L3 MPLS VPN 常用解决方案配置实例

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一 MPLS VPN MCE 配置实例

1 网络拓扑图
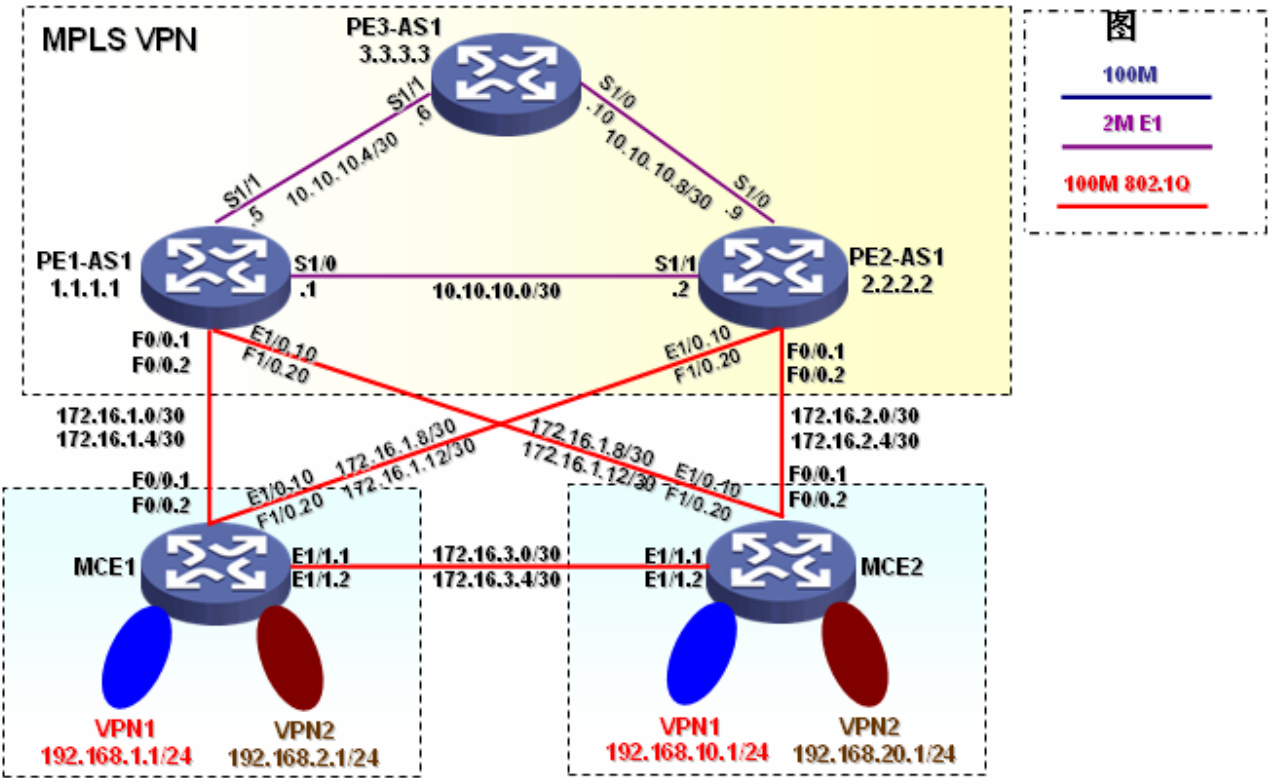
MCE实验

2 拓扑说明

1）分支机构1、分支机构2路由器为 MCE 设备，要求不同的 VPN 之间的用户不能互相访问，但跨设备的同一 VPN 之间用户能够互相访问；

2）为了确保节点接入的可靠性，接入设备 MCE 采用双归属的方式组网；

3 设备配置

3.1 PE1-AS1 设备配置

```
hostname PE1_AS1
!
no ip domain lookup
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex half
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding vpn1
 ip address 172.16.1.1 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip address 172.16.1.5 255.255.255.252
!
interface Serial1/0
 ip address 10.10.10.1 255.255.255.252
 mpls label protocol ldp
 tag-switching ip
 serial restart_delay 0
!
interface Serial1/1
```

```
 ip address 10.10.10.5 255.255.255.252
 mpls label protocol ldp
 tag-switching ip
 serial restart_delay 0
!
interface Ethernet2/0
 no ip address
 duplex half
!
interface Ethernet2/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 172.16.1.9 255.255.255.252
!
interface Ethernet2/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 172.16.1.13 255.255.255.252
!
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 redistribute static
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 10.10.10.0 0.0.0.255 area 0.0.0.0
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 172.16.1.0 0.0.0.3 area 0.0.0.0
 network 172.16.1.8 0.0.0.3 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 172.16.1.4 0.0.0.3 area 0.0.0.0
 network 172.16.1.12 0.0.0.3 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 neighbor 2.2.2.2 next-hop-self
 neighbor 3.3.3.3 remote-as 100
```

```
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 3.3.3.3 next-hop-self
 no auto-summary
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 next-hop-self
 neighbor 2.2.2.2 send-community extended
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 next-hop-self
 neighbor 3.3.3.3 send-community extended
 no auto-summary
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
!
!
end
```

3.2 PE2-AS1 设备配置

```
PE2_AS1#show running-config
Building configuration...

Current configuration : 3669 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE2_AS1
!
logging queue-limit 100
```

```
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
mpls ldp logging neighbor-changes
!
!
!
!
!
!
!
!
!
!
!
!
no voice hpi capture buffer
no voice hpi capture destination
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex half
```

```
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding vpn1
 ip address 172.16.2.1 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding vpn2
 ip address 172.16.2.5 255.255.255.252
!
interface Serial1/0
 ip address 10.10.10.9 255.255.255.252
 mpls label protocol ldp
 tag-switching ip
 serial restart_delay 0
!
interface Serial1/1
 ip address 10.10.10.2 255.255.255.252
 mpls label protocol ldp
 tag-switching ip
 serial restart_delay 0
!
interface Serial1/2
 no ip address
 shutdown
 serial restart_delay 0
!
interface Serial1/3
 no ip address
 shutdown
 serial restart_delay 0
!
interface Serial1/4
 no ip address
 shutdown
 serial restart_delay 0
!
interface Serial1/5
 no ip address
 shutdown
 serial restart_delay 0
!
interface Serial1/6
 no ip address
```

```
 shutdown
 serial restart_delay 0
!
interface Serial1/7
 no ip address
 shutdown
 serial restart_delay 0
!
interface Ethernet2/0
 no ip address
 duplex half
!
interface Ethernet2/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 172.16.2.9 255.255.255.252
!
interface Ethernet2/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 172.16.2.13 255.255.255.252
!
interface Ethernet2/1
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/2
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/3
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/4
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/5
 no ip address
 shutdown
```

```
 duplex half
!
interface Ethernet2/6
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/7
 no ip address
 shutdown
 duplex half
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 2.2.2.2 0.0.0.0 area 0.0.0.0
 network 10.10.10.0 0.0.0.255 area 0.0.0.0
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 172.16.2.0 0.0.0.3 area 0.0.0.0
 network 172.16.2.8 0.0.0.3 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 172.16.2.4 0.0.0.3 area 0.0.0.0
 network 172.16.2.12 0.0.0.3 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 no auto-summary
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community extended
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 send-community extended
 no auto-summary
```

```
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
!
ip classless
no ip http server
no ip http secure-server
!
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
dial-peer cor custom
!
!
!
!
gatekeeper
 shutdown
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
```

!
!
end

3.3 PE3-AS1 设备配置

PE3_AS1#show running
Building configuration...

Current configuration : 3419 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE3_AS1
!
logging queue-limit 100
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf internet
 rd 100:100
 route-target export 100:100
 route-target import 100:100
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
mpls ldp logging neighbor-changes
!
!

```
!
!
!
!
!
!
!
!
!
!
no voice hpi capture buffer
no voice hpi capture destination
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface FastEthernet0/0
 ip address 209.165.200.254 255.255.255.0
 ip nat outside
 duplex half
!
interface Serial1/0
 ip address 10.10.10.10 255.255.255.252
 ip nat inside
 mpls label protocol ldp
 tag-switching ip
 serial restart_delay 0
!
interface Serial1/1
 ip address 10.10.10.6 255.255.255.252
 ip nat inside
 mpls label protocol ldp
 tag-switching ip
 serial restart_delay 0
!
interface Serial1/2
 no ip address
 shutdown
 serial restart_delay 0
```

```
!
interface Serial1/3
 no ip address
 shutdown
 serial restart_delay 0
!
interface Serial1/4
 no ip address
 shutdown
 serial restart_delay 0
!
interface Serial1/5
 no ip address
 shutdown
 serial restart_delay 0
!
interface Serial1/6
 no ip address
 shutdown
 serial restart_delay 0
!
interface Serial1/7
 no ip address
 shutdown
 serial restart_delay 0
!
router ospf 1
 router-id 3.3.3.3
 log-adjacency-changes
 network 3.3.3.3 0.0.0.0 area 0.0.0.0
 network 10.10.10.0 0.0.0.255 area 0.0.0.0
!
router bgp 100
 no synchronization
 no bgp default ipv4-unicast
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 multicast
 no auto-summary
 no synchronization
```

```
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community both
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community both
 no auto-summary
 exit-address-family
 !
 address-family ipv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 next-hop-self
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 next-hop-self
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute static
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute static
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf internet
 no auto-summary
 no synchronization
 exit-address-family
!
ip nat pool pool 209.165.200.100 209.165.200.200 netmask 255.255.255.0
ip nat inside source list 101 pool pool vrf vpn1
ip nat inside source list 102 pool pool vrf vpn2
ip classless
no ip http server
no ip http secure-server
!
!
!
```

```
access-list 101 permit ip 192.168.1.0 0.0.0.255 209.165.201.0 0.0.0.255
access-list 101 permit ip 192.168.10.0 0.0.0.255 209.165.201.0 0.0.0.255
access-list 102 permit ip 192.168.2.0 0.0.0.255 209.165.201.0 0.0.0.255
access-list 102 permit ip 192.168.20.0 0.0.0.255 209.165.201.0 0.0.0.255
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
dial-peer cor custom
!
!
!
!
gatekeeper
 shutdown
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

3.4 MCE1 设备配置

```
MCE1#show running
Building configuration...

Current configuration : 3172 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
```

```
!
hostname MCE1
!
logging queue-limit 100
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
mpls ldp logging neighbor-changes
!
!
!
!
!
!
!
!
!
!
!
!
no voice hpi capture buffer
no voice hpi capture destination
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback1
 ip vrf forwarding vpn1
```

```
 ip address 192.168.1.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpn2
 ip address 192.168.2.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex half
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding vpn1
 ip address 172.16.1.2 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding vpn2
 ip address 172.16.1.6 255.255.255.252
!
interface Ethernet1/0
 no ip address
 duplex half
!
interface Ethernet1/0.1
 encapsulation dot1Q 100
 ip vrf forwarding vpn1
 ip address 172.16.3.1 255.255.255.252
!
interface Ethernet1/1
 no ip address
 duplex half
!
interface Ethernet1/1.2
 encapsulation dot1Q 200
 ip vrf forwarding vpn2
 ip address 172.16.3.5 255.255.255.252
 no cdp enable
!
interface Ethernet1/2
 no ip address
 shutdown
 duplex half
!
interface Ethernet1/3
```

```
 no ip address
 shutdown
 duplex half
!
interface Ethernet1/4
 no ip address
 shutdown
 duplex half
!
interface Ethernet1/5
 no ip address
 shutdown
 duplex half
!
interface Ethernet1/6
 no ip address
 shutdown
 duplex half
!
interface Ethernet1/7
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/0
 no ip address
 duplex half
!
interface Ethernet2/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 172.16.2.10 255.255.255.252
!
interface Ethernet2/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 172.16.2.14 255.255.255.252
!
interface Ethernet2/1
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/2
 no ip address
```

```
 shutdown
 duplex half
!
interface Ethernet2/3
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/4
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/5
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/6
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/7
 no ip address
 shutdown
 duplex half
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 capability vrf-lite
 network 172.16.1.0 0.0.0.3 area 0.0.0.0
 network 172.16.2.8 0.0.0.3 area 0.0.0.0
 network 172.16.3.0 0.0.0.3 area 0.0.0.0
 network 192.168.1.0 0.0.0.255 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 capability vrf-lite
 network 172.16.1.4 0.0.0.3 area 0.0.0.0
 network 172.16.2.12 0.0.0.3 area 0.0.0.0
 network 172.16.3.4 0.0.0.3 area 0.0.0.0
 network 192.168.2.0 0.0.0.255 area 0.0.0.0
!
ip classless
```

```
no ip http server
no ip http secure-server
!
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
dial-peer cor custom
!
!
!
!
gatekeeper
 shutdown
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

3.5 MCE2 设备配置

```
MCE2#show running
Building configuration...

Current configuration : 3182 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
```

```
no service password-encryption
!
hostname MCE2
!
logging queue-limit 100
!
ip subnet-zero
!
!
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
mpls ldp logging neighbor-changes
!
!
!
!
!
!
!
!
!
!
!
!
no voice hpi capture buffer
no voice hpi capture destination
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback1
 ip vrf forwarding vpn1
```

```
 ip address 192.168.10.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpn2
 ip address 192.168.20.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex half
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding vpn1
 ip address 172.16.2.2 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding vpn2
 ip address 172.16.2.6 255.255.255.252
!
interface Ethernet1/0
 no ip address
 duplex half
!
interface Ethernet1/0.1
 encapsulation dot1Q 100
 ip vrf forwarding vpn1
 ip address 172.16.3.2 255.255.255.252
!
interface Ethernet1/0.2
 encapsulation dot1Q 200
 ip vrf forwarding vpn2
 ip address 172.16.3.6 255.255.255.252
!
interface Ethernet1/1
 no ip address
 duplex half
!
interface Ethernet1/1.1
 no cdp enable
!
interface Ethernet1/2
 no ip address
 shutdown
 duplex half
```

```
!
interface Ethernet1/3
 no ip address
 shutdown
 duplex half
!
interface Ethernet1/4
 no ip address
 shutdown
 duplex half
!
interface Ethernet1/5
 no ip address
 shutdown
 duplex half
!
interface Ethernet1/6
 no ip address
 shutdown
 duplex half
!
interface Ethernet1/7
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/0
 no ip address
 duplex half
!
interface Ethernet2/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 172.16.1.10 255.255.255.252
!
interface Ethernet2/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 172.16.1.14 255.255.255.252
!
interface Ethernet2/1
 no ip address
 shutdown
 duplex half
!
```

```
interface Ethernet2/2
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/3
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/4
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/5
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/6
 no ip address
 shutdown
 duplex half
!
interface Ethernet2/7
 no ip address
 shutdown
 duplex half
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 capability vrf-lite
 network 172.16.1.8 0.0.0.3 area 0.0.0.0
 network 172.16.2.0 0.0.0.3 area 0.0.0.0
 network 172.16.3.0 0.0.0.3 area 0.0.0.0
 network 192.168.10.0 0.0.0.255 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 capability vrf-lite
 network 172.16.1.12 0.0.0.3 area 0.0.0.0
 network 172.16.2.4 0.0.0.3 area 0.0.0.0
 network 172.16.3.4 0.0.0.3 area 0.0.0.0
 network 192.168.20.0 0.0.0.255 area 0.0.0.0
```

```
!
ip classless
no ip http server
no ip http secure-server
!
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
dial-peer cor custom
!
!
!
!
gatekeeper
 shutdown
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

3.6　WWW 设备配置

```
www#show running
Building configuration...

Current configuration : 797 bytes
!
version 12.2
```

```
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname www
!
logging queue-limit 100
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
mpls ldp logging neighbor-changes
!
!
!
!
!
!
!
!
!
!
!
!
no voice hpi capture buffer
no voice hpi capture destination
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 209.165.201.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 209.165.200.1 255.255.255.0
 duplex half
!
ip classless
no ip http server
```

```
no ip http secure-server
!
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
dial-peer cor custom
!
!
!
!
gatekeeper
 shutdown
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

4 配置验证

4.1 PE1-AS1 配置验证

```
PE1_AS1#show 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, 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


     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/65] via 10.10.10.2, 01:35:44, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/65] via 10.10.10.6, 01:35:44, Serial1/1
     172.16.0.0/30 is subnetted, 1 subnets
C       172.16.1.4 is directly connected, FastEthernet0/0.2
     10.0.0.0/30 is subnetted, 3 subnets
O       10.10.10.8 [110/128] via 10.10.10.2, 01:35:44, Serial1/0
                   [110/128] via 10.10.10.6, 01:35:44, Serial1/1
C       10.10.10.0 is directly connected, Serial1/0
C       10.10.10.4 is directly connected, Serial1/1
PE1_AS1#show ip route vrf vpn1\
% IP routing table vpn1\ does not exist
PE1_AS1#show ip route vrf vpn1


Routing Table: vpn1
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, 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


     192.168.10.0/32 is subnetted, 1 subnets
O       192.168.10.1 [110/11] via 172.16.1.10, 02:55:08, Ethernet2/0.10
     172.16.0.0/30 is subnetted, 5 subnets
C       172.16.1.8 is directly connected, Ethernet2/0.10
O       172.16.2.8 [110/11] via 172.16.1.2, 02:55:08, FastEthernet0/0.1
C       172.16.1.0 is directly connected, FastEthernet0/0.1
O       172.16.2.0 [110/11] via 172.16.1.10, 02:55:08, Ethernet2/0.10
O       172.16.3.0 [110/11] via 172.16.1.2, 02:55:08, FastEthernet0/0.1
     192.168.1.0/32 is subnetted, 1 subnets
O       192.168.1.1 [110/2] via 172.16.1.2, 02:55:08, FastEthernet0/0.1
PE1_AS1#show ip route vrf vpn2
```

```
Routing Table: vpn2
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, 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

     172.16.0.0/30 is subnetted, 5 subnets
C       172.16.1.12 is directly connected, Ethernet2/0.20
O       172.16.2.12 [110/21] via 172.16.1.14, 02:55:06, Ethernet2/0.20
O       172.16.1.4 [110/22] via 172.16.1.14, 02:55:06, Ethernet2/0.20
O       172.16.2.4 [110/11] via 172.16.1.14, 02:55:06, Ethernet2/0.20
O       172.16.3.4 [110/20] via 172.16.1.14, 02:55:06, Ethernet2/0.20
     192.168.20.0/32 is subnetted, 1 subnets
O       192.168.20.1 [110/11] via 172.16.1.14, 02:55:06, Ethernet2/0.20
     192.168.2.0/32 is subnetted, 1 subnets
O       192.168.2.1 [110/22] via 172.16.1.14, 02:55:06, Ethernet2/0.20
PE1_AS1#
```

4.2 PE2-AS1 配置验证

```
PE2_AS1#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/65] via 10.10.10.1, 02:50:01, Serial1/1
     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/65] via 10.10.10.10, 02:50:01, Serial1/0
     10.0.0.0/30 is subnetted, 3 subnets
C       10.10.10.8 is directly connected, Serial1/0
```

```
C       10.10.10.0 is directly connected, Serial1/1
O       10.10.10.4 [110/128] via 10.10.10.1, 02:50:01, Serial1/1
                   [110/128] via 10.10.10.10, 02:50:01, Serial1/0
PE2_AS1#show ip route  vpn1
Translating "vpn1"
                              ^
% Invalid input detected at '^' marker.

PE2_AS1#show ip route  vrf vpn1


Routing Table: vpn1
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, 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


     192.168.10.0/32 is subnetted, 1 subnets
O       192.168.10.1 [110/2] via 172.16.2.2, 04:09:23, FastEthernet0/0.1
     172.16.0.0/30 is subnetted, 5 subnets
O       172.16.1.8 [110/11] via 172.16.2.2, 04:09:23, FastEthernet0/0.1
C       172.16.2.8 is directly connected, Ethernet2/0.10
O       172.16.1.0 [110/11] via 172.16.2.10, 04:09:23, Ethernet2/0.10
C       172.16.2.0 is directly connected, FastEthernet0/0.1
O       172.16.3.0 [110/11] via 172.16.2.2, 04:09:23, FastEthernet0/0.1
     192.168.1.0/32 is subnetted, 1 subnets
O       192.168.1.1 [110/11] via 172.16.2.10, 04:09:23, Ethernet2/0.10
PE2_AS1#show ip route  vrf vpn2


Routing Table: vpn2
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, 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


     172.16.0.0/30 is subnetted, 5 subnets
```

```
O        172.16.1.12 [110/11] via 172.16.2.6, 04:09:15, FastEthernet0/0.2
C        172.16.2.12 is directly connected, Ethernet2/0.20
O        172.16.1.4 [110/11] via 172.16.2.14, 04:09:15, Ethernet2/0.20
C        172.16.2.4 is directly connected, FastEthernet0/0.2
O        172.16.3.4 [110/11] via 172.16.2.6, 04:09:15, FastEthernet0/0.2
     192.168.20.0/32 is subnetted, 1 subnets
O        192.168.20.1 [110/2] via 172.16.2.6, 04:09:15, FastEthernet0/0.2
     192.168.2.0/32 is subnetted, 1 subnets
O        192.168.2.1 [110/11] via 172.16.2.14, 04:09:15, Ethernet2/0.20
PE2_AS1#
```

4.3 PE3-AS1 配置验证

```
PE3_AS1#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/65] via 10.10.10.5, 02:56:32, Serial1/1
     2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/65] via 10.10.10.9, 02:56:32, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
C        3.3.3.3 is directly connected, Loopback0
C    209.165.200.0/24 is directly connected, FastEthernet0/0
     10.0.0.0/30 is subnetted, 3 subnets
C        10.10.10.8 is directly connected, Serial1/0
O        10.10.10.0 [110/128] via 10.10.10.5, 02:56:32, Serial1/1
                    [110/128] via 10.10.10.9, 02:56:32, Serial1/0
C        10.10.10.4 is directly connected, Serial1/1
PE3_AS1#show ip route vrf vpn1

Routing Table: vpn1
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, 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

        192.168.10.0/32 is subnetted, 1 subnets
B   192.168.10.1 [200/2] via 2.2.2.2, 04:15:48
        172.16.0.0/30 is subnetted, 5 subnets
B   172.16.1.8 [200/0] via 1.1.1.1, 04:22:29
B   172.16.2.8 [200/0] via 2.2.2.2, 04:22:29
B   172.16.1.0 [200/0] via 1.1.1.1, 04:22:29
B   172.16.2.0 [200/0] via 2.2.2.2, 04:22:29
B   172.16.3.0 [200/11] via 1.1.1.1, 04:16:05
        192.168.1.0/32 is subnetted, 1 subnets
B   192.168.1.1 [200/2] via 1.1.1.1, 04:16:04
PE3_AS1#show ip route vrf vpn2

Routing Table: vpn2
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, 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

        172.16.0.0/30 is subnetted, 5 subnets
B   172.16.1.12 [200/0] via 1.1.1.1, 04:22:31
B   172.16.2.12 [200/0] via 2.2.2.2, 04:22:31
B   172.16.1.4 [200/11] via 2.2.2.2, 04:16:20
B   172.16.2.4 [200/0] via 2.2.2.2, 04:22:31
B   172.16.3.4 [200/11] via 2.2.2.2, 04:15:41
        192.168.20.0/32 is subnetted, 1 subnets
B   192.168.20.1 [200/2] via 2.2.2.2, 04:15:39
        192.168.2.0/32 is subnetted, 1 subnets
B   192.168.2.1 [200/11] via 2.2.2.2, 04:16:20
PE3_AS1#

4.4 MCE1 配置验证

MCE1# show 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, 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

MCE1#show ip route vrf vpn1


Routing Table: vpn1
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, 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


      192.168.10.0/32 is subnetted, 1 subnets
O         192.168.10.1 [110/11] via 172.16.3.2, 04:19:06, Ethernet1/0.1
      172.16.0.0/30 is subnetted, 5 subnets
O         172.16.1.8 [110/11] via 172.16.1.1, 04:19:06, FastEthernet0/0.1
C         172.16.2.8 is directly connected, Ethernet2/0.10
C         172.16.1.0 is directly connected, FastEthernet0/0.1
O         172.16.2.0 [110/11] via 172.16.2.9, 04:19:06, Ethernet2/0.10
                    [110/11] via 172.16.3.2, 04:19:06, Ethernet1/0.1
C         172.16.3.0 is directly connected, Ethernet1/0.1
C      192.168.1.0/24 is directly connected, Loopback1
MCE1#show ip route vrf vpn2


Routing Table: vpn2
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, 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
```

```
        172.16.0.0/30 is subnetted, 5 subnets
O       172.16.1.12 [110/21] via 172.16.2.13, 04:18:48, Ethernet2/0.20
C       172.16.2.12 is directly connected, Ethernet2/0.20
C       172.16.1.4 is directly connected, FastEthernet0/0.2
O       172.16.2.4 [110/11] via 172.16.2.13, 04:18:48, Ethernet2/0.20
C       172.16.3.4 is directly connected, Ethernet1/1.2
        192.168.20.0/32 is subnetted, 1 subnets
O       192.168.20.1 [110/12] via 172.16.2.13, 04:18:48, Ethernet2/0.20
C       192.168.2.0/24 is directly connected, Loopback2
MCE1#
```

4.5 MCE2 配置验证

```
MCE2#show 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, 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


MCE2#show ip router vrf vpn1
                 ^

% Invalid input detected at '^' marker.


MCE2#show ip route vrf vpn1


Routing Table: vpn1
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, 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


C    192.168.10.0/24 is directly connected, Loopback1
     172.16.0.0/30 is subnetted, 5 subnets
C       172.16.1.8 is directly connected, Ethernet2/0.10
```

```
O       172.16.2.8 [110/11] via 172.16.2.1, 04:20:23, FastEthernet0/0.1
O       172.16.1.0 [110/11] via 172.16.3.1, 04:20:23, Ethernet1/0.1
                   [110/11] via 172.16.1.9, 04:20:23, Ethernet2/0.10
C       172.16.2.0 is directly connected, FastEthernet0/0.1
C       172.16.3.0 is directly connected, Ethernet1/0.1
     192.168.1.0/32 is subnetted, 1 subnets
O       192.168.1.1 [110/11] via 172.16.3.1, 04:20:24, Ethernet1/0.1
MCE2#show ip route vrf vpn2


Routing Table: vpn2
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, 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


     172.16.0.0/30 is subnetted, 5 subnets
C       172.16.1.12 is directly connected, Ethernet2/0.20
O       172.16.2.12 [110/11] via 172.16.2.5, 04:20:18, FastEthernet0/0.2
O       172.16.1.4 [110/12] via 172.16.2.5, 04:20:18, FastEthernet0/0.2
C       172.16.2.4 is directly connected, FastEthernet0/0.2
C       172.16.3.4 is directly connected, Ethernet1/0.2
C    192.168.20.0/24 is directly connected, Loopback2
     192.168.2.0/32 is subnetted, 1 subnets
O       192.168.2.1 [110/12] via 172.16.2.5, 04:20:18, FastEthernet0/0.2
MCE2#
```

4.5 WWW 配置验证

```
www#show ip rou
www#show 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, 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
```

```
C    209.165.200.0/24 is directly connected, FastEthernet0/0
C    209.165.201.0/24 is directly connected, Loopback0
www#
```

二   MPLS VPN HUB&SPOKE

1   MPLS VPN HUB&SPOKE WITH OSPF

1.1   网络拓扑图

1.2   应用需求

Hub&Spoke 组网方式也称为中心服务器拓扑组网。中心 Site 称为 Hub-Site，它知道同一 VPN 所有其它 Site 的路由；不处于中心的 site 称为 Spoke-Site，它们的流量通过 HUB-Site 到达目的地。Hub-Site 是 Spoke-Site 的中枢节点。

某银行的网络包括各分公司网络与公司总部的网络，要求各分公司之间不能直接交换数据，必须通过总部进行通信，以进行统一控制。采用 Hub&Spoke 拓扑，CE6、CE7、CE8 为 Spoke 站点，CE5 为银行数据中心 Hub 站点，CE6、CE7、CE8 间的通信由 CE5 控制。

- PE2 分别与 PE3、PE4 建立 IBGP 邻居关系，但 PE3 与 PE4 不建立 IBGP 邻居关系，不交换 VPN 路由信息；
- 在 PE2 上创建两个 VPN-instance，引入 VPN-target 属性为 6:6，7:7，8:8 的 VPN 路由，对发布的 VPN 路由设置 VPN-target 属性 200:200；
- 在 PE3 上创建二个 VPN-VRF：VRF CE6-R6，VRF-CE7-R7；二个 VPN VRF 引入 VPN-target 属性为 200:200 的 VPN 路由，VRF-CE6-R6 发布的 VPN 路由设置 VPN-target 属性 6:6，VRF-CE7-R7 发布的 VPN 路由设置 VPN-target 属性 7:7；
- 在 PE4 上创建一个 VPN-VRF：CE8-R8，引入 VPN-target 属性为 200:200 的 VPN 路由，对发布的 VPN 路由设置 VPN-target 属性 8:8。

经过以上配置，CE6-R6，CE7-R7，CE8-R8 之间的互访都必须通过 CE5-R5 中转。

1.3 设备配置

1.3.1 P1-R1 设备配置

```
P1-R1#show running
Building configuration...

Current configuration : 1253 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname P1-R1
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
```

```
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 12.12.12.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 13.13.13.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 ip address 14.14.14.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
```

```
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.2　PE2-R2 设备配置

```
PE2-R2#show running
Building configuration...
```

```
Current configuration : 2490 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE2-R2
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf HUB
 rd 100:1000
 route-target import 6:6
 route-target import 7:7
 route-target import 8:8
!
ip vrf SPOKE
 rd 200:200
 route-target export 200:200
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
```

```
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding HUB
 ip address 25.25.25.1 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding SPOKE
 ip address 25.25.25.5 255.255.255.252
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 12.12.12.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
```

```
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 100 vrf HUB
 log-adjacency-changes
 redistribute bgp 100 subnets tag 0
 network 25.25.25.0 0.0.0.3 area 0.0.0.0
!
router ospf 200 vrf SPOKE
 log-adjacency-changes
 network 25.25.25.4 0.0.0.3 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp router-id 2.2.2.2
 bgp log-neighbor-changes
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf SPOKE
 redistribute connected
 redistribute ospf 200 match internal external 1 external 2
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf HUB
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 send-community extended
 neighbor 4.4.4.4 activate
 neighbor 4.4.4.4 send-community extended
 no auto-summary
 exit-address-family
!
```

```
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

PE2-R2#

1.3.3 PE3-R3 设备配置

```
PE3-R3#show running
Building configuration...

Current configuration : 2213 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE3-R3
```

```
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf CE6-R6
 rd 6:6
 route-target export 6:6
 route-target import 200:200
!
ip vrf CE7-R7
 rd 7:7
 route-target export 7:7
 route-target import 200:200
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
```

```
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 13.13.13.3 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip vrf forwarding CE6-R6
 ip address 36.36.36.3 255.255.255.0
 half-duplex
!
interface Ethernet1/2
 ip vrf forwarding CE7-R7
 ip address 37.37.37.3 255.255.255.0
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 3.3.3.3
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 6 vrf CE6-R6
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 7 vrf CE7-R7
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp router-id 3.3.3.3
```

```
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf CE7-R7
 redistribute connected
 redistribute ospf 7
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf CE6-R6
 redistribute connected
 redistribute ospf 6
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
```

```
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.4 PE4-R4 设备配置

```
PE4-R4#show running
Building configuration...

Current configuration : 1789 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE4-R4
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf CE8-R8
 rd 8:8
 route-target export 8:8
 route-target import 200:200
!
ip cef
mpls label protocol ldp
!
!
!
!
!
!
!
!
```

```
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
!
interface FastEthernet0/0
 ip vrf forwarding CE8-R8
 ip address 48.48.48.4 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 14.14.14.4 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
```

```
 router-id 4.4.4.4
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 8 vrf CE8-R8
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp router-id 4.4.4.4
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf CE8-R8
 redistribute connected
 redistribute ospf 8
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
```

```
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.5 CE5-R5 设备配置

```
CE5-R5#show running
Building configuration...

Current configuration : 937 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE5-R5
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
!
!
!
!
!
!
!
!
!
```

```
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.50.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip address 25.25.25.2 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip address 25.25.25.6 255.255.255.252
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
```

```
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.6 CE6-R6 设备配置

```
CE6-R6#show running
Building configuration...

Current configuration : 768 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE6-R6
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
!
!
!
!
!
!
```

```
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.60.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 36.36.36.6 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
```

```
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.7 CE7-R7 设备配置

```
CE7-R7#show running
Building configuration...

Current configuration : 768 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE7-R7
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
```

```
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.70.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 37.37.37.7 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
```

```
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.8 CE8-R8 设备配置

```
CE8-R8#show running
Building configuration...

Current configuration : 768 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE8-R8
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
```

```
interface Loopback0
 ip address 172.16.80.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 48.48.48.8 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
```

end

1.4 配置验证

1.4.1 P1-R1 配置验证

P1-R1#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
4.4.4.4	1	FULL/BDR	00:00:33	14.14.14.4	Ethernet1/2
3.3.3.3	1	FULL/BDR	00:00:35	13.13.13.3	Ethernet1/1
2.2.2.2	1	FULL/BDR	00:00:31	12.12.12.2	Ethernet1/0

P1-R1#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
C   1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O   2.2.2.2 [110/11] via 12.12.12.2, 04:15:16, Ethernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
O   3.3.3.3 [110/11] via 13.13.13.3, 04:15:16, Ethernet1/1
     4.0.0.0/32 is subnetted, 1 subnets
O   4.4.4.4 [110/11] via 14.14.14.4, 04:15:16, Ethernet1/2
     12.0.0.0/24 is subnetted, 1 subnets
C   12.12.12.0 is directly connected, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
C   13.13.13.0 is directly connected, Ethernet1/1
     14.0.0.0/24 is subnetted, 1 subnets
C   14.14.14.0 is directly connected, Ethernet1/2
P1-R1#

1.4.2 PE2-R2 配置验证

PE2-R2#show ip ospf neighbor

```
Neighbor ID       Pri   State          Dead Time   Address        Interface
172.16.50.1        1    FULL/BDR       00:00:32    25.25.25.6     FastEthernet0/
0.2
172.16.50.1        1    FULL/BDR       00:00:32    25.25.25.2     FastEthernet0/
0.1
1.1.1.1            1    FULL/DR        00:00:38    12.12.12.1     Ethernet1/0
PE2-R2#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/11] via 12.12.12.1, 04:19:39, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/21] via 12.12.12.1, 04:19:39, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/21] via 12.12.12.1, 04:19:39, Ethernet1/0
     12.0.0.0/24 is subnetted, 1 subnets
C       12.12.12.0 is directly connected, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/20] via 12.12.12.1, 04:19:39, Ethernet1/0
     14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/20] via 12.12.12.1, 04:19:40, Ethernet1/0

PE2-R2# show ip bgp summary
BGP router identifier 2.2.2.2, local AS number 100
BGP table version is 1, main routing table version 1

Neighbor        V     AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
3.3.3.3         4    100    283     284        1    0    0 04:25:18         0
4.4.4.4         4    100    272     273        1    0    0 04:22:53         0
PE2-R2#

PE2-R2#show ip bgp neighbor
BGP neighbor is 3.3.3.3,  remote AS 100, internal link
  BGP version 4, remote router ID 3.3.3.3
  BGP state = Established, up for 04:22:08
```

Last read 00:00:08, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
    Address family VPNv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
  Received 280 messages, 0 notifications, 0 in queue
  Sent 281 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
  0 accepted prefixes consume 0 bytes
  Prefix advertised 0, suppressed 0, withdrawn 0

 For address family: VPNv4 Unicast
  BGP table version 33, neighbor version 33
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 2, sent 0
  4 accepted prefixes consume 256 bytes
  Prefix advertised 22, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 2.2.2.2, Local port: 11014
Foreign host: 3.3.3.3, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)

Event Timers (current time is 0xF2C90C):
Timer   Starts   Wakeups   Next
Retrans   297   19   0x0
TimeWait   0   0   0x0
AckHold   277   233   0x0
SendWnd   0   0   0x0
KeepAlive   0   0   0x0
GiveUp   0   0   0x0
PmtuAger   0   0   0x0
DeadWait   0   0   0x0

iss: 4031352652 snduna: 4031359543 sndnxt: 4031359543   sndwnd: 16080

```
    irs: 3473306622  rcvnxt: 3473313131  rcvwnd:      16004  delrcvwnd:     380

SRTT: 540 ms, RTTO: 1121 ms, RTV: 581 ms, KRTT: 0 ms
minRTT: 256 ms, maxRTT: 1276 ms, ACK hold: 200 ms
Flags: higher precedence, nagle

Datagrams (max data segment is 536 bytes):
Rcvd: 476 (out of order: 0), with data: 277, total data bytes: 6508
Sent: 541 (retransmit: 19, fastretransmit: 0), with data: 277, total data bytes:
 6890


BGP neighbor is 4.4.4.4,  remote AS 100, internal link
  BGP version 4, remote router ID 4.4.4.4
  BGP state = Established, up for 04:19:45
  Last read 00:00:46, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
    Address family VPNv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
  Received 269 messages, 0 notifications, 0 in queue
  Sent 270 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 2, Offset 0, Mask 0x4
  Route refresh request: received 0, sent 0
  0 accepted prefixes consume 0 bytes
  Prefix advertised 0, suppressed 0, withdrawn 0

 For address family: VPNv4 Unicast
  BGP table version 33, neighbor version 33
  Index 2, Offset 0, Mask 0x4
  Route refresh request: received 0, sent 0
  2 accepted prefixes consume 128 bytes
  Prefix advertised 12, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 2.2.2.2, Local port: 11015
Foreign host: 4.4.4.4, Foreign port: 179
```

Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)

Event Timers (current time is 0xF2D47C):

Timer	Starts	Wakeups	Next
Retrans	294	26	0x0
TimeWait	0	0	0x0
AckHold	268	218	0x0
SendWnd	0	0	0x0
KeepAlive	0	0	0x0
GiveUp	0	0	0x0
PmtuAger	0	0	0x0
DeadWait	0	0	0x0

iss: 2518791696 snduna: 2518797602 sndnxt: 2518797602   sndwnd: 16061

irs: 84936295 rcvnxt: 84942014 rcvwnd: 16175 delrcvwnd: 209

SRTT: 604 ms, RTTO: 1101 ms, RTV: 497 ms, KRTT: 0 ms

minRTT: 300 ms, maxRTT: 1280 ms, ACK hold: 200 ms

Flags: higher precedence, nagle

Datagrams (max data segment is 536 bytes):

Rcvd: 454 (out of order: 0), with data: 268, total data bytes: 5718

Sent: 516 (retransmit: 26, fastretransmit: 0), with data: 267, total data bytes:
 5905

PE2-R2#show ip bgp vpnv4 vrf HUB

BGP table version is 33, local router ID is 2.2.2.2

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

            r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 100:1000 (default for vrf HUB)					
*> 25.25.25.0/30	0.0.0.0	0		32768	?
*>i36.36.36.0/24	3.3.3.3	0	100	0	?
*>i37.37.37.0/24	3.3.3.3	0	100	0	?
*>i48.48.48.0/24	4.4.4.4	0	100	0	?
*>i172.16.60.1/32	3.3.3.3	11	100	0	?
*>i172.16.70.1/32	3.3.3.3	11	100	0	?
*>i172.16.80.1/32	4.4.4.4	2	100	0	?

PE2-R2#show ip bgp vpnv4 vrf SPOKE

BGP table version is 33, local router ID is 2.2.2.2

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

            r RIB-failure

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

```
      Network          Next Hop         Metric LocPrf Weight Path
Route Distinguisher: 200:200 (default for vrf SPOKE)
*> 25.25.25.0/30     25.25.25.6              2          32768 ?
*> 25.25.25.4/30     0.0.0.0                 0          32768 ?
*> 36.36.36.0/24     25.25.25.6              1          32768 ?
*> 37.37.37.0/24     25.25.25.6              1          32768 ?
*> 48.48.48.0/24     25.25.25.6              1          32768 ?
*> 172.16.50.1/32    25.25.25.6              2          32768 ?
*> 172.16.60.1/32    25.25.25.6             11          32768 ?
*> 172.16.70.1/32    25.25.25.6             11          32768 ?
*> 172.16.80.1/32    25.25.25.6              2          32768 ?
PE2-R2#show ip route vrf HUB
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, 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

     48.0.0.0/24 is subnetted, 1 subnets
B       48.48.48.0 [200/0] via 4.4.4.4, 04:20:22
     36.0.0.0/24 is subnetted, 1 subnets
B       36.36.36.0 [200/0] via 3.3.3.3, 04:22:08
     172.16.0.0/32 is subnetted, 4 subnets
B       172.16.60.1 [200/11] via 3.3.3.3, 04:15:22
O       172.16.50.1 [110/2] via 25.25.25.2, 04:17:48, FastEthernet0/0.1
B       172.16.80.1 [200/2] via 4.4.4.4, 04:08:20
B       172.16.70.1 [200/11] via 3.3.3.3, 04:11:50
     37.0.0.0/24 is subnetted, 1 subnets
B       37.37.37.0 [200/0] via 3.3.3.3, 04:22:08
     25.0.0.0/30 is subnetted, 2 subnets
C       25.25.25.0 is directly connected, FastEthernet0/0.1
O       25.25.25.4 [110/2] via 25.25.25.2, 04:17:49, FastEthernet0/0.1
PE2-R2#show ip route vrf SPOKE
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, 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

      48.0.0.0/24 is subnetted, 1 subnets
O E2   48.48.48.0 [110/1] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
      36.0.0.0/24 is subnetted, 1 subnets
O E2   36.36.36.0 [110/1] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
      172.16.0.0/32 is subnetted, 4 subnets
O E2   172.16.60.1 [110/11] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
O   172.16.50.1 [110/2] via 25.25.25.6, 04:17:57, FastEthernet0/0.2
O E2   172.16.80.1 [110/2] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
O E2   172.16.70.1 [110/11] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
      37.0.0.0/24 is subnetted, 1 subnets
O E2   37.37.37.0 [110/1] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
      25.0.0.0/30 is subnetted, 2 subnets
O   25.25.25.0 [110/2] via 25.25.25.6, 04:17:58, FastEthernet0/0.2
C   25.25.25.4 is directly connected, FastEthernet0/0.2
PE2-R2#

1.4.3 PE3-R3 配置验证

PE3-R3#show ip ospf neighbor

Neighbor ID   Pri   State   Dead Time   Address   Interface
172.16.70.1   1   FULL/BDR   00:00:38   37.37.37.7   Ethernet1/2
172.16.60.1   1   FULL/BDR   00:00:39   36.36.36.6   Ethernet1/1
1.1.1.1   1   FULL/DR   00:00:34   13.13.13.1   Ethernet1/0
PE3-R3#show 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, 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

      1.0.0.0/32 is subnetted, 1 subnets
O   1.1.1.1 [110/11] via 13.13.13.1, 03:30:46, Ethernet1/0
      2.0.0.0/32 is subnetted, 1 subnets
O   2.2.2.2 [110/21] via 13.13.13.1, 03:30:46, Ethernet1/0
      3.0.0.0/32 is subnetted, 1 subnets
C   3.3.3.3 is directly connected, Loopback0
      4.0.0.0/32 is subnetted, 1 subnets

```
O        4.4.4.4 [110/21] via 13.13.13.1, 03:30:46, Ethernet1/0
     12.0.0.0/24 is subnetted, 1 subnets
O        12.12.12.0 [110/20] via 13.13.13.1, 03:30:46, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
C        13.13.13.0 is directly connected, Ethernet1/0
     14.0.0.0/24 is subnetted, 1 subnets
O        14.14.14.0 [110/20] via 13.13.13.1, 03:30:47, Ethernet1/0
PE3-R3#

PE3-R3#show ip bgp summary
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 1, main routing table version 1

Neighbor        V     AS MsgRcvd MsgSent   TblVer   InQ OutQ Up/Down  State/PfxRcd
2.2.2.2         4    100     286     285        1     0    0 04:27:05         0
PE3-R3#show ip bgp neighbor
BGP neighbor is 2.2.2.2,  remote AS 100, internal link
  BGP version 4, remote router ID 2.2.2.2
  BGP state = Established, up for 04:27:14
  Last read 00:00:14, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
    Address family VPNv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
  Received 286 messages, 0 notifications, 0 in queue
  Sent 285 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
  0 accepted prefixes consume 0 bytes
  Prefix advertised 0, suppressed 0, withdrawn 0

 For address family: VPNv4 Unicast
  BGP table version 39, neighbor version 39
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 2
  9 accepted prefixes consume 576 bytes
  Prefix advertised 12, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
```

Last reset never

Connection state is ESTAB, I/O status: 1, unread input bytes: 0

Local host: 3.3.3.3, Local port: 179

Foreign host: 2.2.2.2, Foreign port: 11014

Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)

Event Timers (current time is 0xF5E6EC):

Timer	Starts	Wakeups	Next
Retrans	301	18	0x0
TimeWait	0	0	0x0
AckHold	282	152	0x0
SendWnd	0	0	0x0
KeepAlive	0	0	0x0
GiveUp	0	0	0x0
PmtuAger	0	0	0x0
DeadWait	0	0	0x0

iss: 3473306622 snduna: 3473313226 sndnxt: 3473313226   sndwnd: 15909

irs: 4031352652 rcvnxt: 4031359638 rcvwnd: 15985 delrcvwnd: 399

SRTT: 674 ms, RTTO: 1147 ms, RTV: 473 ms, KRTT: 0 ms

minRTT: 276 ms, maxRTT: 2036 ms, ACK hold: 200 ms

Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 536 bytes):

Rcvd: 567 (out of order: 0), with data: 282, total data bytes: 6985

Sent: 463 (retransmit: 18, fastretransmit: 0), with data: 282, total data bytes:
 6603

PE3-R3#show ip bgp vpnv4 vrf CE6-R6

BGP table version is 39, local router ID is 3.3.3.3

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

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 6:6 (default for vrf CE6-R6)					
*>i25.25.25.0/30	2.2.2.2	2	100	0	?
*>i25.25.25.4/30	2.2.2.2	0	100	0	?
* i36.36.36.0/24	2.2.2.2	1	100	0	?
*>	0.0.0.0	0		32768	?
*>i37.37.37.0/24	2.2.2.2	1	100	0	?
*>i48.48.48.0/24	2.2.2.2	1	100	0	?
*>i172.16.50.1/32	2.2.2.2	2	100	0	?
* i172.16.60.1/32	2.2.2.2	11	100	0	?

```
*>                36.36.36.6              11          32768 ?
*>i172.16.70.1/32  2.2.2.2                11    100     0 ?
*>i172.16.80.1/32  2.2.2.2                 2    100     0 ?
PE3-R3#show ip bgp vpnv4 vrf CE7-R7
BGP table version is 39, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop           Metric LocPrf Weight Path
Route Distinguisher: 7:7 (default for vrf CE7-R7)
*>i25.25.25.0/30   2.2.2.2                 2    100     0 ?
*>i25.25.25.4/30   2.2.2.2                 0    100     0 ?
*>i36.36.36.0/24   2.2.2.2                 1    100     0 ?
* i37.37.37.0/24   2.2.2.2                 1    100     0 ?
*>                 0.0.0.0                 0          32768 ?
*>i48.48.48.0/24   2.2.2.2                 1    100     0 ?
*>i172.16.50.1/32  2.2.2.2                 2    100     0 ?
*>i172.16.60.1/32  2.2.2.2                11    100     0 ?
* i172.16.70.1/32  2.2.2.2                11    100     0 ?
*>                 37.37.37.7             11          32768 ?
*>i172.16.80.1/32  2.2.2.2                 2    100     0 ?
PE3-R3#


PE3-R3#show ip route vrf CE6-R6
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, 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

     48.0.0.0/24 is subnetted, 1 subnets
B       48.48.48.0 [200/1] via 2.2.2.2, 00:25:32
     36.0.0.0/24 is subnetted, 1 subnets
C       36.36.36.0 is directly connected, Ethernet1/1
     172.16.0.0/32 is subnetted, 4 subnets
O       172.16.60.1 [110/11] via 36.36.36.6, 03:32:27, Ethernet1/1
B       172.16.50.1 [200/2] via 2.2.2.2, 04:23:06
B       172.16.80.1 [200/2] via 2.2.2.2, 00:25:32
B       172.16.70.1 [200/11] via 2.2.2.2, 00:25:32
     37.0.0.0/24 is subnetted, 1 subnets
```

```
B        37.37.37.0 [200/1] via 2.2.2.2, 00:25:32
     25.0.0.0/30 is subnetted, 2 subnets
B        25.25.25.0 [200/2] via 2.2.2.2, 04:23:06
B        25.25.25.4 [200/0] via 2.2.2.2, 04:27:37
PE3-R3#show ip route vrf CE7-R7
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, 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


     48.0.0.0/24 is subnetted, 1 subnets
B        48.48.48.0 [200/1] via 2.2.2.2, 00:25:40
     36.0.0.0/24 is subnetted, 1 subnets
B        36.36.36.0 [200/1] via 2.2.2.2, 00:25:40
     172.16.0.0/32 is subnetted, 4 subnets
B        172.16.60.1 [200/11] via 2.2.2.2, 00:25:40
B        172.16.50.1 [200/2] via 2.2.2.2, 04:23:14
B        172.16.80.1 [200/2] via 2.2.2.2, 00:25:40
O        172.16.70.1 [110/11] via 37.37.37.7, 03:32:35, Ethernet1/2
     37.0.0.0/24 is subnetted, 1 subnets
C        37.37.37.0 is directly connected, Ethernet1/2
     25.0.0.0/30 is subnetted, 2 subnets
B        25.25.25.0 [200/2] via 2.2.2.2, 04:23:14
B        25.25.25.4 [200/0] via 2.2.2.2, 04:27:46
PE3-R3#
```

