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Complex MPLS VPN with OSPF on CE-PE Routers

Disclaimer

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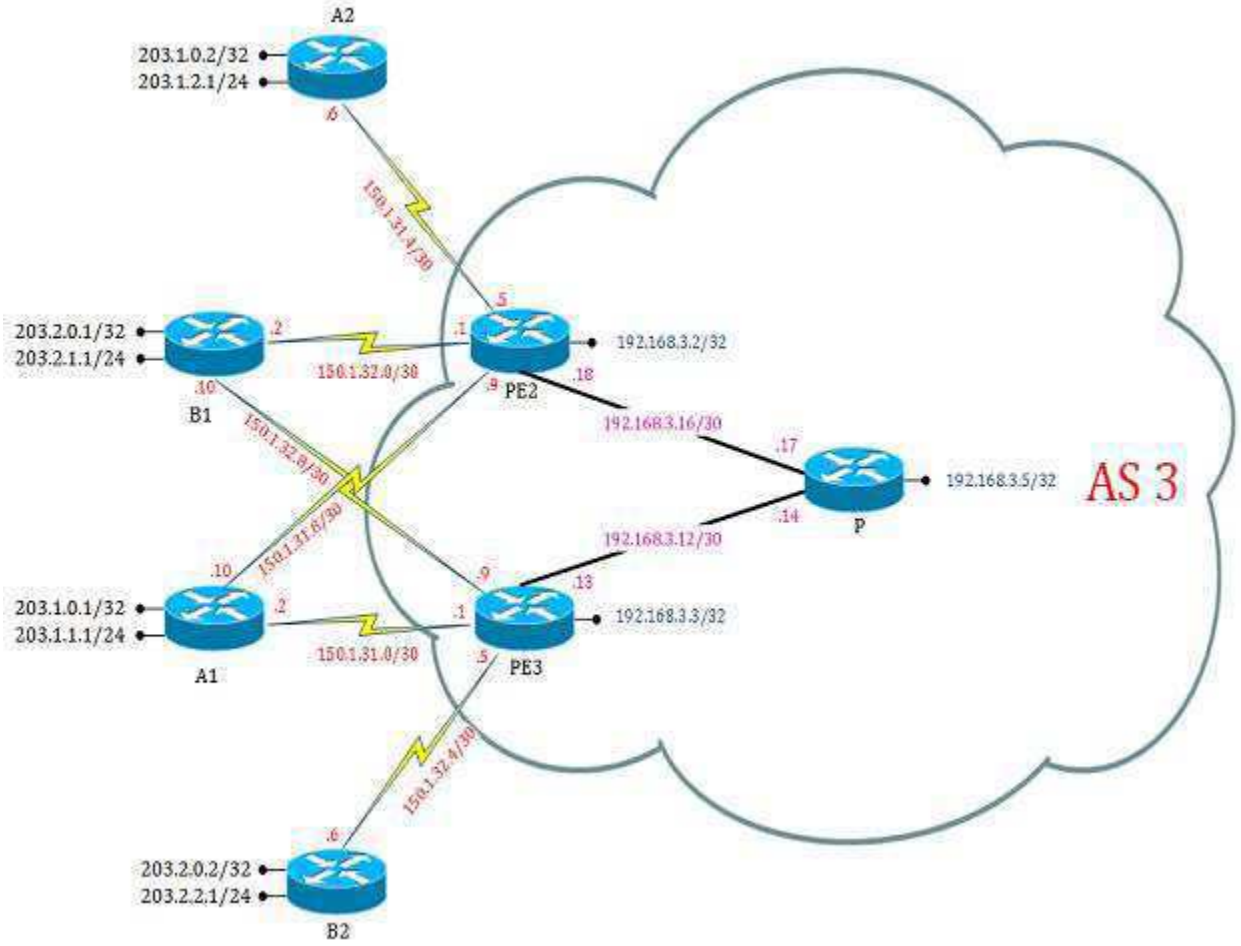
IOS used: c7200-p-mz.120-32.S.bin



Task 1: BASIC OSPF and MPLS setup

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

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

PE2 Router Initial Config:

```
hostname PE2
!
ip cef
mpls label protocol ldp
no tag-switching ip propagate-ttl
!
interface Loopback0
ip address 192.168.3.2 255.255.255.255
!
interface FastEthernet1/0
description **link_to_P**
ip address 192.168.3.18 255.255.255.252
tag-switching ip
no shutdown
!
interface Serial2/0
description **link_to_A2**
ip address 150.1.31.5 255.255.255.252
no shutdown
!
interface Serial2/1
description **link_to_B1**
ip address 150.1.32.1 255.255.255.252
no shutdown
!
interface Serial2/2
description **link_to_A1**
ip address 150.1.31.9 255.255.255.252
no shutdown
!
router ospf 64
log-adjacency-changes
network 192.168.0.0 0.0.255.255 area 0
!
end
```

