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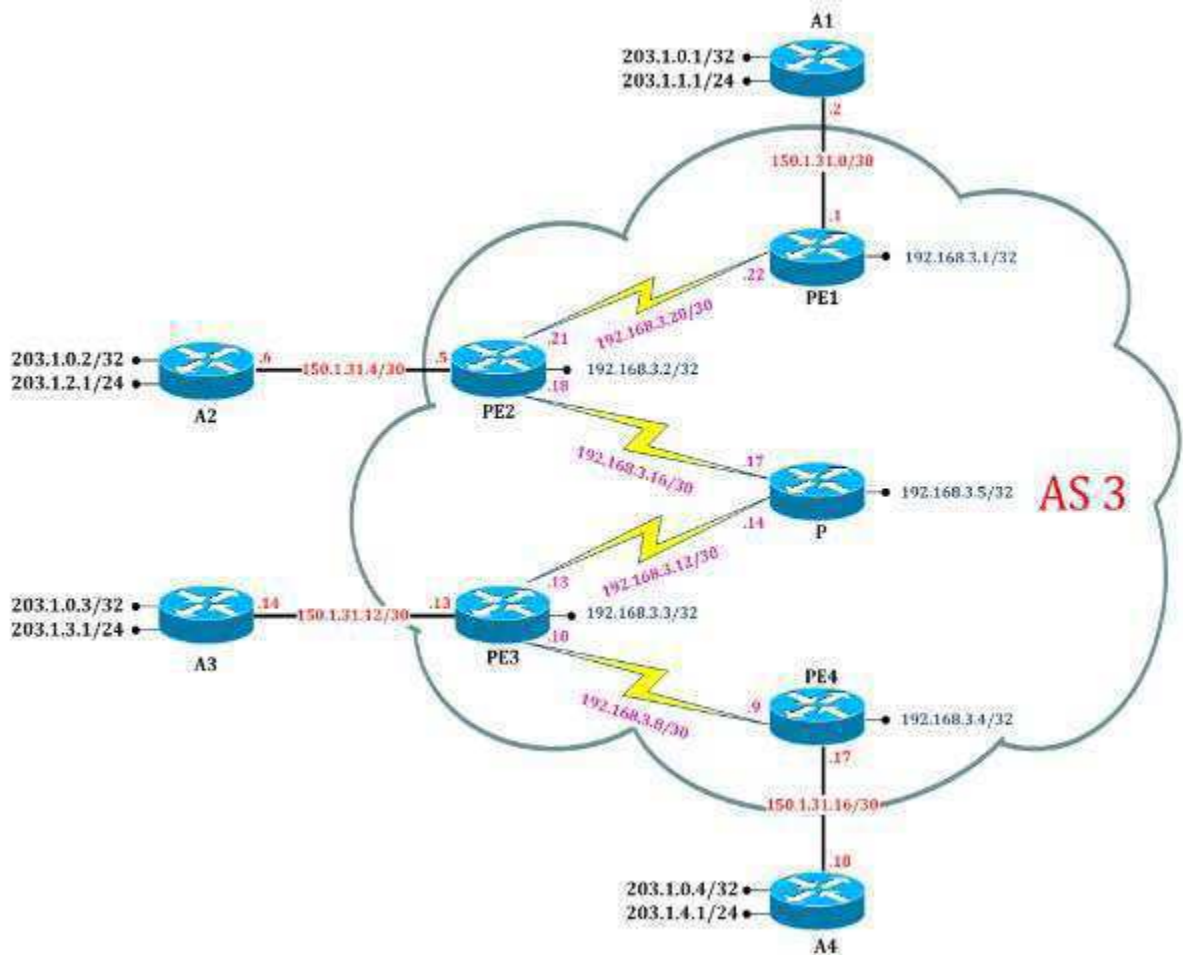
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# Layer3 VPN with OSPF Protocol between CE-PE

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IOS used: c7200-p-mz.120-32.S.bin



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## Task 1: BASIC OSPF MPLS and BGP Setup

Configure OSPF, MPLS, BGP on all PE-routers and P-router

Step 1. Configure following on respective P and PE routers:

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```

PE1 Router Initial Config:
hostname PE1
!
ip cef
mpls label protocol ldp
mpls ldp router-id Loopback0
!
interface Loopback0
ip address 192.168.3.1 255.255.255.255
!
interface FastEthernet0/0
description *** Link to A1 ***
ip address 150.1.31.1 255.255.255.252
no shutdown
!
interface Serial2/0
description *** Link to PE2 ***
ip address 192.168.3.22 255.255.255.252
mpls ip
no shutdown
!
router ospf 1
Network 192.168.3.0 0.0.0.255 area 0
!
router bgp 3
no synchronization
no auto-summary
neighbor 192.168.3.2 remote-as 3
neighbor 192.168.3.2 update-source
Loopback0
network 192.168.3.1 mask 255.255.255.255
!
end

```

```

PE2 Router Initial Config:
hostname PE2
!
ip cef
mpls label protocol ldp
mpls ldp router-id Loopback0
!
interface Loopback0
ip address 192.168.3.2 255.255.255.255
!
interface FastEthernet0/0
description *** Link to A2 ***
ip address 150.1.31.5 255.255.255.252
no shutdown
!
interface Serial2/0
description *** Link to PE1 ***
ip address 192.168.3.21 255.255.255.252
mpls ip
no shutdown
!
interface Serial2/1
description *** Link to P ***
Ip address 192.168.3.18 255.255.255.252
clock rate 64000
mpls ip
no shutdown
!
router ospf 1
network 192.168.3.0 0.0.0.255 area 0
!
router bgp 3
no synchronization
no auto-summary
network 192.168.3.2 mask 255.255.255.255
neighbor 192.168.3.3 remote-as 3
neighbor 192.168.3.3 update-source
Loopback0
neighbor 192.168.3.1 remote-as 3
neighbor 192.168.3.1 update-source
Loopback0
neighbor 192.168.3.1 route-reflector-client
!
end

```

PE3 Router Initial Config:

```
hostname PE3
!
ip cef
mpls label protocol ldp
mpls ldp router-id Loopback0
!
interface Loopback0
ip address 192.168.3.3 255.255.255.255
!
interface FastEthernet0/0
description *** Link to A3 ***
ip address 150.1.31.13 255.255.255.252
no shutdown
!
interface Serial2/1
description *** Link to PE4 ***
ip address 192.168.3.10 255.255.255.252
mpls ip
no shutdown
!
interface Serial2/0
description *** Link to P ***
ip address 192.168.3.13 255.255.255.252
mpls ip
no shutdown
!
router ospf 1
network 192.168.3.0 0.0.0.255 area 0
!
router bgp 3
no synchronization
no auto-summary
network 192.168.3.3 mask 255.255.255.255
neighbor 192.168.3.2 remote-as 3
neighbor 192.168.3.2 update-source Lo0
neighbor 192.168.3.4 remote-as 3
neighbor 192.168.3.4 update-source Lo0
neighbor 192.168.3.4 route-reflector-client
!
end
```

PE4 Router Initial Config:

```
hostname PE4
!
ip cef
mpls label protocol ldp
mpls ldp router-id Loopback0
!
interface Loopback0
ip address 192.168.3.4 255.255.255.255
!
interface FastEthernet0/0
description *** Link to A4 ***
ip address 150.1.31.17 255.255.255.252
no shutdown
!
interface Serial2/1
description *** Link to PE3 ***
ip address 192.168.3.9 255.255.255.252
clock rate 64000
mpls ip
no shutdown
!
Router ospf 1
Network 192.168.3.0 0.0.0.255 area 0
!
router bgp 3
no synchronization
no auto-summary
neighbor 192.168.3.3 remote-as 3
neighbor 192.168.3.3 update-source lo0
network 192.168.3.4 mask 255.255.255.255
!
end
```

**P Router Config:**

```
hostname P
!
ip cef
mpls label protocol ldp
mpls ldp router-id Loopback0
!
interface Loopback0
ip address 192.168.3.5 255.255.255.255
!
interface Serial2/0
description *** Link to PE3 ***
ip address 192.168.3.14 255.255.255.252
clock rate 64000
mpls ip
no shutdown
!
interface Serial2/1
description *** Link to PE2 ***
ip address 192.168.3.17 255.255.255.252
clock rate 64000
mpls ip
no shutdown
!
router ospf 1
network 192.168.3.0 0.0.0.255 area 0
!
end
```

**Verification:**