1.4.4 PE4-R4 配置验证

```
PE4-R4#show ip ospf neighbor


Neighbor ID     Pri  State        Dead Time   Address        Interface
172.16.80.1      1   FULL/BDR     00:00:30    48.48.48.8     FastEthernet0/
0
1.1.1.1          1   FULL/DR      00:00:35    14.14.14.1     Ethernet1/0
PE4-R4#show 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, 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


     1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/11] via 14.14.14.1, 04:50:29, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/21] via 14.14.14.1, 04:50:29, Ethernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.3 [110/21] via 14.14.14.1, 04:50:29, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
C        4.4.4.4 is directly connected, Loopback0
     12.0.0.0/24 is subnetted, 1 subnets
O        12.12.12.0 [110/20] via 14.14.14.1, 04:50:29, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
O        13.13.13.0 [110/20] via 14.14.14.1, 04:50:29, Ethernet1/0
     14.0.0.0/24 is subnetted, 1 subnets
C        14.14.14.0 is directly connected, Ethernet1/0
PE4-R4#show ip bgp summary
BGP router identifier 4.4.4.4, local AS number 100
BGP table version is 1, main routing table version 1


Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
2.2.2.2         4   100    301     300        1    0    0 04:50:34          0
PE4-R4#show ip bgp neighbor
BGP neighbor is 2.2.2.2,  remote AS 100, internal link
  BGP version 4, remote router ID 2.2.2.2
  BGP state = Established, up for 04:50:42
  Last read 00:00:41, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
    Address family VPNv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
  Received 301 messages, 0 notifications, 0 in queue
  Sent 300 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds


 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
```

0 accepted prefixes consume 0 bytes

　　Prefix advertised 0, suppressed 0, withdrawn 0

　For address family: VPNv4 Unicast

　　BGP table version 23, neighbor version 23

　　Index 1, Offset 0, Mask 0x2

　　Route refresh request: received 0, sent 0

　　9 accepted prefixes consume 576 bytes

　　Prefix advertised 6, suppressed 0, withdrawn 0

　　Connections established 1; dropped 0

　　Last reset never

Connection state is ESTAB, I/O status: 1, unread input bytes: 0

Local host: 4.4.4.4, Local port: 179

Foreign host: 2.2.2.2, Foreign port: 11015

Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x10B7800):

Timer	Starts	Wakeups	Next
Retrans	319	19	0x0
TimeWait	0	0	0x0
AckHold	298	160	0x0
SendWnd	0	0	0x0
KeepAlive	0	0	0x0
GiveUp	0	0	0x0
PmtuAger	0	0	0x0
DeadWait	0	0	0x0

iss:　84936295　snduna:　84942603　sndnxt:　84942603　　sndwnd:　16137

irs: 2518791696　rcvnxt: 2518798191　rcvwnd:　　16023　delrcvwnd:　　361

SRTT: 557 ms, RTTO: 826 ms, RTV: 269 ms, KRTT: 0 ms

minRTT: 256 ms, maxRTT: 1968 ms, ACK hold: 200 ms

Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 536 bytes):

Rcvd: 582 (out of order: 0), with data: 298, total data bytes: 6494

Sent: 498 (retransmit: 19, fastretransmit: 0), with data: 299, total data bytes:
 6307

PE4-R4#

PE4-R4#show ip bgp vpnv4 vrf CE8-R8

BGP table version is 23, local router ID is 4.4.4.4

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

```
             r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete


   Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 8:8 (default for vrf CE8-R8)
*>i25.25.25.0/30    2.2.2.2               2    100      0 ?
*>i25.25.25.4/30    2.2.2.2               0    100      0 ?
*>i36.36.36.0/24    2.2.2.2               1    100      0 ?
*>i37.37.37.0/24    2.2.2.2               1    100      0 ?
* i48.48.48.0/24    2.2.2.2               1    100      0 ?
*>                  0.0.0.0               0          32768 ?
*>i172.16.50.1/32   2.2.2.2               2    100      0 ?
*>i172.16.60.1/32   2.2.2.2              11    100      0 ?
*>i172.16.70.1/32   2.2.2.2              11    100      0 ?
* i172.16.80.1/32   2.2.2.2               2    100      0 ?
*>                  48.48.48.8            2          32768 ?
PE4-R4#show ip route vrf CE8-R8
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, 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


     48.0.0.0/24 is subnetted, 1 subnets
C       48.48.48.0 is directly connected, FastEthernet0/0
     36.0.0.0/24 is subnetted, 1 subnets
B       36.36.36.0 [200/1] via 2.2.2.2, 00:51:41
     172.16.0.0/32 is subnetted, 4 subnets
B       172.16.60.1 [200/11] via 2.2.2.2, 00:51:41
B       172.16.50.1 [200/2] via 2.2.2.2, 04:49:13
O       172.16.80.1 [110/2] via 48.48.48.8, 04:40:06, FastEthernet0/0
B       172.16.70.1 [200/11] via 2.2.2.2, 00:51:41
     37.0.0.0/24 is subnetted, 1 subnets
B       37.37.37.0 [200/1] via 2.2.2.2, 00:51:41
     25.0.0.0/30 is subnetted, 2 subnets
B       25.25.25.0 [200/2] via 2.2.2.2, 04:49:13
B       25.25.25.4 [200/0] via 2.2.2.2, 04:51:44
PE4-R4#
```

1.4.5 CE5-R5 配置验证

```
CE5-R5#show ip ospf neighbor

Neighbor ID      Pri  State        Dead Time   Address       Interface
25.25.25.5        1   FULL/DR      00:00:30    25.25.25.5    FastEthernet0/
0.2
25.25.25.1        1   FULL/DR      00:00:30    25.25.25.1    FastEthernet0/
0.1
CE5-R5#show 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, 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

     48.0.0.0/24 is subnetted, 1 subnets
O E2    48.48.48.0 [110/1] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
     36.0.0.0/24 is subnetted, 1 subnets
O E2    36.36.36.0 [110/1] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
O E2    172.16.60.1/32 [110/11] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
C       172.16.50.0/24 is directly connected, Loopback0
O E2    172.16.80.1/32 [110/2] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
O E2    172.16.70.1/32 [110/11] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
     37.0.0.0/24 is subnetted, 1 subnets
O E2    37.37.37.0 [110/1] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
     25.0.0.0/30 is subnetted, 2 subnets
C       25.25.25.0 is directly connected, FastEthernet0/0.1
C       25.25.25.4 is directly connected, FastEthernet0/0.2
CE5-R5#

CE5-R5#traceroute
Protocol [ip]:
Target IP address: 172.16.60.1
Source address: 172.16.50.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
```

```
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.60.1


  1 25.25.25.1 288 msec 288 msec 312 msec
  2 12.12.12.1 [MPLS: Labels 17/23 Exp 0] 1800 msec 1964 msec 1896 msec
  3 36.36.36.3 [MPLS: Label 23 Exp 0] 792 msec 548 msec 600 msec
  4 36.36.36.6 744 msec 1032 msec 1104 msec
CE5-R5#traceroute
Protocol [ip]:
Target IP address: 172.16.70.1
Source address: 172.16.50.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.70.1


  1 25.25.25.1 332 msec 288 msec 360 msec
  2 12.12.12.1 [MPLS: Labels 17/24 Exp 0] 1976 msec 2060 msec 1848 msec
  3 37.37.37.3 [MPLS: Label 24 Exp 0] 600 msec 476 msec 592 msec
  4 37.37.37.7 728 msec 960 msec 1128 msec
CE5-R5#traceroute
Protocol [ip]:
Target IP address: 172.16.80.1
Source address: 172.16.50.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.80.1


  1 25.25.25.1 168 msec 264 msec 240 msec
  2 12.12.12.1 [MPLS: Labels 18/22 Exp 0] 1752 msec 1748 msec 2016 msec
  3 48.48.48.4 [MPLS: Label 22 Exp 0] 696 msec 644 msec 696 msec
```

4 48.48.48.8 960 msec 744 msec 816 msec
CE5-R5#

1.4.6 CE6-R6 配置验证

CE6-R6#show ip ospf neighbor

Neighbor ID   Pri   State   Dead Time   Address   Interface
36.36.36.3   1   FULL/DR   00:00:30   36.36.36.3   FastEthernet0/
0
CE6-R6#show 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, 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

     48.0.0.0/24 is subnetted, 1 subnets
O E2   48.48.48.0 [110/1] via 36.36.36.3, 00:59:54, FastEthernet0/0
     36.0.0.0/24 is subnetted, 1 subnets
C   36.36.36.0 is directly connected, FastEthernet0/0
     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C   172.16.60.0/24 is directly connected, Loopback0
O E2   172.16.50.1/32 [110/2] via 36.36.36.3, 04:55:14, FastEthernet0/0
O E2   172.16.80.1/32 [110/2] via 36.36.36.3, 00:59:54, FastEthernet0/0
O E2   172.16.70.1/32 [110/11] via 36.36.36.3, 00:59:54, FastEthernet0/0
     37.0.0.0/24 is subnetted, 1 subnets
O E2   37.37.37.0 [110/1] via 36.36.36.3, 00:59:54, FastEthernet0/0
     25.0.0.0/30 is subnetted, 2 subnets
O E2   25.25.25.0 [110/2] via 36.36.36.3, 04:55:15, FastEthernet0/0
O E2   25.25.25.4 [110/1] via 36.36.36.3, 04:55:15, FastEthernet0/0
CE6-R6#

CE6-R6#traceroute
Protocol [ip]:
Target IP address: 172.16.50.1
Source address: 172.16.60.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:

```
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.50.1


  1 36.36.36.3 216 msec 120 msec 264 msec
  2 13.13.13.1 [MPLS: Labels 16/24 Exp 0] 1520 msec 1988 msec 1944 msec
  3 25.25.25.5 [MPLS: Label 24 Exp 0] 576 msec 956 msec 816 msec
  4 25.25.25.6 696 msec 840 msec 816 msec
CE6-R6#traceroute
Protocol [ip]:
Target IP address: 172.16.70.1
Source address: 172.16.60.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.70.1


  1 36.36.36.3 216 msec 264 msec 168 msec
  2 13.13.13.1 [MPLS: Labels 16/29 Exp 0] 1824 msec 1832 msec 2124 msec
  3 25.25.25.5 [MPLS: Label 29 Exp 0] 816 msec 860 msec 1452 msec
  4 25.25.25.6 948 msec 792 msec 912 msec
  5 25.25.25.1 936 msec 1080 msec 1032 msec
  6 12.12.12.1 [MPLS: Labels 17/24 Exp 0] 2952 msec 3116 msec 2832 msec
  7 37.37.37.3 [MPLS: Label 24 Exp 0] 1248 msec 1532 msec 1704 msec
  8 37.37.37.7 2184 msec 1992 msec 1800 msec
CE6-R6#traceroute
Protocol [ip]:
Target IP address: 172.16.80.1
Source address: 172.16.60.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
```

Tracing the route to 172.16.80.1

```
  1 36.36.36.3 336 msec 312 msec 192 msec
  2 13.13.13.1 [MPLS: Labels 16/28 Exp 0] 1968 msec 1156 msec 2136 msec
  3 25.25.25.5 [MPLS: Label 28 Exp 0] 840 msec 744 msec 744 msec
  4 25.25.25.6 936 msec 816 msec 900 msec
  5 25.25.25.1 840 msec 984 msec 816 msec
  6 12.12.12.1 [MPLS: Labels 18/22 Exp 0] 3024 msec 2924 msec 2616 msec
  7 48.48.48.4 [MPLS: Label 22 Exp 0] 3408 msec 1460 msec 1800 msec
  8 48.48.48.8 1968 msec 1800 msec 2452 msec
CE6-R6#
```

1.4.7　CE7-R7 配置验证

```
CE7-R7#show 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, 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

     48.0.0.0/24 is subnetted, 1 subnets
O E2    48.48.48.0 [110/1] via 37.37.37.3, 01:09:25, FastEthernet0/0
     36.0.0.0/24 is subnetted, 1 subnets
O E2    36.36.36.0 [110/1] via 37.37.37.3, 01:09:25, FastEthernet0/0
     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
O E2    172.16.60.1/32 [110/11] via 37.37.37.3, 01:09:25, FastEthernet0/0
O E2    172.16.50.1/32 [110/2] via 37.37.37.3, 05:01:16, FastEthernet0/0
O E2    172.16.80.1/32 [110/2] via 37.37.37.3, 01:09:25, FastEthernet0/0
C       172.16.70.0/24 is directly connected, Loopback0
     37.0.0.0/24 is subnetted, 1 subnets
C       37.37.37.0 is directly connected, FastEthernet0/0
     25.0.0.0/30 is subnetted, 2 subnets
O E2    25.25.25.0 [110/2] via 37.37.37.3, 05:01:16, FastEthernet0/0
O E2    25.25.25.4 [110/1] via 37.37.37.3, 05:01:17, FastEthernet0/0
CE7-R7#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
37.37.37.3        1   FULL/DR         00:00:33    37.37.37.3      FastEthernet0/
0
```

```
CE7-R7#

CE7-R7#traceroute
Protocol [ip]:
Target IP address: 172.16.50.1
Source address: 172.16.70.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.50.1

  1 37.37.37.3 240 msec 336 msec 288 msec
  2 13.13.13.1 [MPLS: Labels 16/24 Exp 0] 1992 msec 1940 msec 1800 msec
  3 25.25.25.5 [MPLS: Label 24 Exp 0] 816 msec 860 msec 888 msec
  4 25.25.25.6 912 msec 2508 msec 2336 msec
CE7-R7#traceroute
Protocol [ip]:
Target IP address: 172.16.60.1
Source address: 172.16.70.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.60.1

  1 37.37.37.3 144 msec 312 msec 240 msec
  2 13.13.13.1 [MPLS: Labels 16/27 Exp 0] 2112 msec 1892 msec 1848 msec
  3 25.25.25.5 [MPLS: Label 27 Exp 0] 864 msec 984 msec 912 msec
  4 25.25.25.6 1200 msec 720 msec 744 msec
  5 25.25.25.1 1000 msec 872 msec 816 msec
  6 12.12.12.1 [MPLS: Labels 17/23 Exp 0] 2736 msec 2636 msec 3072 msec
  7 36.36.36.3 [MPLS: Label 23 Exp 0] 1584 msec 1616 msec 1776 msec
  8 36.36.36.6 1872 msec 2328 msec 1536 msec
CE7-R7#traceroute
Protocol [ip]:
Target IP address: 172.16.80.1
```

Source address: 172.16.70.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.80.1

  1 37.37.37.3 288 msec 456 msec 144 msec

  2 13.13.13.1 [MPLS: Labels 16/28 Exp 0] 2040 msec 1868 msec 2188 msec

  3 25.25.25.5 [MPLS: Label 28 Exp 0] 1212 msec 844 msec 816 msec

  4 25.25.25.6 792 msec 960 msec 936 msec

  5 25.25.25.1 2536 msec 1976 msec 1104 msec

  6 12.12.12.1 [MPLS: Labels 18/22 Exp 0] 2928 msec 2876 msec 3168 msec

  7 48.48.48.4 [MPLS: Label 22 Exp 0] 1488 msec 1488 msec 1844 msec

  8 48.48.48.8 1800 msec 2460 msec 1776 msec

CE7-R7#

1.4.8 CE8-R8 配置验证

CE8-R8#show ip ospf neighbor

Neighbor ID   Pri   State   Dead Time   Address   Interface
48.48.48.4   1   FULL/DR   00:00:39   48.48.48.4   FastEthernet0/
0
CE8-R8#show 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, 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

     48.0.0.0/24 is subnetted, 1 subnets
C   48.48.48.0 is directly connected, FastEthernet0/0
     36.0.0.0/24 is subnetted, 1 subnets
O E2   36.36.36.0 [110/1] via 48.48.48.4, 01:15:58, FastEthernet0/0
     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks

```
O E2    172.16.60.1/32 [110/11] via 48.48.48.4, 01:15:58, FastEthernet0/0
O E2    172.16.50.1/32 [110/2] via 48.48.48.4, 05:04:33, FastEthernet0/0
C       172.16.80.0/24 is directly connected, Loopback0
O E2    172.16.70.1/32 [110/11] via 48.48.48.4, 01:15:58, FastEthernet0/0
        37.0.0.0/24 is subnetted, 1 subnets
O E2    37.37.37.0 [110/1] via 48.48.48.4, 01:15:58, FastEthernet0/0
        25.0.0.0/30 is subnetted, 2 subnets
O E2    25.25.25.0 [110/2] via 48.48.48.4, 05:04:34, FastEthernet0/0
O E2    25.25.25.4 [110/1] via 48.48.48.4, 05:04:53, FastEthernet0/0
CE8-R8#
CE8-R8#traceroute
Protocol [ip]:
Target IP address: 172.16.50.1
Source address: 172.16.80.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.50.1

  1 48.48.48.4 288 msec 264 msec 252 msec
  2 14.14.14.1 [MPLS: Labels 16/24 Exp 0] 1936 msec 2008 msec 2092 msec
  3 25.25.25.5 [MPLS: Label 24 Exp 0] 768 msec 908 msec 1032 msec
  4 25.25.25.6 768 msec 1056 msec 960 msec
CE8-R8#traceroute
Protocol [ip]:
Target IP address: 172.16.60.1
Source address: 172.16.80.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.60.1

  1 48.48.48.4 360 msec 216 msec 240 msec
  2 14.14.14.1 [MPLS: Labels 16/27 Exp 0] 2040 msec 2204 msec 2088 msec
  3 25.25.25.5 [MPLS: Label 27 Exp 0] 1128 msec 764 msec 1248 msec
```

4 25.25.25.6 912 msec 1128 msec 1056 msec

5 25.25.25.1 744 msec 984 msec 864 msec

6 12.12.12.1 [MPLS: Labels 17/23 Exp 0] 3096 msec 2924 msec 3140 msec

7 36.36.36.3 [MPLS: Label 23 Exp 0] 1488 msec 1316 msec 1872 msec

8 36.36.36.6 2136 msec 1824 msec 1896 msec

CE8-R8#traceroute

Protocol [ip]:

Target IP address: 172.16.70.1

Source address: 172.16.80.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.70.1

1 48.48.48.4 264 msec 360 msec 144 msec

2 14.14.14.1 [MPLS: Labels 16/29 Exp 0] 1480 msec 2120 msec 2016 msec

3 25.25.25.5 [MPLS: Label 29 Exp 0] 1144 msec 868 msec 744 msec

4 25.25.25.6 936 msec 792 msec 576 msec

5 25.25.25.1 720 msec 888 msec 1200 msec

6 12.12.12.1 [MPLS: Labels 17/24 Exp 0] 3048 msec 2984 msec 2880 msec

7 37.37.37.3 [MPLS: Label 24 Exp 0] 1392 msec 1988 msec 1492 msec

8 37.37.37.7 1508 msec 1728 msec 1608 msec

CE8-R8#

1.5 实现原理及注意事项

1）实现原理：PE2-R2 接收所有从 PE3-R3、PE4-R4 来的私网路由（CE6-R6，CE7-R7，CE8-R8），PE2-R2 的 F0/0.1 绑定到 HUB，那么 CE5-R5 接收到了所有 PE3-R3、PE4-R4 的私网路由，并合成一个路由表；又因为 PE2-R2 的 F0/0.2 绑定到 SPOKE，所以 CE5-R5 把所有的路由发给 PE2-R2，并携带 RT200:200 发送给 PE 邻居。

2）注意事项：PE2-R2 的两个私网接口和 CE5-R5 运行的路由协议是 OSPF，在这种配置下一定要考虑到的一个细节就是 TAG，PE2-R2 私网路由通过 ospf 协议从 F0/0.1 发送给 CE5-R5 时，bgp 会把自己的 as-path 自动加入到 ospf 的 tag 部分，CE5-R5 再把这些携带 TAG 的路由发送给 PE2-R2 时，PE2-R2 会读取私网 OSPF 来的 TAG 标记，如果里面包含自己的 as-path 时，PE2-R2 会忽略掉这些路由。解决的办法就是让 bgp 引入到私网 ospf 时手工修改携带的 tag 信息。

router ospf 100 vrf HUB

log-adjacency-changes

redistribute bgp 100 subnets tag 0

network 25.25.25.0 0.0.0.3 area 0.0.0.0

2 MPLS VPN HUB&SPOKE WITH BGP

2.1 网络拓扑图

2.2 应用需求

Hub&Spoke 组网方式也称为中心服务器拓扑组网。中心 Site 称为 Hub-Site，它知道同一 VPN 所有其它 Site 的路由；不处于中心的 site 称为 Spoke-Site，它们的流量通过 HUB-Site 到达目的地。Hub-Site 是 Spoke-Site 的中枢节点。

某银行的网络包括各分公司网络与公司总部的网络，要求各分公司之间不能直接交换数据，必须通过总部进行通信，以进行统一控制。采用 Hub&Spoke 拓扑，CE6、CE7、CE8 为 Spoke 站点，CE5 为银行数据中心 Hub 站点，CE6、CE7、CE8 间的通信由 CE5 控制。

- PE2 分别与 PE3、PE4 建立 IBGP 邻居关系，但 PE3 与 PE4 不建立 IBGP 邻居关系，不交换 VPN 路由信息；

- 在 PE2 上创建两个 VPN-instance，引入 VPN-target 属性为 6:6，7:7，8:8 的 VPN 路由，对发布的 VPN 路由设置 VPN-target 属性 200:200；

- 在 PE3 上创建二个 VPN-VRF：VRF CE6-R6，VRF-CE7-R7；二个 VPN VRF 引入 VPN-target 属性为 200:200 的 VPN 路由，VRF-CE6-R6 发布的 VPN 路由设置 VPN-target 属性 6:6，VRF-CE7-R7 发布的 VPN 路由设置 VPN-target 属性 7:7；

- 在 PE4 上创建一个 VPN-VRF：CE8-R8，引入 VPN-target 属性为 200:200 的 VPN 路由，对发布的 VPN 路由设置 VPN-target 属性 8:8。

经过以上配置，CE6-R6，CE7-R7，CE8-R8 之间的互访都必须通过 CE5-R5 中转。

2.3 设备配置

2.3.1 P1-R1 设备配置

```
P1-R1#show running
Building configuration...

Current configuration : 1253 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname P1-R1
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
```

```
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 12.12.12.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 13.13.13.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 ip address 14.14.14.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
```

```
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

2.3.2　PE2-R2 设备配置

```
PE2-R2#show running
Building configuration...

Current configuration : 2444 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
```

```
no service password-encryption
!
hostname PE2-R2
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf HUB
 rd 100:1000
 route-target import 6:6
 route-target import 7:7
 route-target import 8:8
!
ip vrf SPOKE
 rd 200:200
 route-target export 200:200
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
```

```
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding HUB
 ip address 25.25.25.1 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding SPOKE
 ip address 25.25.25.5 255.255.255.252
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 12.12.12.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
```

```
 no synchronization
 bgp router-id 2.2.2.2
 bgp log-neighbor-changes
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf SPOKE
 redistribute connected
 neighbor 25.25.25.6 remote-as 65005
 neighbor 25.25.25.6 activate
 neighbor 25.25.25.6 as-override
 neighbor 25.25.25.6 allowas-in
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf HUB
 redistribute connected
 neighbor 25.25.25.2 remote-as 65005
 neighbor 25.25.25.2 activate
 neighbor 25.25.25.2 as-override
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 send-community extended
 neighbor 4.4.4.4 activate
 neighbor 4.4.4.4 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
```

```
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

2.3.3 PE3-R3 设备配置

```
PE3-R3#show running
Building configuration...

Current configuration : 2053 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE3-R3
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf CE6-R6
 rd 6:6
 route-target export 6:6
 route-target import 200:200
```

```
!
ip vrf CE7-R7
 rd 7:7
 route-target export 7:7
 route-target import 200:200
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 13.13.13.3 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
```

```
!
interface Ethernet1/1
 ip vrf forwarding CE6-R6
 ip address 36.36.36.3 255.255.255.0
 half-duplex
!
interface Ethernet1/2
 ip vrf forwarding CE7-R7
 ip address 37.37.37.3 255.255.255.0
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 3.3.3.3
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp router-id 3.3.3.3
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf CE7-R7
 redistribute connected
 neighbor 37.37.37.7 remote-as 65007
 neighbor 37.37.37.7 activate
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf CE6-R6
 redistribute connected
 neighbor 36.36.36.6 remote-as 65006
 neighbor 36.36.36.6 activate
 no auto-summary
 no synchronization
 exit-address-family
 !
```

```
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

2.3.4 PE4-R4 设备配置

```
PE4-R4#show running
Building configuration...

Current configuration : 1709 bytes
!
version 12.2
service timestamps debug datetime msec
```

```
service timestamps log datetime msec
no service password-encryption
!
hostname PE4-R4
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf CE8-R8
 rd 8:8
 route-target export 8:8
 route-target import 200:200
!
ip cef
mpls label protocol ldp
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
!
interface FastEthernet0/0
 ip vrf forwarding CE8-R8
 ip address 48.48.48.4 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
```

```
  shutdown
  duplex auto
  speed auto
!
interface Ethernet1/0
  ip address 14.14.14.4 255.255.255.0
  half-duplex
  mpls label protocol ldp
  tag-switching ip
!
interface Ethernet1/1
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/2
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/3
  no ip address
  shutdown
  half-duplex
!
router ospf 1
  router-id 4.4.4.4
  log-adjacency-changes
  network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
  no synchronization
  bgp router-id 4.4.4.4
  bgp log-neighbor-changes
  neighbor 2.2.2.2 remote-as 100
  neighbor 2.2.2.2 update-source Loopback0
  no auto-summary
  !
  address-family ipv4 vrf CE8-R8
  redistribute connected
  neighbor 48.48.48.8 remote-as 65008
  neighbor 48.48.48.8 activate
  no auto-summary
  no synchronization
  exit-address-family
```

```
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

2.3.5 CE5-R5 设备配置

```
CE5-R5#show running
Building configuration...

Current configuration : 1044 bytes
!
version 12.2
```

```
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE5-R5
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.50.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip address 25.25.25.2 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip address 25.25.25.6 255.255.255.252
!
```

```
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router bgp 65005
 no synchronization
 bgp log-neighbor-changes
 network 172.16.50.0 mask 255.255.255.0
 neighbor 25.25.25.1 remote-as 100
 neighbor 25.25.25.5 remote-as 100
 no auto-summary
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

2.3.6 CE6-R6 设备配置

```
CE6-R6#show running
Building configuration...

Current configuration : 840 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE6-R6
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.60.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 36.36.36.6 255.255.255.0
 duplex auto
 speed auto
```

```
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router bgp 65006
 no synchronization
 bgp log-neighbor-changes
 network 172.16.60.0 mask 255.255.255.0
 neighbor 36.36.36.3 remote-as 100
 no auto-summary
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

2.3.7 CE7-R7 设备配置

```
CE7-R7#show running
Building configuration...

Current configuration : 840 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE7-R7
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.70.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 37.37.37.7 255.255.255.0
 duplex auto
 speed auto
```

```
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router bgp 65007
 no synchronization
 bgp log-neighbor-changes
 network 172.16.70.0 mask 255.255.255.0
 neighbor 37.37.37.3 remote-as 100
 no auto-summary
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

2.3.8 CE8-R8 设备配置

```
CE8-R8#show running
Building configuration...

Current configuration : 840 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE8-R8
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.80.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 48.48.48.8 255.255.255.0
 duplex auto
 speed auto
```

```
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router bgp 65008
 no synchronization
 bgp log-neighbor-changes
 network 172.16.80.0 mask 255.255.255.0
 neighbor 48.48.48.4 remote-as 100
 no auto-summary
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

2.4 设备配置

2.4.1 P1-R1 配置验证

```
P1-R1#show ip ospf neighbor

Neighbor ID     Pri   State        Dead Time    Address       Interface
4.4.4.4          1    FULL/BDR     00:00:33     14.14.14.4    Ethernet1/2
3.3.3.3          1    FULL/BDR     00:00:35     13.13.13.3    Ethernet1/1
2.2.2.2          1    FULL/BDR     00:00:31     12.12.12.2    Ethernet1/0
P1-R1#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 12.12.12.2, 04:15:16, Ethernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/11] via 13.13.13.3, 04:15:16, Ethernet1/1
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/11] via 14.14.14.4, 04:15:16, Ethernet1/2
     12.0.0.0/24 is subnetted, 1 subnets
C       12.12.12.0 is directly connected, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
C       13.13.13.0 is directly connected, Ethernet1/1
     14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Ethernet1/2
P1-R1#
```

2.4.2 PE2-R2 配置验证

```
PE2-R2#show ip ospf neighbor

Neighbor ID     Pri   State        Dead Time    Address       Interface
172.16.50.1      1    FULL/BDR     00:00:32     25.25.25.6    FastEthernet0/
```

```
0.2
172.16.50.1        1   FULL/BDR        00:00:32   25.25.25.2      FastEthernet0/
0.1
1.1.1.1            1   FULL/DR         00:00:38   12.12.12.1      Ethernet1/0
PE2-R2#show 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, 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


     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/11] via 12.12.12.1, 04:19:39, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/21] via 12.12.12.1, 04:19:39, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/21] via 12.12.12.1, 04:19:39, Ethernet1/0
     12.0.0.0/24 is subnetted, 1 subnets
C       12.12.12.0 is directly connected, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/20] via 12.12.12.1, 04:19:39, Ethernet1/0
     14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/20] via 12.12.12.1, 04:19:40, Ethernet1/0


PE2-R2# show ip bgp summary
BGP router identifier 2.2.2.2, local AS number 100
BGP table version is 1, main routing table version 1


Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
3.3.3.3         4   100    283     284        1    0    0 04:25:18         0
4.4.4.4         4   100    272     273        1    0    0 04:22:53         0
PE2-R2#


PE2-R2#show ip bgp neighbor
BGP neighbor is 3.3.3.3,   remote AS 100, internal link
  BGP version 4, remote router ID 3.3.3.3
  BGP state = Established, up for 04:22:08
  Last read 00:00:08, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
```

```
      Route refresh: advertised and received(old & new)
      Address family IPv4 Unicast: advertised and received
      IPv4 MPLS Label capability:
      Address family VPNv4 Unicast: advertised and received
      IPv4 MPLS Label capability:
   Received 280 messages, 0 notifications, 0 in queue
   Sent 281 messages, 0 notifications, 0 in queue
   Default minimum time between advertisement runs is 5 seconds

  For address family: IPv4 Unicast
   BGP table version 1, neighbor version 1
   Index 1, Offset 0, Mask 0x2
   Route refresh request: received 0, sent 0
   0 accepted prefixes consume 0 bytes
   Prefix advertised 0, suppressed 0, withdrawn 0

  For address family: VPNv4 Unicast
   BGP table version 33, neighbor version 33
   Index 1, Offset 0, Mask 0x2
   Route refresh request: received 2, sent 0
   4 accepted prefixes consume 256 bytes
   Prefix advertised 22, suppressed 0, withdrawn 0

   Connections established 1; dropped 0
   Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Local host: 2.2.2.2, Local port: 11014
Foreign host: 3.3.3.3, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0  mis-ordered: 0 (0 bytes)

Event Timers (current time is 0xF2C90C):
Timer          Starts    Wakeups          Next
Retrans          297        19            0x0
TimeWait           0         0            0x0
AckHold          277       233            0x0
SendWnd            0         0            0x0
KeepAlive          0         0            0x0
GiveUp             0         0            0x0
PmtuAger           0         0            0x0
DeadWait           0         0            0x0

iss: 4031352652  snduna: 4031359543  sndnxt: 4031359543     sndwnd:  16080
irs: 3473306622  rcvnxt: 3473313131  rcvwnd:       16004  delrcvwnd:    380
```

SRTT: 540 ms, RTTO: 1121 ms, RTV: 581 ms, KRTT: 0 ms

minRTT: 256 ms, maxRTT: 1276 ms, ACK hold: 200 ms

Flags: higher precedence, nagle

Datagrams (max data segment is 536 bytes):

Rcvd: 476 (out of order: 0), with data: 277, total data bytes: 6508

Sent: 541 (retransmit: 19, fastretransmit: 0), with data: 277, total data bytes:
 6890

BGP neighbor is 4.4.4.4, remote AS 100, internal link

  BGP version 4, remote router ID 4.4.4.4

  BGP state = Established, up for 04:19:45

  Last read 00:00:46, hold time is 180, keepalive interval is 60 seconds

  Neighbor capabilities:

    Route refresh: advertised and received(old & new)

    Address family IPv4 Unicast: advertised and received

    IPv4 MPLS Label capability:

    Address family VPNv4 Unicast: advertised and received

    IPv4 MPLS Label capability:

  Received 269 messages, 0 notifications, 0 in queue

  Sent 270 messages, 0 notifications, 0 in queue

  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast

  BGP table version 1, neighbor version 1

  Index 2, Offset 0, Mask 0x4

  Route refresh request: received 0, sent 0

  0 accepted prefixes consume 0 bytes

  Prefix advertised 0, suppressed 0, withdrawn 0

 For address family: VPNv4 Unicast

  BGP table version 33, neighbor version 33

  Index 2, Offset 0, Mask 0x4

  Route refresh request: received 0, sent 0

  2 accepted prefixes consume 128 bytes

  Prefix advertised 12, suppressed 0, withdrawn 0

  Connections established 1; dropped 0

  Last reset never

Connection state is ESTAB, I/O status: 1, unread input bytes: 0

Local host: 2.2.2.2, Local port: 11015

Foreign host: 4.4.4.4, Foreign port: 179

Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)

```
Event Timers (current time is 0xF2D47C):
Timer          Starts      Wakeups          Next
Retrans           294          26           0x0
TimeWait            0           0           0x0
AckHold           268         218           0x0
SendWnd             0           0           0x0
KeepAlive           0           0           0x0
GiveUp              0           0           0x0
PmtuAger            0           0           0x0
DeadWait            0           0           0x0


iss: 2518791696  snduna: 2518797602  sndnxt: 2518797602    sndwnd:  16061
irs:   84936295  rcvnxt:   84942014  rcvwnd:        16175  delrcvwnd:   209


SRTT: 604 ms, RTTO: 1101 ms, RTV: 497 ms, KRTT: 0 ms
minRTT: 300 ms, maxRTT: 1280 ms, ACK hold: 200 ms
Flags: higher precedence, nagle


Datagrams (max data segment is 536 bytes):
Rcvd: 454 (out of order: 0), with data: 268, total data bytes: 5718
Sent: 516 (retransmit: 26, fastretransmit: 0), with data: 267, total data bytes:
 5905
PE2-R2#show ip bgp vpnv4 vrf HUB
BGP table version is 33, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete


   Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 100:1000 (default for vrf HUB)
*>  25.25.25.0/30    0.0.0.0               0           32768 ?
*>i36.36.36.0/24     3.3.3.3               0    100       0 ?
*>i37.37.37.0/24     3.3.3.3               0    100       0 ?
*>i48.48.48.0/24     4.4.4.4               0    100       0 ?
*>i172.16.60.1/32    3.3.3.3              11    100       0 ?
*>i172.16.70.1/32    3.3.3.3              11    100       0 ?
*>i172.16.80.1/32    4.4.4.4               2    100       0 ?
PE2-R2#show ip bgp vpnv4 vrf SPOKE
BGP table version is 33, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete


   Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 200:200 (default for vrf SPOKE)
```

```
*>  25.25.25.0/30    25.25.25.6            2         32768 ?
*>  25.25.25.4/30    0.0.0.0              0         32768 ?
*>  36.36.36.0/24    25.25.25.6            1         32768 ?
*>  37.37.37.0/24    25.25.25.6            1         32768 ?
*>  48.48.48.0/24    25.25.25.6            1         32768 ?
*>  172.16.50.1/32   25.25.25.6            2         32768 ?
*>  172.16.60.1/32   25.25.25.6           11         32768 ?
*>  172.16.70.1/32   25.25.25.6           11         32768 ?
*>  172.16.80.1/32   25.25.25.6            2         32768 ?
PE2-R2#show ip route vrf HUB
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, 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


     48.0.0.0/24 is subnetted, 1 subnets
B       48.48.48.0 [200/0] via 4.4.4.4, 04:20:22
     36.0.0.0/24 is subnetted, 1 subnets
B       36.36.36.0 [200/0] via 3.3.3.3, 04:22:08
     172.16.0.0/32 is subnetted, 4 subnets
B       172.16.60.1 [200/11] via 3.3.3.3, 04:15:22
O       172.16.50.1 [110/2] via 25.25.25.2, 04:17:48, FastEthernet0/0.1
B       172.16.80.1 [200/2] via 4.4.4.4, 04:08:20
B       172.16.70.1 [200/11] via 3.3.3.3, 04:11:50
     37.0.0.0/24 is subnetted, 1 subnets
B       37.37.37.0 [200/0] via 3.3.3.3, 04:22:08
     25.0.0.0/30 is subnetted, 2 subnets
C       25.25.25.0 is directly connected, FastEthernet0/0.1
O       25.25.25.4 [110/2] via 25.25.25.2, 04:17:49, FastEthernet0/0.1
PE2-R2#show ip route vrf SPOKE
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, 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
```

```
     48.0.0.0/24 is subnetted, 1 subnets
O E2    48.48.48.0 [110/1] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
     36.0.0.0/24 is subnetted, 1 subnets
O E2    36.36.36.0 [110/1] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
     172.16.0.0/32 is subnetted, 4 subnets
O E2    172.16.60.1 [110/11] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
O       172.16.50.1 [110/2] via 25.25.25.6, 04:17:57, FastEthernet0/0.2
O E2    172.16.80.1 [110/2] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
O E2    172.16.70.1 [110/11] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
     37.0.0.0/24 is subnetted, 1 subnets
O E2    37.37.37.0 [110/1] via 25.25.25.6, 03:32:28, FastEthernet0/0.2
     25.0.0.0/30 is subnetted, 2 subnets
O       25.25.25.0 [110/2] via 25.25.25.6, 04:17:58, FastEthernet0/0.2
C       25.25.25.4 is directly connected, FastEthernet0/0.2
PE2-R2#
```

2.4.3　PE3-R3 配置验证

```
PE3-R3#show ip ospf neighbor

Neighbor ID     Pri   State          Dead Time   Address         Interface
172.16.70.1      1    FULL/BDR       00:00:38    37.37.37.7      Ethernet1/2
172.16.60.1      1    FULL/BDR       00:00:39    36.36.36.6      Ethernet1/1
1.1.1.1          1    FULL/DR        00:00:34    13.13.13.1      Ethernet1/0
PE3-R3#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/11] via 13.13.13.1, 03:30:46, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/21] via 13.13.13.1, 03:30:46, Ethernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/21] via 13.13.13.1, 03:30:46, Ethernet1/0
     12.0.0.0/24 is subnetted, 1 subnets
```

```
O       12.12.12.0 [110/20] via 13.13.13.1, 03:30:46, Ethernet1/0
      13.0.0.0/24 is subnetted, 1 subnets
C       13.13.13.0 is directly connected, Ethernet1/0
      14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/20] via 13.13.13.1, 03:30:47, Ethernet1/0
PE3-R3#


PE3-R3#show ip bgp summary
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 1, main routing table version 1

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
2.2.2.2         4   100    286     285        1    0    0 04:27:05          0
PE3-R3#show ip bgp neighbor
BGP neighbor is 2.2.2.2,  remote AS 100, internal link
  BGP version 4, remote router ID 2.2.2.2
  BGP state = Established, up for 04:27:14
  Last read 00:00:14, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
    Address family VPNv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
  Received 286 messages, 0 notifications, 0 in queue
  Sent 285 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
  0 accepted prefixes consume 0 bytes
  Prefix advertised 0, suppressed 0, withdrawn 0

 For address family: VPNv4 Unicast
  BGP table version 39, neighbor version 39
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 2
  9 accepted prefixes consume 576 bytes
  Prefix advertised 12, suppressed 0, withdrawn 0

  Connections established 1; dropped 0
  Last reset never
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
```

Local host: 3.3.3.3, Local port: 179
Foreign host: 2.2.2.2, Foreign port: 11014

Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)

Event Timers (current time is 0xF5E6EC):
Timer	Starts	Wakeups	Next
Retrans	301	18	0x0
TimeWait	0	0	0x0
AckHold	282	152	0x0
SendWnd	0	0	0x0
KeepAlive	0	0	0x0
GiveUp	0	0	0x0
PmtuAger	0	0	0x0
DeadWait	0	0	0x0

iss: 3473306622 snduna: 3473313226 sndnxt: 3473313226   sndwnd: 15909
irs: 4031352652 rcvnxt: 4031359638 rcvwnd: 15985 delrcvwnd: 399

SRTT: 674 ms, RTTO: 1147 ms, RTV: 473 ms, KRTT: 0 ms
minRTT: 276 ms, maxRTT: 2036 ms, ACK hold: 200 ms
Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 536 bytes):
Rcvd: 567 (out of order: 0), with data: 282, total data bytes: 6985
Sent: 463 (retransmit: 18, fastretransmit: 0), with data: 282, total data bytes:
 6603
PE3-R3#show ip bgp vpnv4 vrf CE6-R6
BGP table version is 39, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 6:6 (default for vrf CE6-R6)					
*>i25.25.25.0/30	2.2.2.2	2	100	0	?
*>i25.25.25.4/30	2.2.2.2	0	100	0	?
* i36.36.36.0/24	2.2.2.2	1	100	0	?
*>	0.0.0.0	0		32768	?
*>i37.37.37.0/24	2.2.2.2	1	100	0	?
*>i48.48.48.0/24	2.2.2.2	1	100	0	?
*>i172.16.50.1/32	2.2.2.2	2	100	0	?
* i172.16.60.1/32	2.2.2.2	11	100	0	?
*>	36.36.36.6	11		32768	?
*>i172.16.70.1/32	2.2.2.2	11	100	0	?

```
*>i172.16.80.1/32    2.2.2.2                     2    100       0 ?
PE3-R3#show ip bgp vpnv4 vrf CE7-R7
BGP table version is 39, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete


   Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 7:7 (default for vrf CE7-R7)
*>i25.25.25.0/30    2.2.2.2                 2    100       0 ?
*>i25.25.25.4/30    2.2.2.2                 0    100       0 ?
*>i36.36.36.0/24    2.2.2.2                 1    100       0 ?
* i37.37.37.0/24    2.2.2.2                 1    100       0 ?
*>                  0.0.0.0                 0          32768 ?
*>i48.48.48.0/24    2.2.2.2                 1    100       0 ?
*>i172.16.50.1/32   2.2.2.2                 2    100       0 ?
*>i172.16.60.1/32   2.2.2.2                11    100       0 ?
* i172.16.70.1/32   2.2.2.2                11    100       0 ?
*>                  37.37.37.7             11          32768 ?
*>i172.16.80.1/32   2.2.2.2                 2    100       0 ?
PE3-R3#


PE3-R3#show ip route vrf CE6-R6
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, 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


     48.0.0.0/24 is subnetted, 1 subnets
B       48.48.48.0 [200/1] via 2.2.2.2, 00:25:32
     36.0.0.0/24 is subnetted, 1 subnets
C       36.36.36.0 is directly connected, Ethernet1/1
     172.16.0.0/32 is subnetted, 4 subnets
O       172.16.60.1 [110/11] via 36.36.36.6, 03:32:27, Ethernet1/1
B       172.16.50.1 [200/2] via 2.2.2.2, 04:23:06
B       172.16.80.1 [200/2] via 2.2.2.2, 00:25:32
B       172.16.70.1 [200/11] via 2.2.2.2, 00:25:32
     37.0.0.0/24 is subnetted, 1 subnets
B       37.37.37.0 [200/1] via 2.2.2.2, 00:25:32
     25.0.0.0/30 is subnetted, 2 subnets
```

```
B        25.25.25.0 [200/2] via 2.2.2.2, 04:23:06
B        25.25.25.4 [200/0] via 2.2.2.2, 04:27:37
PE3-R3#show ip route vrf CE7-R7
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, 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

     48.0.0.0/24 is subnetted, 1 subnets
B        48.48.48.0 [200/1] via 2.2.2.2, 00:25:40
     36.0.0.0/24 is subnetted, 1 subnets
B        36.36.36.0 [200/1] via 2.2.2.2, 00:25:40
     172.16.0.0/32 is subnetted, 4 subnets
B        172.16.60.1 [200/11] via 2.2.2.2, 00:25:40
B        172.16.50.1 [200/2] via 2.2.2.2, 04:23:14
B        172.16.80.1 [200/2] via 2.2.2.2, 00:25:40
O        172.16.70.1 [110/11] via 37.37.37.7, 03:32:35, Ethernet1/2
     37.0.0.0/24 is subnetted, 1 subnets
C        37.37.37.0 is directly connected, Ethernet1/2
     25.0.0.0/30 is subnetted, 2 subnets
B        25.25.25.0 [200/2] via 2.2.2.2, 04:23:14
B        25.25.25.4 [200/0] via 2.2.2.2, 04:27:46
PE3-R3#
```

2.4.4 PE4-R4 配置验证

```
PE4-R4#show ip ospf neighbor

Neighbor ID     Pri   State        Dead Time   Address         Interface
172.16.80.1      1    FULL/BDR     00:00:30    48.48.48.8      FastEthernet0/
0
1.1.1.1          1    FULL/DR      00:00:35    14.14.14.1      Ethernet1/0
PE4-R4#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O   1.1.1.1 [110/11] via 14.14.14.1, 04:50:29, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O   2.2.2.2 [110/21] via 14.14.14.1, 04:50:29, Ethernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
O   3.3.3.3 [110/21] via 14.14.14.1, 04:50:29, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
C   4.4.4.4 is directly connected, Loopback0
     12.0.0.0/24 is subnetted, 1 subnets
O   12.12.12.0 [110/20] via 14.14.14.1, 04:50:29, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
O   13.13.13.0 [110/20] via 14.14.14.1, 04:50:29, Ethernet1/0
     14.0.0.0/24 is subnetted, 1 subnets
C   14.14.14.0 is directly connected, Ethernet1/0
PE4-R4#show ip bgp summary
BGP router identifier 4.4.4.4, local AS number 100
BGP table version is 1, main routing table version 1

Neighbor   V   AS MsgRcvd MsgSent   TblVer InQ OutQ Up/Down State/PfxRcd
2.2.2.2   4   100   301   300   1   0   0 04:50:34   0
PE4-R4#show ip bgp neighbor
BGP neighbor is 2.2.2.2, remote AS 100, internal link
  BGP version 4, remote router ID 2.2.2.2
  BGP state = Established, up for 04:50:42
  Last read 00:00:41, hold time is 180, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received(old & new)
    Address family IPv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
    Address family VPNv4 Unicast: advertised and received
    IPv4 MPLS Label capability:
  Received 301 messages, 0 notifications, 0 in queue
  Sent 300 messages, 0 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds

 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
  0 accepted prefixes consume 0 bytes
  Prefix advertised 0, suppressed 0, withdrawn 0

For address family: VPNv4 Unicast

  BGP table version 23, neighbor version 23

  Index 1, Offset 0, Mask 0x2

  Route refresh request: received 0, sent 0

  9 accepted prefixes consume 576 bytes

  Prefix advertised 6, suppressed 0, withdrawn 0

  Connections established 1; dropped 0

  Last reset never

Connection state is ESTAB, I/O status: 1, unread input bytes: 0

Local host: 4.4.4.4, Local port: 179

Foreign host: 2.2.2.2, Foreign port: 11015

Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)

Event Timers (current time is 0x10B7800):

Timer   Starts   Wakeups   Next

Retrans   319   19   0x0

TimeWait   0   0   0x0

AckHold   298   160   0x0

SendWnd   0   0   0x0

KeepAlive   0   0   0x0

GiveUp   0   0   0x0

PmtuAger   0   0   0x0

DeadWait   0   0   0x0

iss: 84936295 snduna: 84942603 sndnxt: 84942603   sndwnd: 16137

irs: 2518791696 rcvnxt: 2518798191 rcvwnd: 16023 delrcvwnd: 361

SRTT: 557 ms, RTTO: 826 ms, RTV: 269 ms, KRTT: 0 ms

minRTT: 256 ms, maxRTT: 1968 ms, ACK hold: 200 ms

Flags: passive open, nagle, gen tcbs

Datagrams (max data segment is 536 bytes):

Rcvd: 582 (out of order: 0), with data: 298, total data bytes: 6494

Sent: 498 (retransmit: 19, fastretransmit: 0), with data: 299, total data bytes:
 6307

PE4-R4#

PE4-R4#show ip bgp vpnv4 vrf CE8-R8

BGP table version is 23, local router ID is 4.4.4.4

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

            r RIB-failure

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

```
      Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 8:8 (default for vrf CE8-R8)
*>i25.25.25.0/30     2.2.2.2                 2    100       0 ?
*>i25.25.25.4/30     2.2.2.2                 0    100       0 ?
*>i36.36.36.0/24     2.2.2.2                 1    100       0 ?
*>i37.37.37.0/24     2.2.2.2                 1    100       0 ?
* i48.48.48.0/24     2.2.2.2                 1    100       0 ?
*>                   0.0.0.0                 0          32768 ?
*>i172.16.50.1/32    2.2.2.2                 2    100       0 ?
*>i172.16.60.1/32    2.2.2.2                11    100       0 ?
*>i172.16.70.1/32    2.2.2.2                11    100       0 ?
* i172.16.80.1/32    2.2.2.2                 2    100       0 ?
*>                   48.48.48.8              2          32768 ?
PE4-R4#show ip route vrf CE8-R8

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, 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


     48.0.0.0/24 is subnetted, 1 subnets
C       48.48.48.0 is directly connected, FastEthernet0/0
     36.0.0.0/24 is subnetted, 1 subnets
B       36.36.36.0 [200/1] via 2.2.2.2, 00:51:41
     172.16.0.0/32 is subnetted, 4 subnets
B       172.16.60.1 [200/11] via 2.2.2.2, 00:51:41
B       172.16.50.1 [200/2] via 2.2.2.2, 04:49:13
O       172.16.80.1 [110/2] via 48.48.48.8, 04:40:06, FastEthernet0/0
B       172.16.70.1 [200/11] via 2.2.2.2, 00:51:41
     37.0.0.0/24 is subnetted, 1 subnets
B       37.37.37.0 [200/1] via 2.2.2.2, 00:51:41
     25.0.0.0/30 is subnetted, 2 subnets
B       25.25.25.0 [200/2] via 2.2.2.2, 04:49:13
B       25.25.25.4 [200/0] via 2.2.2.2, 04:51:44
PE4-R4#
```

2.4.5 CE5-R5 配置验证