PE3 Router Initial Config:

```
hostname PE3
!
ip cef
mpls label protocol ldp
no tag-switching ip propagate-ttl
!
interface Loopback0
ip address 192.168.3.3 255.255.255.255
!
interface FastEthernet0/0
description **link_to_P**
ip address 192.168.3.13 255.255.255.252
tag-switching ip
no shutdown
!
interface Serial2/0
description **link_to_B1**
ip address 150.1.32.9 255.255.255.252
no shutdown
!
interface Serial2/1
description **link_to_A1**
ip address 150.1.31.1 255.255.255.252
no shutdown
!
interface Serial2/2
description **link_to_B2**
ip address 150.1.32.5 255.255.255.252
no shutdown
!
router ospf 64
log-adjacency-changes
network 192.168.0.0 0.0.255.255 area 0
!
end
```

P Router Config:

```
hostname P
!
ip cef
mpls label protocol ldp
```

```
no tag-switching ip propagate-ttl
!
interface Loopback0
ip address 192.168.3.5 255.255.255.255
!
interface FastEthernet0/0
description **link_to_PE3**
ip address 192.168.3.14 255.255.255.252
tag-switching ip
no shutdown
!
interface FastEthernet1/0
description **link_to_PE2**
ip address 192.168.3.17 255.255.255.252
tag-switching ip
no shutdown
!
router ospf 64
log-adjacency-changes
network 192.168.0.0 0.0.255.255 area 0
!
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 Serial2/0
ip address 150.1.31.6 255.255.255.252
clock rate 64000
no shutdown
!
end
```

B1 Router Initial Config:

```
hostname B1
!
interface Loopback0
ip address 203.2.0.1 255.255.255.255
!
interface Loopback1
ip address 203.2.1.1 255.255.255.0
!
interface Serial2/0
ip address 150.1.32.10 255.255.255.252
clock rate 64000
no shutdown
!
interface Serial2/1
ip address 150.1.32.2 255.255.255.252
clock rate 64000
no shutdown
!
```

	end

A1 Router Initial Config:

```
hostname A1
!
interface Loopback0
ip address 203.1.1.1 255.255.255.0
!
interface Loopback1
ip address 203.1.0.1 255.255.255.255
!
interface Serial2/1
ip address 150.1.31.2 255.255.255.252
clock rate 64000
no shutdown
!
interface Serial2/2
ip address 150.1.31.10 255.255.255.252
clock rate 64000
no shutdown
!
end
```

B2 Router Initial Config:

```
hostname B2
!
interface Loopback0
ip address 203.2.0.2 255.255.255.255
!
interface Loopback1
ip address 203.2.2.1 255.255.255.0
!
interface Serial2/2
ip address 150.1.32.6 255.255.255.252
clock rate 64000
no shutdown
!
end
```

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

Step 1 Enable BGP sessions on all PE routers in your Service Provider backbone.

Step 2 Activate VPNv4 BGP sessions between all PE routers in your Service Provider backbone.

Configure the following on PE2 router:

PE2(config)#

```
router bgp 3
 neighbor 192.168.3.3 remote-as 3
 neighbor 192.168.3.3 update-source Loopback0
 !
 address-family ipv4
 no auto-summary
 no synchronization
 neighbor 192.168.3.3 activate
 network 192.168.3.2 mask 255.255.255.255
```

```
 exit-address-family
 !
 address-family vpnv4
 neighbor 192.168.3.3 activate
 neighbor 192.168.3.3 send-community extended
 exit-address-family
```

Configure following on PE3 router:

PE3(config)#

```
router bgp 3
 bgp log-neighbor-changes
 neighbor 192.168.3.2 remote-as 3
 neighbor 192.168.3.2 update-source Loopback0
 !
 address-family ipv4
 no auto-summary
 no synchronization
 neighbor 192.168.3.2 activate
 network 192.168.3.3 mask 255.255.255.255
 exit-address-family
 !
 address-family vpnv4
 neighbor 192.168.3.2 activate
 neighbor 192.168.3.2 send-community extended
 exit-address-family
```

Task 3: Design your VPN Solution Create the virtual private network (VRF) on provider edge (PE2):**PE2(config)#**

```
ip vrf a
 rd 3:1
 route-target both 3:1
!
ip vrf a_central
 rd 3:11
```

```
 route-target both 3:1
 route-target both 3:30
!
ip vrf b_central
 rd 3:21
 route-target both 3:2
 route-target both 3:30
```

Create the virtual private network (VRF) on provider edge (PE3):