```
PE1#sh ip route
 150.1.0.0/30 is subnetted, 1 subnets
C    150.1.31.0 is directly connected, FastEthernet0/0
 192.168.3.0/24 is variably subnetted, 9 subnets, 2 masks
O    192.168.3.8/30 [110/256] via 192.168.3.21, 00:02:51, Serial1/0
O    192.168.3.12/30 [110/192] via 192.168.3.21, 00:02:51, Serial1/0
O    192.168.3.3/32 [110/193] via 192.168.3.21, 00:02:51, Serial1/0
O    192.168.3.2/32 [110/65] via 192.168.3.21, 00:02:51, Serial1/0
C    192.168.3.1/32 is directly connected, Loopback0
O    192.168.3.5/32 [110/129] via 192.168.3.21, 00:02:51, Serial1/0
O    192.168.3.4/32 [110/257] via 192.168.3.21, 00:02:51, Serial1/0
O    192.168.3.16/30 [110/128] via 192.168.3.21, 00:02:51, Serial1/0
C    192.168.3.20/30 is directly connected, Serial1/0
PE4#sh ip bgp
BGP table version is 5, local router ID is 192.168.3.4
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               S Stale
```

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

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i192.168.3.1/32	192.168.3.1	0	100	0	i
*>i192.168.3.2/32	192.168.3.2	0	100	0	i
*>i192.168.3.3/32	192.168.3.3	0	100	0	i
*> 192.168.3.4/32	0.0.0.0	0		32768	i

**A1 Router Initial Config:**

```
hostname A1
!
interface Loopback0
ip address 203.1.0.1 255.255.255.255
!
interface Loopback1
ip address 203.1.1.1 255.255.255.0
!
interface FastEthernet0/0
description *** Link to PE1 ***
ip address 150.1.31.2 255.255.255.252
no shutdown
!
end
```

**A2 Router Initial Config:**

```
hostname A2
!
interface Loopback0
ip address 203.1.0.2 255.255.255.255
!
interface Loopback1
ip address 203.1.2.1 255.255.255.0
!
interface FastEthernet0/0
description *** Link to PE2 ***
ip address 150.1.31.6 255.255.255.252
no shutdown
!
end
```

**A3 Router Initial Config:**

```
hostname A3
!
interface Loopback0
ip address 203.1.0.3 255.255.255.255
!
interface Loopback1
ip address 203.1.3.1 255.255.255.0
!
interface FastEthernet0/0
description *** Link to PE3 ***
ip address 150.1.31.14 255.255.255.252
no shutdown
!
end
```

**A4 Router Initial Config:**

```
hostname A4
!
interface Loopback0
ip address 203.1.0.4 255.255.255.255
!
interface Loopback1
ip address 203.1.4.1 255.255.255.0
!
interface FastEthernet0/0
description *** Link to PE4 ***
ip address 150.1.31.18 255.255.255.252
no shutdown
!
end
```

## **Task 2: Configure Multiprotocol BGP** Configure multi-protocol BGP between provider-edge (PE) routers.

**Step 1** Activate VPNv4 BGP sessions between all PE routers in your Service Provider backbone.

**Step 2** On the PE routers acting as route reflectors, configure the route-reflector clients under the VPNv4 address family.

The following commands need to be entered on the PE-routers:

### **PE1 (config) #**

```
router bgp 3
address-family vpnv4
neighbor 192.168.3.2 activate
no auto-summary
```

### **PE2 (config) #**

```
router bgp 3
address-family vpnv4
neighbor 192.168.3.1 activate
neighbor 192.168.3.1 route-reflector-client
neighbor 192.168.3.3 activate
no auto-summary
```

### **PE3 (config) #**

```
router bgp 3
address-family vpnv4
neighbor 192.168.3.2 activate
neighbor 192.168.3.4 activate
neighbor 192.168.3.4 route-reflector-client
no auto-summary
```

### **PE4 (config) #**

```
router bgp 3
address-family vpnv4
neighbor 192.168.3.3 activate
no auto-summary
```

## **Task 3: Configure VRF Tables**

The following commands need to be entered on PE router:

### **PE1 (config) #**

```
ip vrf vpna
rd 3:10
route-target both 3:10
!
interface FastEthernet0/0
description *** Link to A1 ***
ip vrf forwarding vpna
ip address 150.1.31.1 255.255.255.252
```

Note: "ip vrf forwarding vpna" will remove IP address, so IP address need to be reconfigured

### **PE2 (config) #**