```
CE5-R5#show ip ospf neighbor
```

```
Neighbor ID      Pri   State           Dead Time    Address          Interface
25.25.25.5         1   FULL/DR         00:00:30     25.25.25.5       FastEthernet0/
0.2
25.25.25.1         1   FULL/DR         00:00:30     25.25.25.1       FastEthernet0/
0.1
CE5-R5#show 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, 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

     48.0.0.0/24 is subnetted, 1 subnets
O E2    48.48.48.0 [110/1] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
     36.0.0.0/24 is subnetted, 1 subnets
O E2    36.36.36.0 [110/1] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
O E2    172.16.60.1/32 [110/11] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
C       172.16.50.0/24 is directly connected, Loopback0
O E2    172.16.80.1/32 [110/2] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
O E2    172.16.70.1/32 [110/11] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
     37.0.0.0/24 is subnetted, 1 subnets
O E2    37.37.37.0 [110/1] via 25.25.25.1, 04:05:16, FastEthernet0/0.1
     25.0.0.0/30 is subnetted, 2 subnets
C       25.25.25.0 is directly connected, FastEthernet0/0.1
C       25.25.25.4 is directly connected, FastEthernet0/0.2
CE5-R5#

CE5-R5#traceroute
Protocol [ip]:
Target IP address: 172.16.60.1
Source address: 172.16.50.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
```

Tracing the route to 172.16.60.1

  1 25.25.25.1 288 msec 288 msec 312 msec
  2 12.12.12.1 [MPLS: Labels 17/23 Exp 0] 1800 msec 1964 msec 1896 msec
  3 36.36.36.3 [MPLS: Label 23 Exp 0] 792 msec 548 msec 600 msec
  4 36.36.36.6 744 msec 1032 msec 1104 msec
CE5-R5#traceroute
Protocol [ip]:
Target IP address: 172.16.70.1
Source address: 172.16.50.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.70.1

  1 25.25.25.1 332 msec 288 msec 360 msec
  2 12.12.12.1 [MPLS: Labels 17/24 Exp 0] 1976 msec 2060 msec 1848 msec
  3 37.37.37.3 [MPLS: Label 24 Exp 0] 600 msec 476 msec 592 msec
  4 37.37.37.7 728 msec 960 msec 1128 msec
CE5-R5#traceroute
Protocol [ip]:
Target IP address: 172.16.80.1
Source address: 172.16.50.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.80.1

  1 25.25.25.1 168 msec 264 msec 240 msec
  2 12.12.12.1 [MPLS: Labels 18/22 Exp 0] 1752 msec 1748 msec 2016 msec
  3 48.48.48.4 [MPLS: Label 22 Exp 0] 696 msec 644 msec 696 msec
  4 48.48.48.8 960 msec 744 msec 816 msec
CE5-R5#

2.4.6 CE6-R6 配置验证

CE6-R6#show ip ospf neighbor

```
Neighbor ID     Pri   State           Dead Time   Address         Interface
36.36.36.3       1    FULL/DR         00:00:30    36.36.36.3      FastEthernet0/
0
```
CE6-R6#show 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, 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

     48.0.0.0/24 is subnetted, 1 subnets
O E2   48.48.48.0 [110/1] via 36.36.36.3, 00:59:54, FastEthernet0/0
     36.0.0.0/24 is subnetted, 1 subnets
C   36.36.36.0 is directly connected, FastEthernet0/0
     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C   172.16.60.0/24 is directly connected, Loopback0
O E2   172.16.50.1/32 [110/2] via 36.36.36.3, 04:55:14, FastEthernet0/0
O E2   172.16.80.1/32 [110/2] via 36.36.36.3, 00:59:54, FastEthernet0/0
O E2   172.16.70.1/32 [110/11] via 36.36.36.3, 00:59:54, FastEthernet0/0
     37.0.0.0/24 is subnetted, 1 subnets
O E2   37.37.37.0 [110/1] via 36.36.36.3, 00:59:54, FastEthernet0/0
     25.0.0.0/30 is subnetted, 2 subnets
O E2   25.25.25.0 [110/2] via 36.36.36.3, 04:55:15, FastEthernet0/0
O E2   25.25.25.4 [110/1] via 36.36.36.3, 04:55:15, FastEthernet0/0
CE6-R6#

CE6-R6#traceroute
Protocol [ip]:
Target IP address: 172.16.50.1
Source address: 172.16.60.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.50.1

  1 36.36.36.3 216 msec 120 msec 264 msec

  2 13.13.13.1 [MPLS: Labels 16/24 Exp 0] 1520 msec 1988 msec 1944 msec

  3 25.25.25.5 [MPLS: Label 24 Exp 0] 576 msec 956 msec 816 msec

  4 25.25.25.6 696 msec 840 msec 816 msec

CE6-R6#traceroute

Protocol [ip]:

Target IP address: 172.16.70.1

Source address: 172.16.60.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.70.1

  1 36.36.36.3 216 msec 264 msec 168 msec

  2 13.13.13.1 [MPLS: Labels 16/29 Exp 0] 1824 msec 1832 msec 2124 msec

  3 25.25.25.5 [MPLS: Label 29 Exp 0] 816 msec 860 msec 1452 msec

  4 25.25.25.6 948 msec 792 msec 912 msec

  5 25.25.25.1 936 msec 1080 msec 1032 msec

  6 12.12.12.1 [MPLS: Labels 17/24 Exp 0] 2952 msec 3116 msec 2832 msec

  7 37.37.37.3 [MPLS: Label 24 Exp 0] 1248 msec 1532 msec 1704 msec

  8 37.37.37.7 2184 msec 1992 msec 1800 msec

CE6-R6#traceroute

Protocol [ip]:

Target IP address: 172.16.80.1

Source address: 172.16.60.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.80.1

  1 36.36.36.3 336 msec 312 msec 192 msec

```
    2 13.13.13.1 [MPLS: Labels 16/28 Exp 0] 1968 msec 1156 msec 2136 msec

    3 25.25.25.5 [MPLS: Label 28 Exp 0] 840 msec 744 msec 744 msec

    4 25.25.25.6 936 msec 816 msec 900 msec

    5 25.25.25.1 840 msec 984 msec 816 msec

    6 12.12.12.1 [MPLS: Labels 18/22 Exp 0] 3024 msec 2924 msec 2616 msec

    7 48.48.48.4 [MPLS: Label 22 Exp 0] 3408 msec 1460 msec 1800 msec

    8 48.48.48.8 1968 msec 1800 msec 2452 msec
CE6-R6#
```

2.4.7 CE7-R7 配置验证

```
CE7-R7#show 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, 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

     48.0.0.0/24 is subnetted, 1 subnets
O E2    48.48.48.0 [110/1] via 37.37.37.3, 01:09:25, FastEthernet0/0
     36.0.0.0/24 is subnetted, 1 subnets
O E2    36.36.36.0 [110/1] via 37.37.37.3, 01:09:25, FastEthernet0/0
     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
O E2    172.16.60.1/32 [110/11] via 37.37.37.3, 01:09:25, FastEthernet0/0
O E2    172.16.50.1/32 [110/2] via 37.37.37.3, 05:01:16, FastEthernet0/0
O E2    172.16.80.1/32 [110/2] via 37.37.37.3, 01:09:25, FastEthernet0/0
C       172.16.70.0/24 is directly connected, Loopback0
     37.0.0.0/24 is subnetted, 1 subnets
C       37.37.37.0 is directly connected, FastEthernet0/0
     25.0.0.0/30 is subnetted, 2 subnets
O E2    25.25.25.0 [110/2] via 37.37.37.3, 05:01:16, FastEthernet0/0
O E2    25.25.25.4 [110/1] via 37.37.37.3, 05:01:17, FastEthernet0/0
CE7-R7#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
37.37.37.3        1   FULL/DR         00:00:33    37.37.37.3      FastEthernet0/
0
CE7-R7#


CE7-R7#traceroute
```

Protocol [ip]:

Target IP address: 172.16.50.1

Source address: 172.16.70.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.50.1

  1 37.37.37.3 240 msec 336 msec 288 msec

  2 13.13.13.1 [MPLS: Labels 16/24 Exp 0] 1992 msec 1940 msec 1800 msec

  3 25.25.25.5 [MPLS: Label 24 Exp 0] 816 msec 860 msec 888 msec

  4 25.25.25.6 912 msec 2508 msec 2336 msec

CE7-R7#traceroute

Protocol [ip]:

Target IP address: 172.16.60.1

Source address: 172.16.70.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.60.1

  1 37.37.37.3 144 msec 312 msec 240 msec

  2 13.13.13.1 [MPLS: Labels 16/27 Exp 0] 2112 msec 1892 msec 1848 msec

  3 25.25.25.5 [MPLS: Label 27 Exp 0] 864 msec 984 msec 912 msec

  4 25.25.25.6 1200 msec 720 msec 744 msec

  5 25.25.25.1 1000 msec 872 msec 816 msec

  6 12.12.12.1 [MPLS: Labels 17/23 Exp 0] 2736 msec 2636 msec 3072 msec

  7 36.36.36.3 [MPLS: Label 23 Exp 0] 1584 msec 1616 msec 1776 msec

  8 36.36.36.6 1872 msec 2328 msec 1536 msec

CE7-R7#traceroute

Protocol [ip]:

Target IP address: 172.16.80.1

Source address: 172.16.70.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.80.1

  1 37.37.37.3 288 msec 456 msec 144 msec

  2 13.13.13.1 [MPLS: Labels 16/28 Exp 0] 2040 msec 1868 msec 2188 msec

  3 25.25.25.5 [MPLS: Label 28 Exp 0] 1212 msec 844 msec 816 msec

  4 25.25.25.6 792 msec 960 msec 936 msec

  5 25.25.25.1 2536 msec 1976 msec 1104 msec

  6 12.12.12.1 [MPLS: Labels 18/22 Exp 0] 2928 msec 2876 msec 3168 msec

  7 48.48.48.4 [MPLS: Label 22 Exp 0] 1488 msec 1488 msec 1844 msec

  8 48.48.48.8 1800 msec 2460 msec 1776 msec

CE7-R7#

2.4.8 CE8-R8 配置验证

CE8-R8#show ip ospf neighbor

Neighbor ID   Pri State   Dead Time   Address   Interface
48.48.48.4   1   FULL/DR   00:00:39   48.48.48.4   FastEthernet0/
0
CE8-R8#show 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, 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

     48.0.0.0/24 is subnetted, 1 subnets
C   48.48.48.0 is directly connected, FastEthernet0/0
     36.0.0.0/24 is subnetted, 1 subnets
O E2   36.36.36.0 [110/1] via 48.48.48.4, 01:15:58, FastEthernet0/0
     172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
O E2   172.16.60.1/32 [110/11] via 48.48.48.4, 01:15:58, FastEthernet0/0
O E2   172.16.50.1/32 [110/2] via 48.48.48.4, 05:04:33, FastEthernet0/0
C   172.16.80.0/24 is directly connected, Loopback0

```
O E2     172.16.70.1/32 [110/11] via 48.48.48.4, 01:15:58, FastEthernet0/0
      37.0.0.0/24 is subnetted, 1 subnets
O E2     37.37.37.0 [110/1] via 48.48.48.4, 01:15:58, FastEthernet0/0
      25.0.0.0/30 is subnetted, 2 subnets
O E2     25.25.25.0 [110/2] via 48.48.48.4, 05:04:34, FastEthernet0/0
O E2     25.25.25.4 [110/1] via 48.48.48.4, 05:04:53, FastEthernet0/0
CE8-R8#
CE8-R8#traceroute
Protocol [ip]:
Target IP address: 172.16.50.1
Source address: 172.16.80.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.50.1


  1 48.48.48.4 288 msec 264 msec 252 msec
  2 14.14.14.1 [MPLS: Labels 16/24 Exp 0] 1936 msec 2008 msec 2092 msec
  3 25.25.25.5 [MPLS: Label 24 Exp 0] 768 msec 908 msec 1032 msec
  4 25.25.25.6 768 msec 1056 msec 960 msec
CE8-R8#traceroute
Protocol [ip]:
Target IP address: 172.16.60.1
Source address: 172.16.80.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.60.1


  1 48.48.48.4 360 msec 216 msec 240 msec
  2 14.14.14.1 [MPLS: Labels 16/27 Exp 0] 2040 msec 2204 msec 2088 msec
  3 25.25.25.5 [MPLS: Label 27 Exp 0] 1128 msec 764 msec 1248 msec
  4 25.25.25.6 912 msec 1128 msec 1056 msec
  5 25.25.25.1 744 msec 984 msec 864 msec
  6 12.12.12.1 [MPLS: Labels 17/23 Exp 0] 3096 msec 2924 msec 3140 msec
```

```
    7 36.36.36.3 [MPLS: Label 23 Exp 0] 1488 msec 1316 msec 1872 msec
    8 36.36.36.6 2136 msec 1824 msec 1896 msec
CE8-R8#traceroute
Protocol [ip]:
Target IP address: 172.16.70.1
Source address: 172.16.80.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.70.1


    1 48.48.48.4 264 msec 360 msec 144 msec
    2 14.14.14.1 [MPLS: Labels 16/29 Exp 0] 1480 msec 2120 msec 2016 msec
    3 25.25.25.5 [MPLS: Label 29 Exp 0] 1144 msec 868 msec 744 msec
    4 25.25.25.6 936 msec 792 msec 576 msec
    5 25.25.25.1 720 msec 888 msec 1200 msec
    6 12.12.12.1 [MPLS: Labels 17/24 Exp 0] 3048 msec 2984 msec 2880 msec
    7 37.37.37.3 [MPLS: Label 24 Exp 0] 1392 msec 1988 msec 1492 msec
    8 37.37.37.7 1508 msec 1728 msec 1608 msec
CE8-R8#
```

2.5 实现原理及注意事项

1）实现原理：PE2-R2 接收所有从 PE3-R3、PE4-R4 来的私网路由（CE6-R6，CE7-R7，CE8-R8），PE2-R2 的 F0/0.1 绑定到 HUB，那么 CE5-R5 接收到了所有 PE3-R3、PE4-R4 的私网路由，并合成一个路由表；又因为 PE2-R2 的 F0/0.2 绑定到 SPOKE，所以 CE5-R5 把所有的路由发给 PE2-R2，并携带 RT200:200 发送给 PE 邻居。

2）注意事项：PE2-R2 的两个私网接口和 CE5-R5 运行的路由协议是 BGP，在这种配置下一定要考虑到的一个细节就是环路问题，PE2-R2 私网路由通过 BGP 协议从 F0/0.1 发送给 CE5-R5 时，bgp 会带上自己的 AS-number，CE5-R5 再通过 BGP 将路由传递给 PE2-R2 时，又会带上原来的 AS-number，这样 PE2-R2 就会发现带有自己的 AS-number，认为网络存在环路，则会忽略掉这些路由。解决的办法就是让 bgp 不进行环路检测，具体方法如下：

address-family ipv4 vrf SPOKE
redistribute connected
neighbor 25.25.25.6 remote-as 65005
neighbor 25.25.25.6 activate
neighbor 25.25.25.6 as-override
neighbor 25.25.25.6 allowas-in
no auto-summary

```
no synchronization
exit-address-family
!
address-family ipv4 vrf HUB
redistribute connected
neighbor 25.25.25.2 remote-as 65005
neighbor 25.25.25.2 activate
neighbor 25.25.25.2 as-override
no auto-summary
no synchronization
exit-address-family
!
```

三 MPLS VPN 访问 Internet 组网

1 MPLS VPN 访问 Internet 方式一

1.1 网络拓扑图
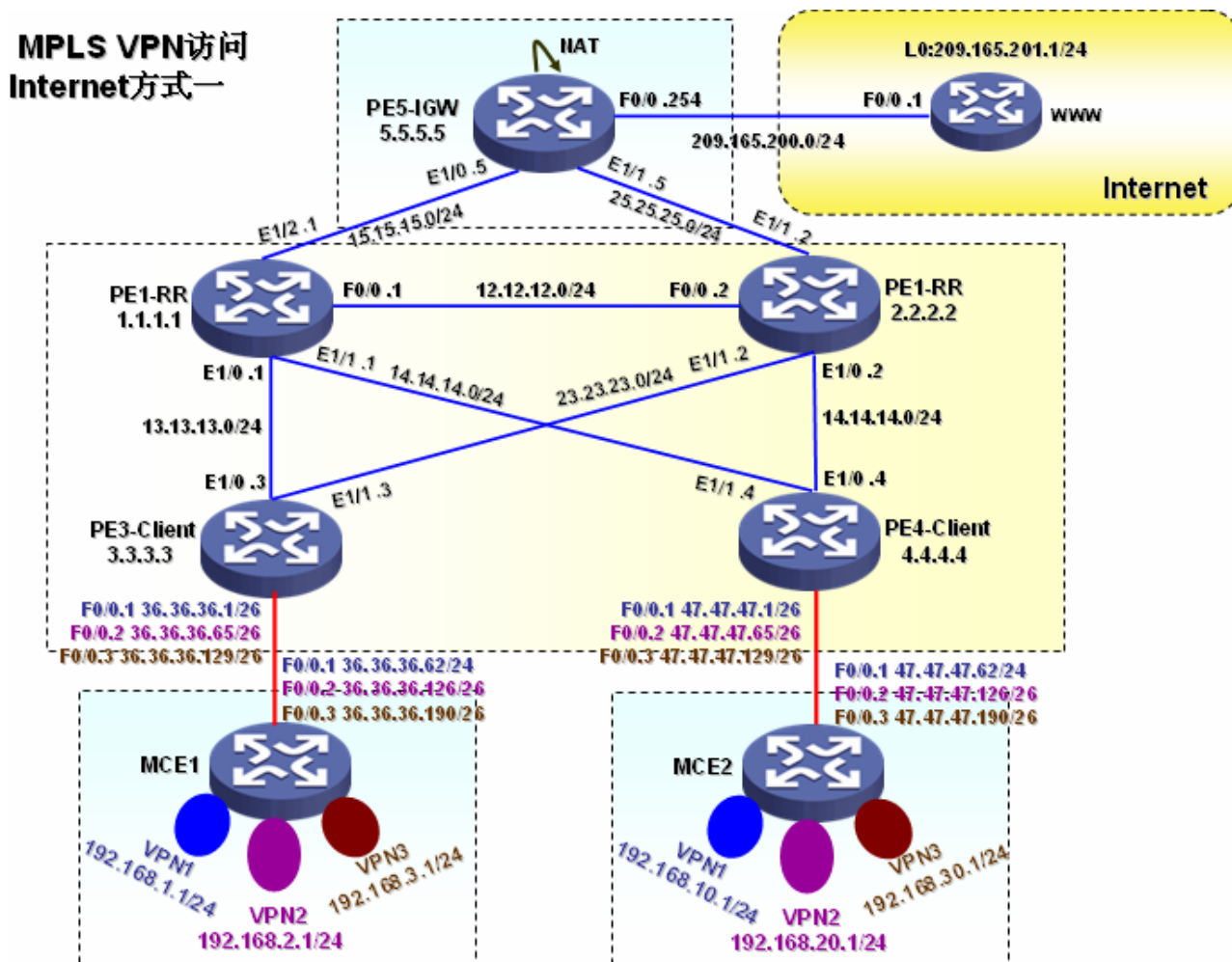
1.2 应用需求

1）不同的 VPN 之间用户不能互访，相同的 VPN 之间的用户能够互访；

2）所有的 VPN 用户都有访问 Internet 的需求，Internet 出口接在 PE5-IGW 设备上，该接口不属于任何的 VPN 实例；

1.3 设备配置

1.3.1 PE1-RR 设备配置

```
hostname PE1-R1
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 ip address 12.12.12.1 255.255.255.0
 duplex auto
 speed auto
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/0
 ip address 13.13.13.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 14.14.14.1 255.255.255.0
 half-duplex
```

```
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 ip address 15.15.15.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 12.12.12.1 0.0.0.0 area 0.0.0.0
 network 13.13.13.1 0.0.0.0 area 0.0.0.0
 network 14.14.14.1 0.0.0.0 area 0.0.0.0
 network 15.15.15.1 0.0.0.0 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 neighbor 2.2.2.2 route-reflector-client
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 3.3.3.3 route-reflector-client
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source Loopback0
 neighbor 4.4.4.4 route-reflector-client
 neighbor 5.5.5.5 remote-as 100
 neighbor 5.5.5.5 update-source Loopback0
 neighbor 5.5.5.5 route-reflector-client
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
```

```
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 route-reflector-client
 neighbor 2.2.2.2 send-community extended
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 route-reflector-client
 neighbor 3.3.3.3 send-community both
 neighbor 4.4.4.4 activate
 neighbor 4.4.4.4 route-reflector-client
 neighbor 4.4.4.4 send-community extended
 neighbor 5.5.5.5 activate
 neighbor 5.5.5.5 route-reflector-client
 neighbor 5.5.5.5 send-community extended
 no auto-summary
 exit-address-family
 !
 !
 end
 PE1-R1#
```

1.3.2 PE2-RR 设备配置

```
hostname PE2-R2
 !
 ip vrf vpn1
  rd 1:1
  route-target export 1:1
  route-target import 1:1
 !
 ip vrf vpn2
  rd 2:2
```

```
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 ip address 12.12.12.2 255.255.255.0
 duplex auto
 speed auto
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/0
 ip address 24.24.24.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 23.23.23.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 ip address 25.25.25.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 2.2.2.2 0.0.0.0 area 0.0.0.0
 network 12.12.12.2 0.0.0.0 area 0.0.0.0
```

```
 network 23.23.23.2 0.0.0.0 area 0.0.0.0
 network 24.24.24.2 0.0.0.0 area 0.0.0.0
 network 25.25.25.2 0.0.0.0 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 1.1.1.1 route-reflector-client
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 3.3.3.3 route-reflector-client
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source Loopback0
 neighbor 4.4.4.4 route-reflector-client
 neighbor 5.5.5.5 remote-as 100
 neighbor 5.5.5.5 update-source Loopback0
 neighbor 5.5.5.5 route-reflector-client
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 route-reflector-client
 neighbor 1.1.1.1 send-community extended
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 route-reflector-client
```

```
 neighbor 3.3.3.3 next-hop-self
 neighbor 3.3.3.3 send-community extended
 neighbor 4.4.4.4 activate
 neighbor 4.4.4.4 route-reflector-client
 neighbor 4.4.4.4 next-hop-self
 neighbor 4.4.4.4 send-community extended
 neighbor 5.5.5.5 activate
 neighbor 5.5.5.5 route-reflector-client
 neighbor 5.5.5.5 send-community extended
 no auto-summary
 exit-address-family
!
end

PE2-R2#
```

1.3.3 PE3-Client 设备配置

```
hostname PE3-R3
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface FastEthernet0/0.1
 encapsulation dot1Q 10
```

```
 ip vrf forwarding vpn1
 ip address 36.36.36.1 255.255.255.192
!
interface FastEthernet0/0.2
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 36.36.36.65 255.255.255.192
!
interface FastEthernet0/0.3
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 36.36.36.129 255.255.255.192
!
interface Ethernet1/0
 ip address 13.13.13.3 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 23.23.23.3 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
router ospf 1
 router-id 3.3.3.3
 log-adjacency-changes
 redistribute static subnets
 network 3.3.3.3 0.0.0.0 area 0.0.0.0
 network 13.13.13.3 0.0.0.0 area 0.0.0.0
 network 23.23.23.3 0.0.0.0 area 0.0.0.0
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 36.36.36.0 0.0.0.63 area 0.0.0.0
 default-information originate always
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 36.36.36.64 0.0.0.63 area 0.0.0.0
 default-information originate always
!
```

```
router ospf 30 vrf vpn3
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 36.36.36.128 0.0.0.63 area 0.0.0.0
 default-information originate always
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 redistribute ospf 30
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community extended
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
```

```
ip route 192.168.1.0 255.255.255.0 FastEthernet0/0.1 36.36.36.62
ip route 192.168.2.0 255.255.255.0 FastEthernet0/0.2 36.36.36.126
ip route 192.168.3.0 255.255.255.0 FastEthernet0/0.3 36.36.36.190
!
end
```

1.3.4 PE4-Client 设备配置

```
hostname PE4-R4
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 47.47.47.1 255.255.255.192
!
interface FastEthernet0/0.20
 encapsulation dot1Q 20
```

```
 ip vrf forwarding vpn2
 ip address 47.47.47.65 255.255.255.192
!
interface FastEthernet0/0.30
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 47.47.47.129 255.255.255.192
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 24.24.24.4 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 14.14.14.4 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
router ospf 1
 router-id 4.4.4.4
 log-adjacency-changes
 network 4.4.4.4 0.0.0.0 area 0.0.0.0
 network 14.14.14.4 0.0.0.0 area 0.0.0.0
 network 24.24.24.4 0.0.0.0 area 0.0.0.0
!
router ospf 10 vrf vpn1
 router-id 47.47.47.1
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 47.47.47.0 0.0.0.63 area 0.0.0.0
!
router ospf 20 vrf vpn2
 router-id 47.47.47.65
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 47.47.47.64 0.0.0.63 area 0.0.0.0
!
```

```
router ospf 30 vrf vpn3
 router-id 47.47.47.129
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 47.47.47.128 0.0.0.63 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute ospf 30
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community extended
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
end
```

1.3.5 PE5-IGW 设备配置

```
hostname PE5-IGW
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
mpls label protocol ldp
!
interface Loopback0
 ip address 5.5.5.5 255.255.255.255
!
interface FastEthernet0/0
 ip address 209.165.200.254 255.255.255.0
 ip nat outside
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 15.15.15.5 255.255.255.0
 ip nat inside
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 25.25.25.5 255.255.255.0
 ip nat inside
 half-duplex
 mpls label protocol ldp
 tag-switching ip
```

```
!
router ospf 1
 router-id 5.5.5.5
 log-adjacency-changes
 network 5.5.5.5 0.0.0.0 area 0.0.0.0
 network 15.15.15.5 0.0.0.0 area 0.0.0.0
 network 25.25.25.5 0.0.0.0 area 0.0.0.0
 network 209.165.200.0 0.0.0.255 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 redistribute static
 default-information originate
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 redistribute static
 default-information originate
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 redistribute static
 default-information originate
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community extended
```

```
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
ip nat translation timeout 3600
ip nat pool pool 209.165.200.100 209.165.200.200 netmask 255.255.255.0
ip nat inside source list 101 pool pool vrf vpn1 overload
ip nat inside source list 102 pool pool vrf vpn2 overload
ip nat inside source list 103 pool pool vrf vpn3 overload
ip classless
ip route 0.0.0.0 0.0.0.0 209.165.200.1
ip route vrf vpn1 0.0.0.0 0.0.0.0 209.165.200.1 global
ip route vrf vpn2 0.0.0.0 0.0.0.0 209.165.200.1 global
ip route vrf vpn3 0.0.0.0 0.0.0.0 209.165.200.1 global
ip http server
!
!
access-list 101 permit ip 192.168.1.0 0.0.0.255 any
access-list 101 permit ip 192.168.10.0 0.0.0.255 any
access-list 102 permit ip 192.168.2.0 0.0.0.255 any
access-list 102 permit ip 192.168.20.0 0.0.0.255 any
access-list 103 permit ip 192.168.3.0 0.0.0.255 any
access-list 103 permit ip 192.168.30.0 0.0.0.255 any
!
end
```

1.3.6　MCE1 设备配置

```
hostname MCE-R6
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
```

```
 route-target import 3:3
!
ip cef
!
interface Loopback1
 ip vrf forwarding vpn1
 ip address 192.168.1.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpn2
 ip address 192.168.2.1 255.255.255.0
!
interface Loopback3
 ip vrf forwarding vpn3
 ip address 192.168.3.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 36.36.36.62 255.255.255.192
!
interface FastEthernet0/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 36.36.36.126 255.255.255.192
!
interface FastEthernet0/0.30
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 36.36.36.190 255.255.255.192
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 capability vrf-lite
 network 36.36.36.0 0.0.0.63 area 0.0.0.0
 network 192.168.1.0 0.0.0.255 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 capability vrf-lite
```

```
 network 36.36.36.64 0.0.0.63 area 0.0.0.0
 network 192.168.2.0 0.0.0.255 area 0.0.0.0
!
router ospf 30 vrf vpn3
 log-adjacency-changes
 capability vrf-lite
 network 36.36.36.128 0.0.0.63 area 0.0.0.0
 network 192.168.3.0 0.0.0.255 area 0.0.0.0
!
end
```

1.3.7　MCE2 设备配置

```
hostname MCE-R7
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
!
interface Loopback1
 ip vrf forwarding vpn1
 ip address 192.168.10.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpn2
 ip address 192.168.20.1 255.255.255.0
!
interface Loopback3
 ip vrf forwarding vpn3
 ip address 192.168.30.1 255.255.255.0
!
```

```
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 47.47.47.62 255.255.255.192
!
interface FastEthernet0/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 47.47.47.126 255.255.255.192
!
interface FastEthernet0/0.30
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 47.47.47.190 255.255.255.192
!
router ospf 10 vrf vpn1
 router-id 192.168.10.1
 log-adjacency-changes
 capability vrf-lite
 network 47.47.47.0 0.0.0.63 area 0.0.0.0
 network 192.168.10.0 0.0.0.255 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 capability vrf-lite
 network 47.47.47.64 0.0.0.63 area 0.0.0.0
 network 192.168.20.0 0.0.0.255 area 0.0.0.0
!
router ospf 30 vrf vpn3
 router-id 192.168.30.1
 log-adjacency-changes
 capability vrf-lite
 network 47.47.47.128 0.0.0.63 area 0.0.0.0
 network 192.168.30.0 0.0.0.255 area 0.0.0.0
!
end
```

1.3.8 Internet 设备配置

```
hostname internet
!
interface Loopback0
 ip address 209.165.201.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 209.165.200.1 255.255.255.0
 duplex auto
 speed auto
!
end
```

1.4 配置验证

1.4.1 PE1-RR 配置验证

```
PE1-R1#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/2] via 12.12.12.2, 00:14:00, FastEthernet0/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/11] via 13.13.13.3, 00:14:00, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/11] via 14.14.14.4, 00:14:00, Ethernet1/1
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/11] via 15.15.15.5, 00:14:00, Ethernet1/2
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/11] via 12.12.12.2, 00:14:00, FastEthernet0/0
O    209.165.200.0/24 [110/11] via 15.15.15.5, 00:14:00, Ethernet1/2
     25.0.0.0/24 is subnetted, 1 subnets
```

```
O        25.25.25.0 [110/11] via 12.12.12.2, 00:14:00, FastEthernet0/0
      24.0.0.0/24 is subnetted, 1 subnets
O        24.24.24.0 [110/11] via 12.12.12.2, 00:14:00, FastEthernet0/0
      12.0.0.0/24 is subnetted, 1 subnets
C        12.12.12.0 is directly connected, FastEthernet0/0
O E2 192.168.1.0/24 [110/20] via 13.13.13.3, 00:14:00, Ethernet1/0
      13.0.0.0/24 is subnetted, 1 subnets
C        13.13.13.0 is directly connected, Ethernet1/0
O E2 192.168.2.0/24 [110/20] via 13.13.13.3, 00:14:00, Ethernet1/0
      14.0.0.0/24 is subnetted, 1 subnets
C        14.14.14.0 is directly connected, Ethernet1/1
O E2 192.168.3.0/24 [110/20] via 13.13.13.3, 00:14:00, Ethernet1/0
      15.0.0.0/24 is subnetted, 1 subnets
C        15.15.15.0 is directly connected, Ethernet1/2
PE1-R1#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0

      192.168.10.0/32 is subnetted, 1 subnets
B        192.168.10.1 [200/2] via 4.4.4.4, 00:11:13
      36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.0 [200/0] via 3.3.3.3, 00:15:16
      192.168.1.0/32 is subnetted, 1 subnets
B        192.168.1.1 [200/2] via 3.3.3.3, 00:12:44
      47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.0 [200/0] via 4.4.4.4, 00:15:01
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:14:15
PE1-R1#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0
```

```
         36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.64 [200/0] via 3.3.3.3, 00:15:18
         192.168.20.0/32 is subnetted, 1 subnets
B        192.168.20.1 [200/2] via 4.4.4.4, 00:11:15
         47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.64 [200/0] via 4.4.4.4, 00:15:03
         192.168.2.0/32 is subnetted, 1 subnets
B        192.168.2.1 [200/2] via 3.3.3.3, 00:12:46
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 00:14:17
PE1-R1#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


         192.168.30.0/32 is subnetted, 1 subnets
B        192.168.30.1 [200/2] via 4.4.4.4, 00:11:18
         36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.128 [200/0] via 3.3.3.3, 00:15:20
         47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.128 [200/0] via 4.4.4.4, 00:15:05
         192.168.3.0/32 is subnetted, 1 subnets
B        192.168.3.1 [200/2] via 3.3.3.3, 00:12:48
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 00:14:19
PE1-R1#


PE1-R1#show mpls ldp neighbor
    Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 1.1.1.1:0
        TCP connection: 2.2.2.2.11016 - 1.1.1.1.646
        State: Oper; Msgs sent/rcvd: 23/38; Downstream
        Up time: 00:17:43
        LDP discovery sources:
          FastEthernet0/0, Src IP addr: 12.12.12.2
        Addresses bound to peer LDP Ident:
          12.12.12.2      2.2.2.2         24.24.24.2      23.23.23.2
          25.25.25.2
    Peer LDP Ident: 4.4.4.4:0; Local LDP Ident 1.1.1.1:0
        TCP connection: 4.4.4.4.11012 - 1.1.1.1.646
        State: Oper; Msgs sent/rcvd: 21/37; Downstream
        Up time: 00:15:57
```

```
        LDP discovery sources:
            Ethernet1/1, Src IP addr: 14.14.14.4
        Addresses bound to peer LDP Ident:
            24.24.24.4      4.4.4.4         14.14.14.4
    Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 1.1.1.1:0
        TCP connection: 3.3.3.3.11015 - 1.1.1.1.646
        State: Oper; Msgs sent/rcvd: 21/36; Downstream
        Up time: 00:15:57
        LDP discovery sources:
            Ethernet1/0, Src IP addr: 13.13.13.3
        Addresses bound to peer LDP Ident:
            13.13.13.3      3.3.3.3         23.23.23.3
    Peer LDP Ident: 5.5.5.5:0; Local LDP Ident 1.1.1.1:0
        TCP connection: 5.5.5.5.11007 - 1.1.1.1.646
        State: Oper; Msgs sent/rcvd: 20/37; Downstream
        Up time: 00:14:45
        LDP discovery sources:
            Ethernet1/2, Src IP addr: 15.15.15.5
        Addresses bound to peer LDP Ident:
            209.165.200.254 15.15.15.5      5.5.5.5         25.25.25.5
PE1-R1#


PE1-R1#show ip bgp vpnv4 all
BGP table version is 31, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete


   Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 1:1 (default for vrf vpn1)
* i0.0.0.0          5.5.5.5               0    100      0 ?
*>i                 5.5.5.5               0    100      0 ?
* i36.36.36.0/26    3.3.3.3               0    100      0 ?
*>i                 3.3.3.3               0    100      0 ?
* i47.47.47.0/26    4.4.4.4               0    100      0 ?
*>i                 4.4.4.4               0    100      0 ?
* i192.168.1.1/32   3.3.3.3               2    100      0 ?
*>i                 3.3.3.3               2    100      0 ?
* i192.168.10.1/32  4.4.4.4               2    100      0 ?
*>i                 4.4.4.4               2    100      0 ?
Route Distinguisher: 2:2 (default for vrf vpn2)
* i0.0.0.0          5.5.5.5               0    100      0 ?
*>i                 5.5.5.5               0    100      0 ?
* i36.36.36.64/26   3.3.3.3               0    100      0 ?
```

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i	3.3.3.3	0	100	0	?
* i47.47.47.64/26	4.4.4.4	0	100	0	?
Network	Next Hop	Metric	LocPrf	Weight	Path
*>i	4.4.4.4	0	100	0	?
* i192.168.2.1/32	3.3.3.3	2	100	0	?
*>i	3.3.3.3	2	100	0	?
* i192.168.20.1/32	4.4.4.4	2	100	0	?
*>i	4.4.4.4	2	100	0	?

Route Distinguisher: 3:3 (default for vrf vpn3)

* i0.0.0.0	5.5.5.5	0	100	0	?
*>i	5.5.5.5	0	100	0	?
* i36.36.36.128/26	3.3.3.3	0	100	0	?
*>i	3.3.3.3	0	100	0	?
* i47.47.47.128/26	4.4.4.4	0	100	0	?
*>i	4.4.4.4	0	100	0	?
* i192.168.3.1/32	3.3.3.3	2	100	0	?
*>i	3.3.3.3	2	100	0	?
* i192.168.30.1/32	4.4.4.4	2	100	0	?
*>i	4.4.4.4	2	100	0	?

PE1-R1#

1.4.2 PE2-RR 配置验证

```
PE2-R2#show 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, 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


     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/2] via 12.12.12.1, 00:16:48, FastEthernet0/0
     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/11] via 23.23.23.3, 00:16:48, Ethernet1/1
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/11] via 24.24.24.4, 00:16:48, Ethernet1/0
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/11] via 25.25.25.5, 00:16:48, Ethernet1/2
```

```
        23.0.0.0/24 is subnetted, 1 subnets
C       23.23.23.0 is directly connected, Ethernet1/1
O    209.165.200.0/24 [110/11] via 25.25.25.5, 00:16:48, Ethernet1/2
        25.0.0.0/24 is subnetted, 1 subnets
C       25.25.25.0 is directly connected, Ethernet1/2
        24.0.0.0/24 is subnetted, 1 subnets
C       24.24.24.0 is directly connected, Ethernet1/0
        12.0.0.0/24 is subnetted, 1 subnets
C       12.12.12.0 is directly connected, FastEthernet0/0
O E2 192.168.1.0/24 [110/20] via 23.23.23.3, 00:16:48, Ethernet1/1
        13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/11] via 12.12.12.1, 00:16:48, FastEthernet0/0
O E2 192.168.2.0/24 [110/20] via 23.23.23.3, 00:16:48, Ethernet1/1
        14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/11] via 12.12.12.1, 00:16:48, FastEthernet0/0
O E2 192.168.3.0/24 [110/20] via 23.23.23.3, 00:16:48, Ethernet1/1
        15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/11] via 12.12.12.1, 00:16:48, FastEthernet0/0
PE2-R2#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0


        192.168.10.0/32 is subnetted, 1 subnets
B       192.168.10.1 [200/2] via 4.4.4.4, 00:14:10
        36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.0 [200/0] via 3.3.3.3, 00:17:56
        192.168.1.0/32 is subnetted, 1 subnets
B       192.168.1.1 [200/2] via 3.3.3.3, 00:15:26
        47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.0 [200/0] via 4.4.4.4, 00:17:41
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:16:56
PE2-R2#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0


     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.64 [200/0] via 3.3.3.3, 00:17:58
     192.168.20.0/32 is subnetted, 1 subnets
B       192.168.20.1 [200/2] via 4.4.4.4, 00:13:56
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.64 [200/0] via 4.4.4.4, 00:17:43
     192.168.2.0/32 is subnetted, 1 subnets
B       192.168.2.1 [200/2] via 3.3.3.3, 00:15:27
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:16:58
PE2-R2#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.30.0/32 is subnetted, 1 subnets
B       192.168.30.1 [200/2] via 4.4.4.4, 00:13:58
     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.128 [200/0] via 3.3.3.3, 00:18:00
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.128 [200/0] via 4.4.4.4, 00:17:44
     192.168.3.0/32 is subnetted, 1 subnets
B       192.168.3.1 [200/2] via 3.3.3.3, 00:15:29
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:17:00
PE2-R2#


PE2-R2#show mpls ldp neighbor
    Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 2.2.2.2:0
        TCP connection: 1.1.1.1.646 - 2.2.2.2.11016
        State: Oper; Msgs sent/rcvd: 41/26; Downstream
        Up time: 00:20:11
        LDP discovery sources:
          FastEthernet0/0, Src IP addr: 12.12.12.1
        Addresses bound to peer LDP Ident:
          12.12.12.1      1.1.1.1         13.13.13.1      14.14.14.1
          15.15.15.1
```

```
    Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 2.2.2.2:0
        TCP connection: 3.3.3.3.11013 - 2.2.2.2.646
        State: Oper; Msgs sent/rcvd: 40/40; Downstream
        Up time: 00:18:26
        LDP discovery sources:
          Ethernet1/1, Src IP addr: 23.23.23.3
        Addresses bound to peer LDP Ident:
          13.13.13.3      3.3.3.3        23.23.23.3
    Peer LDP Ident: 4.4.4.4:0; Local LDP Ident 2.2.2.2:0
        TCP connection: 4.4.4.4.11013 - 2.2.2.2.646
        State: Oper; Msgs sent/rcvd: 40/40; Downstream
        Up time: 00:18:25
        LDP discovery sources:
          Ethernet1/0, Src IP addr: 24.24.24.4
        Addresses bound to peer LDP Ident:
          24.24.24.4      4.4.4.4        14.14.14.4
    Peer LDP Ident: 5.5.5.5:0; Local LDP Ident 2.2.2.2:0
        TCP connection: 5.5.5.5.11006 - 2.2.2.2.646
        State: Oper; Msgs sent/rcvd: 39/40; Downstream
        Up time: 00:17:25
        LDP discovery sources:
          Ethernet1/2, Src IP addr: 25.25.25.5
        Addresses bound to peer LDP Ident:
          209.165.200.254 15.15.15.5      5.5.5.5        25.25.25.5
PE2-R2#


PE2-R2#show ip bgp vpnv4 all
BGP table version is 32, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 1:1 (default for vrf vpn1)
* i0.0.0.0          5.5.5.5               0    100      0 ?
*>i                 5.5.5.5               0    100      0 ?
* i36.36.36.0/26    3.3.3.3               0    100      0 ?
*>i                 3.3.3.3               0    100      0 ?
* i47.47.47.0/26    4.4.4.4               0    100      0 ?
*>i                 4.4.4.4               0    100      0 ?
* i192.168.1.1/32   3.3.3.3               2    100      0 ?
*>i                 3.3.3.3               2    100      0 ?
* i192.168.10.1/32  4.4.4.4               2    100      0 ?
*>i                 4.4.4.4               2    100      0 ?
Route Distinguisher: 2:2 (default for vrf vpn2)
```

		Metric	LocPrf	Weight	Path
*>i0.0.0.0	5.5.5.5	0	100	0	?
* i	5.5.5.5	0	100	0	?
* i36.36.36.64/26	3.3.3.3	0	100	0	?
*>i	3.3.3.3	0	100	0	?
* i47.47.47.64/26	4.4.4.4	0	100	0	?

Network	Next Hop	Metric	LocPrf	Weight	Path
*>i	4.4.4.4	0	100	0	?
* i192.168.2.1/32	3.3.3.3	2	100	0	?
*>i	3.3.3.3	2	100	0	?
* i192.168.20.1/32	4.4.4.4	2	100	0	?
*>i	4.4.4.4	2	100	0	?

Route Distinguisher: 3:3 (default for vrf vpn3)

		Metric	LocPrf	Weight	Path
* i0.0.0.0	5.5.5.5	0	100	0	?
*>i	5.5.5.5	0	100	0	?
* i36.36.36.128/26	3.3.3.3	0	100	0	?
*>i	3.3.3.3	0	100	0	?
* i47.47.47.128/26	4.4.4.4	0	100	0	?
*>i	4.4.4.4	0	100	0	?
* i192.168.3.1/32	3.3.3.3	2	100	0	?
*>i	3.3.3.3	2	100	0	?
* i192.168.30.1/32	4.4.4.4	2	100	0	?
*>i	4.4.4.4	2	100	0	?

1.4.3 PE3-Client 配置验证

```
PE3-R3#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/11] via 13.13.13.1, 00:18:27, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 23.23.23.2, 00:18:27, Ethernet1/1
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/21] via 23.23.23.2, 00:18:27, Ethernet1/1
```

```
                [110/21] via 13.13.13.1, 00:18:27, Ethernet1/0
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/21] via 23.23.23.2, 00:18:27, Ethernet1/1
                [110/21] via 13.13.13.1, 00:18:27, Ethernet1/0
     23.0.0.0/24 is subnetted, 1 subnets
C       23.23.23.0 is directly connected, Ethernet1/1
O    209.165.200.0/24 [110/21] via 23.23.23.2, 00:18:28, Ethernet1/1
                       [110/21] via 13.13.13.1, 00:18:28, Ethernet1/0
     25.0.0.0/24 is subnetted, 1 subnets
O       25.25.25.0 [110/20] via 23.23.23.2, 00:18:28, Ethernet1/1
     24.0.0.0/24 is subnetted, 1 subnets
O       24.24.24.0 [110/20] via 23.23.23.2, 00:18:28, Ethernet1/1
     12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/11] via 23.23.23.2, 00:18:28, Ethernet1/1
                    [110/11] via 13.13.13.1, 00:18:28, Ethernet1/0
S    192.168.1.0/24 [1/0] via 36.36.36.62, FastEthernet0/0.1
     13.0.0.0/24 is subnetted, 1 subnets
C       13.13.13.0 is directly connected, Ethernet1/0
S    192.168.2.0/24 [1/0] via 36.36.36.126, FastEthernet0/0.2
     14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/20] via 13.13.13.1, 00:18:28, Ethernet1/0
S    192.168.3.0/24 [1/0] via 36.36.36.190, FastEthernet0/0.3
     15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/20] via 13.13.13.1, 00:18:28, Ethernet1/0
PE3-R3#


PE3-R3#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.10.0/32 is subnetted, 1 subnets
B       192.168.10.1 [200/2] via 4.4.4.4, 00:16:03
     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.0 is directly connected, FastEthernet0/0.1
     192.168.1.0/32 is subnetted, 1 subnets
O       192.168.1.1 [110/2] via 36.36.36.62, 00:17:44, FastEthernet0/0.1
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.0 [200/0] via 4.4.4.4, 00:19:34
```

```
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 00:18:48
PE3-R3#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0


     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.64 is directly connected, FastEthernet0/0.2
     192.168.20.0/32 is subnetted, 1 subnets
B       192.168.20.1 [200/2] via 4.4.4.4, 00:15:48
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.64 [200/0] via 4.4.4.4, 00:19:35
     192.168.2.0/32 is subnetted, 1 subnets
O       192.168.2.1 [110/2] via 36.36.36.126, 00:17:46, FastEthernet0/0.2
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 00:18:50
PE3-R3#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.30.0/32 is subnetted, 1 subnets
B       192.168.30.1 [200/2] via 4.4.4.4, 00:15:50
     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.128 is directly connected, FastEthernet0/0.3
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.128 [200/0] via 4.4.4.4, 00:19:37
     192.168.3.0/32 is subnetted, 1 subnets
O       192.168.3.1 [110/2] via 36.36.36.190, 00:17:47, FastEthernet0/0.3
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 00:18:52
PE3-R3#


PE3-R3#show mpls ldp neighbor
     Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 3.3.3.3:0
```

```
        TCP connection: 2.2.2.2.646 - 3.3.3.3.11013
        State: Oper; Msgs sent/rcvd: 43/42; Downstream
        Up time: 00:20:19
        LDP discovery sources:
           Ethernet1/1, Src IP addr: 23.23.23.2
        Addresses bound to peer LDP Ident:
           12.12.12.2       2.2.2.2        24.24.24.2       23.23.23.2
           25.25.25.2
    Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 3.3.3.3:0
        TCP connection: 1.1.1.1.646 - 3.3.3.3.11015
        State: Oper; Msgs sent/rcvd: 41/26; Downstream
        Up time: 00:20:18
        LDP discovery sources:
           Ethernet1/0, Src IP addr: 13.13.13.1
        Addresses bound to peer LDP Ident:
           12.12.12.1       1.1.1.1        13.13.13.1       14.14.14.1
           15.15.15.1
PE3-R3#


PE3-R3#show ip bgp vpnv4 all
BGP table version is 32, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete


   Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 1:1 (default for vrf vpn1)
* i0.0.0.0          5.5.5.5              0    100      0 ?
*>i                 5.5.5.5              0    100      0 ?
*> 36.36.36.0/26    0.0.0.0              0          32768 ?
*>i47.47.47.0/26    4.4.4.4              0    100      0 ?
* i                 4.4.4.4              0    100      0 ?
*> 192.168.1.1/32   36.36.36.62          2          32768 ?
* i192.168.10.1/32  4.4.4.4              2    100      0 ?
*>i                 4.4.4.4              2    100      0 ?
Route Distinguisher: 2:2 (default for vrf vpn2)
* i0.0.0.0          5.5.5.5              0    100      0 ?
*>i                 5.5.5.5              0    100      0 ?
*> 36.36.36.64/26   0.0.0.0              0          32768 ?
* i47.47.47.64/26   4.4.4.4              0    100      0 ?
*>i                 4.4.4.4              0    100      0 ?
*> 192.168.2.1/32   36.36.36.126         2          32768 ?
* i192.168.20.1/32  4.4.4.4              2    100      0 ?
   Network          Next Hop          Metric LocPrf Weight Path
*>i                 4.4.4.4              2    100      0 ?
```

Route Distinguisher: 3:3 (default for vrf vpn3)

* i0.0.0.0	5.5.5.5	0	100	0	?
*>i	5.5.5.5	0	100	0	?
*> 36.36.36.128/26	0.0.0.0	0		32768	?
* i47.47.47.128/26	4.4.4.4	0	100	0	?
*>i	4.4.4.4	0	100	0	?
*> 192.168.3.1/32	36.36.36.190	2		32768	?
* i192.168.30.1/32	4.4.4.4	2	100	0	?
*>i	4.4.4.4	2	100	0	?

1.4.4 PE4-Client 配置验证

PE4-R4#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O   1.1.1.1 [110/11] via 14.14.14.1, 00:20:45, Ethernet1/1
     2.0.0.0/32 is subnetted, 1 subnets
O   2.2.2.2 [110/11] via 24.24.24.2, 00:20:45, Ethernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
O   3.3.3.3 [110/21] via 24.24.24.2, 00:20:45, Ethernet1/0
                [110/21] via 14.14.14.1, 00:20:45, Ethernet1/1
     4.0.0.0/32 is subnetted, 1 subnets
C   4.4.4.4 is directly connected, Loopback0
     5.0.0.0/32 is subnetted, 1 subnets
O   5.5.5.5 [110/21] via 24.24.24.2, 00:20:45, Ethernet1/0
                [110/21] via 14.14.14.1, 00:20:45, Ethernet1/1
     23.0.0.0/24 is subnetted, 1 subnets
O   23.23.23.0 [110/20] via 24.24.24.2, 00:20:46, Ethernet1/0
O   209.165.200.0/24 [110/21] via 24.24.24.2, 00:20:46, Ethernet1/0
                      [110/21] via 14.14.14.1, 00:20:46, Ethernet1/1
     25.0.0.0/24 is subnetted, 1 subnets
O   25.25.25.0 [110/20] via 24.24.24.2, 00:20:46, Ethernet1/0
     24.0.0.0/24 is subnetted, 1 subnets
C   24.24.24.0 is directly connected, Ethernet1/0
     12.0.0.0/24 is subnetted, 1 subnets

```
O       12.12.12.0 [110/11] via 24.24.24.2, 00:20:46, Ethernet1/0
                   [110/11] via 14.14.14.1, 00:20:46, Ethernet1/1
O E2 192.168.1.0/24 [110/20] via 24.24.24.2, 00:20:46, Ethernet1/0
                   [110/20] via 14.14.14.1, 00:20:46, Ethernet1/1
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/20] via 14.14.14.1, 00:20:46, Ethernet1/1
O E2 192.168.2.0/24 [110/20] via 24.24.24.2, 00:20:46, Ethernet1/0
                   [110/20] via 14.14.14.1, 00:20:46, Ethernet1/1
     14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Ethernet1/1
O E2 192.168.3.0/24 [110/20] via 24.24.24.2, 00:20:46, Ethernet1/0
                   [110/20] via 14.14.14.1, 00:20:46, Ethernet1/1
     15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/20] via 14.14.14.1, 00:20:46, Ethernet1/1
PE4-R4#


PE4-R4#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.10.0/32 is subnetted, 1 subnets
O       192.168.10.1 [110/2] via 47.47.47.62, 00:18:30, FastEthernet0/0.10
     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.0 [200/0] via 3.3.3.3, 00:22:16
     192.168.1.0/32 is subnetted, 1 subnets
B       192.168.1.1 [200/2] via 3.3.3.3, 00:19:45
     47.0.0.0/26 is subnetted, 1 subnets
C       47.47.47.0 is directly connected, FastEthernet0/0.10
B*  0.0.0.0/0 [200/0] via 5.5.5.5, 00:21:16
PE4-R4#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0


    36.0.0.0/26 is subnetted, 1 subnets
B      36.36.36.64 [200/0] via 3.3.3.3, 00:22:18
    192.168.20.0/32 is subnetted, 1 subnets
O      192.168.20.1 [110/2] via 47.47.47.126, 00:18:31, FastEthernet0/0.20
    47.0.0.0/26 is subnetted, 1 subnets
C      47.47.47.64 is directly connected, FastEthernet0/0.20
    192.168.2.0/32 is subnetted, 1 subnets
B      192.168.2.1 [200/2] via 3.3.3.3, 00:19:46
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:21:17
PE4-R4#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


    192.168.30.0/32 is subnetted, 1 subnets
O      192.168.30.1 [110/2] via 47.47.47.190, 00:18:33, FastEthernet0/0.30
    36.0.0.0/26 is subnetted, 1 subnets
B      36.36.36.128 [200/0] via 3.3.3.3, 00:22:19
    47.0.0.0/26 is subnetted, 1 subnets
C      47.47.47.128 is directly connected, FastEthernet0/0.30
    192.168.3.0/32 is subnetted, 1 subnets
B      192.168.3.1 [200/2] via 3.3.3.3, 00:19:33
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:21:19
PE4-R4#



PE4-R4#show mpls ldp neighbor
    Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 4.4.4.4:0
        TCP connection: 1.1.1.1.646 - 4.4.4.4.11012
        State: Oper; Msgs sent/rcvd: 44/29; Downstream
        Up time: 00:22:48
        LDP discovery sources:
          Ethernet1/1, Src IP addr: 14.14.14.1
        Addresses bound to peer LDP Ident:
          12.12.12.1      1.1.1.1          13.13.13.1      14.14.14.1
          15.15.15.1
    Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 4.4.4.4:0
```

```
        TCP connection: 2.2.2.2.646 - 4.4.4.4.11013
        State: Oper; Msgs sent/rcvd: 44/44; Downstream
        Up time: 00:22:48
        LDP discovery sources:
          Ethernet1/0, Src IP addr: 24.24.24.2
        Addresses bound to peer LDP Ident:
          12.12.12.2      2.2.2.2        24.24.24.2      23.23.23.2
          25.25.25.2
PE4-R4# show ip bgp vpnv4 all
BGP table version is 38, local router ID is 4.4.4.4
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (default for vrf vpn1)					
* i0.0.0.0	5.5.5.5	0	100	0	?
*>i	5.5.5.5	0	100	0	?
*>i36.36.36.0/26	3.3.3.3	0	100	0	?
* i	3.3.3.3	0	100	0	?
*> 47.47.47.0/26	0.0.0.0	0		32768	?
*>i192.168.1.1/32	3.3.3.3	2	100	0	?
* i	3.3.3.3	2	100	0	?
*> 192.168.10.1/32	47.47.47.62	2		32768	?
Route Distinguisher: 2:2 (default for vrf vpn2)					
* i0.0.0.0	5.5.5.5	0	100	0	?
*>i	5.5.5.5	0	100	0	?
*>i36.36.36.64/26	3.3.3.3	0	100	0	?
* i	3.3.3.3	0	100	0	?
*> 47.47.47.64/26	0.0.0.0	0		32768	?
*>i192.168.2.1/32	3.3.3.3	2	100	0	?
* i	3.3.3.3	2	100	0	?