PE3(config)#

```
ip vrf a_central
 rd 3:11
 route-target both 3:1
 route-target both 3:30
!
ip vrf b
 rd 3:2
 route-target both 3:2
!
ip vrf b_central
 rd 3:21
 route-target both 3:2
 route-target both 3:30
```

Task 4: Create VRFs for A2, B1, A1 and B2 Attach the provider edge-to-customer edge (PE-CE) link to the newly created VRFs with the following commands on PE2:**PE2(config)#**

```
interface Serial2/0
 ip vrf forwarding a
 ip address 150.1.31.5 255.255.255.252
!
interface Serial2/1
 ip vrf forwarding b_central
 ip address 150.1.32.1 255.255.255.252
!
```

```
interface Serial2/2
 ip vrf forwarding a_central
 ip address 150.1.31.9 255.255.255.252
```

Note: “ip vrf forwarding name” command removes the IP address from interface, so IP address need to be re-configured.

Attach the PE-CE link to the newly created VRFs with the following commands on PE3:

PE3(config)#

```
interface Serial2/0
 ip vrf forwarding b_central
 ip address 150.1.32.9 255.255.255.252
!
interface Serial2/1
 ip vrf forwarding a_central
 ip address 150.1.31.1 255.255.255.252
!
interface Serial2/2
 ip vrf forwarding b
 ip address 150.1.32.5 255.255.255.252
```

Task 5: Configure OSPF on CE Routers The following commands need to be entered on the A2 router:

A2(config)#

```
router ospf 3
 network 0.0.0.0 255.255.255.255 area 0
```

The following commands need to be entered on the B1 router:

B1(config)#

```
router ospf 3
 network 0.0.0.0 255.255.255.255 area 0
```

The following commands need to be entered on the A1 router:

A1(config)#

```
router ospf 3
 network 0.0.0.0 255.255.255.255 area 0
```

The following commands need to be entered on the B2 router:

B2(config)#

```
router ospf 3
 network 0.0.0.0 255.255.255.255 area 0
```

Task 6: Configure new VRFs for A2, B1, A1, B2 on PE routers The following commands need to be entered on PE2:**PE2(config)#**

```
router ospf 3 vrf a_central
 log-adjacency-changes
 redistribute bgp 3 subnets
 network 150.1.0.0 0.0.255.255 area 0
!
router ospf 4 vrf b_central
 log-adjacency-changes
 redistribute bgp 3 subnets
 network 150.1.0.0 0.0.255.255 area 0
!
router ospf 7 vrf a
 log-adjacency-changes
 redistribute bgp 3 subnets
 network 150.1.0.0 0.0.255.255 area 0
```

The following commands need to be entered on PE3 router:

PE3(config)#

```
router ospf 4 vrf b_central
 log-adjacency-changes
 redistribute bgp 3 subnets
 network 150.1.0.0 0.0.255.255 area 0
!
router ospf 3 vrf a_central
 log-adjacency-changes
 redistribute bgp 3 subnets
 network 150.1.0.0 0.0.255.255 area 0
!
router ospf 6 vrf b
 log-adjacency-changes
 redistribute bgp 3 subnets
 network 150.1.0.0 0.0.255.255 area 0
```

Task 7: Redistribute vrf – ospf in BGP Routing Protocol The following commands need to be entered on PE2:**PE2(config)#**

```
router bgp 3
 bgp log-neighbor-changes
 neighbor 192.168.3.3 remote-as 3
 neighbor 192.168.3.3 update-source Loopback0
 !
 address-family ipv4 vrf b_central
 redistribute ospf 4 vrf b_central
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf a_central
 redistribute ospf 3 vrf a_central
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf a
 redistribute ospf 7 vrf a
 no synchronization
 exit-address-family
```

The following commands need to be entered on PE3 router:

PE3(config)#

```
router bgp 3
 bgp log-neighbor-changes
 neighbor 192.168.3.2 remote-as 3
 neighbor 192.168.3.2 update-source Loopback0
 !
address-family ipv4 vrf b_central
 redistribute ospf 4 vrf b_central
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf b
 redistribute ospf 6 vrf b
 no synchronization
```

```
exit-address-family
!
address-family ipv4 vrf a_central
redistribute ospf 3 vrf a_central
no synchronization
exit-address-family
```

Verification:Step 1: Verify the OSPF adjacency on A2, B1, A1, B2 and on PE2, PE3. Use the "show ip ospf neighbor" command. You should get a printout similar to the one below:**PE3#show ip ospf neighbor**

```
Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.3.5       1   FULL/DR         00:00:39    192.168.3.14    FastEthernet0/0
203.2.2.1         0   FULL/  -        00:00:35    150.1.32.6      Serial2/2
203.1.1.1         0   FULL/  -        00:00:35    150.1.31.2      Serial2/1
203.2.1.1         0   FULL/  -        00:00:35    150.1.32.10     Serial2/0
```

Step 2: Check the OSPF topology database on A1.

