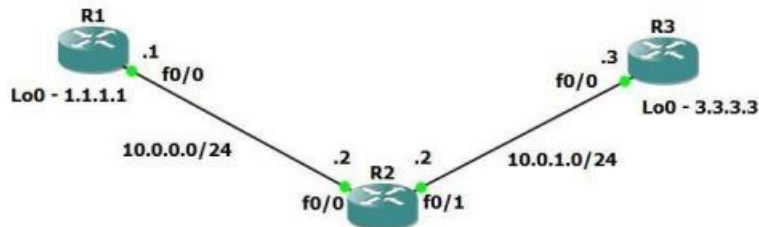


Practical No 8

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
ipospflarea0
intf0/0
ipadd10.0.0.1255.255.255.0
no shut
ipospflarea0

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 this we need to see if we can ping between the loopbacks of R1 and R3

```
R1#ping3.3.3.3source100

Typeescape sequence to abort.

Sending5,100-byteICMPEcho to3.3.3.3,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 into 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 from console
```

```
*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;DownstreamUptime:00:07:46

LDPdiscoverysources:
  FastEthernet0/0,SrcIPAddr:10.0.0.1AddressesboundtopeerLDPIIdent:
    10.0.0.1      1.1.1.1

PeerLDPIIdent:3.3.3.3;LocalLDPIIdent2.2.2.2;TCPconnection:3.3.3.3.22155-2.2.2.2.646

State:Oper;Msgssent/rcvd:12/11;DownstreamUptime:00:03:30

LDPdiscoverysources:
  FastEthernet0/1,SrcIPAddr:10.0.1.3AddressesboundtopeerLDPIIdent:
    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

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
bgp vpnv4 peering to R3 - looking at
the BGP table you can see it says 0 this is because we have not got any routes
in table. We are now going to add two more routers to the topology. These
BGP table version is 1, main routing table version 1 will then create a VRF on
each router and put the interfaces connected to each site router into that VRF.

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
ip add 4.4.4.4 255.255.255.255

ip ospf 2 area
2 int f0/0
```

```
ipadd192.168.1.1255.255.255.0

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
```


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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/lipvrfforwardingRE
  D
  ipaddress223.168.1.1255.255.255.0
  duplexautospeed
  auto
end
```

Now we can start to look into 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#sh ip route vrf red
%IP routing table red does not exist

```

NOTE: The VRF name is case sensitive!

```

R1#sh ip route vrf RED

RoutingTable:RED

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

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

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

```

```

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#shroutevrfRED

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[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

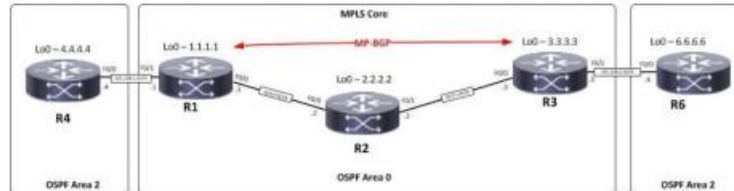
Codes:C-connected,S-static,R-RIP,M-mobile,B
-BGP
Gatewayoflastresortisnotset
```

```

6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/11] via 223.168.2.6, 00:02:44,
FastEthernet0/1
C       223.168.2.0/24 is directly connected,
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#showroute
4.0.0.0/32 is subnetted, 1 subnets
C 4.4.4.4 is directly connected, Loopback0

```



```
C223.168.1.0/24 is directly connected, 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#sh ip route

1.0.0.0/32 is subnetted, 1 subnets
C1.1.1.1 is directly connected, Loopback0
2.0.0.0/32 is subnetted, 1 subnets
O 2.2.2.2 [110/11] via 10.0.0.2, 00:01:04, FastEthernet0/0
3.0.0.0/32 is subnetted, 1 subnets
O 3.3.3.3 [110/21] via 10.0.0.2, 00:00:54, FastEthernet0/0
10.0.0.0/24 is subnetted, 2 subnets
C10.0.0.0 is directly connected, FastEthernet0/0
O10.0.1.0 [110/20] via 10.0.0.2, 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#sh ip route vrf RED
Routing Table: RED
4.0.0.0/32 is subnetted, 1 subnets
```

```
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#sh ip bgp vpnv4 vrf RED  
  
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 ?			
*> 6.6.6.6/32 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)			
*> 4.4.4.4/32 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
routerospf2redistributebgplsbnets
R3
routerospf2redistributebgplsbnets
```

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

```
R4#shroute
4 0.0.0/32isubnetted,1subnets
C
  4.4.4isdirectlyconnected,Loopba
ck06.0.0.0/32isubnetted,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,Loopback00IA223.168.1.0/24(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
Typeescape sequencetoabort.

Sending5,100-byteICMPEchoesto6.6.6.6,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:Label17/20Exp0]36msec40msec
36 msec

223.168.2.1[MPLS:Label20Exp0]16msec40msec16msec

223.168.2.644msec40msec56msecR4#
```