Network	Next Hop	Metric	LocPrf	Weight	Path
*> 192.168.20.1/32	47.47.47.126	2		32768	?
Route Distinguisher: 3:3 (default for vrf vpn3)					
* i0.0.0.0	5.5.5.5	0	100	0	?
*>i	5.5.5.5	0	100	0	?
*>i36.36.36.128/26	3.3.3.3	0	100	0	?
* i	3.3.3.3	0	100	0	?
*> 47.47.47.128/26	0.0.0.0	0		32768	?
*>i192.168.3.1/32	3.3.3.3	2	100	0	?
* i	3.3.3.3	2	100	0	?
*> 192.168.30.1/32	47.47.47.190	2		32768	?

1.4.5 PE5-IGW 配置验证

```
PE5-IGW#show 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, 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 209.165.200.1 to network 0.0.0.0

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/11] via 15.15.15.1, 00:22:40, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 25.25.25.2, 00:22:40, Ethernet1/1
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/21] via 25.25.25.2, 00:22:40, Ethernet1/1
                [110/21] via 15.15.15.1, 00:22:40, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/21] via 25.25.25.2, 00:22:40, Ethernet1/1
                [110/21] via 15.15.15.1, 00:22:40, Ethernet1/0
     5.0.0.0/32 is subnetted, 1 subnets
C       5.5.5.5 is directly connected, Loopback0
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/20] via 25.25.25.2, 00:22:41, Ethernet1/1
C     209.165.200.0/24 is directly connected, FastEthernet0/0
     25.0.0.0/24 is subnetted, 1 subnets
C       25.25.25.0 is directly connected, Ethernet1/1
     24.0.0.0/24 is subnetted, 1 subnets
O       24.24.24.0 [110/20] via 25.25.25.2, 00:22:41, Ethernet1/1
     12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/11] via 25.25.25.2, 00:22:41, Ethernet1/1
                   [110/11] via 15.15.15.1, 00:22:41, Ethernet1/0
O E2 192.168.1.0/24 [110/20] via 25.25.25.2, 00:22:41, Ethernet1/1
                    [110/20] via 15.15.15.1, 00:22:41, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/20] via 15.15.15.1, 00:22:41, Ethernet1/0
O E2 192.168.2.0/24 [110/20] via 25.25.25.2, 00:22:41, Ethernet1/1
                    [110/20] via 15.15.15.1, 00:22:41, Ethernet1/0
     14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/20] via 15.15.15.1, 00:22:41, Ethernet1/0
O E2 192.168.3.0/24 [110/20] via 25.25.25.2, 00:22:41, Ethernet1/1
```

```
                    [110/20] via 15.15.15.1, 00:22:41, Ethernet1/0
     15.0.0.0/24 is subnetted, 1 subnets
C       15.15.15.0 is directly connected, Ethernet1/0
S*   0.0.0.0/0 [1/0] via 209.165.200.1
PE5-IGW#


PE5-IGW#show ip route vrf vpn1
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, 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 209.165.200.1 to network 0.0.0.0


     192.168.10.0/32 is subnetted, 1 subnets
B       192.168.10.1 [200/2] via 4.4.4.4, 00:20:16
     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.0 [200/0] via 3.3.3.3, 00:23:04
     192.168.1.0/32 is subnetted, 1 subnets
B       192.168.1.1 [200/2] via 3.3.3.3, 00:21:46
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.0 [200/0] via 4.4.4.4, 00:23:04
S*   0.0.0.0/0 [1/0] via 209.165.200.1
PE5-IGW#show ip route vrf vpn2
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, 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 209.165.200.1 to network 0.0.0.0


     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.64 [200/0] via 3.3.3.3, 00:23:06
     192.168.20.0/32 is subnetted, 1 subnets
B       192.168.20.1 [200/2] via 4.4.4.4, 00:20:03
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.64 [200/0] via 4.4.4.4, 00:23:06
     192.168.2.0/32 is subnetted, 1 subnets
B       192.168.2.1 [200/2] via 3.3.3.3, 00:21:33
```

```
S*    0.0.0.0/0 [1/0] via 209.165.200.1
PE5-IGW#show ip route vrf vpn3
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, 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 209.165.200.1 to network 0.0.0.0


     192.168.30.0/32 is subnetted, 1 subnets
B        192.168.30.1 [200/2] via 4.4.4.4, 00:20:05
     36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.128 [200/0] via 3.3.3.3, 00:23:07
     47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.128 [200/0] via 4.4.4.4, 00:23:07
     192.168.3.0/32 is subnetted, 1 subnets
B        192.168.3.1 [200/2] via 3.3.3.3, 00:21:35
S*    0.0.0.0/0 [1/0] via 209.165.200.1
PE5-IGW#



PE5-IGW#show mpls ldp neighbor
    Peer LDP Ident: 2.2.2.2:0; Local LDP Ident 5.5.5.5:0
        TCP connection: 2.2.2.2.646 - 5.5.5.5.11006
        State: Oper; Msgs sent/rcvd: 47/45; Downstream
        Up time: 00:23:56
        LDP discovery sources:
          Ethernet1/1, Src IP addr: 25.25.25.2
        Addresses bound to peer LDP Ident:
          12.12.12.2      2.2.2.2         24.24.24.2     23.23.23.2
          25.25.25.2
    Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 5.5.5.5:0
        TCP connection: 1.1.1.1.646 - 5.5.5.5.11008
        State: Oper; Msgs sent/rcvd: 21/4; Downstream
        Up time: 00:01:06
        LDP discovery sources:
          Ethernet1/0, Src IP addr: 15.15.15.1
        Addresses bound to peer LDP Ident:
          12.12.12.1      1.1.1.1         13.13.13.1     14.14.14.1
          15.15.15.1
```

```
PE5-IGW#show ip bgp vpnv4 all
BGP table version is 36, local router ID is 5.5.5.5
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 1:1 (default for vrf vpn1)
*> 0.0.0.0          0.0.0.0                0          32768 ?
*>i36.36.36.0/26    3.3.3.3                0    100       0 ?
* i                 3.3.3.3                0    100       0 ?
*>i47.47.47.0/26    4.4.4.4                0    100       0 ?
* i                 4.4.4.4                0    100       0 ?
*>i192.168.1.1/32   3.3.3.3                2    100       0 ?
* i                 3.3.3.3                2    100       0 ?
* i192.168.10.1/32  4.4.4.4                2    100       0 ?
*>i                 4.4.4.4                2    100       0 ?
Route Distinguisher: 2:2 (default for vrf vpn2)
*> 0.0.0.0          0.0.0.0                0          32768 ?
*>i36.36.36.64/26   3.3.3.3                0    100       0 ?
* i                 3.3.3.3                0    100       0 ?
*>i47.47.47.64/26   4.4.4.4                0    100       0 ?
* i                 4.4.4.4                0    100       0 ?
*>i192.168.2.1/32   3.3.3.3                2    100       0 ?
   Network          Next Hop          Metric LocPrf Weight Path
* i                 3.3.3.3                2    100       0 ?
* i192.168.20.1/32  4.4.4.4                2    100       0 ?
*>i                 4.4.4.4                2    100       0 ?
Route Distinguisher: 3:3 (default for vrf vpn3)
*> 0.0.0.0          0.0.0.0                0          32768 ?
*>i36.36.36.128/26  3.3.3.3                0    100       0 ?
* i                 3.3.3.3                0    100       0 ?
*>i47.47.47.128/26  4.4.4.4                0    100       0 ?
* i                 4.4.4.4                0    100       0 ?
*>i192.168.3.1/32   3.3.3.3                2    100       0 ?
* i                 3.3.3.3                2    100       0 ?
* i192.168.30.1/32  4.4.4.4                2    100       0 ?
*>i                 4.4.4.4                2    100       0 ?
```

1.4.6 MCE1 配置验证

```
MCE-R6#show 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, 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

MCE-R6#show ip route vrf vpn1
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, 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 36.36.36.1 to network 0.0.0.0


     192.168.10.0/32 is subnetted, 1 subnets
O IA    192.168.10.1 [110/3] via 36.36.36.1, 01:37:01, FastEthernet0/0.10
     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.0 is directly connected, FastEthernet0/0.10
C    192.168.1.0/24 is directly connected, Loopback1
     47.0.0.0/26 is subnetted, 1 subnets
O IA    47.47.47.0 [110/2] via 36.36.36.1, 01:39:06, FastEthernet0/0.10
O*E2 0.0.0.0/0 [110/1] via 36.36.36.1, 01:39:06, FastEthernet0/0.10
MCE-R6#show ip route vrf vpn2
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, 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 36.36.36.65 to network 0.0.0.0


     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.64 is directly connected, FastEthernet0/0.20
     192.168.20.0/32 is subnetted, 1 subnets
O IA    192.168.20.1 [110/3] via 36.36.36.65, 01:36:50, FastEthernet0/0.20
     47.0.0.0/26 is subnetted, 1 subnets
O IA    47.47.47.64 [110/2] via 36.36.36.65, 01:39:08, FastEthernet0/0.20
C    192.168.2.0/24 is directly connected, Loopback2
```

```
O*E2 0.0.0.0/0 [110/1] via 36.36.36.65, 01:39:08, FastEthernet0/0.20
MCE-R6#show ip route vrf vpn3
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, 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 36.36.36.129 to network 0.0.0.0


     192.168.30.0/32 is subnetted, 1 subnets
O IA     192.168.30.1 [110/3] via 36.36.36.129, 01:36:51, FastEthernet0/0.30
     36.0.0.0/26 is subnetted, 1 subnets
C        36.36.36.128 is directly connected, FastEthernet0/0.30
     47.0.0.0/26 is subnetted, 1 subnets
O IA     47.47.47.128 [110/2] via 36.36.36.129, 01:39:09, FastEthernet0/0.30
C    192.168.3.0/24 is directly connected, Loopback3
O*E2 0.0.0.0/0 [110/1] via 36.36.36.129, 01:39:09, FastEthernet0/0.30
MCE-R6#


MCE-R6#ping vrf vpn1 ip 192.168.10.1 source 192.168.1.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1032/1359/1632 ms
MCE-R6#ping vrf vpn1 ip 209.165.201.1 source 192.168.1.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1296/1371/1536 ms
MCE-R6#


MCE-R6#ping vrf vpn2 ip 192.168.20.1 source 192.168.2.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1032/1251/1512 ms
```

```
MCE-R6#ping vrf vpn2 209.165.201.1 source 192.168.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1280/1398/1536 ms
MCE-R6#ping vrf vpn3 ip 192.168.30.1 source 192.168.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1080/1184/1316 ms
MCE-R6#ping vrf vpn3 209.165.201.1 source 192.168.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
...!.
Success rate is 20 percent (1/5), round-trip min/avg/max = 1932/1932/1932 ms
MCE-R6#ping vrf vpn3 209.165.201.1 source 192.168.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1128/1400/1532 ms
MCE-R6#
```

1.4.7 MCE2 配置验证

```
MCE-R7#show ip rou
MCE-R7#show 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, 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
```

```
MCE-R7#show ip route vrf vpn1
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, 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

C    192.168.10.0/24 is directly connected, Loopback1
     36.0.0.0/26 is subnetted, 1 subnets
O IA    36.36.36.0 [110/2] via 47.47.47.1, 01:42:39, FastEthernet0/0.10
     192.168.1.0/32 is subnetted, 1 subnets
O IA    192.168.1.1 [110/3] via 47.47.47.1, 01:42:39, FastEthernet0/0.10
     47.0.0.0/26 is subnetted, 1 subnets
C       47.47.47.0 is directly connected, FastEthernet0/0.10
MCE-R7#show ip route vrf vpn2
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, 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

     36.0.0.0/26 is subnetted, 1 subnets
O IA    36.36.36.64 [110/2] via 47.47.47.65, 01:42:22, FastEthernet0/0.20
C    192.168.20.0/24 is directly connected, Loopback2
     47.0.0.0/26 is subnetted, 1 subnets
C       47.47.47.64 is directly connected, FastEthernet0/0.20
     192.168.2.0/32 is subnetted, 1 subnets
O IA    192.168.2.1 [110/3] via 47.47.47.65, 01:42:22, FastEthernet0/0.20
MCE-R7#show ip route vrf vpn3
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, 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

```
C      192.168.30.0/24 is directly connected, Loopback3
       36.0.0.0/26 is subnetted, 1 subnets
O IA     36.36.36.128 [110/2] via 47.47.47.129, 01:44:03, FastEthernet0/0.30
       47.0.0.0/26 is subnetted, 1 subnets
C        47.47.47.128 is directly connected, FastEthernet0/0.30
       192.168.3.0/32 is subnetted, 1 subnets
O IA     192.168.3.1 [110/3] via 47.47.47.129, 01:44:03, FastEthernet0/0.30
```

1.4.8   Internet 配置验证

```
internet# show 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, 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

C    209.165.200.0/24 is directly connected, FastEthernet0/0
C    209.165.201.0/24 is directly connected, Loopback0
internet#
```

2 MPLS VPN 访问 Internet 方式二

2.1 网络拓扑图
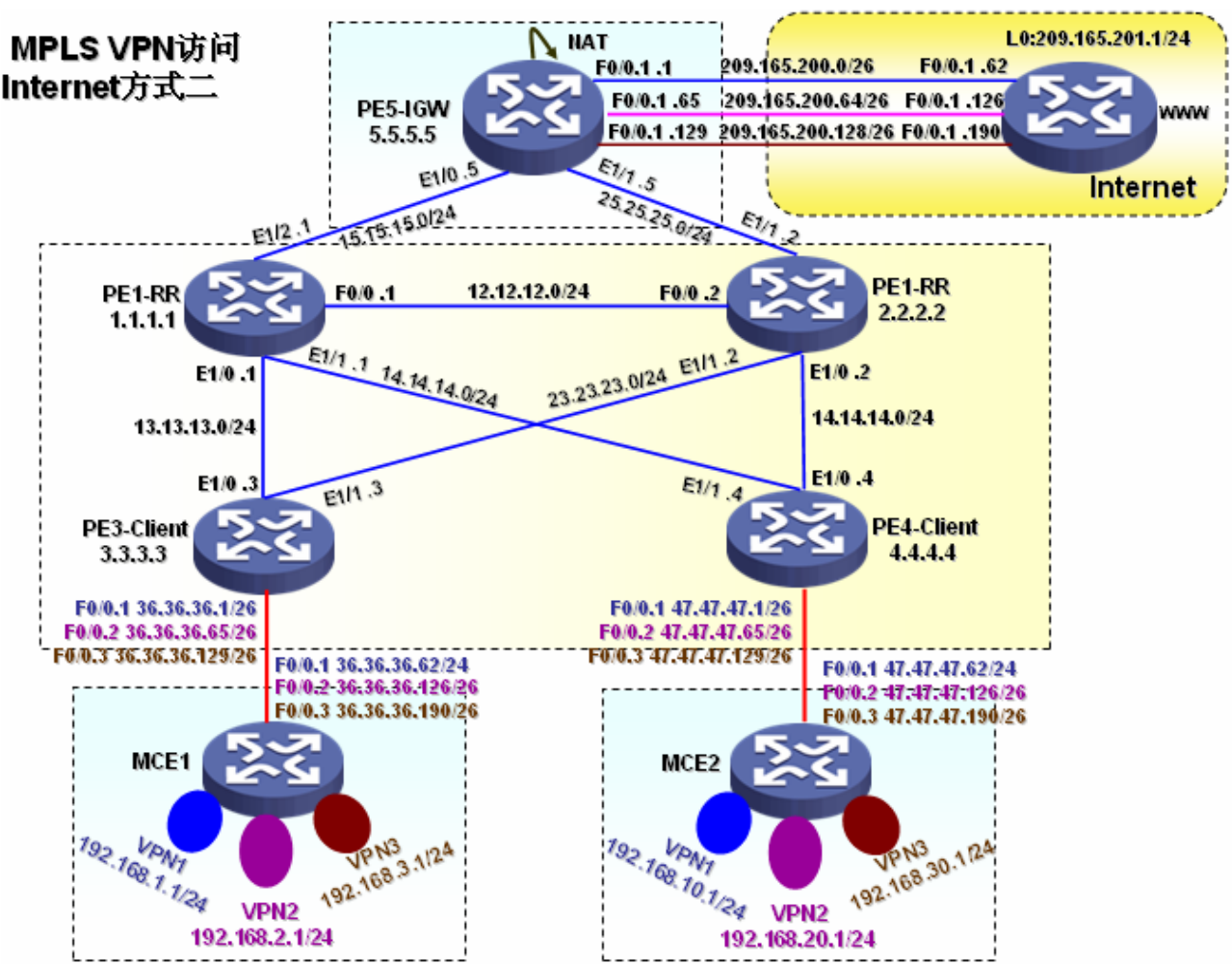
2.2 应用需求

1) 不同的 VPN 之间用户不能互访,相同的 VPN 之间的用户能够互访;
2) 所有的 VPN 用户都有访问 Internet 的需求,Internet 出口接在 PE5-IGW 设备上,每个 VPN 要求有自己的独立的 Internet 出口;

2.3 设备配置

2.3.1 PE1-RR 设备配置

```
hostname PE1-R1
!
ip vrf vpn1
```

```
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 ip address 12.12.12.1 255.255.255.0
 duplex auto
 speed auto
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/0
 ip address 13.13.13.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 14.14.14.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 ip address 15.15.15.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
```

```
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 12.12.12.1 0.0.0.0 area 0.0.0.0
 network 13.13.13.1 0.0.0.0 area 0.0.0.0
 network 14.14.14.1 0.0.0.0 area 0.0.0.0
 network 15.15.15.1 0.0.0.0 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 neighbor 2.2.2.2 route-reflector-client
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 3.3.3.3 route-reflector-client
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source Loopback0
 neighbor 4.4.4.4 route-reflector-client
 neighbor 5.5.5.5 remote-as 100
 neighbor 5.5.5.5 update-source Loopback0
 neighbor 5.5.5.5 route-reflector-client
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
```

```
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 route-reflector-client
 neighbor 2.2.2.2 send-community extended
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 route-reflector-client
 neighbor 3.3.3.3 send-community both
 neighbor 4.4.4.4 activate
 neighbor 4.4.4.4 route-reflector-client
 neighbor 4.4.4.4 send-community extended
 neighbor 5.5.5.5 activate
 neighbor 5.5.5.5 route-reflector-client
 neighbor 5.5.5.5 send-community extended
 no auto-summary
 exit-address-family
!
end
```

2.3.2 PE2-RR 设备配置

```
hostname PE2-R2
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
```

```
 ip address 12.12.12.2 255.255.255.0
 duplex auto
 speed auto
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/0
 ip address 24.24.24.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 23.23.23.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 ip address 25.25.25.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 2.2.2.2 0.0.0.0 area 0.0.0.0
 network 12.12.12.2 0.0.0.0 area 0.0.0.0
 network 23.23.23.2 0.0.0.0 area 0.0.0.0
 network 24.24.24.2 0.0.0.0 area 0.0.0.0
 network 25.25.25.2 0.0.0.0 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 1.1.1.1 route-reflector-client
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 3.3.3.3 route-reflector-client
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source Loopback0
 neighbor 4.4.4.4 route-reflector-client
```

```
neighbor 5.5.5.5 remote-as 100
neighbor 5.5.5.5 update-source Loopback0
neighbor 5.5.5.5 route-reflector-client
no auto-summary
!
address-family ipv4 vrf vpn3
redistribute connected
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf vpn2
redistribute connected
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf vpn1
redistribute connected
no auto-summary
no synchronization
exit-address-family
!
address-family vpnv4
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 route-reflector-client
neighbor 1.1.1.1 send-community extended
neighbor 3.3.3.3 activate
neighbor 3.3.3.3 route-reflector-client
neighbor 3.3.3.3 next-hop-self
neighbor 3.3.3.3 send-community extended
neighbor 4.4.4.4 activate
neighbor 4.4.4.4 route-reflector-client
neighbor 4.4.4.4 next-hop-self
neighbor 4.4.4.4 send-community extended
neighbor 5.5.5.5 activate
neighbor 5.5.5.5 route-reflector-client
neighbor 5.5.5.5 send-community extended
no auto-summary
exit-address-family
!
end
```

2.3.3 PE3-Client 设备配置

```
hostname PE3-R3
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 36.36.36.1 255.255.255.192
!
interface FastEthernet0/0.2
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 36.36.36.65 255.255.255.192
!
interface FastEthernet0/0.3
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
```

```
 ip address 36.36.36.129 255.255.255.192
!
interface Ethernet1/0
 ip address 13.13.13.3 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 23.23.23.3 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
router ospf 1
 router-id 3.3.3.3
 log-adjacency-changes
 redistribute static subnets
 network 3.3.3.3 0.0.0.0 area 0.0.0.0
 network 13.13.13.3 0.0.0.0 area 0.0.0.0
 network 23.23.23.3 0.0.0.0 area 0.0.0.0
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 36.36.36.0 0.0.0.63 area 0.0.0.0
 default-information originate always
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 36.36.36.64 0.0.0.63 area 0.0.0.0
 default-information originate always
!
router ospf 30 vrf vpn3
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 36.36.36.128 0.0.0.63 area 0.0.0.0
 default-information originate always
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
```

```
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 redistribute ospf 30
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community extended
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
end
```

2.3.4 PE4-Client 设备配置

```
hostname PE4-R4
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
```

```
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 47.47.47.1 255.255.255.192
!
interface FastEthernet0/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 47.47.47.65 255.255.255.192
!
interface FastEthernet0/0.30
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 47.47.47.129 255.255.255.192
!
interface Ethernet1/0
 ip address 24.24.24.4 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 14.14.14.4 255.255.255.0
```

```
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
router ospf 1
 router-id 4.4.4.4
 log-adjacency-changes
 network 4.4.4.4 0.0.0.0 area 0.0.0.0
 network 14.14.14.4 0.0.0.0 area 0.0.0.0
 network 24.24.24.4 0.0.0.0 area 0.0.0.0
!
router ospf 10 vrf vpn1
 router-id 47.47.47.1
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 47.47.47.0 0.0.0.63 area 0.0.0.0
 default-information originate always
!
router ospf 20 vrf vpn2
 router-id 47.47.47.65
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 47.47.47.64 0.0.0.63 area 0.0.0.0
 default-information originate always
!
router ospf 30 vrf vpn3
 router-id 47.47.47.129
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 47.47.47.128 0.0.0.63 area 0.0.0.0
 default-information originate always
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute ospf 30
 no auto-summary
 no synchronization
```

```
  exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community extended
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
end
```

2.3.5 PE5-Client 设备配置

```
hostname PE5-IGW
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
```

```
ip cef
mpls label protocol ldp
!
interface Loopback0
 ip address 5.5.5.5 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 209.165.200.1 255.255.255.192
 ip nat outside
!
interface FastEthernet0/0.2
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 209.165.200.65 255.255.255.192
 ip nat outside
!
interface FastEthernet0/0.3
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 209.165.200.129 255.255.255.192
 ip nat outside
!
interface Ethernet1/0
 ip address 15.15.15.5 255.255.255.0
 ip nat inside
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 25.25.25.5 255.255.255.0
 ip nat inside
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
router ospf 1
 router-id 5.5.5.5
```

```
 log-adjacency-changes
 network 5.5.5.5 0.0.0.0 area 0.0.0.0
 network 15.15.15.5 0.0.0.0 area 0.0.0.0
 network 25.25.25.5 0.0.0.0 area 0.0.0.0
 network 209.165.200.0 0.0.0.255 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 redistribute static
 default-information originate
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 redistribute static
 default-information originate
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 redistribute static
 default-information originate
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community extended
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
```

```
 exit-address-family
!
ip nat translation timeout 3600
ip nat inside source list 101 interface FastEthernet0/0.1 vrf vpn1 overload
ip nat inside source list 102 interface FastEthernet0/0.2 vrf vpn2 overload
ip nat inside source list 103 interface FastEthernet0/0.3 vrf vpn3 overload
ip classless
ip route vrf vpn1 0.0.0.0 0.0.0.0 209.165.200.62
ip route vrf vpn2 0.0.0.0 0.0.0.0 209.165.200.126
ip route vrf vpn3 0.0.0.0 0.0.0.0 209.165.200.190
ip http server
!
!
access-list 101 permit ip 192.168.1.0 0.0.0.255 any
access-list 101 permit ip 192.168.10.0 0.0.0.255 any
access-list 102 permit ip 192.168.2.0 0.0.0.255 any
access-list 102 permit ip 192.168.20.0 0.0.0.255 any
access-list 103 permit ip 192.168.3.0 0.0.0.255 any
access-list 103 permit ip 192.168.30.0 0.0.0.255 any
!
!
end
```

2.3.6 MCE1 设备配置

```
hostname MCE-R6
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
!
```

```
interface Loopback1
 ip vrf forwarding vpn1
 ip address 192.168.1.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpn2
 ip address 192.168.2.1 255.255.255.0
!
interface Loopback3
 ip vrf forwarding vpn3
 ip address 192.168.3.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 36.36.36.62 255.255.255.192
!
interface FastEthernet0/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 36.36.36.126 255.255.255.192
!
interface FastEthernet0/0.30
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 36.36.36.190 255.255.255.192
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 capability vrf-lite
 network 36.36.36.0 0.0.0.63 area 0.0.0.0
 network 192.168.1.0 0.0.0.255 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 capability vrf-lite
 network 36.36.36.64 0.0.0.63 area 0.0.0.0
 network 192.168.2.0 0.0.0.255 area 0.0.0.0
!
router ospf 30 vrf vpn3
```

```
 log-adjacency-changes
 capability vrf-lite
 network 36.36.36.128 0.0.0.63 area 0.0.0.0
 network 192.168.3.0 0.0.0.255 area 0.0.0.0
!
end
```

2.3.7　MCE2 设备配置

```
hostname MCE-R7
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
!
interface Loopback1
 ip vrf forwarding vpn1
 ip address 192.168.10.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpn2
 ip address 192.168.20.1 255.255.255.0
!
interface Loopback3
 ip vrf forwarding vpn3
 ip address 192.168.30.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
```

```
!
interface FastEthernet0/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 47.47.47.62 255.255.255.192
!
interface FastEthernet0/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 47.47.47.126 255.255.255.192
!
interface FastEthernet0/0.30
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 47.47.47.190 255.255.255.192
!
router ospf 10 vrf vpn1
 router-id 192.168.10.1
 log-adjacency-changes
 capability vrf-lite
 network 47.47.47.0 0.0.0.63 area 0.0.0.0
 network 192.168.10.0 0.0.0.255 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 capability vrf-lite
 network 47.47.47.64 0.0.0.63 area 0.0.0.0
 network 192.168.20.0 0.0.0.255 area 0.0.0.0
!
router ospf 30 vrf vpn3
 router-id 192.168.30.1
 log-adjacency-changes
 capability vrf-lite
 network 47.47.47.128 0.0.0.63 area 0.0.0.0
 network 192.168.30.0 0.0.0.255 area 0.0.0.0
!
end
```

2.3.8 Internet 设备配置

```
hostname internet
!
interface Loopback0
 ip address 209.165.201.1 255.255.255.0
```

```
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 10
 ip address 209.165.200.62 255.255.255.192
!
interface FastEthernet0/0.2
 encapsulation dot1Q 20
 ip address 209.165.200.126 255.255.255.192
!
interface FastEthernet0/0.3
 encapsulation dot1Q 30
 ip address 209.165.200.190 255.255.255.192
!
!
end
```

2.4 配置验证

2.4.1 PE1-RR 设备验证

```
PE1-R1# show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/2] via 12.12.12.2, 01:22:37, FastEthernet0/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/11] via 13.13.13.3, 01:22:37, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/11] via 14.14.14.4, 01:22:37, Ethernet1/1
```

```
         5.0.0.0/32 is subnetted, 1 subnets
O        5.5.5.5 [110/11] via 15.15.15.5, 01:22:37, Ethernet1/2
         23.0.0.0/24 is subnetted, 1 subnets
O        23.23.23.0 [110/11] via 12.12.12.2, 01:22:37, FastEthernet0/0
         25.0.0.0/24 is subnetted, 1 subnets
O        25.25.25.0 [110/11] via 12.12.12.2, 01:22:38, FastEthernet0/0
         24.0.0.0/24 is subnetted, 1 subnets
O        24.24.24.0 [110/11] via 12.12.12.2, 01:22:38, FastEthernet0/0
         12.0.0.0/24 is subnetted, 1 subnets
C        12.12.12.0 is directly connected, FastEthernet0/0
         13.0.0.0/24 is subnetted, 1 subnets
C        13.13.13.0 is directly connected, Ethernet1/0
         14.0.0.0/24 is subnetted, 1 subnets
C        14.14.14.0 is directly connected, Ethernet1/1
         15.0.0.0/24 is subnetted, 1 subnets
C        15.15.15.0 is directly connected, Ethernet1/2
PE1-R1#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0

     192.168.10.0/32 is subnetted, 1 subnets
B        192.168.10.1 [200/2] via 4.4.4.4, 00:17:17
     36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.0 [200/0] via 3.3.3.3, 01:28:46
     209.165.200.0/26 is subnetted, 1 subnets
B        209.165.200.0 [200/0] via 5.5.5.5, 01:22:13
     192.168.1.0/32 is subnetted, 1 subnets
B        192.168.1.1 [200/2] via 3.3.3.3, 01:20:43
     47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.0 [200/0] via 4.4.4.4, 01:26:15
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:22:13
PE1-R1#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0


     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.64 [200/0] via 3.3.3.3, 01:28:47
     209.165.200.0/26 is subnetted, 1 subnets
B       209.165.200.64 [200/0] via 5.5.5.5, 01:22:15
     192.168.20.0/32 is subnetted, 1 subnets
B       192.168.20.1 [200/2] via 4.4.4.4, 00:19:06
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.64 [200/0] via 4.4.4.4, 01:26:17
     192.168.2.0/32 is subnetted, 1 subnets
B       192.168.2.1 [200/2] via 3.3.3.3, 01:20:30
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:22:15
PE1-R1#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.30.0/32 is subnetted, 1 subnets
B       192.168.30.1 [200/2] via 4.4.4.4, 00:17:22
     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.128 [200/0] via 3.3.3.3, 01:28:51
     209.165.200.0/26 is subnetted, 1 subnets
B       209.165.200.128 [200/0] via 5.5.5.5, 01:22:19
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.128 [200/0] via 4.4.4.4, 01:26:21
     192.168.3.0/32 is subnetted, 1 subnets
B       192.168.3.1 [200/2] via 3.3.3.3, 01:20:19
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:22:19
PE1-R1#
```

2.4.2 PE2-RR 设备验证

```
PE2-R2#show 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, 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


     1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/2] via 12.12.12.1, 01:27:48, FastEthernet0/0
     2.0.0.0/32 is subnetted, 1 subnets
C        2.2.2.2 is directly connected, Loopback0
     3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.3 [110/11] via 23.23.23.3, 01:27:48, Ethernet1/1
     4.0.0.0/32 is subnetted, 1 subnets
O        4.4.4.4 [110/11] via 24.24.24.4, 01:27:48, Ethernet1/0
     5.0.0.0/32 is subnetted, 1 subnets
O        5.5.5.5 [110/11] via 25.25.25.5, 01:27:48, Ethernet1/2
     23.0.0.0/24 is subnetted, 1 subnets
C        23.23.23.0 is directly connected, Ethernet1/1
     25.0.0.0/24 is subnetted, 1 subnets
C        25.25.25.0 is directly connected, Ethernet1/2
     24.0.0.0/24 is subnetted, 1 subnets
C        24.24.24.0 is directly connected, Ethernet1/0
     12.0.0.0/24 is subnetted, 1 subnets
C        12.12.12.0 is directly connected, FastEthernet0/0
     13.0.0.0/24 is subnetted, 1 subnets
O        13.13.13.0 [110/11] via 12.12.12.1, 01:27:48, FastEthernet0/0
     14.0.0.0/24 is subnetted, 1 subnets
O        14.14.14.0 [110/11] via 12.12.12.1, 01:27:49, FastEthernet0/0
     15.0.0.0/24 is subnetted, 1 subnets
O        15.15.15.0 [110/11] via 12.12.12.1, 01:27:49, FastEthernet0/0
PE2-R2#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.10.0/32 is subnetted, 1 subnets
B        192.168.10.1 [200/2] via 4.4.4.4, 00:22:32
```

```
      36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.0 [200/0] via 3.3.3.3, 01:34:06
      209.165.200.0/26 is subnetted, 1 subnets
B        209.165.200.0 [200/0] via 5.5.5.5, 01:27:35
      192.168.1.0/32 is subnetted, 1 subnets
B        192.168.1.1 [200/2] via 3.3.3.3, 01:26:04
      47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.0 [200/0] via 4.4.4.4, 01:31:20
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:27:36
PE2-R2#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0


      36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.64 [200/0] via 3.3.3.3, 01:34:08
      209.165.200.0/26 is subnetted, 1 subnets
B        209.165.200.64 [200/0] via 5.5.5.5, 01:27:38
      192.168.20.0/32 is subnetted, 1 subnets
B        192.168.20.1 [200/2] via 4.4.4.4, 00:24:10
      47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.64 [200/0] via 4.4.4.4, 01:31:22
      192.168.2.0/32 is subnetted, 1 subnets
B        192.168.2.1 [200/2] via 3.3.3.3, 01:25:36
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:27:38
PE2-R2#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


      192.168.30.0/32 is subnetted, 1 subnets
B        192.168.30.1 [200/2] via 4.4.4.4, 00:22:36
      36.0.0.0/26 is subnetted, 1 subnets
```

```
B        36.36.36.128 [200/0] via 3.3.3.3, 01:34:10
     209.165.200.0/26 is subnetted, 1 subnets
B        209.165.200.128 [200/0] via 5.5.5.5, 01:27:40
     47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.128 [200/0] via 4.4.4.4, 01:31:24
     192.168.3.0/32 is subnetted, 1 subnets
B        192.168.3.1 [200/2] via 3.3.3.3, 01:25:23
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:27:40
PE2-R2#
```

2.4.3 PE3-Client 设备验证

```
PE3-R3#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/11] via 13.13.13.1, 01:31:08, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/11] via 23.23.23.2, 01:31:08, Ethernet1/1
     3.0.0.0/32 is subnetted, 1 subnets
C        3.3.3.3 is directly connected, Loopback0
     4.0.0.0/32 is subnetted, 1 subnets
O        4.4.4.4 [110/21] via 13.13.13.1, 01:31:08, Ethernet1/0
                 [110/21] via 23.23.23.2, 01:31:08, Ethernet1/1
     5.0.0.0/32 is subnetted, 1 subnets
O        5.5.5.5 [110/21] via 23.23.23.2, 01:31:08, Ethernet1/1
                 [110/21] via 13.13.13.1, 01:31:08, Ethernet1/0
     23.0.0.0/24 is subnetted, 1 subnets
C        23.23.23.0 is directly connected, Ethernet1/1
     25.0.0.0/24 is subnetted, 1 subnets
O        25.25.25.0 [110/20] via 23.23.23.2, 01:31:09, Ethernet1/1
     24.0.0.0/24 is subnetted, 1 subnets
O        24.24.24.0 [110/20] via 23.23.23.2, 01:31:09, Ethernet1/1
     12.0.0.0/24 is subnetted, 1 subnets
O        12.12.12.0 [110/11] via 23.23.23.2, 01:31:09, Ethernet1/1
                    [110/11] via 13.13.13.1, 01:31:09, Ethernet1/0
```

```
        13.0.0.0/24 is subnetted, 1 subnets
C       13.13.13.0 is directly connected, Ethernet1/0
        14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/20] via 13.13.13.1, 01:31:09, Ethernet1/0
        15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/20] via 13.13.13.1, 01:31:09, Ethernet1/0
PE3-R3# show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0

     192.168.10.0/32 is subnetted, 1 subnets
B       192.168.10.1 [200/2] via 4.4.4.4, 00:23:59
     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.0 is directly connected, FastEthernet0/0.1
     209.165.200.0/26 is subnetted, 1 subnets
B       209.165.200.0 [200/0] via 5.5.5.5, 01:30:30
     192.168.1.0/32 is subnetted, 1 subnets
O       192.168.1.1 [110/2] via 36.36.36.62, 01:29:16, FastEthernet0/0.1
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.0 [200/0] via 4.4.4.4, 01:34:47
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:30:30
PE3-R3#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0

     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.64 is directly connected, FastEthernet0/0.2
     209.165.200.0/26 is subnetted, 1 subnets
B       209.165.200.64 [200/0] via 5.5.5.5, 01:30:33
     192.168.20.0/32 is subnetted, 1 subnets
B       192.168.20.1 [200/2] via 4.4.4.4, 00:26:02
```

```
       47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.64 [200/0] via 4.4.4.4, 01:34:35
       192.168.2.0/32 is subnetted, 1 subnets
O        192.168.2.1 [110/2] via 36.36.36.126, 01:28:54, FastEthernet0/0.2
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 01:30:33
PE3-R3#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


       192.168.30.0/32 is subnetted, 1 subnets
B        192.168.30.1 [200/2] via 4.4.4.4, 00:24:12
       36.0.0.0/26 is subnetted, 1 subnets
C        36.36.36.128 is directly connected, FastEthernet0/0.3
       209.165.200.0/26 is subnetted, 1 subnets
B        209.165.200.128 [200/0] via 5.5.5.5, 01:30:36
       47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.128 [200/0] via 4.4.4.4, 01:34:38
       192.168.3.0/32 is subnetted, 1 subnets
O        192.168.3.1 [110/2] via 36.36.36.190, 01:28:47, FastEthernet0/0.3
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 01:30:36
PE3-R3#
```

2.4.4 PE4-Client 设备验证

```
PE4-R4#show 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, 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


       1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/11] via 14.14.14.1, 01:34:43, Ethernet1/1
```

```
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 24.24.24.2, 01:34:43, Ethernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/21] via 14.14.14.1, 01:34:43, Ethernet1/1
                [110/21] via 24.24.24.2, 01:34:43, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/21] via 24.24.24.2, 01:34:43, Ethernet1/0
                [110/21] via 14.14.14.1, 01:34:43, Ethernet1/1
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/20] via 24.24.24.2, 01:34:43, Ethernet1/0
     25.0.0.0/24 is subnetted, 1 subnets
O       25.25.25.0 [110/20] via 24.24.24.2, 01:34:43, Ethernet1/0
     24.0.0.0/24 is subnetted, 1 subnets
C       24.24.24.0 is directly connected, Ethernet1/0
     12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/11] via 14.14.14.1, 01:34:43, Ethernet1/1
                   [110/11] via 24.24.24.2, 01:34:43, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/20] via 14.14.14.1, 01:34:43, Ethernet1/1
     14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Ethernet1/1
     15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/20] via 14.14.14.1, 01:34:43, Ethernet1/1
PE4-R4#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.10.0/32 is subnetted, 1 subnets
O       192.168.10.1 [110/2] via 47.47.47.62, 00:28:05, FastEthernet0/0.10
     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.0 [200/0] via 3.3.3.3, 01:38:24
     209.165.200.0/26 is subnetted, 1 subnets
B       209.165.200.0 [200/0] via 5.5.5.5, 01:34:07
     192.168.1.0/32 is subnetted, 1 subnets
B       192.168.1.1 [200/2] via 3.3.3.3, 01:32:35
     47.0.0.0/26 is subnetted, 1 subnets
```

```
C        47.47.47.0 is directly connected, FastEthernet0/0.10
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:34:07
PE4-R4#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0


     36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.64 [200/0] via 3.3.3.3, 01:38:27
     209.165.200.0/26 is subnetted, 1 subnets
B        209.165.200.64 [200/0] via 5.5.5.5, 01:34:10
     192.168.20.0/32 is subnetted, 1 subnets
O        192.168.20.1 [110/2] via 47.47.47.126, 00:30:11, FastEthernet0/0.20
     47.0.0.0/26 is subnetted, 1 subnets
C        47.47.47.64 is directly connected, FastEthernet0/0.20
     192.168.2.0/32 is subnetted, 1 subnets
B        192.168.2.1 [200/2] via 3.3.3.3, 01:32:08
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:34:10
PE4-R4#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.30.0/32 is subnetted, 1 subnets
O        192.168.30.1 [110/2] via 47.47.47.190, 00:28:08, FastEthernet0/0.30
     36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.128 [200/0] via 3.3.3.3, 01:38:28
     209.165.200.0/26 is subnetted, 1 subnets
B        209.165.200.128 [200/0] via 5.5.5.5, 01:34:11
     47.0.0.0/26 is subnetted, 1 subnets
C        47.47.47.128 is directly connected, FastEthernet0/0.30
     192.168.3.0/32 is subnetted, 1 subnets
B        192.168.3.1 [200/2] via 3.3.3.3, 01:31:54
```

```
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 01:34:11
PE4-R4#
```

2.4.5 PE5-Client 设备验证

```
PE5-Client#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/11] via 15.15.15.1, 01:34:41, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/11] via 25.25.25.2, 01:34:41, Ethernet1/1
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/21] via 25.25.25.2, 01:34:41, Ethernet1/1
                [110/21] via 15.15.15.1, 01:34:41, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/21] via 25.25.25.2, 01:34:41, Ethernet1/1
                [110/21] via 15.15.15.1, 01:34:41, Ethernet1/0
     5.0.0.0/32 is subnetted, 1 subnets
C       5.5.5.5 is directly connected, Loopback0
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/20] via 25.25.25.2, 01:34:43, Ethernet1/1
     25.0.0.0/24 is subnetted, 1 subnets
C       25.25.25.0 is directly connected, Ethernet1/1
     24.0.0.0/24 is subnetted, 1 subnets
O       24.24.24.0 [110/20] via 25.25.25.2, 01:34:43, Ethernet1/1
     12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/11] via 25.25.25.2, 01:34:43, Ethernet1/1
                   [110/11] via 15.15.15.1, 01:34:43, Ethernet1/0
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/20] via 15.15.15.1, 01:34:43, Ethernet1/0
     14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/20] via 15.15.15.1, 01:34:43, Ethernet1/0
     15.0.0.0/24 is subnetted, 1 subnets
C       15.15.15.0 is directly connected, Ethernet1/0
PE5-IGW#show ip route vrf vpn1
```

```
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, 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 209.165.200.62 to network 0.0.0.0

     192.168.10.0/32 is subnetted, 1 subnets
B       192.168.10.1 [200/2] via 4.4.4.4, 00:29:23
     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.0 [200/0] via 3.3.3.3, 01:34:21
     209.165.200.0/26 is subnetted, 1 subnets
C       209.165.200.0 is directly connected, FastEthernet0/0.1
     192.168.1.0/32 is subnetted, 1 subnets
B       192.168.1.1 [200/2] via 3.3.3.3, 01:32:50
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.0 [200/0] via 4.4.4.4, 01:34:21
S*   0.0.0.0/0 [1/0] via 209.165.200.62
PE5-IGW#show ip route vrf vpn2
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, 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 209.165.200.126 to network 0.0.0.0

     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.64 [200/0] via 3.3.3.3, 01:34:23
     209.165.200.0/26 is subnetted, 1 subnets
C       209.165.200.64 is directly connected, FastEthernet0/0.2
     192.168.20.0/32 is subnetted, 1 subnets
B       192.168.20.1 [200/2] via 4.4.4.4, 00:31:19
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.64 [200/0] via 4.4.4.4, 01:34:23
     192.168.2.0/32 is subnetted, 1 subnets
B       192.168.2.1 [200/2] via 3.3.3.3, 01:32:22
S*   0.0.0.0/0 [1/0] via 209.165.200.126
PE5-IGW#show ip route vrf vpn3
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, 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 209.165.200.190 to network 0.0.0.0

     192.168.30.0/32 is subnetted, 1 subnets
B        192.168.30.1 [200/2] via 4.4.4.4, 00:29:34
     36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.128 [200/0] via 3.3.3.3, 01:34:24
     209.165.200.0/26 is subnetted, 1 subnets
C        209.165.200.128 is directly connected, FastEthernet0/0.3
     47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.128 [200/0] via 4.4.4.4, 01:34:24
     192.168.3.0/32 is subnetted, 1 subnets
B        192.168.3.1 [200/2] via 3.3.3.3, 01:32:08
S*   0.0.0.0/0 [1/0] via 209.165.200.190
PE5-IGW#
```

2.4.6 MCE1 设备验证

