEthernet0/0

6.0.0.0/32is subnetted, 1 subnets

C

6.6.6.6isdirectlyconnected,Loopback0OIA223.168.1.0/24[110

/11]via
223.168.2.1,00:01:22,FastEthernet0/0

C223.168.2.0/24isdirectlyconnected,FastEthernet0/0
```

Brilliant we have 4.4.4.4 in there so we should be able to ping across the MPLS

```
R4#ping6.6.6.6
Typeescapesequencetoabort.

Sending5,100-byteICMPEchosto6.6.6.6,timeoutis2seconds:

!!!!!

Success rate is 100 percent (5/5), round-
tripmin/avg/max=40/48/52ms
```

Which we can – to prove this is going over the MPLS and be label switched and not routed, lets do a trace

```
R4#trace6.6.6.6
```

```
Type escape sequence to

abort.Tracingtherouteto6.6.6.6



223.168.1.120msec8msec8msec

 210.0.0.2[MPLS:Labels17/20Exp0]36msec40msec
36 msec

 223.168.2.1[MPLS:Label20Exp0]16msec40msec16msec

 223.168.2.644msec40msec56msecR4#
```