```
ip vrf vpna
rd 3:10
route-target both 3:10
```

```

!
interface FastEthernet0/0
description *** Link to A2 ***
ip vrf forwarding vpna
ip address 150.1.31.5 255.255.255.252

PE3(config)#
ip vrf vpna
rd 3:10
route-target both 3:10
!
interface fastEthernet0/0
description *** Link to A3 ***
ip vrf forwarding vpna
ip address 150.1.31.13 255.255.255.252

PE4(config)#
ip vrf vpna
rd 3:10
route-target both 3:10
!
interface FastEthernet0/0
description *** Link to A4 ***
ip vrf forwarding vpna
ip address 150.1.31.17 255.255.255.252

```

**Verification:**

```

PE3#show ip vrf
Name      Default RD   Interfaces
vpna      3:10        FastEthernet0/0

```

**Task 3: Configure PE-CE Routing** Configure OSPF Routing Protocol between PE and CE router.

**Step 1** Configure OSPF on all PE routers to learn routes from respective CE routers.

**Step 2** Configure IPv4 BGP instance for customer VRF VPNA on PE routers

**Step 3** Redistribute between OSPF and BGP on PE routers

The following commands need to be entered on all PE router:

```

router ospf 3 vrf vpna
log-adjacency-changes
redistribute bgp 3 subnets
network 150.1.0.0 0.0.255.255 area 0
!
router bgp 3
address-family ipv4 vrf vpna
redistribute ospf 3 vrf vpna

```

**Step 4:** Configure OSPF on all CE routers

The following commands need to be entered on all CE router:

```

(config)#
router ospf 3
log-adjacency-changes
network 0.0.0.0 255.255.255.255 area 0

```

**Verification:**

**Step 5** To check status of link between PE and CE use **VRF Ping**. Normal ping will not work as your PE – CE link



and interface is not part of global routing table, it is now part of VRF table.

A sample VRF Ping printout is shown below:

```
PE1#ping 150.1.31.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 150.1.31.2, timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
```

```
PE1#ping vrf vpna 150.1.31.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 150.1.31.2, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/47/68 ms
```

**Step 6** A sample VRF Telnet printout is shown below:

```
PE1#telnet 150.1.31.2 /vrf vpna
Trying 150.1.31.2 ... Open
User Access Verification
Password:
```

**Step 7** To check VRF table for VPNA give following command on PE1 router

```
PE1#show ip route vrf vpna
Routing Table: vpna
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       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
```

Gateway of last resort is not set

```

   203.1.4.0/32 is subnetted, 1 subnets
B       203.1.4.1 [200/2] via 192.168.3.4, 00:13:43
   203.1.3.0/32 is subnetted, 1 subnets
B       203.1.3.1 [200/2] via 192.168.3.3, 00:13:58
   203.1.2.0/32 is subnetted, 1 subnets
B       203.1.2.1 [200/2] via 192.168.3.2, 00:13:58
   203.1.1.0/32 is subnetted, 1 subnets
O       203.1.1.1 [110/2] via 150.1.31.2, 00:14:16, FastEthernet0/0
   203.1.0.0/32 is subnetted, 4 subnets
B       203.1.0.2 [200/2] via 192.168.3.2, 00:13:58
B       203.1.0.3 [200/2] via 192.168.3.3, 00:13:58
O       203.1.0.1 [110/2] via 150.1.31.2, 00:14:18, FastEthernet0/0
B       203.1.0.4 [200/2] via 192.168.3.4, 00:13:45
   150.1.0.0/30 is subnetted, 5 subnets
B       150.1.31.8 [200/0] via 192.168.3.3, 00:13:45
B       150.1.31.12 [200/0] via 192.168.3.3, 00:13:45
C       150.1.31.0 is directly connected, FastEthernet0/0
B       150.1.31.4 [200/0] via 192.168.3.2, 00:14:01
B       150.1.31.16 [200/0] via 192.168.3.4, 00:13:45
PE1#
```

**Step 8** To check BGP table for VRF VPNA give following command on PE1 router