```
MCE-R6#show 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, 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

MCE-R6#show ip route vrf vpn1
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, 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 36.36.36.1 to network 0.0.0.0

```
     192.168.10.0/32 is subnetted, 1 subnets
O IA    192.168.10.1 [110/3] via 36.36.36.1, 00:32:57, FastEthernet0/0.10
     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.0 is directly connected, FastEthernet0/0.10
     209.165.200.0/26 is subnetted, 1 subnets
O E2    209.165.200.0 [110/1] via 36.36.36.1, 01:39:51, FastEthernet0/0.10
C    192.168.1.0/24 is directly connected, Loopback1
     47.0.0.0/26 is subnetted, 1 subnets
O IA    47.47.47.0 [110/2] via 36.36.36.1, 01:39:51, FastEthernet0/0.10
O*E2 0.0.0.0/0 [110/1] via 36.36.36.1, 01:39:51, FastEthernet0/0.10
MCE-R6#show ip route vrf vpn2
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, 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 36.36.36.65 to network 0.0.0.0

```
     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.64 is directly connected, FastEthernet0/0.20
     209.165.200.0/26 is subnetted, 1 subnets
O E2    209.165.200.64 [110/1] via 36.36.36.65, 01:39:07, FastEthernet0/0.20
     192.168.20.0/32 is subnetted, 1 subnets
O IA    192.168.20.1 [110/3] via 36.36.36.65, 00:35:35, FastEthernet0/0.20
     47.0.0.0/26 is subnetted, 1 subnets
O IA    47.47.47.64 [110/2] via 36.36.36.65, 01:39:07, FastEthernet0/0.20
C    192.168.2.0/24 is directly connected, Loopback2
O*E2 0.0.0.0/0 [110/1] via 36.36.36.65, 01:39:08, FastEthernet0/0.20
MCE-R6#show ip route vrf vpn3
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, 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 36.36.36.129 to network 0.0.0.0

```
     192.168.30.0/32 is subnetted, 1 subnets
```

```
O IA     192.168.30.1 [110/3] via 36.36.36.129, 00:35:37, FastEthernet0/0.30
        36.0.0.0/26 is subnetted, 1 subnets
C        36.36.36.128 is directly connected, FastEthernet0/0.30
        209.165.200.0/26 is subnetted, 1 subnets
O E2     209.165.200.128 [110/1] via 36.36.36.129, 01:39:09, FastEthernet0/0.30
        47.0.0.0/26 is subnetted, 1 subnets
O IA     47.47.47.128 [110/2] via 36.36.36.129, 01:39:09, FastEthernet0/0.30
C     192.168.3.0/24 is directly connected, Loopback3
O*E2 0.0.0.0/0 [110/1] via 36.36.36.129, 01:39:09, FastEthernet0/0.30
MCE-R6#


MCE-R6#ping vrf vpn1 192.168.10.1 source 192.168.1.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
!!!!.
Success rate is 80 percent (4/5), round-trip min/avg/max = 1436/1518/1632 ms
MCE-R6#ping vrf vpn2 192.168.20.1 source 192.168.1.1


% Invalid source address- IP address not on any of our up interfaces
MCE-R6#ping vrf vpn2 192.168.20.1 source 192.168.2.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1032/1277/1392 ms
MCE-R6#ping vrf vpn3 192.168.30.1 source 192.168.3.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 984/1371/1656 ms
MCE-R6#ping vrf vpn1 209.165.201.1 source 192.168.1.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
...!!
Success rate is 40 percent (2/5), round-trip min/avg/max = 1200/1426/1652 ms
MCE-R6#ping vrf vpn2 209.165.201.1 source 192.168.2.1


Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
.....
Success rate is 0 percent (0/5)
MCE-R6#ping vrf vpn2 209.165.201.1 source 192.168.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
.....
Success rate is 0 percent (0/5)
MCE-R6#ping vrf vpn2 209.165.201.1 source 192.168.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1256/1460/1584 ms
MCE-R6#ping vrf vpn3 209.165.201.1 source 192.168.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1152/1337/1488 ms
MCE-R6#tracer
MCE-R6#traceroute vrf vpn1 ?
  WORD       Trace route to destination address or hostname
  appletalk  AppleTalk Trace
  clns       ISO CLNS Trace
  ip         IP Trace
  ipv6       IPv6 Trace
  ipx        IPX Trace
  <cr>

MCE-R6#traceroute vrf vpn1
Protocol [ip]:
Target IP address: 192.168.10.1
Source address: 192.168.1.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
```

Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.10.1

  1 36.36.36.1 404 msec 312 msec 528 msec
  2 23.23.23.2 [MPLS: Labels 24/31 Exp 0] 2376 msec 2588 msec 2112 msec
  3 47.47.47.1 [MPLS: Label 31 Exp 0] 912 msec 1364 msec 912 msec
  4 47.47.47.62 1536 msec 1224 msec 1416 msec
MCE-R6#traceroute vrf vpn2
Protocol [ip]:
Target IP address: 192.168.20.1
Source address: 192.168.2.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.20.1

  1 36.36.36.65 360 msec 264 msec 336 msec
  2 23.23.23.2 [MPLS: Labels 24/33 Exp 0] 2544 msec 2492 msec 2256 msec
  3 47.47.47.65 [MPLS: Label 33 Exp 0] 936 msec 1028 msec 864 msec
  4 47.47.47.126 1320 msec 1500 msec 1416 msec
MCE-R6#traceroute vrf vpn3
Protocol [ip]:
Target IP address: 192.168.3.1
Source address: 192.168
% Invalid source address
MCE-R6#
MCE-R6#
MCE-R6#
MCE-R6#traceroute vrf vpn3
Protocol [ip]:
Target IP address: 192.168.30.1
Source address: 192.168.3.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 192.168.30.1


```
  1 36.36.36.129 240 msec 432 msec 312 msec
  2 13.13.13.1 [MPLS: Labels 18/32 Exp 0] 2208 msec 2636 msec 2064 msec
  3 47.47.47.129 [MPLS: Label 32 Exp 0] 1440 msec 908 msec 1008 msec
  4 47.47.47.190 1224 msec 1176 msec 1104 msec
MCE-R6#
```

MCE-R6#traceroute vrf vpn1

Protocol [ip]:

Target IP address: 209.165.201.1

Source address: 192.168.1.1

Numeric display [n]:

Timeout in seconds [3]:

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 209.165.201.1


```
  1 36.36.36.1 288 msec 408 msec 264 msec
  2  *  *  *
  3 209.165.200.1 [MPLS: Label 28 Exp 0] 1104 msec 1052 msec 936 msec
  4 209.165.200.62 1416 msec 1608 msec 1272 msec
MCE-R6#
```

MCE-R6#traceroute vrf vpn2

Protocol [ip]:

Target IP address: 209.165.201.1

Source address: 192.168.2.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 209.165.201.1


```
  1 36.36.36.65 360 msec 456 msec 312 msec
  2  *  *  *
```

```
    3 209.165.200.65 [MPLS: Label 30 Exp 0] 1080 msec 1532 msec 840 msec
    4 209.165.200.126 1464 msec 1296 msec 1296 msec
MCE-R6#


MCE-R6#traceroute vrf vpn3
Protocol [ip]:
Target IP address: 209.165.201.1
Source address: 192.168.3.1
Numeric display [n]:
Timeout in seconds [3]: 20
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 209.165.201.1


    1 36.36.36.129 456 msec 360 msec 336 msec
    2  *  *  *
    3 209.165.200.129 [MPLS: Label 32 Exp 0] 932 msec 980 msec 840 msec
    4 209.165.200.190 1536 msec 1340 msec 1152 msec
MCE-R6#
```

2.4.7 MCE2 设备验证

```
MCE-R7#show 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, 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


MCE-R7#show ip route vrf vpn1
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, 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 47.47.47.1 to network 0.0.0.0


C    192.168.10.0/24 is directly connected, Loopback1
     36.0.0.0/26 is subnetted, 1 subnets
O IA    36.36.36.0 [110/2] via 47.47.47.1, 00:50:13, FastEthernet0/0.10
     209.165.200.0/26 is subnetted, 1 subnets
O E2    209.165.200.0 [110/1] via 47.47.47.1, 00:50:13, FastEthernet0/0.10
     192.168.1.0/32 is subnetted, 1 subnets
O IA    192.168.1.1 [110/3] via 47.47.47.1, 00:50:13, FastEthernet0/0.10
     47.0.0.0/26 is subnetted, 1 subnets
C       47.47.47.0 is directly connected, FastEthernet0/0.10
O*E2 0.0.0.0/0 [110/1] via 47.47.47.1, 00:50:13, FastEthernet0/0.10
MCE-R7#show ip route vrf vpn2
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, 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 47.47.47.65 to network 0.0.0.0


     36.0.0.0/26 is subnetted, 1 subnets
O IA    36.36.36.64 [110/2] via 47.47.47.65, 00:52:51, FastEthernet0/0.20
     209.165.200.0/26 is subnetted, 1 subnets
O E2    209.165.200.64 [110/1] via 47.47.47.65, 00:52:51, FastEthernet0/0.20
C    192.168.20.0/24 is directly connected, Loopback2
     47.0.0.0/26 is subnetted, 1 subnets
C       47.47.47.64 is directly connected, FastEthernet0/0.20
     192.168.2.0/32 is subnetted, 1 subnets
O IA    192.168.2.1 [110/3] via 47.47.47.65, 00:52:51, FastEthernet0/0.20
O*E2 0.0.0.0/0 [110/1] via 47.47.47.65, 00:52:51, FastEthernet0/0.20
MCE-R7#show ip route vrf vpn3
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, 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 47.47.47.129 to network 0.0.0.0
```

```
C     192.168.30.0/24 is directly connected, Loopback3
      36.0.0.0/26 is subnetted, 1 subnets
O IA    36.36.36.128 [110/2] via 47.47.47.129, 00:50:19, FastEthernet0/0.30
      209.165.200.0/26 is subnetted, 1 subnets
O E2    209.165.200.128 [110/1] via 47.47.47.129, 00:50:19, FastEthernet0/0.30
      47.0.0.0/26 is subnetted, 1 subnets
C       47.47.47.128 is directly connected, FastEthernet0/0.30
      192.168.3.0/32 is subnetted, 1 subnets
O IA    192.168.3.1 [110/3] via 47.47.47.129, 00:50:19, FastEthernet0/0.30
O*E2 0.0.0.0/0 [110/1] via 47.47.47.129, 00:50:19, FastEthernet0/0.30
MCE-R7#


MCE-R7#ping vrf vpn1 192.168.1.1 source 192.168.10.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.10.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1184/1450/1916 ms
MCE-R7#ping vrf vpn2 192.168.2.1 source 192.168.20.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.20.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1128/1284/1416 ms
MCE-R7#ping vrf vpn3 vpn3 192.168.3.1 source 192.168.30.1
Translating "vpn3"...domain server (255.255.255.255) % Name lookup aborted


Translating "vrf"...domain server (255.255.255.255) % Name lookup aborted
                              ^

% Invalid input detected at '^' marker.


MCE-R7#ping vrf vpn3 192.168.3.1 source 192.168.30.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.30.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1056/1237/1364 ms
MCE-R7#ping vrf vpn1 209.165.201.1 source 192.168.1.1


% Invalid source address- IP address not on any of our up interfaces
MCE-R7#ping vrf vpn1 209.165.201.1 source 192.168.10.1
```

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.10.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1128/1278/1536 ms

MCE-R7#ping vrf vpn2 209.165.201.1 source 192.168.20.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.20.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1032/1167/1344 ms

MCE-R7#ping vrf vpn3 209.165.201.1 source 192.168.30.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:

Packet sent with a source address of 192.168.30.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1248/1392/1488 ms

MCE-R7#

2.4.8　Interent 设备验证

```
internet# show 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, 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

     209.165.200.0/26 is subnetted, 3 subnets
C       209.165.200.128 is directly connected, FastEthernet0/0.3
C       209.165.200.0 is directly connected, FastEthernet0/0.1
C       209.165.200.64 is directly connected, FastEthernet0/0.2
C    209.165.201.0/24 is directly connected, Loopback0
internet#
```

2.5 实现原理及注意事项

1）实现原理：PE2-R2 接收所有从 PE3-R3、PE4-R4 来的私网路由（CE6-R6，CE7-R7，CE8-R8），PE2-R2 的 F0/0.1 绑定到 HUB，那么 CE5-R5 接收到了所有 PE3-R3、PE4-R4 的私网路由，并合成一个路由表；又因为 PE2-R2 的 F0/0.2 绑定到 SPOKE，所以 CE5-R5 把所有的路由发给 PE2-R2，并携带 RT200:200 发送给 PE 邻居。

2）注意事项：PE2-R2 的两个私网接口和 CE5-R5 运行的路由协议是 BGP，在这种配置下一定要考虑到的一个细节就是 TAG，PE2-R2 私网路由通过 ospf 协议从 F0/0.1 发送给 CE5-R5 时，bgp 会把自己的 as-path 自动加入到 ospf 的 tag 部分，CE5-R5 再把这些携带 TAG 的路由发送给 PE2-R2 时，PE2-R2 会读取私网 OSPF 来的 TAG 标记，如果里面包含自己的 as-path 时，PE2-R2 会忽略掉这些路由。解决的办法就是让 bgp 引入到私网 ospf 时手工修改携带的 tag 信息。

   router ospf 100 vrf HUB
   log-adjacency-changes
   redistribute bgp 100 subnets tag 0
   network 25.25.25.0 0.0.0.3 area 0.0.0.0

3 MPLS VPN 访问 Internet 方式三

3.1 网络拓扑图
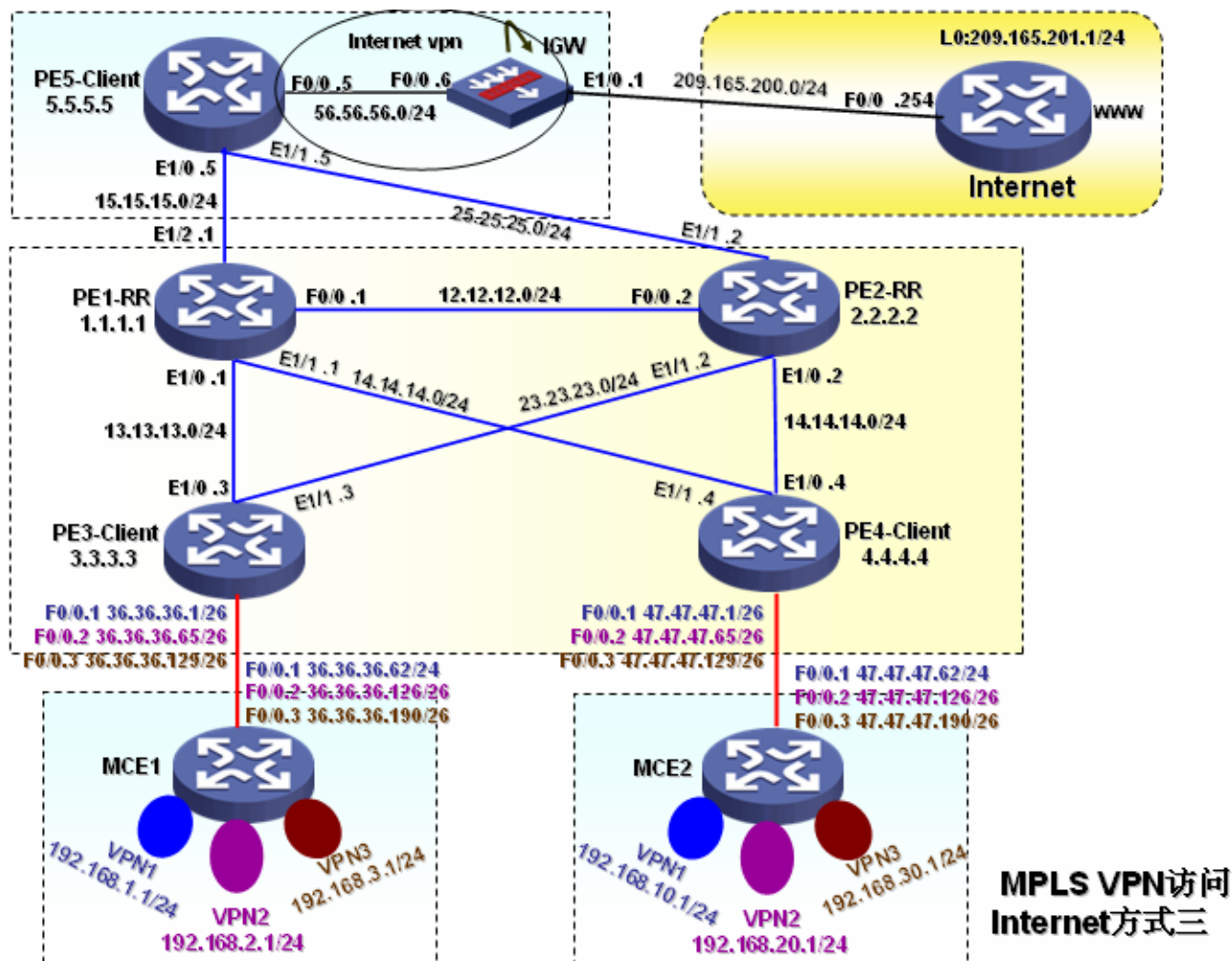
3.2 应用需求

1）不同的 VPN 之间用户不能互访，相同的 VPN 之间的用户能够互访；

2）所有的 VPN 用户都有访问 Internet 的需求，Internet 出口接在 PE5-Client 上，Internet 出口属于一个专门的 VPN，为 Internet VPN；

3）为了实现所有的 VPN 用户都能够通过 PE5-Client Internet VPN 访问 Internet，将 PE5-Client 配置成 Super-PE，在 Internet VPN 私网路由表上，引入 VPN1，VPN2，VPN3 的路由表（通过 Import RT 控制），同时在 VPN1，VPN2，VPN3 私网路由表上，引入 Internet 的路由表（通过 Import RT 控制）。另外，为了确保 PE3，PE4 下面的所有的 VPN 用户访问 Internet 的数据报文能够被正确传递地到 PE5-Client 上来，在 PE5-Client BGP VPNv4 上强制生成一条缺省路由，通告给 PE3，PE4。

3.3 设备配置

3.3.1 PE1-RR 设备配置

```
hostname PE1-RR
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
 route-target import 100:100
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
 route-target import 100:100
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
 route-target import 100:100
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 ip address 12.12.12.1 255.255.255.0
 duplex auto
 speed auto
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/0
 ip address 13.13.13.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
```

```
!
interface Ethernet1/1
 ip address 14.14.14.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 ip address 15.15.15.1 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 12.12.12.1 0.0.0.0 area 0.0.0.0
 network 13.13.13.1 0.0.0.0 area 0.0.0.0
 network 14.14.14.1 0.0.0.0 area 0.0.0.0
 network 15.15.15.1 0.0.0.0 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 neighbor 2.2.2.2 route-reflector-client
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 3.3.3.3 route-reflector-client
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source Loopback0
 neighbor 4.4.4.4 route-reflector-client
 neighbor 5.5.5.5 remote-as 100
 neighbor 5.5.5.5 update-source Loopback0
 neighbor 5.5.5.5 route-reflector-client
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
```

```
 address-family ipv4 vrf vpn2
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 route-reflector-client
 neighbor 2.2.2.2 send-community extended
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 route-reflector-client
 neighbor 3.3.3.3 send-community both
 neighbor 4.4.4.4 activate
 neighbor 4.4.4.4 route-reflector-client
 neighbor 4.4.4.4 send-community extended
 neighbor 5.5.5.5 activate
 neighbor 5.5.5.5 route-reflector-client
 neighbor 5.5.5.5 send-community extended
 no auto-summary
 exit-address-family
!
end
```

3.3.2 PE2-RR 设备配置

```
hostname PE2-RR
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
 route-target import 100:100
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
```

```
 route-target import 100:100
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
 route-target import 100:100
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 ip address 12.12.12.2 255.255.255.0
 duplex auto
 speed auto
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/0
 ip address 24.24.24.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 23.23.23.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 ip address 25.25.25.2 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 2.2.2.2 0.0.0.0 area 0.0.0.0
 network 12.12.12.2 0.0.0.0 area 0.0.0.0
```

```
  network 23.23.23.2 0.0.0.0 area 0.0.0.0
  network 24.24.24.2 0.0.0.0 area 0.0.0.0
  network 25.25.25.2 0.0.0.0 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 1.1.1.1 route-reflector-client
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 3.3.3.3 route-reflector-client
 neighbor 4.4.4.4 remote-as 100
 neighbor 4.4.4.4 update-source Loopback0
 neighbor 4.4.4.4 route-reflector-client
 neighbor 5.5.5.5 remote-as 100
 neighbor 5.5.5.5 update-source Loopback0
 neighbor 5.5.5.5 route-reflector-client
 no auto-summary
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 route-reflector-client
 neighbor 1.1.1.1 send-community extended
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 route-reflector-client
```

```
 neighbor 3.3.3.3 next-hop-self
 neighbor 3.3.3.3 send-community extended
 neighbor 4.4.4.4 activate
 neighbor 4.4.4.4 route-reflector-client
 neighbor 4.4.4.4 next-hop-self
 neighbor 4.4.4.4 send-community extended
 neighbor 5.5.5.5 activate
 neighbor 5.5.5.5 route-reflector-client
 neighbor 5.5.5.5 send-community extended
 no auto-summary
 exit-address-family
!
end
```

3.3.3 PE3-Client 设备配置

Current configuration : 3249 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE3-R3
!
!
ip subnet-zero
!
!
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
 route-target import 100:100
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
 route-target import 100:100
!
ip vrf vpn3
 rd 3:3

```
   route-target export 3:3
   route-target import 3:3
   route-target import 100:100
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
  ip address 3.3.3.3 255.255.255.255
!
interface FastEthernet0/0
  no ip address
  duplex auto
  speed auto
!
interface FastEthernet0/0.1
  encapsulation dot1Q 10
  ip vrf forwarding vpn1
  ip address 36.36.36.1 255.255.255.192
!
interface FastEthernet0/0.2
  encapsulation dot1Q 20
  ip vrf forwarding vpn2
  ip address 36.36.36.65 255.255.255.192
!
interface FastEthernet0/0.3
  encapsulation dot1Q 30
  ip vrf forwarding vpn3
  ip address 36.36.36.129 255.255.255.192
```

```
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 13.13.13.3 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 23.23.23.3 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 3.3.3.3
 log-adjacency-changes
 redistribute static subnets
 network 3.3.3.3 0.0.0.0 area 0.0.0.0
 network 13.13.13.3 0.0.0.0 area 0.0.0.0
 network 23.23.23.3 0.0.0.0 area 0.0.0.0
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 36.36.36.0 0.0.0.63 area 0.0.0.0
 default-information originate always
!
router ospf 20 vrf vpn2
 log-adjacency-changes
```

```
   redistribute bgp 100 subnets
   network 36.36.36.64 0.0.0.63 area 0.0.0.0
   default-information originate always
 !
router ospf 30 vrf vpn3
  log-adjacency-changes
  redistribute bgp 100 subnets
  network 36.36.36.128 0.0.0.63 area 0.0.0.0
  default-information originate always
 !
router bgp 100
  no synchronization
  bgp log-neighbor-changes
  neighbor 1.1.1.1 remote-as 100
  neighbor 1.1.1.1 update-source Loopback0
  neighbor 2.2.2.2 remote-as 100
  neighbor 2.2.2.2 update-source Loopback0
  no auto-summary
  !
  address-family ipv4 vrf vpn3
  redistribute connected
  redistribute ospf 30
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family ipv4 vrf vpn2
  redistribute connected
  redistribute ospf 20
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family ipv4 vrf vpn1
  redistribute connected
  redistribute ospf 10
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family vpnv4
  neighbor 1.1.1.1 activate
  neighbor 1.1.1.1 send-community extended
  neighbor 2.2.2.2 activate
  neighbor 2.2.2.2 send-community extended
```

```
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

3.3.4　PE4-Client 设备配置

```
Current configuration : 3248 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE4-Client
!
!
```

```
ip subnet-zero
!
!
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
 route-target import 100:100
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
 route-target import 100:100
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
 route-target import 100:100
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
!
```

```
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 47.47.47.1 255.255.255.192
!
interface FastEthernet0/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 47.47.47.65 255.255.255.192
!
interface FastEthernet0/0.30
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 47.47.47.129 255.255.255.192
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 24.24.24.4 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 14.14.14.4 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
```

```
  no ip address
  shutdown
  half-duplex
!
router ospf 1
  router-id 4.4.4.4
  log-adjacency-changes
  network 4.4.4.4 0.0.0.0 area 0.0.0.0
  network 14.14.14.4 0.0.0.0 area 0.0.0.0
  network 24.24.24.4 0.0.0.0 area 0.0.0.0
!
router ospf 10 vrf vpn1
  router-id 47.47.47.1
  log-adjacency-changes
  redistribute bgp 100 subnets
  network 47.47.47.0 0.0.0.63 area 0.0.0.0
  default-information originate always
!
router ospf 20 vrf vpn2
  router-id 47.47.47.65
  log-adjacency-changes
  redistribute bgp 100 subnets
  network 47.47.47.64 0.0.0.63 area 0.0.0.0
  default-information originate always
!
router ospf 30 vrf vpn3
  router-id 47.47.47.129
  log-adjacency-changes
  redistribute bgp 100 subnets
  network 47.47.47.128 0.0.0.63 area 0.0.0.0
  default-information originate always
!
router bgp 100
  no synchronization
  bgp log-neighbor-changes
  neighbor 1.1.1.1 remote-as 100
  neighbor 1.1.1.1 update-source Loopback0
  neighbor 2.2.2.2 remote-as 100
  neighbor 2.2.2.2 update-source Loopback0
  no auto-summary
  !
  address-family ipv4 vrf vpn3
  redistribute ospf 30
  no auto-summary
```

```
  no synchronization
  exit-address-family
  !
  address-family ipv4 vrf vpn2
  redistribute ospf 20
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family ipv4 vrf vpn1
  redistribute connected
  redistribute ospf 10
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family vpnv4
  neighbor 1.1.1.1 activate
  neighbor 1.1.1.1 send-community extended
  neighbor 2.2.2.2 activate
  neighbor 2.2.2.2 send-community extended
  no auto-summary
  exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
```

```
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

3.3.5 PE5-Client 设备配置

```
PE5-Client#show running
Building configuration...

Current configuration : 2114 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE5-Client
!
!
ip subnet-zero
!
!
!
ip vrf internet
  rd 100:100
  route-target export 100:100
  route-target import 1:1
  route-target import 2:2
  route-target import 3:3
!
ip cef
mpls label protocol ldp
!
!
!
!
!
!
!
```

```
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 5.5.5.5 255.255.255.255
!
interface FastEthernet0/0
 ip vrf forwarding internet
 ip address 58.58.58.5 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 15.15.15.5 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 25.25.25.5 255.255.255.0
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
```

```
  half-duplex
!
router ospf 1
  router-id 5.5.5.5
  log-adjacency-changes
  network 5.5.5.5 0.0.0.0 area 0.0.0.0
  network 15.15.15.5 0.0.0.0 area 0.0.0.0
  network 25.25.25.5 0.0.0.0 area 0.0.0.0
  network 209.165.200.0 0.0.0.255 area 0.0.0.0
!
router bgp 100
  no synchronization
  bgp log-neighbor-changes
  neighbor 1.1.1.1 remote-as 100
  neighbor 1.1.1.1 update-source Loopback0
  neighbor 2.2.2.2 remote-as 100
  neighbor 2.2.2.2 update-source Loopback0
  no auto-summary
  !
  address-family ipv4 vrf internet
  redistribute connected
  redistribute static
  default-information originate
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family vpnv4
  neighbor 1.1.1.1 activate
  neighbor 1.1.1.1 send-community extended
  neighbor 2.2.2.2 activate
  neighbor 2.2.2.2 send-community extended
  no auto-summary
  exit-address-family
!
ip nat translation timeout 3600
ip classless
ip route vrf internet 0.0.0.0 0.0.0.0 58.58.58.8
ip http server
!
!
!
!
!
```

```
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

3.3.6　MCE1 设备配置

```
MCE-1#show running
Building configuration...

Current configuration : 1898 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname MCE-1
!
!
ip subnet-zero
!
!
no ip domain lookup
!
ip vrf vpn1
  rd 1:1
```

```
  route-target export 1:1
  route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback1
 ip vrf forwarding vpn1
 ip address 192.168.1.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpn2
 ip address 192.168.2.1 255.255.255.0
!
interface Loopback3
 ip vrf forwarding vpn3
 ip address 192.168.3.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
```

```
  duplex auto
  speed auto
!
interface FastEthernet0/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 36.36.36.62 255.255.255.192
!
interface FastEthernet0/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 36.36.36.126 255.255.255.192
!
interface FastEthernet0/0.30
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 36.36.36.190 255.255.255.192
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 10 vrf vpn1
 log-adjacency-changes
 capability vrf-lite
 network 36.36.36.0 0.0.0.63 area 0.0.0.0
 network 192.168.1.0 0.0.0.255 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 capability vrf-lite
 network 36.36.36.64 0.0.0.63 area 0.0.0.0
 network 192.168.2.0 0.0.0.255 area 0.0.0.0
!
router ospf 30 vrf vpn3
 log-adjacency-changes
 capability vrf-lite
 network 36.36.36.128 0.0.0.63 area 0.0.0.0
 network 192.168.3.0 0.0.0.255 area 0.0.0.0
!
ip classless
ip http server
```

```
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

3.3.7 MCE2 设备配置

```
MCE-2#show running
Building configuration...

Current configuration : 1932 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname MCE-2
!
!
ip subnet-zero
!
```

```
!
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback1
 ip vrf forwarding vpn1
 ip address 192.168.10.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpn2
 ip address 192.168.20.1 255.255.255.0
!
interface Loopback3
 ip vrf forwarding vpn3
```

```
  ip address 192.168.30.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.10
 encapsulation dot1Q 10
 ip vrf forwarding vpn1
 ip address 47.47.47.62 255.255.255.192
!
interface FastEthernet0/0.20
 encapsulation dot1Q 20
 ip vrf forwarding vpn2
 ip address 47.47.47.126 255.255.255.192
!
interface FastEthernet0/0.30
 encapsulation dot1Q 30
 ip vrf forwarding vpn3
 ip address 47.47.47.190 255.255.255.192
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 10 vrf vpn1
 router-id 192.168.10.1
 log-adjacency-changes
 capability vrf-lite
 network 47.47.47.0 0.0.0.63 area 0.0.0.0
 network 192.168.10.0 0.0.0.255 area 0.0.0.0
!
router ospf 20 vrf vpn2
 log-adjacency-changes
 capability vrf-lite
 network 47.47.47.64 0.0.0.63 area 0.0.0.0
 network 192.168.20.0 0.0.0.255 area 0.0.0.0
!
router ospf 30 vrf vpn3
 router-id 192.168.30.1
 log-adjacency-changes
```

```
  capability vrf-lite
  network 47.47.47.128 0.0.0.63 area 0.0.0.0
  network 192.168.30.0 0.0.0.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

3.3.8 IGW 设备配置

```
IGW#show running
Building configuration...

Current configuration : 1156 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
```

```
!
hostname IGW
!
!
ip subnet-zero
!
!
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 209.165.201.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 58.58.58.8 255.255.255.0
 ip nat inside
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 209.165.200.1 255.255.255.0
 ip nat outside
 half-duplex
```

```
!
interface Ethernet1/1
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
ip nat inside source list 100 interface Ethernet1/0 overload
ip classless
ip route 0.0.0.0 0.0.0.0 209.165.200.254
ip route 192.168.0.0 255.255.0.0 58.58.58.5
ip http server
!
!
access-list 100 permit ip 192.168.0.0 0.0.255.255 any
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
```

```
 login
!
!
end
```

3.3.9 Internet 设备配置

```
Internet#show running
Building configuration...

Current configuration : 623 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname Internet
!
!
ip subnet-zero
!
!
no ip domain lookup
!
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface FastEthernet0/0
 ip address 209.165.200.254 255.255.255.0
 duplex auto
```

```
  speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

3.4 配置验证

3.4.1 PE1-RR 配置验证

```
PE1-RR#show 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, 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


     1.0.0.0/32 is subnetted, 1 subnets
C        1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/2] via 12.12.12.2, 03:16:37, FastEthernet0/0
     3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.3 [110/11] via 13.13.13.3, 03:16:37, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
O        4.4.4.4 [110/11] via 14.14.14.4, 03:16:37, Ethernet1/1
     5.0.0.0/32 is subnetted, 1 subnets
O        5.5.5.5 [110/11] via 15.15.15.5, 03:16:37, Ethernet1/2
     23.0.0.0/24 is subnetted, 1 subnets
O        23.23.23.0 [110/11] via 12.12.12.2, 03:16:37, FastEthernet0/0
     25.0.0.0/24 is subnetted, 1 subnets
O        25.25.25.0 [110/11] via 12.12.12.2, 03:16:37, FastEthernet0/0
     24.0.0.0/24 is subnetted, 1 subnets
O        24.24.24.0 [110/11] via 12.12.12.2, 03:16:37, FastEthernet0/0
     12.0.0.0/24 is subnetted, 1 subnets
C        12.12.12.0 is directly connected, FastEthernet0/0
     13.0.0.0/24 is subnetted, 1 subnets
C        13.13.13.0 is directly connected, Ethernet1/0
     14.0.0.0/24 is subnetted, 1 subnets
C        14.14.14.0 is directly connected, Ethernet1/1
     15.0.0.0/24 is subnetted, 1 subnets
C        15.15.15.0 is directly connected, Ethernet1/2
PE1-RR#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.10.0/32 is subnetted, 1 subnets
B        192.168.10.1 [200/2] via 4.4.4.4, 03:13:21
```

```
       36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.0 [200/0] via 3.3.3.3, 03:23:23
       58.0.0.0/24 is subnetted, 1 subnets
B        58.58.58.0 [200/0] via 5.5.5.5, 00:58:44
       192.168.1.0/32 is subnetted, 1 subnets
B        192.168.1.1 [200/2] via 3.3.3.3, 03:15:22
       47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.0 [200/0] via 4.4.4.4, 03:19:53
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:52:56
PE1-RR#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0


       36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.64 [200/0] via 3.3.3.3, 03:23:25
       58.0.0.0/24 is subnetted, 1 subnets
B        58.58.58.0 [200/0] via 5.5.5.5, 00:58:46
       192.168.20.0/32 is subnetted, 1 subnets
B        192.168.20.1 [200/2] via 4.4.4.4, 03:13:23
       47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.64 [200/0] via 4.4.4.4, 03:19:55
       192.168.2.0/32 is subnetted, 1 subnets
B        192.168.2.1 [200/2] via 3.3.3.3, 03:15:24
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:52:58
PE1-RR#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


       192.168.30.0/32 is subnetted, 1 subnets
B        192.168.30.1 [200/2] via 4.4.4.4, 03:13:24
       36.0.0.0/26 is subnetted, 1 subnets
```

```
B        36.36.36.128 [200/0] via 3.3.3.3, 03:23:27
    58.0.0.0/24 is subnetted, 1 subnets
B        58.58.58.0 [200/0] via 5.5.5.5, 00:58:48
    47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.128 [200/0] via 4.4.4.4, 03:19:56
    192.168.3.0/32 is subnetted, 1 subnets
B        192.168.3.1 [200/2] via 3.3.3.3, 03:15:25
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:53:00
PE1-RR#
```

3.4.2 PE2-RR 配置验证

```
PE2-RR#show 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, 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

    1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/2] via 12.12.12.1, 03:22:21, FastEthernet0/0
    2.0.0.0/32 is subnetted, 1 subnets
C        2.2.2.2 is directly connected, Loopback0
    3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.3 [110/11] via 23.23.23.3, 03:22:21, Ethernet1/1
    4.0.0.0/32 is subnetted, 1 subnets
O        4.4.4.4 [110/11] via 24.24.24.4, 03:22:21, Ethernet1/0
    5.0.0.0/32 is subnetted, 1 subnets
O        5.5.5.5 [110/11] via 25.25.25.5, 03:22:21, Ethernet1/2
    23.0.0.0/24 is subnetted, 1 subnets
C        23.23.23.0 is directly connected, Ethernet1/1
    25.0.0.0/24 is subnetted, 1 subnets
C        25.25.25.0 is directly connected, Ethernet1/2
    24.0.0.0/24 is subnetted, 1 subnets
C        24.24.24.0 is directly connected, Ethernet1/0
    12.0.0.0/24 is subnetted, 1 subnets
C        12.12.12.0 is directly connected, FastEthernet0/0
    13.0.0.0/24 is subnetted, 1 subnets
O        13.13.13.0 [110/11] via 12.12.12.1, 03:22:22, FastEthernet0/0
    14.0.0.0/24 is subnetted, 1 subnets
```

```
O       14.14.14.0 [110/11] via 12.12.12.1, 03:22:22, FastEthernet0/0
     15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/11] via 12.12.12.1, 03:22:22, FastEthernet0/0
PE2-RR#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0

     192.168.10.0/32 is subnetted, 1 subnets
B       192.168.10.1 [200/2] via 4.4.4.4, 03:18:57
     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.0 [200/0] via 3.3.3.3, 03:29:13
     58.0.0.0/24 is subnetted, 1 subnets
B       58.58.58.0 [200/0] via 5.5.5.5, 00:56:11
     192.168.1.0/32 is subnetted, 1 subnets
B       192.168.1.1 [200/2] via 3.3.3.3, 03:20:57
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.0 [200/0] via 4.4.4.4, 03:25:42
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:56:11
PE2-RR#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0

     36.0.0.0/26 is subnetted, 1 subnets
B       36.36.36.64 [200/0] via 3.3.3.3, 03:29:15
     58.0.0.0/24 is subnetted, 1 subnets
B       58.58.58.0 [200/0] via 5.5.5.5, 00:56:13
     192.168.20.0/32 is subnetted, 1 subnets
B       192.168.20.1 [200/2] via 4.4.4.4, 03:18:59
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.64 [200/0] via 4.4.4.4, 03:25:45
     192.168.2.0/32 is subnetted, 1 subnets
```

```
B        192.168.2.1 [200/2] via 3.3.3.3, 03:21:15
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 00:56:13
PE2-RR#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0

     192.168.30.0/32 is subnetted, 1 subnets
B        192.168.30.1 [200/2] via 4.4.4.4, 03:19:01
     36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.128 [200/0] via 3.3.3.3, 03:29:17
     58.0.0.0/24 is subnetted, 1 subnets
B        58.58.58.0 [200/0] via 5.5.5.5, 00:56:15
     47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.128 [200/0] via 4.4.4.4, 03:25:46
     192.168.3.0/32 is subnetted, 1 subnets
B        192.168.3.1 [200/2] via 3.3.3.3, 03:21:01
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 00:56:15
PE2-RR#
```

3.4.3 PE3-Client 配置验证

```
PE3-R3#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/11] via 13.13.13.1, 03:26:11, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/11] via 23.23.23.2, 03:26:11, Ethernet1/1
     3.0.0.0/32 is subnetted, 1 subnets
```

```
C        3.3.3.3 is directly connected, Loopback0
      4.0.0.0/32 is subnetted, 1 subnets
O        4.4.4.4 [110/21] via 23.23.23.2, 03:26:11, Ethernet1/1
                  [110/21] via 13.13.13.1, 03:26:11, Ethernet1/0
      5.0.0.0/32 is subnetted, 1 subnets
O        5.5.5.5 [110/21] via 23.23.23.2, 03:26:11, Ethernet1/1
                  [110/21] via 13.13.13.1, 03:26:11, Ethernet1/0
      23.0.0.0/24 is subnetted, 1 subnets
C        23.23.23.0 is directly connected, Ethernet1/1
      25.0.0.0/24 is subnetted, 1 subnets
O        25.25.25.0 [110/20] via 23.23.23.2, 03:26:11, Ethernet1/1
      24.0.0.0/24 is subnetted, 1 subnets
O        24.24.24.0 [110/20] via 23.23.23.2, 03:26:11, Ethernet1/1
      12.0.0.0/24 is subnetted, 1 subnets
O        12.12.12.0 [110/11] via 23.23.23.2, 03:26:11, Ethernet1/1
                     [110/11] via 13.13.13.1, 03:26:11, Ethernet1/0
      13.0.0.0/24 is subnetted, 1 subnets
C        13.13.13.0 is directly connected, Ethernet1/0
      14.0.0.0/24 is subnetted, 1 subnets
O        14.14.14.0 [110/20] via 13.13.13.1, 03:26:12, Ethernet1/0
      15.0.0.0/24 is subnetted, 1 subnets
O        15.15.15.0 [110/20] via 13.13.13.1, 03:26:12, Ethernet1/0
PE3-R3#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0


      192.168.10.0/32 is subnetted, 1 subnets
B        192.168.10.1 [200/2] via 4.4.4.4, 03:22:55
      36.0.0.0/26 is subnetted, 1 subnets
C        36.36.36.0 is directly connected, FastEthernet0/0.1
      58.0.0.0/24 is subnetted, 1 subnets
B        58.58.58.0 [200/0] via 5.5.5.5, 00:32:29
      192.168.1.0/32 is subnetted, 1 subnets
O        192.168.1.1 [110/2] via 36.36.36.62, 03:25:05, FastEthernet0/0.1
      47.0.0.0/26 is subnetted, 1 subnets
B        47.47.47.0 [200/0] via 4.4.4.4, 03:29:27
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:32:29
PE3-R3#show ip route vrf vpn2
```

```
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, 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 5.5.5.5 to network 0.0.0.0


     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.64 is directly connected, FastEthernet0/0.2
     58.0.0.0/24 is subnetted, 1 subnets
B       58.58.58.0 [200/0] via 5.5.5.5, 00:32:31
     192.168.20.0/32 is subnetted, 1 subnets
B       192.168.20.1 [200/2] via 4.4.4.4, 03:22:43
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.64 [200/0] via 4.4.4.4, 03:29:29
     192.168.2.0/32 is subnetted, 1 subnets
O       192.168.2.1 [110/2] via 36.36.36.126, 03:25:07, FastEthernet0/0.2
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:32:31
PE3-R3#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.30.0/32 is subnetted, 1 subnets
B       192.168.30.1 [200/2] via 4.4.4.4, 03:22:40
     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.128 is directly connected, FastEthernet0/0.3
     58.0.0.0/24 is subnetted, 1 subnets
B       58.58.58.0 [200/0] via 5.5.5.5, 00:31:47
     47.0.0.0/26 is subnetted, 1 subnets
B       47.47.47.128 [200/0] via 4.4.4.4, 03:29:30
     192.168.3.0/32 is subnetted, 1 subnets
O       192.168.3.1 [110/2] via 36.36.36.190, 03:25:08, FastEthernet0/0.3
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:31:47
PE3-R3#
```

3.4.4 PE4-Client 配置验证

PE4-Client#show 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, 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

```
     1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/11] via 14.14.14.1, 03:29:11, Ethernet1/1
     2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/11] via 24.24.24.2, 03:29:11, Ethernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.3 [110/21] via 24.24.24.2, 03:29:11, Ethernet1/0
                 [110/21] via 14.14.14.1, 03:29:11, Ethernet1/1
     4.0.0.0/32 is subnetted, 1 subnets
C        4.4.4.4 is directly connected, Loopback0
     5.0.0.0/32 is subnetted, 1 subnets
O        5.5.5.5 [110/21] via 24.24.24.2, 03:29:11, Ethernet1/0
                 [110/21] via 14.14.14.1, 03:29:11, Ethernet1/1
     23.0.0.0/24 is subnetted, 1 subnets
O        23.23.23.0 [110/20] via 24.24.24.2, 03:29:11, Ethernet1/0
     25.0.0.0/24 is subnetted, 1 subnets
O        25.25.25.0 [110/20] via 24.24.24.2, 03:29:11, Ethernet1/0
     24.0.0.0/24 is subnetted, 1 subnets
C        24.24.24.0 is directly connected, Ethernet1/0
     12.0.0.0/24 is subnetted, 1 subnets
O        12.12.12.0 [110/11] via 24.24.24.2, 03:29:11, Ethernet1/0
                    [110/11] via 14.14.14.1, 03:29:11, Ethernet1/1
     13.0.0.0/24 is subnetted, 1 subnets
O        13.13.13.0 [110/20] via 14.14.14.1, 03:29:11, Ethernet1/1
     14.0.0.0/24 is subnetted, 1 subnets
C        14.14.14.0 is directly connected, Ethernet1/1
     15.0.0.0/24 is subnetted, 1 subnets
O        15.15.15.0 [110/20] via 14.14.14.1, 03:29:11, Ethernet1/1
PE4-Client#show ip route vrf vpn1
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.10.0/32 is subnetted, 1 subnets
O        192.168.10.1 [110/2] via 47.47.47.62, 03:26:11, FastEthernet0/0.10
     36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.0 [200/0] via 3.3.3.3, 03:32:53
     58.0.0.0/24 is subnetted, 1 subnets
B        58.58.58.0 [200/0] via 5.5.5.5, 00:58:45
     192.168.1.0/32 is subnetted, 1 subnets
B        192.168.1.1 [200/2] via 3.3.3.3, 03:27:51
     47.0.0.0/26 is subnetted, 1 subnets
C        47.47.47.0 is directly connected, FastEthernet0/0.10
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 00:58:45
PE4-Client#show ip route vrf vpn2
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, 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 5.5.5.5 to network 0.0.0.0


     36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.64 [200/0] via 3.3.3.3, 03:32:54
     58.0.0.0/24 is subnetted, 1 subnets
B        58.58.58.0 [200/0] via 5.5.5.5, 00:58:01
     192.168.20.0/32 is subnetted, 1 subnets
O        192.168.20.1 [110/2] via 47.47.47.126, 03:26:12, FastEthernet0/0.20
     47.0.0.0/26 is subnetted, 1 subnets
C        47.47.47.64 is directly connected, FastEthernet0/0.20
     192.168.2.0/32 is subnetted, 1 subnets
B        192.168.2.1 [200/2] via 3.3.3.3, 03:27:53
B*    0.0.0.0/0 [200/0] via 5.5.5.5, 00:58:01
PE4-Client#show ip route vrf vpn3
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, 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 5.5.5.5 to network 0.0.0.0


     192.168.30.0/32 is subnetted, 1 subnets
O        192.168.30.1 [110/2] via 47.47.47.190, 03:26:04, FastEthernet0/0.30
     36.0.0.0/26 is subnetted, 1 subnets
B        36.36.36.128 [200/0] via 3.3.3.3, 03:32:56
     58.0.0.0/24 is subnetted, 1 subnets
B        58.58.58.0 [200/0] via 5.5.5.5, 00:58:03
     47.0.0.0/26 is subnetted, 1 subnets
C        47.47.47.128 is directly connected, FastEthernet0/0.30
     192.168.3.0/32 is subnetted, 1 subnets
B        192.168.3.1 [200/2] via 3.3.3.3, 03:27:55
B*   0.0.0.0/0 [200/0] via 5.5.5.5, 00:58:03
PE4-Client#
```

3.4.5 PE5-Client 配置验证

```
PE5-Client#show 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, 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


     1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/11] via 15.15.15.1, 02:28:42, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/11] via 25.25.25.2, 02:28:42, Ethernet1/1
     3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.3 [110/21] via 25.25.25.2, 02:28:42, Ethernet1/1
                 [110/21] via 15.15.15.1, 02:28:42, Ethernet1/0
     4.0.0.0/32 is subnetted, 1 subnets
O        4.4.4.4 [110/21] via 25.25.25.2, 02:28:42, Ethernet1/1
                 [110/21] via 15.15.15.1, 02:28:42, Ethernet1/0
     5.0.0.0/32 is subnetted, 1 subnets
C        5.5.5.5 is directly connected, Loopback0
```

```
        23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/20] via 25.25.25.2, 02:28:43, Ethernet1/1
        25.0.0.0/24 is subnetted, 1 subnets
C       25.25.25.0 is directly connected, Ethernet1/1
        24.0.0.0/24 is subnetted, 1 subnets
O       24.24.24.0 [110/20] via 25.25.25.2, 02:28:43, Ethernet1/1
        12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/11] via 25.25.25.2, 02:28:43, Ethernet1/1
                   [110/11] via 15.15.15.1, 02:28:43, Ethernet1/0
        13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/20] via 15.15.15.1, 02:28:43, Ethernet1/0
        14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/20] via 15.15.15.1, 02:28:43, Ethernet1/0
        15.0.0.0/24 is subnetted, 1 subnets
C       15.15.15.0 is directly connected, Ethernet1/0
PE5-Client#show ip route vrf internet
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, 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 58.58.58.8 to network 0.0.0.0

        192.168.30.0/32 is subnetted, 1 subnets
B       192.168.30.1 [200/2] via 4.4.4.4, 02:24:46
        192.168.10.0/32 is subnetted, 1 subnets
B       192.168.10.1 [200/2] via 4.4.4.4, 02:24:46
        36.0.0.0/26 is subnetted, 3 subnets
B       36.36.36.0 [200/0] via 3.3.3.3, 02:24:46
B       36.36.36.64 [200/0] via 3.3.3.3, 02:24:46
B       36.36.36.128 [200/0] via 3.3.3.3, 02:24:46
        58.0.0.0/24 is subnetted, 1 subnets
C       58.58.58.0 is directly connected, FastEthernet0/0
        192.168.20.0/32 is subnetted, 1 subnets
B       192.168.20.1 [200/2] via 4.4.4.4, 02:24:46
        192.168.1.0/32 is subnetted, 1 subnets
B       192.168.1.1 [200/2] via 3.3.3.3, 02:24:46
        47.0.0.0/26 is subnetted, 3 subnets
B       47.47.47.0 [200/0] via 4.4.4.4, 02:24:46
B       47.47.47.64 [200/0] via 4.4.4.4, 02:24:46
B       47.47.47.128 [200/0] via 4.4.4.4, 02:24:46
        192.168.2.0/32 is subnetted, 1 subnets
```

```
B        192.168.2.1 [200/2] via 3.3.3.3, 02:24:46
     192.168.3.0/32 is subnetted, 1 subnets
B        192.168.3.1 [200/2] via 3.3.3.3, 02:24:46
S*   0.0.0.0/0 [1/0] via 58.58.58.8
PE5-Client#
```