Use the "show ip ospf database" command. You should see router link states (resulting from OSPF connectivity between the PE and the CE router) and type-5 external link states.

A1#show ip ospf database

```
            OSPF Router with ID (203.1.1.1) (Process ID 3)


                Router Link States (Area 0)


Link ID         ADV Router      Age         Seq#       Checksum Link Count
150.1.31.1      150.1.31.1      253         0x80000002 0x5ABC   2
150.1.31.9      150.1.31.9      283         0x80000002 0xFAFB   2
203.1.1.1       203.1.1.1       253         0x80000003 0x3057   6


                Type-5 AS External Link States


Link ID         ADV Router      Age         Seq#       Checksum Tag
150.1.31.4      150.1.31.1      199         0x80000001 0x264A   3489660931
150.1.31.4      150.1.31.9      216         0x80000001 0xF572   3489660931
150.1.32.0      150.1.31.1      153         0x80000002 0xFA18   3489660931
```

```
150.1.32.0      150.1.31.9      216         0x80000001 0x1358   3489660931
150.1.32.8      150.1.31.1      153         0x80000002 0xF079   3489660931
150.1.32.8      150.1.31.9      216         0x80000001 0x7C87   3489660931
203.1.0.2       150.1.31.1      199         0x80000001 0xD058   3489660931
203.1.0.2       150.1.31.9      216         0x80000001 0xA080   3489660931
203.1.2.1       150.1.31.1      199         0x80000001 0xC463   3489660931
203.1.2.1       150.1.31.9      216         0x80000001 0x948B   3489660931
203.2.0.1       150.1.31.1      199         0x80000001 0xCE5A   3489660931
203.2.0.1       150.1.31.9      218         0x80000001 0x9E82   3489660931
203.2.1.1       150.1.31.1      200         0x80000001 0xC364   3489660931
203.2.1.1       150.1.31.9      218         0x80000001 0x938C   3489660931
```

Step 3: Inspect individual link-state advertisement (LSA) on the CE router

Use “show ip ospf database type prefix” command and verify the settings of the down bit.

A1#sh ip ospf database external 150.1.31.4

```
            OSPF Router with ID (203.1.1.1) (Process ID 3)


                Type-5 AS External Link States


  Routing Bit Set on this LSA
  LS age: 859
  Options: (No TOS-capability, DC)
  LS Type: AS External Link
  Link State ID: 150.1.31.4 (External Network Number )
  Advertising Router: 150.1.31.1
  LS Seq Number: 80000001
  Checksum: 0x264A
  Length: 36
  Network Mask: /30
        Metric Type: 2 (Larger than any link state path)
        TOS: 0
        Metric: 1
        Forward Address: 0.0.0.0
        External Route Tag: 3489660931
```

```
  Routing Bit Set on this LSA
  LS age: 877
  Options: (No TOS-capability, DC)
  LS Type: AS External Link
  Link State ID: 150.1.31.4 (External Network Number )
  Advertising Router: 150.1.31.9
  LS Seq Number: 80000001
  Checksum: 0xF572
  Length: 36
  Network Mask: /30
        Metric Type: 2 (Larger than any link state path)
        TOS: 0
        Metric: 1
        Forward Address: 0.0.0.0
        External Route Tag: 3489660931
```

Step 4: Inspect the BGP routes on the PE routersand identify the OSPF specific attributes and their meaning.

Use the "show ip bgp vpnv4 vrf name prefix" command, which will produce a printout similar to the one below:

PE3#show ip bgp vpnv4 vrf a_central 203.2.0.1

```
BGP routing table entry for 3:11:203.2.0.1/32, version 75
Paths: (1 available, best #1, table a_central)
  Not advertised to any peer
  Local, imported path from 3:21:203.2.0.1/32
    150.1.32.10 (via b_central) from 0.0.0.0 (192.168.3.3)
      Origin incomplete, metric 49, localpref 100, weight 32768, valid, external, best
      Extended Community: RT:3:2 RT:3:30 OSPF DOMAIN ID:0x0005:0x000000040200
        OSPF RT:0.0.0.0:2:0 OSPF ROUTER ID:150.1.32.9:512
```

Step 5: Inspect the OSPF routes on the PE routers and verify that the OSPF routes announced by other PE routers are not used (as indicated by the routing bit not set printout).

Step 6: Verify connectivity across VPN by using ping and trace commands on the CE routers and ping vrf and trace vrf commands on the PE routers.