```
PE1#show ip bgp vpnv4 vrf vpna
BGP table version is 25, local router ID is 192.168.3.1
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: 3:10 (default for vrf vpna)
*> 150.1.31.0/30    0.0.0.0          0           32768 ?
*>i150.1.31.4/30    192.168.3.2      0          100        0 ?
*>i150.1.31.8/30    192.168.3.3      0          100        0 ?
*>i150.1.31.12/30   192.168.3.3      0          100        0 ?
*>i150.1.31.16/30   192.168.3.4      0          100        0 ?
*> 203.1.0.1/32     150.1.31.2        2           32768 ?
*>i203.1.0.2/32     192.168.3.2      2          100        0 ?
*>i203.1.0.3/32     192.168.3.3      2          100        0 ?
*>i203.1.0.4/32     192.168.3.4      2          100        0 ?
*> 203.1.1.1/32     150.1.31.2        2           32768 ?
*>i203.1.2.1/32     192.168.3.2      2          100        0 ?
*>i203.1.3.1/32     192.168.3.3      2          100        0 ?
*>i203.1.4.1/32     192.168.3.4      2          100        0 ?
PE1#

```

**Step 9** To check CE Routing table give following command on A1 router

**A1#show ip route**

```

Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       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

```

Gateway of last resort is not set

```

      203.1.4.0/32 is subnetted, 1 subnets
O IA   203.1.4.1 [110/3] via 150.1.31.1, 00:16:27, FastEthernet0/0
      203.1.3.0/32 is subnetted, 1 subnets
O IA   203.1.3.1 [110/3] via 150.1.31.1, 00:16:27, FastEthernet0/0
      203.1.2.0/32 is subnetted, 1 subnets
O IA   203.1.2.1 [110/3] via 150.1.31.1, 00:16:27, FastEthernet0/0
C      203.1.1.0/24 is directly connected, Loopback1
      203.1.0.0/32 is subnetted, 4 subnets
O IA   203.1.0.2 [110/3] via 150.1.31.1, 00:16:27, FastEthernet0/0
O IA   203.1.0.3 [110/3] via 150.1.31.1, 00:16:27, FastEthernet0/0
C      203.1.0.1 is directly connected, Loopback0
O IA   203.1.0.4 [110/3] via 150.1.31.1, 00:16:27, FastEthernet0/0
      150.1.0.0/30 is subnetted, 5 subnets
O IA   150.1.31.8 [110/2] via 150.1.31.1, 00:16:34, FastEthernet0/0
O IA   150.1.31.12 [110/2] via 150.1.31.1, 00:16:34, FastEthernet0/0
C      150.1.31.0 is directly connected, FastEthernet0/0
O IA   150.1.31.4 [110/2] via 150.1.31.1, 00:16:34, FastEthernet0/0
O IA   150.1.31.16 [110/2] via 150.1.31.1, 00:16:34, FastEthernet0/0
A1#

```

**Step 10** To check CE Routing table give following command on A4 router

**A4#show ip route**

```

Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       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

```

Gateway of last resort is not set

```
C    203.1.4.0/24 is directly connected, Loopback1
    203.1.3.0/32 is subnetted, 1 subnets
O IA  203.1.3.1 [110/3] via 150.1.31.17, 00:18:33, FastEthernet0/0
    203.1.2.0/32 is subnetted, 1 subnets
O IA  203.1.2.1 [110/3] via 150.1.31.17, 00:18:33, FastEthernet0/0
    203.1.1.0/32 is subnetted, 1 subnets
O IA  203.1.1.1 [110/3] via 150.1.31.17, 00:18:33, FastEthernet0/0
    203.1.0.0/32 is subnetted, 4 subnets
O IA  203.1.0.2 [110/3] via 150.1.31.17, 00:18:33, FastEthernet0/0
O IA  203.1.0.3 [110/3] via 150.1.31.17, 00:18:33, FastEthernet0/0
O IA  203.1.0.1 [110/3] via 150.1.31.17, 00:18:33, FastEthernet0/0
C    203.1.0.4 is directly connected, Loopback0
    150.1.0.0/30 is subnetted, 5 subnets
O IA  150.1.31.8 [110/2] via 150.1.31.17, 00:18:34, FastEthernet0/0
O IA  150.1.31.12 [110/2] via 150.1.31.17, 00:18:34, FastEthernet0/0
O IA  150.1.31.0 [110/2] via 150.1.31.17, 00:18:34, FastEthernet0/0
O IA  150.1.31.4 [110/2] via 150.1.31.17, 00:18:34, FastEthernet0/0
C    150.1.31.16 is directly connected, FastEthernet0/0
```

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