3.4.6 MCE1 配置验证

```
MCE-1#show 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, 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


MCE-1#show ip route vrf vpn1
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, 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 36.36.36.1 to network 0.0.0.0


     192.168.10.0/32 is subnetted, 1 subnets
O IA    192.168.10.1 [110/3] via 36.36.36.1, 03:40:14, FastEthernet0/0.10
     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.0 is directly connected, FastEthernet0/0.10
     58.0.0.0/24 is subnetted, 1 subnets
O E2    58.58.58.0 [110/1] via 36.36.36.1, 00:39:28, FastEthernet0/0.10
C    192.168.1.0/24 is directly connected, Loopback1
     47.0.0.0/26 is subnetted, 1 subnets
O IA    47.47.47.0 [110/2] via 36.36.36.1, 03:42:34, FastEthernet0/0.10
O*E2 0.0.0.0/0 [110/1] via 36.36.36.1, 00:39:28, FastEthernet0/0.10
MCE-1#show ip route vrf vpn2
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, 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 36.36.36.65 to network 0.0.0.0

     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.64 is directly connected, FastEthernet0/0.20
     58.0.0.0/24 is subnetted, 1 subnets
O E2    58.58.58.0 [110/1] via 36.36.36.65, 00:39:30, FastEthernet0/0.20
     192.168.20.0/32 is subnetted, 1 subnets
O IA    192.168.20.1 [110/3] via 36.36.36.65, 03:39:55, FastEthernet0/0.20
     47.0.0.0/26 is subnetted, 1 subnets
O IA    47.47.47.64 [110/2] via 36.36.36.65, 03:42:47, FastEthernet0/0.20
C    192.168.2.0/24 is directly connected, Loopback2
O*E2 0.0.0.0/0 [110/1] via 36.36.36.65, 00:39:30, FastEthernet0/0.20
MCE-1#show ip route vrf vpn3
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, 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 36.36.36.129 to network 0.0.0.0

     192.168.30.0/32 is subnetted, 1 subnets
O IA    192.168.30.1 [110/3] via 36.36.36.129, 03:39:56, FastEthernet0/0.30
     36.0.0.0/26 is subnetted, 1 subnets
C       36.36.36.128 is directly connected, FastEthernet0/0.30
     58.0.0.0/24 is subnetted, 1 subnets
O E2    58.58.58.0 [110/1] via 36.36.36.129, 00:38:36, FastEthernet0/0.30
     47.0.0.0/26 is subnetted, 1 subnets
O IA    47.47.47.128 [110/2] via 36.36.36.129, 03:42:48, FastEthernet0/0.30
C    192.168.3.0/24 is directly connected, Loopback3
O*E2 0.0.0.0/0 [110/1] via 36.36.36.129, 00:38:36, FastEthernet0/0.30
MCE-1#


MCE-1#ping vrf vpn1 209.165.200.254 source 192.168.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.200.254, timeout is 2 seconds:
```

Packet sent with a source address of 192.168.1.1
!!.!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1436/1703/1904 ms
MCE-1#traceroute vrf vpn1
Protocol [ip]:
Target IP address: 209.165.200.254
Source address: 192.168.1.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 209.165.200.254

  1 36.36.36.1 408 msec 336 msec 360 msec
  2 13.13.13.1 [MPLS: Labels 22/25 Exp 0] 2376 msec 2948 msec 2256 msec
  3 58.58.58.5 [MPLS: Label 25 Exp 0] 1248 msec * *
  4 * *
    58.58.58.8 1984 msec
  5 * * *
  6 * * *
  7 * *
    209.165.200.254 496 msec
MCE-1#

MCE-1#ping vrf vpn2 209.165.200.254 source 192.168.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.200.254, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1344/1665/1992 ms
MCE-1#traceroute vrf vpn2
Protocol [ip]:
Target IP address: 209.165.200.254
Source address: 192.168.2.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 209.165.200.254

  1 36.36.36.65 264 msec 336 msec 240 msec
  2 13.13.13.1 [MPLS: Labels 22/25 Exp 0] 2448 msec 2468 msec 2568 msec
  3 58.58.58.5 [MPLS: Label 25 Exp 0] 960 msec 1148 msec 1076 msec
  4 58.58.58.8 1320 msec 1320 msec 1608 msec
  5 209.165.200.254 1956 msec 1800 msec 1608 msec
MCE-1#ping vrf vpn3 209.165.200.254 source 192.168.3.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 209.165.200.254, timeout is 2 seconds:

Packet sent with a source address of 192.168.3.1

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1540/1733/1872 ms

MCE-1#traceroute vrf vpn3

Protocol [ip]:

Target IP address: 209.165.200.254

Source address: 192.168.3.1

Numeric display [n]:

Timeout in seconds [3]:

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 209.165.200.254

  1 36.36.36.129 420 msec 504 msec 288 msec
  2 13.13.13.1 [MPLS: Labels 22/25 Exp 0] 2712 msec 2420 msec 2232 msec
  3 58.58.58.5 [MPLS: Label 25 Exp 0] 1104 msec 1028 msec 1008 msec
  4 58.58.58.8 1368 msec 1320 msec 1452 msec
  5 209.165.200.254 1788 msec 1884 msec 1752 msec
MCE-1#

3.4.7 MCE2 配置验证

MCE-2#show 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, 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


MCE-2#show ip route vrf vpn1
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, 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 47.47.47.1 to network 0.0.0.0


C       192.168.10.0/24 is directly connected, Loopback1
           36.0.0.0/26 is subnetted, 1 subnets
O IA      36.36.36.0 [110/2] via 47.47.47.1, 03:48:22, FastEthernet0/0.10
           58.0.0.0/24 is subnetted, 1 subnets
O E2      58.58.58.0 [110/1] via 47.47.47.1, 01:12:55, FastEthernet0/0.10
           192.168.1.0/32 is subnetted, 1 subnets
O IA      192.168.1.1 [110/3] via 47.47.47.1, 03:48:22, FastEthernet0/0.10
           47.0.0.0/26 is subnetted, 1 subnets
C          47.47.47.0 is directly connected, FastEthernet0/0.10
O*E2 0.0.0.0/0 [110/1] via 47.47.47.1, 01:12:55, FastEthernet0/0.10
MCE-2#show ip route vrf vpn2
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, 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 47.47.47.65 to network 0.0.0.0


           36.0.0.0/26 is subnetted, 1 subnets
O IA     36.36.36.64 [110/2] via 47.47.47.65, 03:48:23, FastEthernet0/0.20
           58.0.0.0/24 is subnetted, 1 subnets
O E2     58.58.58.0 [110/1] via 47.47.47.65, 01:11:59, FastEthernet0/0.20
C       192.168.20.0/24 is directly connected, Loopback2
           47.0.0.0/26 is subnetted, 1 subnets
C          47.47.47.64 is directly connected, FastEthernet0/0.20
```

```
        192.168.2.0/32 is subnetted, 1 subnets
O IA    192.168.2.1 [110/3] via 47.47.47.65, 03:48:23, FastEthernet0/0.20
O*E2 0.0.0.0/0 [110/1] via 47.47.47.65, 01:11:59, FastEthernet0/0.20
MCE-2#show ip route vrf vpn3
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, 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 47.47.47.129 to network 0.0.0.0


C    192.168.30.0/24 is directly connected, Loopback3
     36.0.0.0/26 is subnetted, 1 subnets
O IA    36.36.36.128 [110/2] via 47.47.47.129, 03:48:14, FastEthernet0/0.30
     58.0.0.0/24 is subnetted, 1 subnets
O E2    58.58.58.0 [110/1] via 47.47.47.129, 01:12:01, FastEthernet0/0.30
     47.0.0.0/26 is subnetted, 1 subnets
C       47.47.47.128 is directly connected, FastEthernet0/0.30
     192.168.3.0/32 is subnetted, 1 subnets
O IA    192.168.3.1 [110/3] via 47.47.47.129, 03:48:14, FastEthernet0/0.30
O*E2 0.0.0.0/0 [110/1] via 47.47.47.129, 01:12:01, FastEthernet0/0.30
MCE-2#


MCE-2#ping vrf vpn1 209.165.200.254 source 192.168.10.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.200.254, timeout is 2 seconds:
Packet sent with a source address of 192.168.10.1
...!!
Success rate is 40 percent (2/5), round-trip min/avg/max = 1728/1750/1772 ms
MCE-2#traceroute vrf vpn1
Protocol [ip]:
Target IP address: 209.165.200.254
Source address: 192.168.10.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
```

Tracing the route to 209.165.200.254

  1 47.47.47.1 464 msec 276 msec 360 msec
  2 24.24.24.2 [MPLS: Labels 22/25 Exp 0] 2376 msec 2408 msec 2468 msec
  3 58.58.58.5 [MPLS: Label 25 Exp 0] 888 msec 1884 msec 1344 msec
  4 58.58.58.8 1464 msec 1592 msec 1416 msec
  5 209.165.200.254 1728 msec 1572 msec 1416 msec
MCE-2#ping vrf vpn2 209.165.200.254 source 192.168.20.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.200.254, timeout is 2 seconds:
Packet sent with a source address of 192.168.20.1
!!!..
Success rate is 60 percent (3/5), round-trip min/avg/max = 1540/1662/1768 ms
MCE-2#traceroute vrf vpn2
Protocol [ip]:
Target IP address: 209.165.200.254
Source address: 192.168.20.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 209.165.200.254

  1 47.47.47.65 680 msec 444 msec 504 msec
  2 14.14.14.1 [MPLS: Labels 22/25 Exp 0] 2716 msec 2284 msec 2076 msec
  3 58.58.58.5 [MPLS: Label 25 Exp 0] 1056 msec 1076 msec 1056 msec
  4 58.58.58.8 1656 msec * 1284 msec
  5 209.165.200.254 1584 msec 1860 msec 1776 msec
MCE-2#ping vrf vpn3 209.165.200.254 source 192.168.30.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.200.254, timeout is 2 seconds:
Packet sent with a source address of 192.168.30.1
!.!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 1432/1632/1824 ms
MCE-2#traceroute vrf vpn3
Protocol [ip]:
Target IP address: 209.165.200.254
Source address: 192.168.30.1
Numeric display [n]:

```
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 209.165.200.254

  1 47.47.47.129 368 msec 488 msec 408 msec
  2  *
    24.24.24.2 [MPLS: Labels 22/25 Exp 0] 2420 msec 2524 msec
  3 58.58.58.5 [MPLS: Label 25 Exp 0] 1272 msec 1092 msec 984 msec
  4 58.58.58.8 1248 msec 1508 msec 1128 msec
  5 209.165.200.254 2256 msec 1720 msec 1464 msec
MCE-2#
```

3.4.8　IGW 配置验证

```
IGW#show 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, 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 209.165.200.254 to network 0.0.0.0

C    209.165.200.0/24 is directly connected, Ethernet1/0
C    209.165.201.0/24 is directly connected, Loopback0
     58.0.0.0/24 is subnetted, 1 subnets
C       58.58.58.0 is directly connected, FastEthernet0/0
S*   0.0.0.0/0 [1/0] via 209.165.200.254
S    192.168.0.0/16 [1/0] via 58.58.58.5
IGW#
```

3.4.9　Internet 配置验证

```
Internet#show 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, 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

C   209.165.200.0/24 is directly connected, FastEthernet0/0

Internet#

四 Cisco MPLS TE 配置实例

1 MPLS TE（OSPF）配置实例

1.1 网络拓扑图

1.2 网络拓扑说明

1）R4 流量工程策略

MPLS TE 隧道 Tunnel0、Tunnel1、Tunnel2 分别引导数据通过路径 R4—R1—R3—R2—R6、

R4—R1—R5—R2—R6 和 R4—R1—R2—R6。Tunnel0 被配置成使用 R4—R1—R3—R2—R6 作为它的第一条路径（按照优先级的顺序），R4—R1—R5—R2—R6 作为它的第二条路径（按照优先级顺序），R4—R1—R2—R6 作为它的第三条路径（按照优先级顺序）。第三条路径为动态路径作为 fallback 路径。动态路径是由 OSPF IGP 导出的路径。根据 OSPF 的选路原则，动态必定是：R4—R1—R2—R6。

2）R6 流量工程策略

MPLS TE 隧道 Tunnel0、Tunnel1、Tunnel2 分别引导数据通过路径 R6—R2—R3—R1—R4、R6—R2—R5—R1—R4、R6—R2—R1—R4。Tunnel0 被配置成使用 R6—R2—R5—R1—R4 作为它的第一条路径（按照优先级的顺序），R6—R2—R3—R1—R4 作为它的第二条路径（按照优先级顺序）。R6—R2—R1—R4 作为它的第三条路径（按照优先级顺序）如果由于链路或节点故障，第一条和第二条路径不可用的情况下，动态路径就作为 fallback 路径。第三条路径为动态路径作为 fallback 路径。动态路径是由 OSPF IGP 导出的路径。根据 OSPF 的选路原则，动态必定是：R6—R2—R1—R4。

1.3 路由器配置

1.3.1 R1 路由器配置

```
hostname r1
!
ip cef   //启用 CEF 特性，这对于 MPLS TE 此功能是必须的
mpls traffic-eng tunnels   //在设备上启用 MPLS TE 隧道特性
!
interface Loopback0   //建立环回接口，此环回接口必须使用一个 32 位掩码的 IP 地址，这个地址在后继配置 MPLS 和 TE
                        时会使用到，另外这个环回接口地址必须位于 IGP 中，而且必须通过公网路由选择表可达
 ip address 1.1.1.1 255.255.255.255   //配置环回接口 IP 地址
!
interface Serial1/0
 description Connect_to_R4_S1/0
 bandwidth 1544   //设置接口的带宽，此值跟接口的实际带宽一致（可以通过 show interface 命令来得到准确数值）
 ip address 14.14.14.1 255.255.255.0
 mpls traffic-eng tunnels   //在接口模式下，启用 MPLS TE 隧道特性。在一条 LSP 可能经过的任何链路的两端，都需要
                             执行此命令
 serial restart_delay 0
 ip rsvp bandwidth 500 500   //在所有的 MPLS TE 接口上使能 RSVP 信令协议,并指出 RSVP 所能预留的带宽,单位是 Kbit/s。
                             第一个 500 表示可预留的最大带宽（此值如果不指定，则缺省是可用带宽的 75%），第二个
                             500 是可预留的最大带宽（此值如果不指定，缺省是可用带宽的 100%）
!
interface Serial1/1
 description Connect_to_R3_S1/1
```

```
 bandwidth 1544
 ip address 13.13.13.1 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/2
 description Connect_to_R2_S1/2
 bandwidth 1544
 ip address 12.12.12.1 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/3
 description Connect_to_R5_S1/3
 bandwidth 1544
 ip address 15.15.15.1 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router ospf 1
 mpls traffic-eng router-id Loopback0   //设置本 TE 节点的路由器 ID 就是 Loopback 0 接口地址
 mpls traffic-eng area 0   //设置 OSPF 区域 0，支持 MPLS TE 特性
 router-id 1.1.1.1
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 12.12.12.1 0.0.0.0 area 0.0.0.0
 network 13.13.13.1 0.0.0.0 area 0.0.0.0
 network 14.14.14.1 0.0.0.0 area 0.0.0.0
 network 15.15.15.1 0.0.0.0 area 0.0.0.0
!
```

1.3.2 R2 路由器配置

```
ip cef
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface Serial1/0
 description Connect_to_R6_S1/0
```

```
  bandwidth 1544
  ip address 26.26.26.2 255.255.255.0
  mpls traffic-eng tunnels
  serial restart_delay 0
  ip rsvp bandwidth 500 500
!
interface Serial1/1
  description Connect_to_R3_S1/0
  bandwidth 1544
  ip address 23.23.23.2 255.255.255.0
  mpls traffic-eng tunnels
  serial restart_delay 0
  ip rsvp bandwidth 500 500
!
interface Serial1/2
  description Connect_to_R1_S1/2
  bandwidth 1544
  ip address 12.12.12.2 255.255.255.0
  mpls traffic-eng tunnels
  serial restart_delay 0
  ip rsvp bandwidth 500 500
!
interface Serial1/3
  description Connect_to_R5_S1/0
  bandwidth 1544
  ip address 25.25.25.2 255.255.255.0
  mpls traffic-eng tunnels
  serial restart_delay 0
  ip rsvp bandwidth 500 500
!
router ospf 2
  mpls traffic-eng router-id Loopback0
  mpls traffic-eng area 0
  router-id 2.2.2.2
  log-adjacency-changes
  network 2.2.2.2 0.0.0.0 area 0.0.0.0
  network 12.12.12.2 0.0.0.0 area 0.0.0.0
  network 23.23.23.2 0.0.0.0 area 0.0.0.0
  network 25.25.25.2 0.0.0.0 area 0.0.0.0
  network 26.26.26.2 0.0.0.0 area 0.0.0.0
!
```

1.3.3 R3 路由器配置

```
hostname r3
!
ip cef
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface Serial1/0
 description Connect_to_R2_S1/1
 bandwidth 1544
 ip address 23.23.23.3 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router ospf 3
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 log-adjacency-changes
 network 3.3.3.3 0.0.0.0 area 0.0.0.0
 network 13.13.13.3 0.0.0.0 area 0.0.0.0
 network 23.23.23.3 0.0.0.0 area 0.0.0.0
!
```

1.3.4 R4 路由器配置

```
hostname r4
!
!
ip cef  //启用 CEF 特性, 这对于 MPLS TE 此功能是必须的
mpls traffic-eng tunnels  //在设备上启用 MPLS TE 隧道特性
!
interface Loopback0  //建立环回接口, 此环回接口必须使用一个 32 位掩码的 IP 地址, 这个地址在后继配置 MPLS 和 TE
                       时会使用到, 另外这个环回接口地址必须位于 IGP 中, 而且必须通过公网路由选择表可达
ip address 4.4.4.4 255.255.255.255  //配置环回接口 IP 地址
!
interface Loopback1
 ip address 40.40.40.1 255.255.255.0
!
interface Tunnel0  //配置一个隧道接口, 进入接口的配置模式
 ip unnumbered Loopback0  //为了实现流量转发, 必须配置隧道接口的 IP 地址, 但由于 MPLS TE 隧道是单向的, 不存在
```

対端地址的问题，因此，没有必要为 Tunnel 接口单独配置 IP 地址。通常的做法是 Tunnel 接口借用本节点作为 LSR ID 的 Loopback 接口的地址。

tunnel destination 6.6.6.6　//指定隧道尾端路由器地址。尾端路由器地址必须是路由器 ID 或者是尾端路由器的环回接口 IP 地址

　tunnel mode mpls traffic-eng　//设置隧道的封装模式为 MPLS TE 模式，隧道封装的其他模式有 GRE 和 IPSec，这二种模式通常用于 VPN

　tunnel mpls traffic-eng autoroute announce　//设置一条 IGP 可以使用的 MPLS TE 隧道，向路由选择信息库（RIB）宣告该隧道尾端的可达性。这将使得 IGP 在它的增强 SPF 计算中使用该隧道

　tunnel mpls traffic-eng priority 1 1　//设置隧道的优先级

　tunnel mpls traffic-eng bandwidth　500　//配置本 tunnel 可用的带宽，在此设置为 500Kbit/s

　tunnel mpls traffic-eng path-option 1 explicit name r4r1r3r2r6　//指定隧道的路径计算方法。隧道具有两种建立路径的方法—优先显式路径和备份动态路径。这条命令用来配置隧道，让它使用一条命名的 IP 显式路径

!
interface Tunnel1
 ip unnumbered Loopback0
 tunnel destination 6.6.6.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 2 2
 tunnel mpls traffic-eng bandwidth　500
 tunnel mpls traffic-eng path-option 2 explicit name r4r1r5r2r6
!
interface Tunnel2
 ip unnumbered Loopback0
 tunnel destination 6.6.6.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 3 3
 tunnel mpls traffic-eng bandwidth　500
 tunnel mpls traffic-eng path-option 1 dynamic　//使用动态路径，动态路径是通过流量工程拓扑数据库动态计算得到的路径

!
interface Serial1/0
 description Connect_to_R1_S1/0
 bandwidth 1544
 ip address 14.14.14.4 255.255.255.0
 ip ospf cost 100
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router ospf 4

```
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 router-id 4.4.4.4
 log-adjacency-changes
 network 4.4.4.4 0.0.0.0 area 0.0.0.0
 network 14.14.14.4 0.0.0.0 area 0.0.0.0
 network 40.40.40.0 0.0.0.255 area 0.0.0.0
!
!
ip explicit-path name r4r1r3r2r6 enable    //配置显式路径，优先显式路径是通过创建显式路径条目，手工建立的。每
                                            个条目指示到目标的一跳。指定的每一跳是一个RID，或者是下一跳路由器
                                            的下一跳接口地址。为了创建或修改命名的路径，需要进入IP显式路径的
                                            子命令模式，使用命令ip explicit-path。一条IP显式路径就是一个IP
                                            地址列表，列表中的每个地址代表显式路径中的一个节点或者一条链路
 next-address 14.14.14.1
 next-address 13.13.13.3
 next-address 23.23.23.2
 next-address 26.26.26.6
!
ip explicit-path name r4r1r5r2r6 enable
 next-address 14.14.14.1
 next-address 15.15.15.5
 next-address 25.25.25.2
 next-address 26.26.26.6
!
```

1.3.5　R5 路由器配置

```
r5#show running
hostname r5
!
ip cef
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 5.5.5.5 255.255.255.255
!
interface Serial1/0
 description Connect_to_R2_S1/3
 bandwidth 1544
 ip address 25.25.25.5 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
```

```
!
interface Serial1/3
 description Connect_to_R1_S1/3
 bandwidth 1544
 ip address 15.15.15.5 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router ospf 5
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 router-id 5.5.5.5
 log-adjacency-changes
 network 5.5.5.5 0.0.0.0 area 0.0.0.0
 network 15.15.15.5 0.0.0.0 area 0.0.0.0
 network 25.25.25.5 0.0.0.0 area 0.0.0.0
!
```

1.3.6　R6 路由器配置

```
hostname r6
!
ip cef
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 6.6.6.6 255.255.255.255
 ip ospf cost 1
!
interface Loopback1
 ip address 60.60.60.1 255.255.255.0
!
interface Tunnel0
 ip unnumbered Loopback0
 tunnel destination 4.4.4.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 1 explicit name r6r2r5r1r4
!
interface Tunnel1
 ip unnumbered Loopback0
```

```
 tunnel destination 4.4.4.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 2 2
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 2 explicit name r6r2r3r1r4
!
interface Tunnel2
 ip unnumbered Loopback0
 tunnel destination 4.4.4.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 3 3
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 1 dynamic
!
interface Serial1/0
 description Connect_to_R2_S1/0
 bandwidth 1544
 ip address 26.26.26.6 255.255.255.0
 ip ospf cost 100
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router ospf 6
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 router-id 6.6.6.6
 log-adjacency-changes
 network 6.6.6.6 0.0.0.0 area 0.0.0.0
 network 26.26.26.6 0.0.0.0 area 0.0.0.0
 network 60.60.60.0 0.0.0.255 area 0.0.0.0
!
ip explicit-path name r6r2r5r1r4 enable
 next-address 26.26.26.2
 next-address 25.25.25.5
 next-address 15.15.15.1
 next-address 14.14.14.4
!
ip explicit-path name r6r2r3r1r4 enable
 next-address 26.26.26.2
 next-address 23.23.23.3
 next-address 13.13.13.1
 next-address 14.14.14.4
```

!

1.4 配置验证

1.4.1 R4 路由器状态信息

r4#show ip inter brief //显示路由器接口状态信息

Interface	IP-Address	OK? Method Status	Prot
Serial1/0	14.14.14.4	YES NVRAM up	up
Loopback0	4.4.4.4	YES NVRAM up	up
Loopback1	40.40.40.1	YES manual up	up
Tunnel0	4.4.4.4	YES TFTP up	up //活动的隧道
Tunnel1	4.4.4.4	YES TFTP up	down //备用的隧道
Tunnel2	4.4.4.4	YES TFTP up	down //备用的隧道

r4#show ip ospf nei //显示路由器 OSPF 邻居状态信息

Neighbor ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	0	FULL/ -	00:00:38	14.14.14.1	Serial1/0

r4#show ip route //显示路由器路由表
```
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, 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
     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/101] via 14.14.14.1, 00:05:57, Serial1/0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/165] via 14.14.14.1, 00:05:57, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/165] via 14.14.14.1, 00:05:57, Serial1/0
     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/165] via 14.14.14.1, 00:05:57, Serial1/0
     6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/229] via 0.0.0.0, 00:05:57, Tunnel0
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/228] via 14.14.14.1, 00:06:02, Serial1/0
     25.0.0.0/24 is subnetted, 1 subnets
O       25.25.25.0 [110/228] via 14.14.14.1, 00:06:02, Serial1/0
```

```
       40.0.0.0/24 is subnetted, 1 subnets
C       40.40.40.0 is directly connected, Loopback1
       26.0.0.0/24 is subnetted, 1 subnets
O       26.26.26.0 [110/228] via 14.14.14.1, 00:06:02, Serial1/0
       12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/164] via 14.14.14.1, 00:06:02, Serial1/0
       13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/164] via 14.14.14.1, 00:06:02, Serial1/0
       14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Serial1/0
       60.0.0.0/32 is subnetted, 1 subnets
O       60.60.60.1 [110/229] via 0.0.0.0, 00:06:02, Tunnel0
       15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/164] via 14.14.14.1, 00:06:02, Serial1/0


r4#show mpls traffic-eng tunnels brief  //显示路由器 MPLS TE 隧道状态情况，可以查看隧道是否已经成功建立
Signalling Summary:
     LSP Tunnels Process:          running
     RSVP Process:                 running
     Forwarding:                   enabled
     Periodic reoptimization:      every 3600 seconds, next in 1236 seconds
     Periodic auto-bw collection:  disabled
TUNNEL NAME                 DESTINATION    UP IF     DOWN IF    STATE/PROT
r4_t0                       6.6.6.6        -         Se1/0      up/up  //活动的隧道
r4_t1                       6.6.6.6        -         unknown    up/down  //备用的隧道
r4_t2                       6.6.6.6        -         unknown    up/down  //备用的隧道
r6_t0                       4.4.4.4        Se1/0     -          up/up  //活动的隧道
Displayed 3 (of 3) heads, 0 (of 0) midpoints, 1 (of 1) tails


r4#show mpls traffic-eng tunnels statistics  //显示路由器所有的隧道状态
Tunnel0 (Destination 6.6.6.6; Name r4_t0)
  Management statistics:
    Path:   91 no path, 0 path no longer valid, 0 missing ip exp path
            5 path changes
    State:  5 transitions, 0 admin down, 2 oper down
  Signalling statistics:
    Opens:  3 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 0 no b/w, 0 no route, 0 admin
            0 bad exp route, 0 rec route loop, 0 other
Tunnel1 (Destination 6.6.6.6; Name r4_t1)
  Management statistics:
    Path:   419 no path, 0 path no longer valid, 0 missing ip exp path
            64 path changes
    State:  2 transitions, 0 admin down, 1 oper down
```

```
   Signalling statistics:
      Opens:  1 succeeded, 0 timed out, 0 bad path spec
              0 other aborts
      Errors: 62 no b/w, 0 no route, 1 admin
              0 bad exp route, 0 rec route loop, 0 other
Tunnel2 (Destination 6.6.6.6; Name r4_t2)
   Management statistics:
      Path:   22 no path, 0 path no longer valid, 0 missing ip exp path
              36 path changes
      State:  0 transitions, 0 admin down, 0 oper down
   Signalling statistics:
      Opens:  0 succeeded, 0 timed out, 0 bad path spec
              0 other aborts
      Errors: 36 no b/w, 0 no route, 0 admin
              0 bad exp route, 0 rec route loop, 0 other
6.6.6.6 0 (Destination 4.4.4.4; Name r6_t0)


r4#show mpls traffic-eng tunnels

Name: r4_t0                               (Tunnel0) Destination: 6.6.6.6
  Status:
    Admin: up        Oper: up     Path: valid      Signalling: connected

    path option 1, type explicit r4r1r3r2r6 (Basis for Setup, path weight 292)

  Config Parameters:
    Bandwidth: 500       kbps (Global) Priority: 1  1   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled   LockDown: disabled Loadshare: 500      bw-based
    auto-bw: disabled

  InLabel  :  -
  OutLabel : Serial1/0, 17
  RSVP Signalling Info:
       Src 4.4.4.4, Dst 6.6.6.6, Tun_Id 0, Tun_Instance 94
    RSVP Path Info:
      My Address: 4.4.4.4
      Explicit Route: 14.14.14.1 13.13.13.3 23.23.23.2 26.26.26.6
                      6.6.6.6
      Record Route:  NONE
      Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
    RSVP Resv Info:
      Record Route:  NONE
      Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
  History:
```

```
  Tunnel:
    Time since created: 1 hours, 40 minutes
    Time since path change: 7 minutes, 7 seconds
  Current LSP:
    Uptime: 7 minutes, 7 seconds
  Prior LSP:
    ID: path option 3 [79]
    Removal Trigger: path option removed


Name: r4_t1                            (Tunnel1) Destination: 6.6.6.6
  Status:
    Admin: up        Oper: down   Path: not valid   Signalling: Down
    path option 2, type explicit r4r1r5r2r6

  Config Parameters:
    Bandwidth: 500       kbps (Global)  Priority: 2  2   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute:  enabled   LockDown: disabled  Loadshare: 500      bw-based
    auto-bw: disabled

  History:
    Tunnel:
      Time since created: 1 hours, 40 minutes
      Time since path change: 7 minutes, 5 seconds
    Prior LSP:
      ID: path option 2 [466]
      Removal Trigger: path error
      Last Error: PCALC:: Can't use link 0.0.0.0 on node 4.4.4.4

Name: r4_t2                            (Tunnel2) Destination: 6.6.6.6
  Status:
    Admin: up        Oper: down   Path: not valid   Signalling: Down
    path option 1, type dynamic

  Config Parameters:
    Bandwidth: 500       kbps (Global)  Priority: 3  3   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute:  enabled   LockDown: disabled  Loadshare: 500      bw-based
    auto-bw: disabled

  History:
    Tunnel:
      Time since created: 9 minutes, 9 seconds
      Time since path change: 7 minutes, 6 seconds
    Prior LSP:
```

```
        ID: path option 1 [43]
        Removal Trigger: path error
        Last Error: PCALC:: No path to destination, 6.6.6.6


LSP Tunnel r6_t0 is signalled, connection is up
  InLabel  : Serial1/0, implicit-null
  OutLabel :  -
  RSVP Signalling Info:
       Src 6.6.6.6, Dst 4.4.4.4, Tun_Id 0, Tun_Instance 54
    RSVP Path Info:
      My Address: 4.4.4.4
      Explicit Route:  NONE
      Record Route:  NONE
      Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
    RSVP Resv Info:
      Record Route:  NONE
      Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
r4#


r4#traceroute  //通过带源地址 traceroute，确认数据的路径跟设计的一致
Protocol [ip]:
Target IP address: 60.60.60.1
Source address: 40.40.40.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 60.60.60.1

  1 14.14.14.1 [MPLS: Label 17 Exp 0] 532 msec 752 msec 716 msec
  2 13.13.13.3 [MPLS: Label 16 Exp 0] 660 msec 556 msec 400 msec
  3 23.23.23.2 [MPLS: Label 16 Exp 0] 172 msec 672 msec 376 msec
  4 26.26.26.6 888 msec 752 msec 844 msec
r4#
```

1.4.2 R6 路由器状态信息

```
r6#show ip inter brief
Interface                IP-Address      OK? Method Status          Prot
```

Serial1/0	26.26.26.6	YES NVRAM	up		up
Loopback0	6.6.6.6	YES NVRAM	up		up
Loopback1	60.60.60.1	YES manual	up		up
Tunnel0	6.6.6.6	YES TFTP	up		up
Tunnel1	6.6.6.6	YES TFTP	up		down
Tunnel2	6.6.6.6	YES TFTP	up		down

```
r6#show ip ospf neighbor

Neighbor ID     Pri  State          Dead Time  Address       Interface
2.2.2.2          0   FULL/  -       00:00:38   26.26.26.2    Serial1/0
r6#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/165] via 26.26.26.2, 00:15:14, Serial1/0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/101] via 26.26.26.2, 00:15:14, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/165] via 26.26.26.2, 00:15:14, Serial1/0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/229] via 0.0.0.0, 00:15:14, Tunnel0
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/165] via 26.26.26.2, 00:15:14, Serial1/0
     6.0.0.0/32 is subnetted, 1 subnets
C       6.6.6.6 is directly connected, Loopback0
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/164] via 26.26.26.2, 00:15:15, Serial1/0
     25.0.0.0/24 is subnetted, 1 subnets
O       25.25.25.0 [110/164] via 26.26.26.2, 00:15:15, Serial1/0
     40.0.0.0/32 is subnetted, 1 subnets
```

```
O       40.40.40.1 [110/229] via 0.0.0.0, 00:15:15, Tunnel0
     26.0.0.0/24 is subnetted, 1 subnets
C       26.26.26.0 is directly connected, Serial1/0
     12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/164] via 26.26.26.2, 00:15:15, Serial1/0
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/228] via 26.26.26.2, 00:15:15, Serial1/0
     14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/228] via 26.26.26.2, 00:15:15, Serial1/0
     60.0.0.0/24 is subnetted, 1 subnets
C       60.60.60.0 is directly connected, Loopback1
     15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/228] via 26.26.26.2, 00:15:15, Serial1/0


r6#show mpls traffic-eng tunnels brief
Signalling Summary:
    LSP Tunnels Process:          running
    RSVP Process:                 running
    Forwarding:                   enabled
    Periodic reoptimization:      every 3600 seconds, next in 929 seconds
    Periodic auto-bw collection:  disabled
TUNNEL NAME                    DESTINATION     UP IF     DOWN IF    STATE/PROT
r6_t0                          4.4.4.4         -         Se1/0      up/up
r6_t1                          4.4.4.4         -         unknown    up/down
r6_t2                          4.4.4.4         -         unknown    up/down
r4_t0                          6.6.6.6         Se1/0     -          up/up
Displayed 3 (of 3) heads, 0 (of 0) midpoints, 1 (of 1) tails
r6#show mpls traffic-eng tunnels stat
r6#show mpls traffic-eng tunnels statistics
Tunnel0 (Destination 4.4.4.4; Name r6_t0)
  Management statistics:
    Path:   52 no path, 0 path no longer valid, 0 missing ip exp path
            3 path changes
    State:  3 transitions, 0 admin down, 1 oper down
  Signalling statistics:
    Opens:  2 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 0 no b/w, 1 no route, 0 admin
            0 bad exp route, 0 rec route loop, 0 other
Tunnel1 (Destination 4.4.4.4; Name r6_t1)
  Management statistics:
    Path:   451 no path, 0 path no longer valid, 0 missing ip exp path
            46 path changes
    State:  0 transitions, 0 admin down, 0 oper down
  Signalling statistics:
```

```
        Opens:  0 succeeded, 0 timed out, 0 bad path spec
                0 other aborts
        Errors: 46 no b/w, 0 no route, 0 admin
                0 bad exp route, 0 rec route loop, 0 other
Tunnel2 (Destination 4.4.4.4; Name r6_t2)
  Management statistics:
     Path:   26 no path, 0 path no longer valid, 0 missing ip exp path
             0 path changes
     State:  0 transitions, 0 admin down, 0 oper down
  Signalling statistics:
     Opens:  0 succeeded, 0 timed out, 0 bad path spec
             0 other aborts
     Errors: 0 no b/w, 0 no route, 0 admin
             0 bad exp route, 0 rec route loop, 0 other
4.4.4.4 0 (Destination 6.6.6.6; Name r4_t0)
r6#


r6#show mpls traffic-eng tunnels

Name: r6_t0                              (Tunnel0) Destination: 4.4.4.4
  Status:
    Admin: up        Oper: up     Path: valid      Signalling: connected

    path option 1, type explicit r6r2r5r1r4 (Basis for Setup, path weight 292)


  Config Parameters:
    Bandwidth: 500       kbps (Global)  Priority: 1  1   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled   LockDown: disabled Loadshare: 500       bw-based
    auto-bw: disabled


  InLabel  :  -
  OutLabel : Serial1/0, 17
  RSVP Signalling Info:
       Src 6.6.6.6, Dst 4.4.4.4, Tun_Id 0, Tun_Instance 54
    RSVP Path Info:
      My Address: 6.6.6.6
      Explicit Route: 26.26.26.2 25.25.25.5 15.15.15.1 14.14.14.4
                      4.4.4.4
      Record Route:  NONE
      Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
    RSVP Resv Info:
      Record Route:  NONE
      Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
  History:
```

```
    Tunnel:
       Time since created: 1 hours, 45 minutes
       Time since path change: 23 minutes, 8 seconds
    Current LSP:
       Uptime: 23 minutes, 8 seconds
    Prior LSP:
       ID: path option 1 [13]
       Removal Trigger: path error


Name: r6_t1                            (Tunnel1) Destination: 4.4.4.4
  Status:
    Admin: up         Oper: down   Path: not valid   Signalling: Down
    path option 2, type explicit r6r2r3r1r4


  Config Parameters:
    Bandwidth: 500       kbps (Global)  Priority: 2  2   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute:  enabled   LockDown: disabled  Loadshare: 500      bw-based
    auto-bw: disabled


  History:
    Tunnel:
       Time since created: 1 hours, 45 minutes
       Time since path change: 23 minutes, 8 seconds
    Prior LSP:
       ID: path option 3 [413]
       Removal Trigger: path error
    Path Option 2:
       Last Error: PCALC:: Can't use link 0.0.0.0 on node 6.6.6.6


Name: r6_t2                            (Tunnel2) Destination: 4.4.4.4
  Status:
    Admin: up         Oper: down   Path: not valid   Signalling: Down
    path option 1, type dynamic


  Config Parameters:
    Bandwidth: 500       kbps (Global)  Priority: 3  3   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute:  enabled   LockDown: disabled  Loadshare: 500      bw-based
    auto-bw: disabled


  History:
    Tunnel:
       Time since created: 14 minutes, 12 seconds
    Path Option 1:
```

```
       Last Error: PCALC:: No path to destination, 4.4.4.4


LSP Tunnel r4_t0 is signalled, connection is up
   InLabel  : Serial1/0, implicit-null
   OutLabel :  -
   RSVP Signalling Info:
        Src 4.4.4.4, Dst 6.6.6.6, Tun_Id 0, Tun_Instance 94
     RSVP Path Info:
       My Address: 6.6.6.6
       Explicit Route:  NONE
       Record Route:  NONE
       Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
     RSVP Resv Info:
       Record Route:  NONE
       Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
r6#



r6#traceroute
Protocol [ip]:
Target IP address: 40.40.40.1
Source address: 60.60.60.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 40.40.40.1

  1 26.26.26.2 [MPLS: Label 17 Exp 0] 772 msec 660 msec 600 msec
  2 25.25.25.5 [MPLS: Label 16 Exp 0] 580 msec 636 msec 600 msec
  3 15.15.15.1 [MPLS: Label 16 Exp 0] 260 msec 484 msec 552 msec
  4 14.14.14.4 676 msec 872 msec 640 msec
r6#
```

1.4.3 R1 路由器状态信息

```
r1#show ip inte bri
Interface                 IP-Address      OK? Method Status              Prot
ocol
FastEthernet0/0           unassigned      YES NVRAM  administratively down down
```

```
Serial1/0                  14.14.14.1     YES NVRAM  up                      up

Serial1/1                  13.13.13.1     YES NVRAM  up                      up

Serial1/2                  12.12.12.1     YES NVRAM  up                      up

Serial1/3                  15.15.15.1     YES NVRAM  up                      up

Loopback0                  1.1.1.1        YES NVRAM  up                      up

r1#show ip ospf neighbor

Neighbor ID     Pri   State          Dead Time   Address         Interface
5.5.5.5           0   FULL/  -       00:00:30    15.15.15.5      Serial1/3
4.4.4.4           0   FULL/  -       00:00:36    14.14.14.4      Serial1/0
3.3.3.3           0   FULL/  -       00:00:32    13.13.13.3      Serial1/1
2.2.2.2           0   FULL/  -       00:00:36    12.12.12.2      Serial1/2

r1#show ip rou
r1#show 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, 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


     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/65] via 12.12.12.2, 00:18:38, Serial1/2
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/65] via 13.13.13.3, 00:18:38, Serial1/1
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/65] via 14.14.14.4, 00:18:38, Serial1/0
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/65] via 15.15.15.5, 00:18:38, Serial1/3
     6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/129] via 12.12.12.2, 00:18:38, Serial1/2
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/128] via 12.12.12.2, 00:18:39, Serial1/2
```

```
                [110/128] via 13.13.13.3, 00:18:39, Serial1/1
      25.0.0.0/24 is subnetted, 1 subnets
O        25.25.25.0 [110/128] via 12.12.12.2, 00:18:39, Serial1/2
                    [110/128] via 15.15.15.5, 00:18:39, Serial1/3
      40.0.0.0/32 is subnetted, 1 subnets
O        40.40.40.1 [110/65] via 14.14.14.4, 00:18:39, Serial1/0
      26.0.0.0/24 is subnetted, 1 subnets
O        26.26.26.0 [110/128] via 12.12.12.2, 00:18:39, Serial1/2
      12.0.0.0/24 is subnetted, 1 subnets
C        12.12.12.0 is directly connected, Serial1/2
      13.0.0.0/24 is subnetted, 1 subnets
C        13.13.13.0 is directly connected, Serial1/1
      14.0.0.0/24 is subnetted, 1 subnets
C        14.14.14.0 is directly connected, Serial1/0
      60.0.0.0/32 is subnetted, 1 subnets
O        60.60.60.1 [110/129] via 12.12.12.2, 00:18:39, Serial1/2
      15.0.0.0/24 is subnetted, 1 subnets
C        15.15.15.0 is directly connected, Serial1/3


r1#show mpls traffic-eng tunnels brief
Signalling Summary:
    LSP Tunnels Process:          running
    RSVP Process:                 running
    Forwarding:                   enabled
    Periodic reoptimization:      every 3600 seconds, next in 532 seconds
    Periodic auto-bw collection:  disabled
TUNNEL NAME                     DESTINATION      UP IF    DOWN IF   STATE/PROT
r4_t0                           6.6.6.6          Se1/0    Se1/1     up/up
r6_t0                           4.4.4.4          Se1/3    Se1/0     up/up
Displayed 0 (of 0) heads, 2 (of 2) midpoints, 0 (of 0) tails



r1#show mpls traffic-eng tunnels statistics
4.4.4.4 0 (Destination 6.6.6.6; Name r4_t0)
6.6.6.6 0 (Destination 4.4.4.4; Name r6_t0)


r1#show mpls traffic-eng tunnels

LSP Tunnel r4_t0 is signalled, connection is up
  InLabel  : Serial1/0, 17
  OutLabel : Serial1/1, 16
  RSVP Signalling Info:
       Src 4.4.4.4, Dst 6.6.6.6, Tun_Id 0, Tun_Instance 39
    RSVP Path Info:
      My Address: 14.14.14.1
```

```
        Explicit Route: 13.13.13.3 23.23.23.2 26.26.26.6 6.6.6.6
        Record Route:  NONE
        Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
     RSVP Resv Info:
        Record Route:  NONE
        Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits


LSP Tunnel r6_t0 is signalled, connection is up
  InLabel  : Serial1/3, 16
  OutLabel : Serial1/0, implicit-null
  RSVP Signalling Info:
       Src 6.6.6.6, Dst 4.4.4.4, Tun_Id 0, Tun_Instance 13
     RSVP Path Info:
        My Address: 15.15.15.1
        Explicit Route: 14.14.14.4 4.4.4.4
        Record Route:  NONE
        Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
     RSVP Resv Info:
        Record Route:  NONE
        Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
r1#
```

1.4.4　R2 路由器状态信息

```
r2#show ip inter bri
Interface               IP-Address      OK? Method Status          Prot

Serial1/0               26.26.26.2      YES NVRAM  up              up

Serial1/1               23.23.23.2      YES NVRAM  up              up

Serial1/2               12.12.12.2      YES NVRAM  up              up

Serial1/3               25.25.25.2      YES NVRAM  up              up

Loopback0               2.2.2.2         YES NVRAM  up              up

r2#show ip ospf neig

Neighbor ID     Pri   State         Dead Time   Address         Interface
6.6.6.6           0   FULL/  -      00:00:36    26.26.26.6      Serial1/0
5.5.5.5           0   FULL/  -      00:00:30    25.25.25.5      Serial1/3
3.3.3.3           0   FULL/  -      00:00:31    23.23.23.3      Serial1/1
1.1.1.1           0   FULL/  -      00:00:32    12.12.12.1      Serial1/2
```

```
r2#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/65] via 12.12.12.1, 00:31:55, Serial1/2
     2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/65] via 23.23.23.3, 00:31:55, Serial1/1
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/129] via 12.12.12.1, 00:31:55, Serial1/2
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/65] via 25.25.25.5, 00:31:55, Serial1/3
     6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/65] via 26.26.26.6, 00:31:55, Serial1/0
     23.0.0.0/24 is subnetted, 1 subnets
C       23.23.23.0 is directly connected, Serial1/1
     25.0.0.0/24 is subnetted, 1 subnets
C       25.25.25.0 is directly connected, Serial1/3
     40.0.0.0/32 is subnetted, 1 subnets
O       40.40.40.1 [110/129] via 12.12.12.1, 00:31:56, Serial1/2
     26.0.0.0/24 is subnetted, 1 subnets
C       26.26.26.0 is directly connected, Serial1/0
     12.0.0.0/24 is subnetted, 1 subnets
C       12.12.12.0 is directly connected, Serial1/2
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/128] via 12.12.12.1, 00:31:56, Serial1/2
                   [110/128] via 23.23.23.3, 00:31:56, Serial1/1
     14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/128] via 12.12.12.1, 00:31:56, Serial1/2
     60.0.0.0/32 is subnetted, 1 subnets
O       60.60.60.1 [110/65] via 26.26.26.6, 00:31:56, Serial1/0
     15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/128] via 12.12.12.1, 00:31:56, Serial1/2
                   [110/128] via 25.25.25.5, 00:31:56, Serial1/3
r2#show mpls traffic-eng tunnels brief
Signalling Summary:
```

```
      LSP Tunnels Process:           running
      RSVP Process:                  running
      Forwarding:                    enabled
      Periodic reoptimization:       every 3600 seconds, next in 3551 seconds
      Periodic auto-bw collection:   disabled
TUNNEL NAME                     DESTINATION     UP IF     DOWN IF   STATE/PROT
r4_t0                           6.6.6.6         Se1/1     Se1/0     up/up
r6_t0                           4.4.4.4         Se1/0     Se1/3     up/up
Displayed 0 (of 0) heads, 2 (of 2) midpoints, 0 (of 0) tails
r2#show mpls tu
r2#show mpls t
r2#show mpls traffic-eng tunn
r2#show mpls traffic-eng tunnels

LSP Tunnel r4_t0 is signalled, connection is up
  InLabel  : Serial1/1, 16
  OutLabel : Serial1/0, implicit-null
  RSVP Signalling Info:
       Src 4.4.4.4, Dst 6.6.6.6, Tun_Id 0, Tun_Instance 39
    RSVP Path Info:
      My Address: 23.23.23.2
      Explicit Route: 26.26.26.6 6.6.6.6
      Record Route:  NONE
      Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
    RSVP Resv Info:
      Record Route:  NONE
      Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits

LSP Tunnel r6_t0 is signalled, connection is up
  InLabel  : Serial1/0, 17
  OutLabel : Serial1/3, 16
  RSVP Signalling Info:
       Src 6.6.6.6, Dst 4.4.4.4, Tun_Id 0, Tun_Instance 13
    RSVP Path Info:
      My Address: 26.26.26.2
      Explicit Route: 25.25.25.5 15.15.15.1 14.14.14.4 4.4.4.4
      Record Route:  NONE
      Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
    RSVP Resv Info:
      Record Route:  NONE
      Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
r2#show mpls traffic-eng tunnels sta
r2#show mpls traffic-eng tunnels statistics
4.4.4.4 0 (Destination 6.6.6.6; Name r4_t0)
6.6.6.6 0 (Destination 4.4.4.4; Name r6_t0)
```

r2#

1.4.5 R3 路由器状态信息

r3#show ip inte bri
Interface   IP-Address   OK? Method Status   Prot

Serial1/0   23.23.23.3   YES NVRAM up   up

Serial1/1   13.13.13.3   YES NVRAM up   up

Loopback0   3.3.3.3   YES NVRAM up   up

r3# show ip ospf nei

Neighbor ID   Pri   State   Dead Time   Address   Interface
2.2.2.2   0   FULL/ -   00:00:39   23.23.23.2   Serial1/0
1.1.1.1   0   FULL/ -   00:00:36   13.13.13.1   Serial1/1
r3#show mpls traff
r3#show mpls traffic-eng tunnels brief
Signalling Summary:
    LSP Tunnels Process: running
    RSVP Process: running
    Forwarding: enabled
    Periodic reoptimization: every 3600 seconds, next in 3398 seconds
    Periodic auto-bw collection: disabled
TUNNEL NAME   DESTINATION   UP IF   DOWN IF   STATE/PROT
r4_t0   6.6.6.6   Se1/1   Se1/0   up/up
Displayed 0 (of 0) heads, 1 (of 1) midpoints, 0 (of 0) tails
r3#show mpls traffic-eng tunnels sta
r3#show mpls traffic-eng tunnels statistics
4.4.4.4 0 (Destination 6.6.6.6; Name r4_t0)
r3#show mpls traffic-eng tunnels

LSP Tunnel r4_t0 is signalled, connection is up
  InLabel : Serial1/1, 16
  OutLabel : Serial1/0, 16
  RSVP Signalling Info:
       Src 4.4.4.4, Dst 6.6.6.6, Tun_Id 0, Tun_Instance 39
    RSVP Path Info:
      My Address: 13.13.13.3
      Explicit Route: 23.23.23.2 26.26.26.6 6.6.6.6
      Record Route: NONE
      Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits

```
    RSVP Resv Info:
       Record Route:  NONE
       Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
r3#
```

1.4.6 R5 路由器状态信息

```
r5#show ip interface brief
Interface               IP-Address      OK? Method Status          Prot

Serial1/0               25.25.25.5      YES NVRAM  up              up

Serial1/3               15.15.15.5      YES NVRAM  up              up

Loopback0               5.5.5.5         YES NVRAM  up              up

r5#show ip ospf neig

Neighbor ID     Pri   State         Dead Time   Address         Interface
2.2.2.2           0   FULL/  -      00:00:38    25.25.25.2      Serial1/0
1.1.1.1           0   FULL/  -      00:00:36    15.15.15.1      Serial1/3
r5#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/65] via 15.15.15.1, 00:45:50, Serial1/3
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/65] via 25.25.25.2, 00:45:50, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/129] via 25.25.25.2, 00:45:50, Serial1/0
                [110/129] via 15.15.15.1, 00:45:50, Serial1/3
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/129] via 15.15.15.1, 00:45:50, Serial1/3
     5.0.0.0/32 is subnetted, 1 subnets
C       5.5.5.5 is directly connected, Loopback0
     6.0.0.0/32 is subnetted, 1 subnets
```

```
O       6.6.6.6 [110/129] via 25.25.25.2, 00:45:50, Serial1/0
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/128] via 25.25.25.2, 00:45:51, Serial1/0
     25.0.0.0/24 is subnetted, 1 subnets
C       25.25.25.0 is directly connected, Serial1/0
     40.0.0.0/32 is subnetted, 1 subnets
O       40.40.40.1 [110/129] via 15.15.15.1, 00:45:51, Serial1/3
     26.0.0.0/24 is subnetted, 1 subnets
O       26.26.26.0 [110/128] via 25.25.25.2, 00:45:51, Serial1/0
     12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/128] via 25.25.25.2, 00:45:51, Serial1/0
                   [110/128] via 15.15.15.1, 00:45:51, Serial1/3
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/128] via 15.15.15.1, 00:45:51, Serial1/3
     14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/128] via 15.15.15.1, 00:45:51, Serial1/3
     60.0.0.0/32 is subnetted, 1 subnets
O       60.60.60.1 [110/129] via 25.25.25.2, 00:45:51, Serial1/0
     15.0.0.0/24 is subnetted, 1 subnets
C       15.15.15.0 is directly connected, Serial1/3


r5#show mpls traffic-eng tunnels brief
Signalling Summary:
    LSP Tunnels Process:          running
    RSVP Process:                 running
    Forwarding:                   enabled
    Periodic reoptimization:      every 3600 seconds, next in 3080 seconds
    Periodic auto-bw collection:  disabled
TUNNEL NAME                   DESTINATION     UP IF    DOWN IF   STATE/PROT
r6_t0                         4.4.4.4         Se1/0    Se1/3     up/up
Displayed 0 (of 0) heads, 1 (of 1) midpoints, 0 (of 0) tails
r5#show mpls traffic-eng tunnels sta
r5#show mpls traffic-eng tunnels statistics
6.6.6.6 0 (Destination 4.4.4.4; Name r6_t0)


r5#show mpls traffic-eng tunnels

LSP Tunnel r6_t0 is signalled, connection is up
  InLabel  : Serial1/0, 16
  OutLabel : Serial1/3, 16
  RSVP Signalling Info:
       Src 6.6.6.6, Dst 4.4.4.4, Tun_Id 0, Tun_Instance 13
    RSVP Path Info:
      My Address: 25.25.25.5
      Explicit Route: 15.15.15.1 14.14.14.4 4.4.4.4
```

```
      Record Route:   NONE
      Tspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
    RSVP Resv Info:
      Record Route:   NONE
      Fspec: ave rate=500 kbits, burst=1000 bytes, peak rate=500 kbits
r5#
```

1.5   隧道切换测试

1   将 R1 端口 S1/1 shutdown：

```
r4#
*Oct  4 21:13:15.283: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, c
hanged state to down
*Oct  4 21:13:34.635: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel1, c
hanged state to up

r4#show ip inter bri
Interface               IP-Address      OK? Method Status          Prot

Serial1/0               14.14.14.4      YES NVRAM  up              up

Loopback0               4.4.4.4         YES NVRAM  up              up

Loopback1               40.40.40.1      YES manual up              up

Tunnel0                 4.4.4.4         YES TFTP   up              down

Tunnel1                 4.4.4.4         YES TFTP   up              up

Tunnel2                 4.4.4.4         YES TFTP   up              down

r4#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/101] via 14.14.14.1, 00:01:12, Serial1/0
```

```
      2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/165] via 14.14.14.1, 00:01:12, Serial1/0
      3.0.0.0/32 is subnetted, 1 subnets
O        3.3.3.3 [110/229] via 14.14.14.1, 00:01:12, Serial1/0
      4.0.0.0/32 is subnetted, 1 subnets
C        4.4.4.4 is directly connected, Loopback0
      5.0.0.0/32 is subnetted, 1 subnets
O        5.5.5.5 [110/165] via 14.14.14.1, 00:01:12, Serial1/0
      6.0.0.0/32 is subnetted, 1 subnets
O        6.6.6.6 [110/229] via 0.0.0.0, 00:01:12, Tunnel1
      23.0.0.0/24 is subnetted, 1 subnets
O        23.23.23.0 [110/228] via 14.14.14.1, 00:01:12, Serial1/0
      25.0.0.0/24 is subnetted, 1 subnets
O        25.25.25.0 [110/228] via 14.14.14.1, 00:01:12, Serial1/0
      40.0.0.0/24 is subnetted, 1 subnets
C        40.40.40.0 is directly connected, Loopback1
      26.0.0.0/24 is subnetted, 1 subnets
O        26.26.26.0 [110/228] via 14.14.14.1, 00:01:12, Serial1/0
      12.0.0.0/24 is subnetted, 1 subnets
O        12.12.12.0 [110/164] via 14.14.14.1, 00:01:12, Serial1/0
      14.0.0.0/24 is subnetted, 1 subnets
C        14.14.14.0 is directly connected, Serial1/0
      60.0.0.0/32 is subnetted, 1 subnets
O        60.60.60.1 [110/229] via 0.0.0.0, 00:01:12, Tunnel1
      15.0.0.0/24 is subnetted, 1 subnets
O        15.15.15.0 [110/164] via 14.14.14.1, 00:01:12, Serial1/0
r4#

r4#traceroute
Protocol [ip]:
Target IP address: 60.60.60.1
Source address: 40.40.40.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 60.60.60.1

  1 14.14.14.1 [MPLS: Label 17 Exp 0] 596 msec 604 msec 488 msec
  2 15.15.15.5 [MPLS: Label 17 Exp 0] 536 msec 744 msec 384 msec
  3 25.25.25.2 [MPLS: Label 16 Exp 0] 220 msec 548 msec 368 msec
```

```
  4 26.26.26.6 560 msec 368 msec *
r4#
```

2 在第 1 步的基础上，继续将 R1 端口 S1/3 shutdown：

```
r4#
*Oct  4 21:28:15.759: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel1, c
hanged state to down
r4#
*Oct  4 21:28:34.391: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel2, c
hanged state to up
r4#

*Oct  4 21:28:03.887: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel2, c
hanged state to up
*Oct  4 21:28:13.727: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, c
hanged state to down

r4#show ip inter brief
Interface               IP-Address      OK? Method Status           Prot

Serial1/0               14.14.14.4      YES NVRAM  up               up

Virtual-Access1         unassigned      YES unset  up               up

Loopback0               4.4.4.4         YES NVRAM  up               up

Loopback1               40.40.40.1      YES manual up               up

Tunnel0                 4.4.4.4         YES TFTP   up               down

Tunnel1                 4.4.4.4         YES TFTP   up               down

Tunnel2                 4.4.4.4         YES TFTP   up               up

r4# show ip rou
r4# show 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, 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
```

```
       1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/101] via 14.14.14.1, 00:01:53, Serial1/0
       2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/165] via 14.14.14.1, 00:01:53, Serial1/0
       3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/229] via 14.14.14.1, 00:01:53, Serial1/0
       4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
       5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/229] via 14.14.14.1, 00:01:53, Serial1/0
       6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/229] via 0.0.0.0, 00:01:53, Tunnel2
       23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/228] via 14.14.14.1, 00:01:54, Serial1/0
       25.0.0.0/24 is subnetted, 1 subnets
O       25.25.25.0 [110/228] via 14.14.14.1, 00:01:54, Serial1/0
       40.0.0.0/24 is subnetted, 1 subnets
C       40.40.40.0 is directly connected, Loopback1
       26.0.0.0/24 is subnetted, 1 subnets
O       26.26.26.0 [110/228] via 14.14.14.1, 00:01:54, Serial1/0
       12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/164] via 14.14.14.1, 00:01:54, Serial1/0
       14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Serial1/0
       60.0.0.0/32 is subnetted, 1 subnets
O       60.60.60.1 [110/229] via 0.0.0.0, 00:01:54, Tunnel2
r4#tracer
r4#traceroute
Protocol [ip]:
Target IP address: 60.60.60.1
Source address: 40.40.40.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 60.60.60.1

  1 14.14.14.1 [MPLS: Label 17 Exp 0] 432 msec 696 msec 448 msec
  2 12.12.12.2 [MPLS: Label 16 Exp 0] 420 msec 324 msec 268 msec
  3 26.26.26.6 336 msec 448 msec *
```

r4#

r6#show ip interface brief

Interface	IP-Address	OK? Method Status		Prot
Serial1/0	26.26.26.6	YES	NVRAM up	up
Loopback0	6.6.6.6	YES	NVRAM up	up
Loopback1	60.60.60.1	YES	manual up	up
Tunnel0	6.6.6.6	YES	TFTP up	down
Tunnel1	6.6.6.6	YES	TFTP up	down
Tunnel2	6.6.6.6	YES	TFTP up	up

r6#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O   1.1.1.1 [110/165] via 26.26.26.2, 00:02:55, Serial1/0
     2.0.0.0/32 is subnetted, 1 subnets
O   2.2.2.2 [110/101] via 26.26.26.2, 00:02:55, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
O   3.3.3.3 [110/165] via 26.26.26.2, 00:02:55, Serial1/0
     4.0.0.0/32 is subnetted, 1 subnets
O   4.4.4.4 [110/229] via 0.0.0.0, 00:02:55, Tunnel2
     5.0.0.0/32 is subnetted, 1 subnets
O   5.5.5.5 [110/165] via 26.26.26.2, 00:02:55, Serial1/0
     6.0.0.0/32 is subnetted, 1 subnets
C   6.6.6.6 is directly connected, Loopback0
     23.0.0.0/24 is subnetted, 1 subnets
O   23.23.23.0 [110/164] via 26.26.26.2, 00:02:56, Serial1/0
     25.0.0.0/24 is subnetted, 1 subnets
O   25.25.25.0 [110/164] via 26.26.26.2, 00:02:56, Serial1/0
     40.0.0.0/32 is subnetted, 1 subnets

O   40.40.40.1 [110/229] via 0.0.0.0, 00:02:56, Tunnel2
     26.0.0.0/24 is subnetted, 1 subnets
C   26.26.26.0 is directly connected, Serial1/0
     12.0.0.0/24 is subnetted, 1 subnets
O   12.12.12.0 [110/164] via 26.26.26.2, 00:02:56, Serial1/0
     14.0.0.0/24 is subnetted, 1 subnets
O   14.14.14.0 [110/228] via 26.26.26.2, 00:02:56, Serial1/0
     60.0.0.0/24 is subnetted, 1 subnets
C   60.60.60.0 is directly connected, Loopback1
r6#tracer
r6#traceroute
Protocol [ip]:
Target IP address: 40.40.40.1
Source address: 60.60.60.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 40.40.40.1

  1 26.26.26.2 [MPLS: Label 17 Exp 0] 320 msec 720 msec 300 msec
  2 12.12.12.1 [MPLS: Label 16 Exp 0] 304 msec 300 msec 148 msec
  3 14.14.14.4 264 msec 740 msec 248 msec
r6#

2 MPLS TE（IS-IS）配置实例

2.1 网络拓扑图
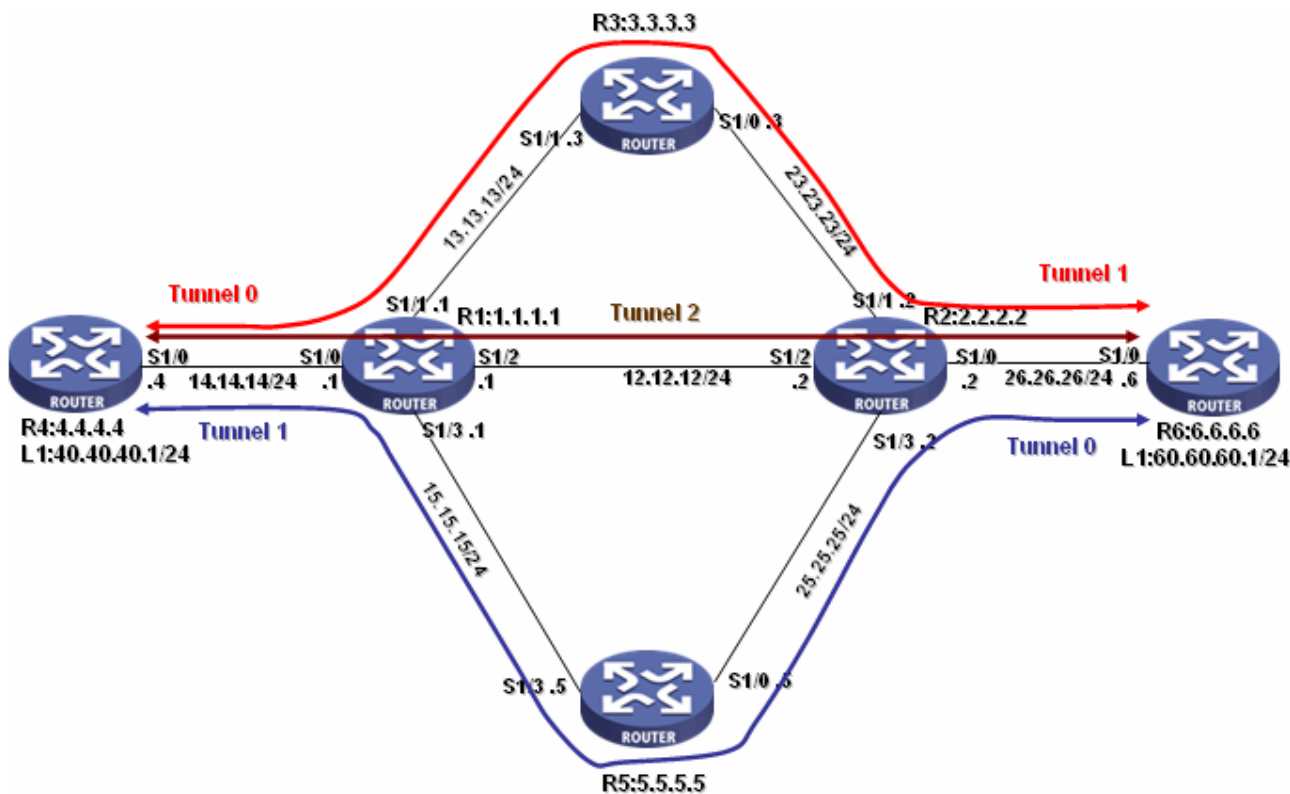
2.2 网络拓扑说明

1）R4 流量工程策略

MPLS TE 隧道 Tunnel0、Tunnel1、Tunnel2 分别引导数据通过路径 R4—R1—R3—R2—R6、R4—R1—R5—R2—R6 和 R4—R1—R2—R6。Tunnel0 被配置成使用 R4—R1—R3—R2—R6 作为它的第一条路径（按照优先级的顺序），R4—R1—R5—R2—R6 作为它的第二条路径（按照优先级顺序），R4—R1—R2—R6 作为它的第三条路径（按照优先级顺序）。第三条路径为动态路径作为 fallback 路径。动态路径是由 IS-IS IGP 导出的路径。

1）R6 流量工程策略

MPLS TE 隧道 Tunnel0、Tunnel1、Tunnel2 分别引导数据通过路径 R6—R2—R3—R1—R4、R6—R2—R5—R1—R4、R6—R2—R1—R4。Tunnel0 被配置成使用 R6—R2—R5—R1—R4 作为它的第一条路径（按照优先级的顺序），R6—R2—R3—R1—R4 作为它的第二条路径（按照优先级顺序）。R6—R2—R1—R4 作为它的第三条路径（按照优先级顺序）如果由于链路或节点故障，第一条和第二条路径不可用的情况下，动态路径就作为 fallback 路径。第三条路径为动态路径作为 fallback 路径。动态路径是由 IS-IS IGP 导出的路径。

2.3 路由器配置

2.3.1 R1 路由器配置

```
hostname r1
!
ip cef
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
 ip router isis
!
interface Serial1/0
 description Connect_to_R4_S1/0
 bandwidth 1544
 ip address 14.14.14.1 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/1
 description Connect_to_R3_S1/1
 bandwidth 1544
 ip address 13.13.13.1 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/2
 description Connect_to_R2_S1/2
 bandwidth 1544
 ip address 12.12.12.1 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/3
 description Connect_to_R5_S1/3
 bandwidth 1544
```

```
 ip address 15.15.15.1 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router isis
 net 49.0001.0000.0000.0001.00
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
```

2.3.2 R2 路由器配置

```
hostname r2
!
ip cef
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
 ip router isis
!
interface Serial1/0
 description Connect_to_R6_S1/0
 bandwidth 1544
 ip address 26.26.26.2 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/1
 description Connect_to_R3_S1/0
 bandwidth 1544
 ip address 23.23.23.2 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/2
 description Connect_to_R1_S1/2
```

```
 bandwidth 1544
 ip address 12.12.12.2 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/3
 description Connect_to_R5_S1/0
 bandwidth 1544
 ip address 25.25.25.2 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router isis
 net 49.0001.0000.0000.0002.00
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
```

2.3.3　R3 路由器配置

```
hostname r3
!
ip cef
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
 ip router isis
!
interface Serial1/0
 description Connect_to_R2_S1/1
 bandwidth 1544
 ip address 23.23.23.3 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/1
```

```
 description Connect_to_R1_S1/1
 bandwidth 1544
 ip address 13.13.13.3 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router isis
 net 49.0001.0000.0000.0003.00
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
!
```

2.3.4 R4 路由器配置

```
hostname r4
!
ip cef
mpls traffic-eng tunnels
!
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
 ip router isis
!
interface Loopback1
 ip address 40.40.40.1 255.255.255.0
 ip router isis
!
interface Tunnel0
 ip unnumbered Loopback0
 tunnel destination 6.6.6.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 1 explicit name r4r1r3r2r6
!
interface Tunnel1
 ip unnumbered Loopback0
 tunnel destination 6.6.6.6
```

```
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 2 2
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 2 explicit name r4r1r5r2r6
!
interface Tunnel2
 ip unnumbered Loopback0
 tunnel destination 6.6.6.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 3 3
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 3 dynamic
!
interface Serial1/0
 description Connect_to_R1_S1/0
 bandwidth 1544
 ip address 14.14.14.4 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router isis
 net 49.0001.0000.0000.0004.00
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
!
ip explicit-path name r4r1r3r2r6 enable
 next-address 14.14.14.1
 next-address 13.13.13.3
 next-address 23.23.23.2
 next-address 26.26.26.6
!
ip explicit-path name r4r1r5r2r6 enable
 next-address 14.14.14.1
 next-address 15.15.15.5
 next-address 25.25.25.2
 next-address 26.26.26.6
!
```

2.3.5　R5 路由器配置

```
hostname r5
!
ip cef
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 5.5.5.5 255.255.255.255
 ip router isis
!
interface Serial1/0
 description Connect_to_R5_S1/0
 bandwidth 1544
 ip address 25.25.25.5 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/3
 description Connect_to_R1_S1/3
 bandwidth 1544
 ip address 15.15.15.5 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router isis
 net 49.0001.0000.0000.0005.00
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
```

2.3.6　R6 路由器配置

```
hostname r6
!
ip cef
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 6.6.6.6 255.255.255.255
```

```
 ip router isis
!
interface Loopback1
 ip address 60.60.60.1 255.255.255.0
 ip router isis
!
interface Tunnel0
 ip unnumbered Loopback0
 tunnel destination 4.4.4.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 1 explicit name r6r2r5r1r4
!
interface Tunnel1
 ip unnumbered Loopback0
 tunnel destination 4.4.4.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 2 2
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 2 explicit name r6r2r3r1r4
!
interface Tunnel2
 ip unnumbered Loopback0
 tunnel destination 4.4.4.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 3 3
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 3 dynamic
!
interface Serial1/0
 description Connect_to_r2_s1/0
 bandwidth 1544
 ip address 26.26.26.6 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router isis
 net 49.0001.0000.0000.0006.00
 is-type level-1
```

```
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
!
ip explicit-path name r6r2r5r1r4 enable
 next-address 26.26.26.2
 next-address 25.25.25.5
 next-address 15.15.15.1
 next-address 14.14.14.4
!
ip explicit-path name r6r2r3r1r4 enable
 next-address 26.26.26.2
 next-address 23.23.23.3
 next-address 13.13.13.1
 next-address 14.14.14.4
!
```

2.4 配置验证

2.4.1 R4 路由器状态信息

```
r4#show clns neighbors

System Id      Interface   SNPA              State  Holdtime  Type Protocol
r1             Se1/0       *HDLC*            Up     24        L1   IS-IS
r4#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
i L1    1.1.1.1 [115/20] via 14.14.14.1, Serial1/0
     2.0.0.0/32 is subnetted, 1 subnets
i L1    2.2.2.2 [115/30] via 14.14.14.1, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
i L1    3.3.3.3 [115/30] via 14.14.14.1, Serial1/0
     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
```

```
      5.0.0.0/32 is subnetted, 1 subnets
i L1    5.5.5.5 [115/30] via 14.14.14.1, Serial1/0
      6.0.0.0/32 is subnetted, 1 subnets
i L1    6.6.6.6 [115/40] via 6.6.6.6, Tunnel0
      23.0.0.0/24 is subnetted, 1 subnets
i L1    23.23.23.0 [115/30] via 14.14.14.1, Serial1/0
      25.0.0.0/24 is subnetted, 1 subnets
i L1    25.25.25.0 [115/30] via 14.14.14.1, Serial1/0
      40.0.0.0/24 is subnetted, 1 subnets
C       40.40.40.0 is directly connected, Loopback1
      26.0.0.0/24 is subnetted, 1 subnets
i L1    26.26.26.0 [115/30] via 14.14.14.1, Serial1/0
      12.0.0.0/24 is subnetted, 1 subnets
i L1    12.12.12.0 [115/20] via 14.14.14.1, Serial1/0
      13.0.0.0/24 is subnetted, 1 subnets
i L1    13.13.13.0 [115/20] via 14.14.14.1, Serial1/0
      14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Serial1/0
      60.0.0.0/24 is subnetted, 1 subnets
i L1    60.60.60.0 [115/40] via 6.6.6.6, Tunnel0
      15.0.0.0/24 is subnetted, 1 subnets
i L1    15.15.15.0 [115/20] via 14.14.14.1, Serial1/0
r4#show mpls traff
r4#show mpls traffic-eng tunnel summary
Signalling Summary:
    LSP Tunnels Process:           running
    RSVP Process:                  running
    Forwarding:                    enabled
    Head: 3 interfaces, 1 active signalling attempts, 1 established
          592 activations, 591 deactivations
    Midpoints: 0, Tails: 1
    Periodic reoptimization:       every 3600 seconds, next in 2057 seconds
    Periodic auto-bw collection:   disabled
r4#show mpls traffic-eng tunnel brief
Signalling Summary:
    LSP Tunnels Process:           running
    RSVP Process:                  running
    Forwarding:                    enabled
    Periodic reoptimization:       every 3600 seconds, next in 2050 seconds
    Periodic auto-bw collection:   disabled
TUNNEL NAME                    DESTINATION       UP IF       DOWN IF     STATE/PROT
r4_t0                          6.6.6.6           -           Se1/0       up/up
r4_t1                          6.6.6.6           -           unknown     up/down
r4_t2                          6.6.6.6           -           unknown     up/down
r6_t0                          4.4.4.4           Se1/0       -           up/up
```

Displayed 3 (of 3) heads, 0 (of 0) midpoints, 1 (of 1) tails

r4#show mpls traffic-eng tunnel static

```
                                          ^
```
% Invalid input detected at '^' marker.

r4#show mpls traffic-eng tunnel sta

Tunnel0 (Destination 6.6.6.6; Name r4_t0)

  Management statistics:

    Path: 639 no path, 30 path no longer valid, 0 missing ip exp path

          41 path changes

    State: 9 transitions, 0 admin down, 4 oper down

  Signalling statistics:

    Opens: 5 succeeded, 0 timed out, 0 bad path spec

          0 other aborts

    Errors: 0 no b/w, 4 no route, 0 admin

          2 bad exp route, 0 rec route loop, 0 other

Tunnel1 (Destination 6.6.6.6; Name r4_t1)

  Management statistics:

    Path: 576 no path, 31 path no longer valid, 0 missing ip exp path

          200 path changes

    State: 10 transitions, 0 admin down, 5 oper down

  Signalling statistics:

    Opens: 5 succeeded, 0 timed out, 0 bad path spec

          0 other aborts

    Errors: 158 no b/w, 2 no route, 3 admin

          0 bad exp route, 0 rec route loop, 0 other

Tunnel2 (Destination 6.6.6.6; Name r4_t2)

  Management statistics:

    Path: 457 no path, 19 path no longer valid, 0 missing ip exp path

          371 path changes

    State: 22 transitions, 0 admin down, 11 oper down

  Signalling statistics:

    Opens: 11 succeeded, 1 timed out, 0 bad path spec

          0 other aborts

    Errors: 332 no b/w, 0 no route, 8 admin

          0 bad exp route, 0 rec route loop, 0 other

6.6.6.6 0 (Destination 4.4.4.4; Name r6_t0)

r4#show ip rsvp interface

interface   allocated i/f max flow max sub max

Se1/0   500K   500K   500K   0

r4#tracer

r4#traceroute

Protocol [ip]:

Target IP address: 60.60.60.1

Source address: 40.40.40.1

Numeric display [n]:

Timeout in seconds [3]:

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 60.60.60.1

```
  1 14.14.14.1 [MPLS: Label 16 Exp 0] 1612 msec 944 msec 1580 msec
  2 13.13.13.3 [MPLS: Label 16 Exp 0] 1412 msec 1044 msec 1392 msec
  3 23.23.23.2 [MPLS: Label 16 Exp 0] 1060 msec 676 msec 1016 msec
  4 26.26.26.6 1412 msec 1324 msec 1220 msec
```
r4#

2.4.2 R6 路由器状态信息

r6#show clns neighbors

```
System Id       Interface  SNPA                State  Holdtime  Type Protocol
r2              Se1/0      *HDLC*              Up     25        L1   IS-IS
```
r6#show 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, 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

```
     1.0.0.0/32 is subnetted, 1 subnets
i L1    1.1.1.1 [115/30] via 26.26.26.2, Serial1/0
     2.0.0.0/32 is subnetted, 1 subnets
i L1    2.2.2.2 [115/20] via 26.26.26.2, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
i L1    3.3.3.3 [115/30] via 26.26.26.2, Serial1/0
     4.0.0.0/32 is subnetted, 1 subnets
i L1    4.4.4.4 [115/40] via 4.4.4.4, Tunnel0
     5.0.0.0/32 is subnetted, 1 subnets
```

```
i L1    5.5.5.5 [115/30] via 26.26.26.2, Serial1/0
        6.0.0.0/32 is subnetted, 1 subnets
C       6.6.6.6 is directly connected, Loopback0
        23.0.0.0/24 is subnetted, 1 subnets
i L1    23.23.23.0 [115/20] via 26.26.26.2, Serial1/0
        25.0.0.0/24 is subnetted, 1 subnets
i L1    25.25.25.0 [115/20] via 26.26.26.2, Serial1/0
        40.0.0.0/24 is subnetted, 1 subnets
i L1    40.40.40.0 [115/40] via 4.4.4.4, Tunnel0
        26.0.0.0/24 is subnetted, 1 subnets
C       26.26.26.0 is directly connected, Serial1/0
        12.0.0.0/24 is subnetted, 1 subnets
i L1    12.12.12.0 [115/20] via 26.26.26.2, Serial1/0
        13.0.0.0/24 is subnetted, 1 subnets
i L1    13.13.13.0 [115/30] via 26.26.26.2, Serial1/0
        14.0.0.0/24 is subnetted, 1 subnets
i L1    14.14.14.0 [115/30] via 26.26.26.2, Serial1/0
        60.0.0.0/24 is subnetted, 1 subnets
C       60.60.60.0 is directly connected, Loopback1
        15.0.0.0/24 is subnetted, 1 subnets
i L1    15.15.15.0 [115/30] via 26.26.26.2, Serial1/0
r6#show mpls traff
r6#show mpls traffic-eng tun
r6#show mpls traffic-eng tunnels sum
r6#show mpls traffic-eng tunnels summary
Signalling Summary:
    LSP Tunnels Process:        running
    RSVP Process:               running
    Forwarding:                 enabled
    Head: 3 interfaces, 1 active signalling attempts, 1 established
          644 activations, 643 deactivations
    Midpoints: 0, Tails: 1
    Periodic reoptimization:    every 3600 seconds, next in 2163 seconds
    Periodic auto-bw collection: disabled
r6#show mpls traffic-eng tunnels brief
Signalling Summary:
    LSP Tunnels Process:        running
    RSVP Process:               running
    Forwarding:                 enabled
    Periodic reoptimization:    every 3600 seconds, next in 2158 seconds
    Periodic auto-bw collection: disabled
TUNNEL NAME                     DESTINATION     UP IF    DOWN IF    STATE/PROT
r6_t0                           4.4.4.4         -        Se1/0      up/up
r6_t1                           4.4.4.4         -        unknown    up/down
r6_t2                           4.4.4.4         -        unknown    up/down
```

r4_t0   6.6.6.6   Se1/0   -   up/up
Displayed 3 (of 3) heads, 0 (of 0) midpoints, 1 (of 1) tails
r6#show mpls traffic-eng tunnels sta
r6#show mpls traffic-eng tunnels statistics
Tunnel0 (Destination 4.4.4.4; Name r6_t0)
  Management statistics:
    Path: 332 no path, 29 path no longer valid, 0 missing ip exp path
            36 path changes
    State: 9 transitions, 0 admin down, 4 oper down
  Signalling statistics:
    Opens: 5 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 0 no b/w, 2 no route, 0 admin
            0 bad exp route, 0 rec route loop, 0 other
Tunnel1 (Destination 4.4.4.4; Name r6_t1)
  Management statistics:
    Path: 645 no path, 13 path no longer valid, 0 missing ip exp path
            328 path changes
    State: 6 transitions, 0 admin down, 3 oper down
  Signalling statistics:
    Opens: 3 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 308 no b/w, 3 no route, 1 admin
            0 bad exp route, 0 rec route loop, 0 other
Tunnel2 (Destination 4.4.4.4; Name r6_t2)
  Management statistics:
    Path: 438 no path, 16 path no longer valid, 0 missing ip exp path
            298 path changes
    State: 22 transitions, 0 admin down, 11 oper down
  Signalling statistics:
    Opens: 11 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 263 no b/w, 0 no route, 8 admin
            0 bad exp route, 0 rec route loop, 0 other
4.4.4.4 0 (Destination 6.6.6.6; Name r4_t0)
r6#show ip rsvp interface
interface   allocated i/f max flow max sub max
Se1/0   500K   500K   500K   0
r6#tracer
r6#traceroute
Protocol [ip]:
Target IP address: 40.40.40.1
Source address: 60.60.60.1
Numeric display [n]:
Timeout in seconds [3]:

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 40.40.40.1

  1 26.26.26.2 [MPLS: Label 17 Exp 0] 1020 msec 1260 msec 1400 msec

  2 25.25.25.5 [MPLS: Label 16 Exp 0] 912 msec 1328 msec 2024 msec

  3 15.15.15.1 [MPLS: Label 17 Exp 0] 1676 msec 632 msec 1224 msec

  4 14.14.14.4 1584 msec 1284 msec 1760 msec

r6#

2.5　隧道切换测试

1　将 R1 路由器 S1/1 端口 shutdown 后的情况：

r4#

*Oct 7 12:27:02.446: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, c
hanged state to down

r4#

*Oct 7 12:27:28.018: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel1, c
hanged state to up

r4#

r4#show 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, 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

    1.0.0.0/32 is subnetted, 1 subnets

i L1   1.1.1.1 [115/20] via 14.14.14.1, Serial1/0

    2.0.0.0/32 is subnetted, 1 subnets

i L1   2.2.2.2 [115/30] via 14.14.14.1, Serial1/0

    3.0.0.0/32 is subnetted, 1 subnets

i L1   3.3.3.3 [115/40] via 14.14.14.1, Serial1/0

    4.0.0.0/32 is subnetted, 1 subnets

C   4.4.4.4 is directly connected, Loopback0

```
        5.0.0.0/32 is subnetted, 1 subnets
i L1    5.5.5.5 [115/30] via 14.14.14.1, Serial1/0
        6.0.0.0/32 is subnetted, 1 subnets
i L1    6.6.6.6 [115/40] via 6.6.6.6, Tunnel1
        23.0.0.0/24 is subnetted, 1 subnets
i L1    23.23.23.0 [115/30] via 14.14.14.1, Serial1/0
        25.0.0.0/24 is subnetted, 1 subnets
i L1    25.25.25.0 [115/30] via 14.14.14.1, Serial1/0
        40.0.0.0/24 is subnetted, 1 subnets
C       40.40.40.0 is directly connected, Loopback1
        26.0.0.0/24 is subnetted, 1 subnets
i L1    26.26.26.0 [115/30] via 14.14.14.1, Serial1/0
        12.0.0.0/24 is subnetted, 1 subnets
i L1    12.12.12.0 [115/20] via 14.14.14.1, Serial1/0
        14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Serial1/0
        60.0.0.0/24 is subnetted, 1 subnets
i L1    60.60.60.0 [115/40] via 6.6.6.6, Tunnel1
        15.0.0.0/24 is subnetted, 1 subnets
i L1    15.15.15.0 [115/20] via 14.14.14.1, Serial1/0
r4#

r4#show 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, 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

        1.0.0.0/32 is subnetted, 1 subnets
i L1    1.1.1.1 [115/20] via 14.14.14.1, Serial1/0
        2.0.0.0/32 is subnetted, 1 subnets
i L1    2.2.2.2 [115/30] via 14.14.14.1, Serial1/0
        3.0.0.0/32 is subnetted, 1 subnets
i L1    3.3.3.3 [115/40] via 14.14.14.1, Serial1/0
        4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
        5.0.0.0/32 is subnetted, 1 subnets
i L1    5.5.5.5 [115/30] via 14.14.14.1, Serial1/0
        6.0.0.0/32 is subnetted, 1 subnets
i L1    6.6.6.6 [115/40] via 6.6.6.6, Tunnel1
```

```
      23.0.0.0/24 is subnetted, 1 subnets
i L1    23.23.23.0 [115/30] via 14.14.14.1, Serial1/0
      25.0.0.0/24 is subnetted, 1 subnets
i L1    25.25.25.0 [115/30] via 14.14.14.1, Serial1/0
      40.0.0.0/24 is subnetted, 1 subnets
C       40.40.40.0 is directly connected, Loopback1
      26.0.0.0/24 is subnetted, 1 subnets
i L1    26.26.26.0 [115/30] via 14.14.14.1, Serial1/0
      12.0.0.0/24 is subnetted, 1 subnets
i L1    12.12.12.0 [115/20] via 14.14.14.1, Serial1/0
      14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Serial1/0
      60.0.0.0/24 is subnetted, 1 subnets
i L1    60.60.60.0 [115/40] via 6.6.6.6, Tunnel1
      15.0.0.0/24 is subnetted, 1 subnets
i L1    15.15.15.0 [115/20] via 14.14.14.1, Serial1/0
r4#show mpls tr
r4#show mpls traffic-eng tunn
r4#show mpls traffic-eng tunnels sta
r4#show mpls traffic-eng tunnels statistics ?
  summary  Summarize tunnel counters and statistics
  |        Output modifiers
  <cr>


r4#show mpls traffic-eng tunnels statistics
Tunnel0 (Destination 6.6.6.6; Name r4_t0)
  Management statistics:
    Path:   829 no path, 31 path no longer valid, 0 missing ip exp path
            44 path changes
    State:  13 transitions, 1 admin down, 6 oper down
  Signalling statistics:
    Opens:  6 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 0 no b/w, 4 no route, 0 admin
            2 bad exp route, 0 rec route loop, 0 other
Tunnel1 (Destination 6.6.6.6; Name r4_t1)
  Management statistics:
    Path:   699 no path, 31 path no longer valid, 0 missing ip exp path
            203 path changes
    State:  14 transitions, 1 admin down, 6 oper down
  Signalling statistics:
    Opens:  7 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 158 no b/w, 2 no route, 3 admin
            0 bad exp route, 0 rec route loop, 0 other
```

```
Tunnel2 (Destination 6.6.6.6; Name r4_t2)
  Management statistics:
    Path:   722 no path, 19 path no longer valid, 0 missing ip exp path
            488 path changes
    State:  22 transitions, 0 admin down, 11 oper down
  Signalling statistics:
    Opens:  11 succeeded, 1 timed out, 0 bad path spec
            0 other aborts
    Errors: 449 no b/w, 0 no route, 8 admin
            0 bad exp route, 0 rec route loop, 0 other
6.6.6.6 0 (Destination 4.4.4.4; Name r6_t0)
r4#show mpls traffic-eng tunnels bri
r4#show mpls traffic-eng tunnels brief ?
  |   Output modifiers
  <cr>

r4#show mpls traffic-eng tunnels brief
Signalling Summary:
    LSP Tunnels Process:            running
    RSVP Process:                   running
    Forwarding:                     enabled
    Periodic reoptimization:        every 3600 seconds, next in 1828 seconds
    Periodic auto-bw collection:    disabled
TUNNEL NAME                       DESTINATION       UP IF     DOWN IF    STATE/PROT
r4_t0                             6.6.6.6           –         unknown    up/down
r4_t1                             6.6.6.6           –         Se1/0      up/up
r4_t2                             6.6.6.6           –         unknown    up/down
r6_t0                             4.4.4.4           Se1/0     –          up/up
Displayed 3 (of 3) heads, 0 (of 0) midpoints, 1 (of 1) tails
r4#tra
r4#traceroute
Protocol [ip]: 60.60.60.1
% Unknown protocol – "60.60.60.1", type "trace ?" for help
r4#traceroute
Protocol [ip]:
Target IP address: 60.60.60.1
Source address:
Numeric display [n]:
% Y or N
r4#
r4#traceroute
Protocol [ip]:
Target IP address: 60.60.60.1
Source address: 40.40.40.1
Numeric display [n]:
```

Timeout in seconds [3]:

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 60.60.60.1

　1 14.14.14.1 [MPLS: Label 16 Exp 0] 984 msec 1332 msec 1396 msec

　2 15.15.15.5 [MPLS: Label 17 Exp 0] 1404 msec 700 msec 1404 msec

　3 25.25.25.2 [MPLS: Label 16 Exp 0] 1092 msec 724 msec 520 msec

　4 26.26.26.6 1300 msec 1268 msec 1740 msec

r4#

2 在第 1 步的基础上，将 R1 路由器端口 S1/3 也 shutdown 后的情况：

r4#

*Oct 7 12:32:32.686: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel1, c

hanged state to down

*Oct 7 12:32:54.126: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel2, c

hanged state to up

r4#show 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, 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

　　　1.0.0.0/32 is subnetted, 1 subnets

i L1　　1.1.1.1 [115/20] via 14.14.14.1, Serial1/0

　　　2.0.0.0/32 is subnetted, 1 subnets

i L1　　2.2.2.2 [115/30] via 14.14.14.1, Serial1/0

　　　3.0.0.0/32 is subnetted, 1 subnets

i L1　　3.3.3.3 [115/40] via 14.14.14.1, Serial1/0

　　　4.0.0.0/32 is subnetted, 1 subnets

C　　　4.4.4.4 is directly connected, Loopback0

　　　5.0.0.0/32 is subnetted, 1 subnets

i L1　　5.5.5.5 [115/40] via 14.14.14.1, Serial1/0

　　　6.0.0.0/32 is subnetted, 1 subnets

i L1　　6.6.6.6 [115/40] via 6.6.6.6, Tunnel2

```
       23.0.0.0/24 is subnetted, 1 subnets
i L1    23.23.23.0 [115/30] via 14.14.14.1, Serial1/0
       25.0.0.0/24 is subnetted, 1 subnets
i L1    25.25.25.0 [115/30] via 14.14.14.1, Serial1/0
       40.0.0.0/24 is subnetted, 1 subnets
C       40.40.40.0 is directly connected, Loopback1
       26.0.0.0/24 is subnetted, 1 subnets
i L1    26.26.26.0 [115/30] via 14.14.14.1, Serial1/0
       12.0.0.0/24 is subnetted, 1 subnets
i L1    12.12.12.0 [115/20] via 14.14.14.1, Serial1/0
       14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Serial1/0
       60.0.0.0/24 is subnetted, 1 subnets
i L1    60.60.60.0 [115/40] via 6.6.6.6, Tunnel2
r4#show mpls tra
r4#show mpls traffic-eng tunnel brief
Signalling Summary:
    LSP Tunnels Process:          running
    RSVP Process:                 running
    Forwarding:                   enabled
    Periodic reoptimization:      every 3600 seconds, next in 1547 seconds
    Periodic auto-bw collection:  disabled
TUNNEL NAME                  DESTINATION    UP IF    DOWN IF   STATE/PROT
r4_t0                        6.6.6.6        -        unknown   up/down
r4_t1                        6.6.6.6        -        unknown   up/down
r4_t2                        6.6.6.6        -        Se1/0     up/up
r6_t2                        4.4.4.4        Se1/0    -         up/up
Displayed 3 (of 3) heads, 0 (of 0) midpoints, 1 (of 1) tails
r4#show mpls traffic-eng tunnel sta
r4#show mpls traffic-eng tunnel statistics
Tunnel0 (Destination 6.6.6.6; Name r4_t0)
  Management statistics:
    Path:  847 no path, 31 path no longer valid, 0 missing ip exp path
           44 path changes
    State: 13 transitions, 1 admin down, 6 oper down
  Signalling statistics:
    Opens:  6 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 0 no b/w, 4 no route, 0 admin
            2 bad exp route, 0 rec route loop, 0 other
Tunnel1 (Destination 6.6.6.6; Name r4_t1)
  Management statistics:
    Path:  710 no path, 32 path no longer valid, 0 missing ip exp path
           204 path changes
    State: 15 transitions, 1 admin down, 7 oper down
```

```
   Signalling statistics:
      Opens:  7 succeeded, 0 timed out, 0 bad path spec
              0 other aborts
      Errors: 158 no b/w, 2 no route, 3 admin
              0 bad exp route, 0 rec route loop, 0 other
Tunnel2 (Destination 6.6.6.6; Name r4_t2)
   Management statistics:
      Path:   738 no path, 19 path no longer valid, 0 missing ip exp path
              489 path changes
      State:  23 transitions, 0 admin down, 11 oper down
   Signalling statistics:
      Opens:  12 succeeded, 1 timed out, 0 bad path spec
              0 other aborts
      Errors: 449 no b/w, 0 no route, 8 admin
              0 bad exp route, 0 rec route loop, 0 other
6.6.6.6 2 (Destination 4.4.4.4; Name r6_t2)
r4#


r4#traceroute
Protocol [ip]:
Target IP address: 60.60.60.1
Source address: 40.40.40.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 60.60.60.1

  1 14.14.14.1 [MPLS: Label 17 Exp 0] 556 msec 756 msec 1312 msec
  2 12.12.12.2 [MPLS: Label 16 Exp 0] 812 msec 396 msec 452 msec
  3 26.26.26.6 1584 msec 684 msec 1264 msec
r4#


r6#
*Oct  7 12:36:29.870: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel2, c
hanged state to up
*Oct  7 12:36:40.974: %LINEPROTO-5-UPDOWN: Line protocol on Interface Tunnel0, c
hanged state to down

r6#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
i L1    1.1.1.1 [115/30] via 26.26.26.2, Serial1/0
     2.0.0.0/32 is subnetted, 1 subnets
i L1    2.2.2.2 [115/20] via 26.26.26.2, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
i L1    3.3.3.3 [115/30] via 26.26.26.2, Serial1/0
     4.0.0.0/32 is subnetted, 1 subnets
i L1    4.4.4.4 [115/40] via 4.4.4.4, Tunnel2
     5.0.0.0/32 is subnetted, 1 subnets
i L1    5.5.5.5 [115/30] via 26.26.26.2, Serial1/0
     6.0.0.0/32 is subnetted, 1 subnets
C       6.6.6.6 is directly connected, Loopback0
     23.0.0.0/24 is subnetted, 1 subnets
i L1    23.23.23.0 [115/20] via 26.26.26.2, Serial1/0
     25.0.0.0/24 is subnetted, 1 subnets
i L1    25.25.25.0 [115/20] via 26.26.26.2, Serial1/0
     40.0.0.0/24 is subnetted, 1 subnets
i L1    40.40.40.0 [115/40] via 4.4.4.4, Tunnel2
     26.0.0.0/24 is subnetted, 1 subnets
C       26.26.26.0 is directly connected, Serial1/0
     12.0.0.0/24 is subnetted, 1 subnets
i L1    12.12.12.0 [115/20] via 26.26.26.2, Serial1/0
     14.0.0.0/24 is subnetted, 1 subnets
i L1    14.14.14.0 [115/30] via 26.26.26.2, Serial1/0
     60.0.0.0/24 is subnetted, 1 subnets
C       60.60.60.0 is directly connected, Loopback1
r6#show mpls traff
r6#show mpls traffic-eng tunnel brief
Signalling Summary:
    LSP Tunnels Process:           running
    RSVP Process:                  running
    Forwarding:                    enabled
    Periodic reoptimization:       every 3600 seconds, next in 1933 seconds
    Periodic auto-bw collection:   disabled
TUNNEL NAME                    DESTINATION     UP IF   DOWN IF   STATE/PROT
```

```
r6_t0                          4.4.4.4          -         unknown   up/down
r6_t1                          4.4.4.4          -         unknown   up/down
r6_t2                          4.4.4.4          -         Se1/0     up/up
r4_t2                          6.6.6.6       Se1/0        -         up/up
Displayed 3 (of 3) heads, 0 (of 0) midpoints, 1 (of 1) tails
r6#show mpls traffic-eng tunnel sta
r6#show mpls traffic-eng tunnel statistics
Tunnel0 (Destination 4.4.4.4; Name r6_t0)
  Management statistics:
    Path:   347 no path, 30 path no longer valid, 0 missing ip exp path
            37 path changes
    State:  10 transitions, 0 admin down, 5 oper down
  Signalling statistics:
    Opens:  5 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 0 no b/w, 2 no route, 0 admin
            0 bad exp route, 0 rec route loop, 0 other
Tunnel1 (Destination 4.4.4.4; Name r6_t1)
  Management statistics:
    Path:   915 no path, 13 path no longer valid, 0 missing ip exp path
            328 path changes
    State:  6 transitions, 0 admin down, 3 oper down
  Signalling statistics:
    Opens:  3 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 308 no b/w, 3 no route, 1 admin
            0 bad exp route, 0 rec route loop, 0 other
Tunnel2 (Destination 4.4.4.4; Name r6_t2)
  Management statistics:
    Path:   695 no path, 16 path no longer valid, 0 missing ip exp path
            299 path changes
    State:  23 transitions, 0 admin down, 11 oper down
  Signalling statistics:
    Opens:  12 succeeded, 0 timed out, 0 bad path spec
            0 other aborts
    Errors: 263 no b/w, 0 no route, 8 admin
            0 bad exp route, 0 rec route loop, 0 other
4.4.4.4 2 (Destination 6.6.6.6; Name r4_t2)
r6#tra
r6#traceroute
Protocol [ip]:
Target IP address: 40.40.40.1
Source address: 60.60.60.1
Numeric display [n]:
Timeout in seconds [3]:
```

```
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 40.40.40.1

  1 26.26.26.2 [MPLS: Label 17 Exp 0] 564 msec 896 msec 1048 msec
  2 12.12.12.1 [MPLS: Label 16 Exp 0] 1068 msec 736 msec 692 msec
  3 14.14.14.4 1044 msec 996 msec 1048 msec
r6#
```

3 MPLS TE FRR—LINK Protection 配置实例

3.1 网络拓扑图
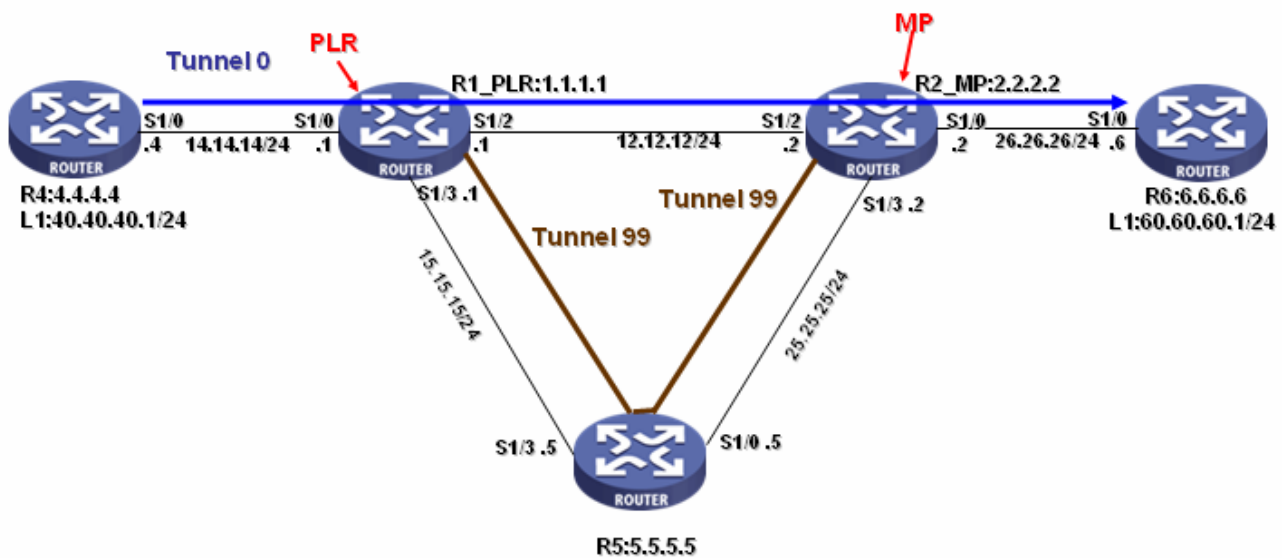
3.2 网络拓扑说明

1）在 R4 和 R6 之间建立单向的 tunnel0，作为主 tunnel；

2）为了保护在 R1 和 R2 之间链路有问题的情况下，R4 和 R6 之间的数据传输不会中断，对 R1 和 R2 之间的链路进行保护，保护的路径为：R4—R5—R2；同时为了确保在 R1 和 R2 之间在链路出现问题的情况下，在切换至备份链路时，能够尽可能少地丢包，使用 FRR（快速重路由）技术；

3.3 路由器配置

3.3.1 R1 路由器配置

```
R1_PLR#show running-config
Building configuration...

Current configuration : 2078 bytes
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname R1_PLR
!
boot-start-marker
boot-end-marker
!
!
ip subnet-zero
!
!
ip cef
mpls traffic-eng tunnels
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
 no ip directed-broadcast
!
interface Tunnel99
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 2.2.2.2
```

```
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 1 explicit name secours
 tunnel mpls traffic-eng record-route
!
interface FastEthernet0/0
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/0
 bandwidth 1544
 ip address 14.14.14.1 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 ip rsvp bandwidth 500 500
!
interface Serial1/1
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/2
 bandwidth 1544
 ip address 12.12.12.1 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 mpls traffic-eng backup-path Tunnel99
 ip rsvp bandwidth 500 500
!
interface Serial1/3
 bandwidth 1544
 ip address 15.15.15.1 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 ip rsvp bandwidth 500 500
!
interface Serial1/4
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/5
 no ip address
```

```
 no ip directed-broadcast
 shutdown
!
interface Serial1/6
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/7
 no ip address
 no ip directed-broadcast
 shutdown
!
router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0.0.0.0
 router-id 1.1.1.1
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 12.12.12.1 0.0.0.0 area 0.0.0.0
 network 14.14.14.1 0.0.0.0 area 0.0.0.0
 network 15.15.15.1 0.0.0.0 area 0.0.0.0
!
ip classless
!
!
ip explicit-path name secours enable
 next-address 15.15.15.5
 next-address 25.25.25.2
!
!
control-plane
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
!
no cns aaa enable
end
```

R1_PLR#

3.3.2 R2 路由器配置

R2_MP#
Building configuration...

Current configuration : 1652 bytes
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname R2_MP
!
boot-start-marker
boot-end-marker
!
!
ip subnet-zero
!
!
ip cef
mpls traffic-eng tunnels
!
!
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
 no ip directed-broadcast
!
interface FastEthernet0/0
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/0
 bandwidth 1544
 ip address 26.26.26.2 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 ip rsvp bandwidth 500 500

```
!
interface Serial1/1
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/2
 bandwidth 1544
 ip address 12.12.12.2 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 ip rsvp bandwidth 500 500
!
interface Serial1/3
 bandwidth 1544
 no ip address
 no ip directed-broadcast
 mpls traffic-eng tunnels
 ip rsvp bandwidth 500 500
!
interface Serial1/4
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/5
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/6
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/7
 no ip address
 no ip directed-broadcast
 shutdown
!
router ospf 2
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0.0.0.0
 router-id 2.2.2.2
 log-adjacency-changes
```

```
 network 2.2.2.2 0.0.0.0 area 0.0.0.0
 network 12.12.12.2 0.0.0.0 area 0.0.0.0
 network 25.25.25.2 0.0.0.0 area 0.0.0.0
 network 26.26.26.2 0.0.0.0 area 0.0.0.0
!
ip classless
!
!
!
control-plane
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
!
no cns aaa enable
end

R2_MP#
```

3.3.3 R4 路由器配置

```
R4#show running-config
Building configuration...

Current configuration : 1791 bytes
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname R4
!
boot-start-marker
boot-end-marker
!
!
```

```
ip subnet-zero
!
!
ip cef
mpls traffic-eng tunnels
!
!
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
 no ip directed-broadcast
!
interface Tunnel0
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 6.6.6.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 3 3
 tunnel mpls traffic-eng bandwidth  500
 tunnel mpls traffic-eng path-option 1 dynamic
 tunnel mpls traffic-eng record-route
 tunnel mpls traffic-eng fast-reroute
!
interface FastEthernet0/0
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/0
 bandwidth 1544
 ip address 14.14.14.4 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 ip rsvp bandwidth 500 500
!
interface Serial1/1
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/2
 no ip address
 no ip directed-broadcast
 shutdown
```

```
!
interface Serial1/3
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/4
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/5
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/6
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/7
 no ip address
 no ip directed-broadcast
 shutdown
!
router ospf 4
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0.0.0.0
 router-id 4.4.4.4
 log-adjacency-changes
 network 4.4.4.4 0.0.0.0 area 0.0.0.0
 network 14.14.14.4 0.0.0.0 area 0.0.0.0
!
ip classless
!
!
!
control-plane
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
```

```
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
!
no cns aaa enable
end

R4#
```

3.3.4 R5 路由器配置

```
R5#show running-config
Building configuration...

00:13:43: %SYS-5-CONFIG_I: Configured from console by console
Current configuration : 1539 bytes
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname R5
!
boot-start-marker
boot-end-marker
!
!
ip subnet-zero
!
!
ip cef
mpls traffic-eng tunnels
!
!
!
interface Loopback0
 ip address 5.5.5.5 255.255.255.255
 no ip directed-broadcast
!
interface FastEthernet0/0
 no ip address
 no ip directed-broadcast
```

```
 shutdown
!
interface Serial1/0
 bandwidth 1544
 ip address 25.25.25.5 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 ip rsvp bandwidth 500 500
!
interface Serial1/1
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/2
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/3
 bandwidth 1544
 ip address 15.15.15.5 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 ip rsvp bandwidth 500 500
!
interface Serial1/4
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/5
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/6
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/7
 no ip address
 no ip directed-broadcast
 shutdown
```

```
!
router ospf 5
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0.0.0.0
 router-id 5.5.5.5
 log-adjacency-changes
 network 5.5.5.5 0.0.0.0 area 0.0.0.0
 network 15.15.15.5 0.0.0.0 area 0.0.0.0
 network 25.25.25.5 0.0.0.0 area 0.0.0.0
!
ip classless
!
!
!
control-plane
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
!
no cns aaa enable
end

R5#
```

3.3.5　R6 路由器配置

```
R6#show running-config
Building configuration...

Current configuration : 1417 bytes
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname R6
```

```
!
boot-start-marker
boot-end-marker
!
!
ip subnet-zero
!
!
ip cef
mpls traffic-eng tunnels
!
!
!
interface Loopback0
 ip address 6.6.6.6 255.255.255.255
 no ip directed-broadcast
!
interface FastEthernet0/0
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/0
 bandwidth 1544
 ip address 26.26.26.6 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 ip rsvp bandwidth 500 500
!
interface Serial1/1
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/2
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/3
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/4
```

```
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/5
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/6
 no ip address
 no ip directed-broadcast
 shutdown
!
interface Serial1/7
 no ip address
 no ip directed-broadcast
 shutdown
!
router ospf 6
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0.0.0.0
 router-id 6.6.6.6
 log-adjacency-changes
 network 6.6.6.6 0.0.0.0 area 0.0.0.0
 network 26.26.26.6 0.0.0.0 area 0.0.0.0
!
ip classless
!
!
!
control-plane
!
!
line con 0
 exec-timeout 0 0
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 exec-timeout 0 0
 login
!
no cns aaa enable
end
```

R6#

4 MPLS VPN OVER TE 配置实例

4.1 网络拓扑图
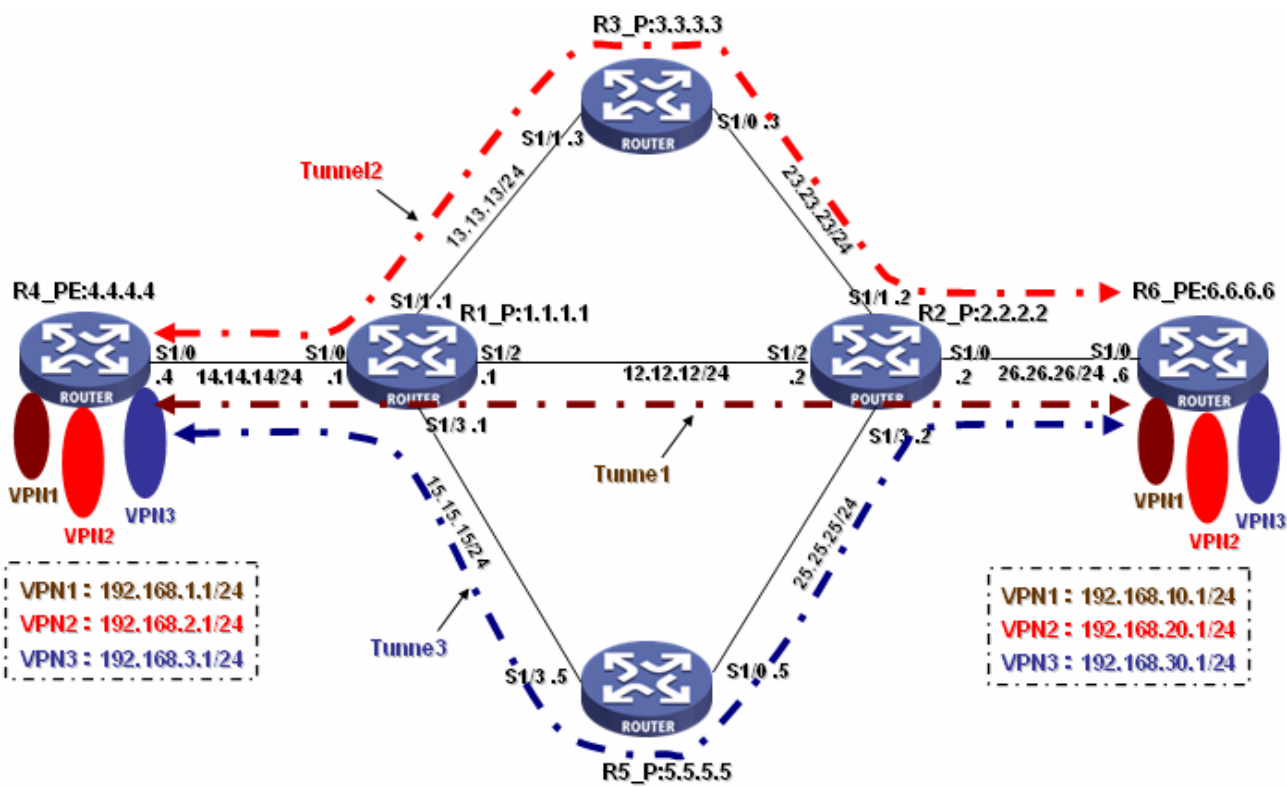
4.2 网络拓扑说明

1）R4 流量工程策略

MPLS TE 隧道 Tunnel1（R4—R1—R2—R6）用于传输到达 R6_PE 上的 VPN1 数据流；Tunnel2（R4—R1—R3—R2—R6）用于传输到达 R6_PE 上的 VPN2 数据流；、Tunnel3（R4—R1—R5—R2—R6）用于传输到达 R6_PE 上的 VPN3 数据流。

2）R6 流量工程策略

MPLS TE 隧道 Tunnel1（R6—R2—R1—R6）用于传输到达 R4_PE 上的 VPN1 数据流；Tunnel2（R6—R2—R3—R1—R4）用于传输到达 R4_PE 上的 VPN2 数据流；、Tunnel3（R6—R2—R5—R1—R4）用于传输到达 R4_PE 上的 VPN3 数据流。

3）思科采用改变 BGP 下一跳的方法来达到 MPLS VPN OVER MPLS TE；

4.3 设备配置

4.3.1 R4_PE 路由器配置

```
hostname R4_PE
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
mpls ldp logging neighbor-changes
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
!
interface Loopback1
 ip address 172.10.10.1 255.255.255.255
!
interface Loopback2
 ip address 172.20.20.1 255.255.255.255
!
interface Loopback3
 ip address 172.30.30.1 255.255.255.255
!
interface Loopback11
 ip vrf forwarding vpn1
 ip address 192.168.1.1 255.255.255.0
!
interface Loopback22
```

```
 ip vrf forwarding vpn2
 ip address 192.168.2.1 255.255.255.0
!
interface Loopback33
 ip vrf forwarding vpn3
 ip address 192.168.3.1 255.255.255.0
!
interface Tunnel1
 ip unnumbered Loopback1
 tunnel destination 6.6.6.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  150
 tunnel mpls traffic-eng path-option 10 explicit name r4r1r2r6
!
interface Tunnel2
 ip unnumbered Loopback2
 tunnel destination 6.6.6.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  150
 tunnel mpls traffic-eng path-option 20 explicit name r4r1r3r2r6
!
interface Tunnel3
 ip unnumbered Loopback3
 tunnel destination 6.6.6.6
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  150
 tunnel mpls traffic-eng path-option 30 explicit name r4r1r5r2r6
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex half
!
interface Serial1/0
 bandwidth 1544
 ip address 14.14.14.4 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
```

```
!
router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 log-adjacency-changes
 network 4.4.4.4 0.0.0.0 area 0.0.0.0
 network 14.14.14.4 0.0.0.0 area 0.0.0.0
!
router bgp 65001
 no synchronization
 bgp log-neighbor-changes
 neighbor 6.6.6.6 remote-as 65001
 neighbor 6.6.6.6 update-source Loopback0
 no auto-summary
 !
 address-family vpnv4
 neighbor 6.6.6.6 activate
 neighbor 6.6.6.6 send-community both
 neighbor 6.6.6.6 route-map match-community out
 no auto-summary
 exit-address-family
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
!
ip classless
ip route 172.10.10.10 255.255.255.255 Tunnel1
ip route 172.20.20.20 255.255.255.255 Tunnel2
ip route 172.30.30.30 255.255.255.255 Tunnel3
no ip http server
```

```
no ip http secure-server
!
ip extcommunity-list 1 permit rt 1:1
ip extcommunity-list 2 permit rt 2:2
ip extcommunity-list 3 permit rt 3:3
ip bgp-community new-format
!
ip explicit-path name r4r1r2r6 enable
 next-address 14.14.14.1
 next-address 12.12.12.2
 next-address 26.26.26.6
!
ip explicit-path name r4r1r3r2r6 enable
 next-address 14.14.14.1
 next-address 13.13.13.3
 next-address 23.23.23.2
 next-address 26.26.26.6
!
ip explicit-path name r4r1r5r2r6 enable
 next-address 14.14.14.1
 next-address 15.15.15.5
 next-address 25.25.25.2
 next-address 26.26.26.6
!
!
!
route-map match-community permit 10
 match extcommunity 1
 set ip next-hop 172.10.10.1
!
route-map match-community permit 20
 match extcommunity 2
 set ip next-hop 172.20.20.1
!
route-map match-community permit 30
 match extcommunity 3
 set ip next-hop 172.30.30.1
!
end

R4_PE#
```

4.3.2　R6_PE 路由器配置

```
hostname R6_PE
!
ip vrf vpn1
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpn2
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip vrf vpn3
 rd 3:3
 route-target export 3:3
 route-target import 3:3
!
ip cef
mpls ldp logging neighbor-changes
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 6.6.6.6 255.255.255.255
!
interface Loopback1
 ip address 172.10.10.10 255.255.255.255
!
interface Loopback2
 ip address 172.20.20.20 255.255.255.255
!
interface Loopback3
 ip address 172.30.30.30 255.255.255.255
!
interface Loopback11
 ip vrf forwarding vpn1
 ip address 192.168.10.1 255.255.255.0
!
interface Loopback22
 ip vrf forwarding vpn2
 ip address 192.168.20.1 255.255.255.0
!
interface Loopback33
```

```
 ip vrf forwarding vpn3
 ip address 192.168.30.1 255.255.255.0
!
interface Tunnel1
 ip unnumbered Loopback1
 tunnel destination 4.4.4.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  150
 tunnel mpls traffic-eng path-option 10 explicit name r6r2r1r4
!
interface Tunnel2
 ip unnumbered Loopback2
 tunnel destination 4.4.4.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  150
 tunnel mpls traffic-eng path-option 20 explicit name r6r2r3r1r4
!
interface Tunnel3
 ip unnumbered Loopback3
 tunnel destination 4.4.4.4
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 1 1
 tunnel mpls traffic-eng bandwidth  150
 tunnel mpls traffic-eng path-option 30 explicit name r6r2r5r1r4
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex half
!
interface Serial1/0
 bandwidth 1544
 ip address 26.26.26.6 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

```
  log-adjacency-changes
  network 6.6.6.6 0.0.0.0 area 0.0.0.0
  network 26.26.26.6 0.0.0.0 area 0.0.0.0
!
router bgp 65001
 no synchronization
 bgp log-neighbor-changes
 neighbor 4.4.4.4 remote-as 65001
 neighbor 4.4.4.4 update-source Loopback0
 no auto-summary
 !
 address-family vpnv4
 neighbor 4.4.4.4 activate
 neighbor 4.4.4.4 send-community both
 neighbor 4.4.4.4 route-map match-community out
 no auto-summary
 exit-address-family
 !
 address-family ipv4 vrf vpn3
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpn1
 redistribute connected
 no auto-summary
 no synchronization
 exit-address-family
!
ip classless
ip route 172.10.10.1 255.255.255.255 Tunnel1
ip route 172.20.20.1 255.255.255.255 Tunnel2
ip route 172.30.30.1 255.255.255.255 Tunnel3
no ip http server
no ip http secure-server
!
ip extcommunity-list 1 permit rt 1:1
ip extcommunity-list 2 permit rt 2:2
```

```
ip extcommunity-list 3 permit rt 3:3
ip bgp-community new-format
!
ip explicit-path name r6r2r1r4 enable
 next-address 26.26.26.2
 next-address 12.12.12.1
 next-address 14.14.14.4
!
ip explicit-path name r6r2r3r1r4 enable
 next-address 26.26.26.2
 next-address 23.23.23.3
 next-address 13.13.13.1
 next-address 14.14.14.4
!
ip explicit-path name r6r2r5r1r4 enable
 next-address 26.26.26.2
 next-address 25.25.25.5
 next-address 15.15.15.1
 next-address 14.14.14.4
!
!
!
route-map match-community permit 10
 match extcommunity 1
 set ip next-hop 172.10.10.10
!
route-map match-community permit 20
 match extcommunity 2
 set ip next-hop 172.20.20.20
!
route-map match-community permit 30
 match extcommunity 3
 set ip next-hop 172.30.30.30
!
R6_PE#
```

4.3.3 R1_P 路由器配置

```
hostname R1_P
!
ip cef
mpls ldp logging neighbor-changes
mpls traffic-eng tunnels
!
```

```
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface Serial1/0
 bandwidth 1544
 ip address 14.14.14.1 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/1
 bandwidth 1544
 ip address 13.13.13.1 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/2
 bandwidth 1544
 ip address 12.12.12.1 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/3
 bandwidth 1544
 ip address 15.15.15.1 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 12.12.12.1 0.0.0.0 area 0.0.0.0
 network 13.13.13.1 0.0.0.0 area 0.0.0.0
 network 14.14.14.1 0.0.0.0 area 0.0.0.0
 network 15.15.15.1 0.0.0.0 area 0.0.0.0
!
```

4.3.4 R2_P 路由器配置

```
hostname R2_P
!
ip cef
mpls ldp logging neighbor-changes
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex half
!
interface Serial1/0
 bandwidth 1544
 ip address 26.26.26.2 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/1
 bandwidth 1544
 ip address 23.23.23.2 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/2
 bandwidth 1544
 ip address 12.12.12.2 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/3
 bandwidth 1544
 ip address 25.25.25.2 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
```

```
router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 log-adjacency-changes
 network 2.2.2.2 0.0.0.0 area 0.0.0.0
 network 12.12.12.2 0.0.0.0 area 0.0.0.0
 network 23.23.23.2 0.0.0.0 area 0.0.0.0
 network 25.25.25.2 0.0.0.0 area 0.0.0.0
 network 26.26.26.2 0.0.0.0 area 0.0.0.0
!
end
R2_P#
```

4.3.5 R3_P 路由器配置

```
hostname R3_P
!
ip cef
mpls ldp logging neighbor-changes
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface Serial1/0
 bandwidth 1544
 ip address 23.23.23.3 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/1
 bandwidth 1544
 ip address 13.13.13.3 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 log-adjacency-changes
 network 3.3.3.3 0.0.0.0 area 0.0.0.0
 network 13.13.13.3 0.0.0.0 area 0.0.0.0
```

```
 network 23.23.23.3 0.0.0.0 area 0.0.0.0
!
end

R3_P#
```

4.3.6 R5_P 路由器配置

```
hostname R5_P
!
ip cef
mpls ldp logging neighbor-changes
mpls traffic-eng tunnels
!
interface Loopback0
 ip address 5.5.5.5 255.255.255.255
!
interface Serial1/0
 bandwidth 1544
 ip address 25.25.25.5 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 ip rsvp bandwidth 500 500
!
interface Serial1/3
 bandwidth 1544
 ip address 15.15.15.5 255.255.255.0
 mpls traffic-eng tunnels
 serial restart_delay 0
 fair-queue 64 256 16
 ip rsvp bandwidth 500 500
!
router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 log-adjacency-changes
 network 5.5.5.5 0.0.0.0 area 0.0.0.0
 network 15.15.15.5 0.0.0.0 area 0.0.0.0
 network 25.25.25.5 0.0.0.0 area 0.0.0.0
!
end

R5_P#
```

4.4 配置验证

4.4.1 R4_PE 验证

```
R4_PE#  show 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, 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


     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/65] via 14.14.14.1, 00:31:52, Serial1/0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/129] via 14.14.14.1, 00:31:52, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/129] via 14.14.14.1, 00:31:52, Serial1/0
     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/129] via 14.14.14.1, 00:31:52, Serial1/0
     6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/193] via 0.0.0.0, 00:31:52, Tunnel1
                [110/193] via 0.0.0.0, 00:31:52, Tunnel2
                [110/193] via 0.0.0.0, 00:31:52, Tunnel3
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/192] via 14.14.14.1, 00:31:52, Serial1/0
     172.10.0.0/32 is subnetted, 2 subnets
S       172.10.10.10 is directly connected, Tunnel1
C       172.10.10.1 is directly connected, Loopback1
     172.20.0.0/32 is subnetted, 2 subnets
C       172.20.20.1 is directly connected, Loopback2
S       172.20.20.20 is directly connected, Tunnel2
     172.30.0.0/32 is subnetted, 2 subnets
C       172.30.30.1 is directly connected, Loopback3
S       172.30.30.30 is directly connected, Tunnel3
     25.0.0.0/24 is subnetted, 1 subnets
O       25.25.25.0 [110/192] via 14.14.14.1, 00:31:52, Serial1/0
     26.0.0.0/24 is subnetted, 1 subnets
```

```
O        26.26.26.0 [110/192] via 14.14.14.1, 00:31:52, Serial1/0
     12.0.0.0/24 is subnetted, 1 subnets
O        12.12.12.0 [110/128] via 14.14.14.1, 00:31:52, Serial1/0
     13.0.0.0/24 is subnetted, 1 subnets
O        13.13.13.0 [110/128] via 14.14.14.1, 00:31:52, Serial1/0
     14.0.0.0/24 is subnetted, 1 subnets
C        14.14.14.0 is directly connected, Serial1/0
     15.0.0.0/24 is subnetted, 1 subnets
O        15.15.15.0 [110/128] via 14.14.14.1, 00:31:53, Serial1/0
R4_PE#


R4_PE#  show ip route vrf vpn1


Routing Table: vpn1
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, 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


B    192.168.10.0/24 [200/0] via 172.10.10.10, 00:31:14
C    192.168.1.0/24 is directly connected, Loopback11
R4_PE#  show ip route vrf vpn2


Routing Table: vpn2
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, 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


B    192.168.20.0/24 [200/0] via 172.20.20.20, 00:31:18
C    192.168.2.0/24 is directly connected, Loopback22
R4_PE#  show ip route vrf vpn3


Routing Table: vpn3
```

```
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, 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

B    192.168.30.0/24 [200/0] via 172.30.30.30, 00:31:21
C    192.168.3.0/24 is directly connected, Loopback33
R4_PE#


R4_PE#show ip bgp vpn all
BGP table version is 13, local router ID is 172.30.30.1
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: 1:1 (default for vrf vpn1)
*> 192.168.1.0      0.0.0.0                  0         32768 ?
*>i192.168.10.0     172.10.10.10             0    100      0 ?
Route Distinguisher: 2:2 (default for vrf vpn2)
*> 192.168.2.0      0.0.0.0                  0         32768 ?
*>i192.168.20.0     172.20.20.20             0    100      0 ?
Route Distinguisher: 3:3 (default for vrf vpn3)
*> 192.168.3.0      0.0.0.0                  0         32768 ?
*>i192.168.30.0     172.30.30.30             0    100      0 ?
R4_PE#


R4_PE#show interfaces tunnel 1 accounting
Tunnel1
                Protocol    Pkts In    Chars In   Pkts Out   Chars Out
                      IP          0           0        287       16031
                     Tag          0           0         13        1136
R4_PE#show interfaces tunnel 2 accounting
Tunnel2
                Protocol    Pkts In    Chars In   Pkts Out   Chars Out
                      IP          0           0         28        2584
                     Tag          0           0         13        1136
R4_PE#show interfaces tunnel 3 accounting
Tunnel3
```

```
                Protocol   Pkts In   Chars In   Pkts Out   Chars Out
                      IP         0          0          3          84
                     Tag         0          0          3          96
R4_PE#



R4_PE#show mpls traffic-eng tunnels tunnel 1

Name: R4_PE_t1                          (Tunnel1) Destination: 6.6.6.6
  Status:
    Admin: up        Oper: up     Path: valid      Signalling: connected

    path option 10, type explicit r4r1r2r6 (Basis for Setup, path weight 192)

  Config Parameters:
    Bandwidth: 150      kbps (Global) Priority: 1  1   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled   LockDown: disabled  Loadshare: 150      bw-based
    auto-bw: disabled

  InLabel  :  -
  OutLabel : Serial1/0, 16
  RSVP Signalling Info:
       Src 4.4.4.4, Dst 6.6.6.6, Tun_Id 1, Tun_Instance 22
    RSVP Path Info:
      My Address: 4.4.4.4
      Explicit Route: 14.14.14.1 12.12.12.2 26.26.26.6 6.6.6.6
      Record Route:  NONE
      Tspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
    RSVP Resv Info:
      Record Route:  NONE
      Fspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 192 (TE)
    Explicit Route: 14.14.14.1 12.12.12.2 26.26.26.6 6.6.6.6
  History:
    Tunnel:
      Time since created: 3 hours, 59 minutes
      Time since path change: 3 hours, 45 minutes
    Current LSP:
      Uptime: 3 hours, 45 minutes
R4_PE#


R4_PE#show mpls traffic-eng tunnels tunnel 2
```

Name: R4_PE_t2   (Tunnel2) Destination: 6.6.6.6
  Status:
    Admin: up   Oper: up   Path: valid   Signalling: connected

    path option 20, type explicit r4r1r3r2r6 (Basis for Setup, path weight 256)

  Config Parameters:
    Bandwidth: 150   kbps (Global) Priority: 1 1   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled   LockDown: disabled Loadshare: 150   bw-based
    auto-bw: disabled

  InLabel : -
  OutLabel : Serial1/0, 17
  RSVP Signalling Info:
       Src 4.4.4.4, Dst 6.6.6.6, Tun_Id 2, Tun_Instance 22
    RSVP Path Info:
      My Address: 4.4.4.4
      Explicit Route: 14.14.14.1 13.13.13.3 23.23.23.2 26.26.26.6
                      6.6.6.6
      Record Route: NONE
      Tspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
    RSVP Resv Info:
      Record Route: NONE
      Fspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 192 (TE)
    Explicit Route: 14.14.14.1 12.12.12.2 26.26.26.6 6.6.6.6
  History:
    Tunnel:
      Time since created: 3 hours, 56 minutes
      Time since path change: 2 hours, 34 minutes
    Current LSP:
      Uptime: 2 hours, 34 minutes
    Prior LSP:
      ID: path option 20 [21]
      Removal Trigger: tunnel shutdown
R4_PE#show mpls traffic-eng tunnels tunnel 3

Name: R4_PE_t3   (Tunnel3) Destination: 6.6.6.6
  Status:
    Admin: up   Oper: up   Path: valid   Signalling: connected

    path option 30, type explicit r4r1r5r2r6 (Basis for Setup, path weight 256)

```
  Config Parameters:
    Bandwidth: 150      kbps (Global) Priority: 1  1   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled   LockDown: disabled Loadshare: 150      bw-based
    auto-bw: disabled


  InLabel  :  -
  OutLabel : Serial1/0, 18
  RSVP Signalling Info:
       Src 4.4.4.4, Dst 6.6.6.6, Tun_Id 3, Tun_Instance 121
    RSVP Path Info:
      My Address: 4.4.4.4
      Explicit Route: 14.14.14.1 15.15.15.5 25.25.25.2 26.26.26.6
                      6.6.6.6
      Record Route:  NONE
      Tspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
    RSVP Resv Info:
      Record Route:  NONE
      Fspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 192 (TE)
    Explicit Route: 14.14.14.1 12.12.12.2 26.26.26.6 6.6.6.6
  History:
    Tunnel:
      Time since created: 3 hours, 28 minutes
      Time since path change: 2 hours, 32 minutes
    Current LSP:
      Uptime: 2 hours, 32 minutes
R4_PE#



R4_PE#show ip bgp vpnv4 vrf vpn1 labels
   Network          Next Hop      In label/Out label
Route Distinguisher: 1:1 (vpn1)
   192.168.1.0      0.0.0.0          16/aggregate(vpn1)
   192.168.10.0     172.10.10.10    nolabel/16


R4_PE#show ip bgp vpnv4 vrf vpn2 labels
   Network          Next Hop      In label/Out label
Route Distinguisher: 2:2 (vpn2)
   192.168.2.0      0.0.0.0          17/aggregate(vpn2)
   192.168.20.0     172.20.20.20    nolabel/17


R4_PE#show ip bgp vpnv4 vrf vpn3 labels
```

```
    Network          Next Hop      In label/Out label
Route Distinguisher: 3:3 (vpn3)
    192.168.3.0      0.0.0.0           18/aggregate(vpn3)
    192.168.30.0     172.30.30.30    nolabel/18


R4_PE#


R4_PE#ping vrf vpn1 192.168.10.1 source 192.168.1.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 420/576/816 ms
R4_PE#ping vrf vpn2 192.168.20.1 source 192.168.2.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.20.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 680/1198/1616 ms


R4_PE#ping vrf vpn3 192.168.30.1 source 192.168.3.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.30.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 828/1016/1196 ms
R4_PE#


R4_PE#traceroute vrf vpn1 ip


Target IP address: 192.168.10.1
Source address: 192.168.1.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.10.1
```

```
   1 14.14.14.1 [MPLS: Labels 16/16 Exp 0] 528 msec 836 msec 884 msec
   2 12.12.12.2 [MPLS: Labels 16/16 Exp 0] 720 msec 864 msec 608 msec
   3 192.168.10.1 1140 msec 672 msec 924 msec
R4_PE#traceroute vrf vpn2 ip

Target IP address: 192.168.20.1
Source address: 192.168.2.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.20.1

   1 14.14.14.1 [MPLS: Labels 17/17 Exp 0] 1344 msec 768 msec 568 msec
   2 13.13.13.3 [MPLS: Labels 16/17 Exp 0] 988 msec 884 msec 884 msec
   3 23.23.23.2 [MPLS: Labels 17/17 Exp 0] 1240 msec 904 msec 836 msec
   4 192.168.20.1 916 msec 796 msec 852 msec
R4_PE#traceroute vrf vpn3 ip

Target IP address: 192.168.30.1
Source address: 192.168.3.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.30.1

   1 14.14.14.1 [MPLS: Labels 18/18 Exp 0] 1204 msec 928 msec 852 msec
   2 15.15.15.5 [MPLS: Labels 16/18 Exp 0] 1036 msec 1036 msec 884 msec
   3 25.25.25.2 [MPLS: Labels 18/18 Exp 0] 956 msec 988 msec 908 msec
   4 192.168.30.1 908 msec 1012 msec 1076 msec
R4_PE#
```

4.4.2 R6_PE 验证

```
R6_PE#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/129] via 26.26.26.2, 02:58:53, Serial1/0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/65] via 26.26.26.2, 02:58:53, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/129] via 26.26.26.2, 02:58:53, Serial1/0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/193] via 0.0.0.0, 02:58:53, Tunnel3
                [110/193] via 0.0.0.0, 02:58:53, Tunnel1
                [110/193] via 0.0.0.0, 02:58:53, Tunnel2
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/129] via 26.26.26.2, 02:58:53, Serial1/0
     6.0.0.0/32 is subnetted, 1 subnets
C       6.6.6.6 is directly connected, Loopback0
     23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/128] via 26.26.26.2, 02:58:54, Serial1/0
     172.10.0.0/32 is subnetted, 2 subnets
C       172.10.10.10 is directly connected, Loopback1
S       172.10.10.1 is directly connected, Tunnel1
     172.20.0.0/32 is subnetted, 2 subnets
S       172.20.20.1 is directly connected, Tunnel2
C       172.20.20.20 is directly connected, Loopback2
     172.30.0.0/32 is subnetted, 2 subnets
S       172.30.30.1 is directly connected, Tunnel3
C       172.30.30.30 is directly connected, Loopback3
     25.0.0.0/24 is subnetted, 1 subnets
O       25.25.25.0 [110/128] via 26.26.26.2, 02:58:54, Serial1/0
     26.0.0.0/24 is subnetted, 1 subnets
C       26.26.26.0 is directly connected, Serial1/0
     12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/128] via 26.26.26.2, 02:58:54, Serial1/0
     13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/192] via 26.26.26.2, 02:58:54, Serial1/0
     14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/192] via 26.26.26.2, 02:58:54, Serial1/0
```

```
        15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/192] via 26.26.26.2, 02:58:54, Serial1/0
R6_PE#


R6_PE#show ip route vrf vpn1


Routing Table: vpn1
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, 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


C    192.168.10.0/24 is directly connected, Loopback11
B    192.168.1.0/24 [200/0] via 172.10.10.1, 01:28:07
R6_PE#show ip route vrf vpn2


Routing Table: vpn2
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, 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


C    192.168.20.0/24 is directly connected, Loopback22
B    192.168.2.0/24 [200/0] via 172.20.20.1, 01:28:10
R6_PE#show ip route vrf vpn3


Routing Table: vpn3
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, 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

C   192.168.30.0/24 is directly connected, Loopback33
B   192.168.3.0/24 [200/0] via 172.30.30.1, 01:28:12
R6_PE#

R6_PE#show ip bgp vpn all
BGP table version is 31, local router ID is 172.30.30.30
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: 1:1 (default for vrf vpn1)
*>i192.168.1.0   172.10.10.1   0   100   0 ?
*> 192.168.10.0   0.0.0.0   0   32768 ?
Route Distinguisher: 2:2 (default for vrf vpn2)
*>i192.168.2.0   172.20.20.1   0   100   0 ?
*> 192.168.20.0   0.0.0.0   0   32768 ?
Route Distinguisher: 3:3 (default for vrf vpn3)
*>i192.168.3.0   172.30.30.1   0   100   0 ?
*> 192.168.30.0   0.0.0.0   0   32768 ?
R6_PE#

R6_PE# show mpls traffic-eng tunnels tunnel 1

Name: R6_PE_t1   (Tunnel1) Destination: 4.4.4.4
  Status:
    Admin: up   Oper: up   Path: valid   Signalling: connected

    path option 10, type explicit r6r2r1r4 (Basis for Setup, path weight 192)

  Config Parameters:
    Bandwidth: 150   kbps (Global) Priority: 1 1   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled   LockDown: disabled Loadshare: 150   bw-based
    auto-bw: disabled

  InLabel : -
  OutLabel : Serial1/0, 19
  RSVP Signalling Info:
       Src 6.6.6.6, Dst 4.4.4.4, Tun_Id 1, Tun_Instance 10

```
    RSVP Path Info:
      My Address: 6.6.6.6
      Explicit Route: 26.26.26.2 12.12.12.1 14.14.14.4 4.4.4.4
      Record Route:  NONE
      Tspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
    RSVP Resv Info:
      Record Route:  NONE
      Fspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 192 (TE)
    Explicit Route: 26.26.26.2 12.12.12.1 14.14.14.4 4.4.4.4
  History:
    Tunnel:
      Time since created: 3 hours, 19 minutes
      Time since path change: 3 hours, 9 minutes
    Current LSP:
      Uptime: 3 hours, 9 minutes
    Prior LSP:
      ID: path option 10 [5]
      Removal Trigger: configuration changed
R6_PE# show mpls traffic-eng tunnels tunnel 2

Name: R6_PE_t2                          (Tunnel2) Destination: 4.4.4.4
  Status:
    Admin: up        Oper: up     Path: valid       Signalling: connected

    path option 20, type explicit r6r2r3r1r4 (Basis for Setup, path weight 256)

  Config Parameters:
    Bandwidth: 150      kbps (Global) Priority: 1  1   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled   LockDown: disabled Loadshare: 150       bw-based
    auto-bw: disabled

  InLabel  :  -
  OutLabel : Serial1/0, 20
  RSVP Signalling Info:
       Src 6.6.6.6, Dst 4.4.4.4, Tun_Id 2, Tun_Instance 13
    RSVP Path Info:
      My Address: 6.6.6.6
      Explicit Route: 26.26.26.2 23.23.23.3 13.13.13.1 14.14.14.4
                      4.4.4.4
      Record Route:  NONE
      Tspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
    RSVP Resv Info:
```

```
      Record Route:  NONE
       Fspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
    Shortest Unconstrained Path Info:
      Path Weight: 192 (TE)
      Explicit Route: 26.26.26.2 12.12.12.1 14.14.14.4 4.4.4.4
    History:
      Tunnel:
        Time since created: 3 hours, 17 minutes
        Time since path change: 3 hours, 8 minutes
      Current LSP:
        Uptime: 3 hours, 8 minutes
      Prior LSP:
        ID: path option 20 [6]
        Removal Trigger: configuration changed
R6_PE# show mpls traffic-eng tunnels tunnel 3


Name: R6_PE_t3                          (Tunnel3) Destination: 4.4.4.4
  Status:
    Admin: up        Oper: up     Path: valid      Signalling: connected


    path option 30, type explicit r6r2r5r1r4 (Basis for Setup, path weight 256)


  Config Parameters:
    Bandwidth: 150      kbps (Global) Priority: 1  1   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: enabled   LockDown: disabled Loadshare: 150      bw-based
    auto-bw: disabled


  InLabel  :  -
  OutLabel : Serial1/0, 21
  RSVP Signalling Info:
       Src 6.6.6.6, Dst 4.4.4.4, Tun_Id 3, Tun_Instance 11
    RSVP Path Info:
      My Address: 6.6.6.6
      Explicit Route: 26.26.26.2 25.25.25.5 15.15.15.1 14.14.14.4
                      4.4.4.4
      Record Route:  NONE
      Tspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
    RSVP Resv Info:
      Record Route:  NONE
       Fspec: ave rate=150 kbits, burst=1000 bytes, peak rate=150 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 192 (TE)
    Explicit Route: 26.26.26.2 12.12.12.1 14.14.14.4 4.4.4.4
  History:
```

```
    Tunnel:
      Time since created: 3 hours, 16 minutes
      Time since path change: 3 hours, 12 minutes
    Current LSP:
      Uptime: 3 hours, 12 minutes
    Prior LSP:
      ID: path option 30 [5]
      Removal Trigger: configuration changed
R6_PE#


R6_PE# show ip bgp vpnv4 vrf vpn1 labels
   Network         Next Hop      In label/Out label
Route Distinguisher: 1:1 (vpn1)
   192.168.1.0     172.10.10.1     nolabel/16
   192.168.10.0    0.0.0.0         16/aggregate(vpn1)


R6_PE# show ip bgp vpnv4 vrf vpn2 labels
   Network         Next Hop      In label/Out label
Route Distinguisher: 2:2 (vpn2)
   192.168.2.0     172.20.20.1     nolabel/17
   192.168.20.0    0.0.0.0         17/aggregate(vpn2)


R6_PE# show ip bgp vpnv4 vrf vpn3 labels
   Network         Next Hop      In label/Out label
Route Distinguisher: 3:3 (vpn3)
   192.168.3.0     172.30.30.1     nolabel/18
   192.168.30.0    0.0.0.0         18/aggregate(vpn3)


R6_PE#



R6_PE#ping vrf vpn1 192.168.1.1 source 192.168.10.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.10.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 476/620/712 ms
R6_PE#ping vrf vpn2 192.168.2.1 source 192.168.20.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.20.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 920/1012/1180 ms
```

```
R6_PE#ping vrf vpn2 192.168.3.1 source 192.168.30.1

% Invalid source address- IP address not on any of our up interfaces
R6_PE#ping vrf vpn3 192.168.3.1 source 192.168.30.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.30.1
!!!

R6_PE#traceroute vrf vpn1
Protocol [ip]:
Target IP address: 192.168.1.1
Source address: 192.168.10.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 26.26.26.2 [MPLS: Labels 19/16 Exp 0] 716 msec 812 msec 868 msec
  2 12.12.12.1 [MPLS: Labels 19/16 Exp 0] 628 msec 508 msec 828 msec
  3 192.168.1.1 852 msec 748 msec 528 msec
R6_PE#traceroute vrf vpn2
Protocol [ip]:
Target IP address: 192.168.2.1
Source address: 192.168.20.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.2.1

  1 26.26.26.2 [MPLS: Labels 20/17 Exp 0] 1320 msec 644 msec 748 msec
  2 23.23.23.3 [MPLS: Labels 17/17 Exp 0] 540 msec 764 msec 812 msec
  3 13.13.13.1 [MPLS: Labels 20/17 Exp 0] 1156 msec 860 msec 716 msec
  4 192.168.2.1 812 msec 836 msec 956 msec
```

```
R6_PE#traceroute vrf vpn3
Protocol [ip]:
Target IP address: 192.168.3.1
Source address: 192.168.30.1
Numeric display [n]:
Timeout in seconds [3]:
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.3.1

  1 26.26.26.2 [MPLS: Labels 21/18 Exp 0] 1212 msec 764 msec 812 msec
  2 25.25.25.5 [MPLS: Labels 17/18 Exp 0] 588 msec 852 msec 1100 msec
  3 15.15.15.1 [MPLS: Labels 21/18 Exp 0] 1148 msec 892 msec 692 msec
  4 192.168.3.1 1228 msec 1100 msec 1028 msec
R6_PE#
```

4.4.3 R1_P 验证

```
R1_P#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/65] via 12.12.12.2, 02:12:57, Serial1/2
     3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/65] via 13.13.13.3, 02:12:57, Serial1/1
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/65] via 14.14.14.4, 02:12:57, Serial1/0
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/65] via 15.15.15.5, 02:12:57, Serial1/3
     6.0.0.0/32 is subnetted, 1 subnets
```

```
O       6.6.6.6 [110/129] via 12.12.12.2, 02:12:57, Serial1/2
    23.0.0.0/24 is subnetted, 1 subnets
O       23.23.23.0 [110/128] via 12.12.12.2, 02:12:58, Serial1/2
                   [110/128] via 13.13.13.3, 02:12:58, Serial1/1
    25.0.0.0/24 is subnetted, 1 subnets
O       25.25.25.0 [110/128] via 12.12.12.2, 02:12:58, Serial1/2
                   [110/128] via 15.15.15.5, 02:12:58, Serial1/3
    26.0.0.0/24 is subnetted, 1 subnets
O       26.26.26.0 [110/128] via 12.12.12.2, 02:12:58, Serial1/2
    12.0.0.0/24 is subnetted, 1 subnets
C       12.12.12.0 is directly connected, Serial1/2
    13.0.0.0/24 is subnetted, 1 subnets
C       13.13.13.0 is directly connected, Serial1/1
    14.0.0.0/24 is subnetted, 1 subnets
C       14.14.14.0 is directly connected, Serial1/0
    15.0.0.0/24 is subnetted, 1 subnets
C       15.15.15.0 is directly connected, Serial1/3
R1_P#
```

4.4.4 R2_P 验证

```
R2_P#show 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, 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

    1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/65] via 12.12.12.1, 02:15:20, Serial1/2
    2.0.0.0/32 is subnetted, 1 subnets
C       2.2.2.2 is directly connected, Loopback0
    3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/65] via 23.23.23.3, 02:15:20, Serial1/1
    4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/129] via 12.12.12.1, 02:15:20, Serial1/2
    5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/65] via 25.25.25.5, 02:15:20, Serial1/3
    6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/65] via 26.26.26.6, 02:15:20, Serial1/0
```

```
        23.0.0.0/24 is subnetted, 1 subnets
C       23.23.23.0 is directly connected, Serial1/1
        25.0.0.0/24 is subnetted, 1 subnets
C       25.25.25.0 is directly connected, Serial1/3
        26.0.0.0/24 is subnetted, 1 subnets
C       26.26.26.0 is directly connected, Serial1/0
        12.0.0.0/24 is subnetted, 1 subnets
C       12.12.12.0 is directly connected, Serial1/2
        13.0.0.0/24 is subnetted, 1 subnets
O       13.13.13.0 [110/128] via 12.12.12.1, 02:15:21, Serial1/2
                   [110/128] via 23.23.23.3, 02:15:21, Serial1/1
        14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/128] via 12.12.12.1, 02:15:21, Serial1/2
        15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/128] via 12.12.12.1, 02:15:21, Serial1/2
                   [110/128] via 25.25.25.5, 02:15:21, Serial1/3
R2_P#
```

4.4.5 R3_P 验证

```
R3_P# show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/65] via 13.13.13.1, 02:22:04, Serial1/1
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/65] via 23.23.23.2, 02:22:04, Serial1/0
     3.0.0.0/32 is subnetted, 1 subnets
C       3.3.3.3 is directly connected, Loopback0
     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/129] via 13.13.13.1, 02:22:04, Serial1/1
     5.0.0.0/32 is subnetted, 1 subnets
O       5.5.5.5 [110/129] via 23.23.23.2, 02:22:04, Serial1/0
                [110/129] via 13.13.13.1, 02:22:04, Serial1/1
     6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/129] via 23.23.23.2, 02:22:04, Serial1/0
```

```
        23.0.0.0/24 is subnetted, 1 subnets
C       23.23.23.0 is directly connected, Serial1/0
        25.0.0.0/24 is subnetted, 1 subnets
O       25.25.25.0 [110/128] via 23.23.23.2, 02:22:05, Serial1/0
        26.0.0.0/24 is subnetted, 1 subnets
O       26.26.26.0 [110/128] via 23.23.23.2, 02:22:05, Serial1/0
        12.0.0.0/24 is subnetted, 1 subnets
O       12.12.12.0 [110/128] via 13.13.13.1, 02:22:05, Serial1/1
                   [110/128] via 23.23.23.2, 02:22:05, Serial1/0
        13.0.0.0/24 is subnetted, 1 subnets
C       13.13.13.0 is directly connected, Serial1/1
        14.0.0.0/24 is subnetted, 1 subnets
O       14.14.14.0 [110/128] via 13.13.13.1, 02:22:05, Serial1/1
        15.0.0.0/24 is subnetted, 1 subnets
O       15.15.15.0 [110/128] via 13.13.13.1, 02:22:05, Serial1/1
R3_P#
```

4.4.6 R5_P 验证

```
R5_P#show 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, 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

        1.0.0.0/32 is subnetted, 1 subnets
O       1.1.1.1 [110/65] via 15.15.15.1, 02:25:40, Serial1/3
        2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/65] via 25.25.25.2, 02:25:40, Serial1/0
        3.0.0.0/32 is subnetted, 1 subnets
O       3.3.3.3 [110/129] via 25.25.25.2, 02:25:40, Serial1/0
                [110/129] via 15.15.15.1, 02:25:40, Serial1/3
        4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/129] via 15.15.15.1, 02:25:40, Serial1/3
        5.0.0.0/32 is subnetted, 1 subnets
C       5.5.5.5 is directly connected, Loopback0
        6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/129] via 25.25.25.2, 02:25:40, Serial1/0
        23.0.0.0/24 is subnetted, 1 subnets
```

```
O        23.23.23.0 [110/128] via 25.25.25.2, 02:25:41, Serial1/0
     25.0.0.0/24 is subnetted, 1 subnets
C        25.25.25.0 is directly connected, Serial1/0
     26.0.0.0/24 is subnetted, 1 subnets
O        26.26.26.0 [110/128] via 25.25.25.2, 02:25:41, Serial1/0
     12.0.0.0/24 is subnetted, 1 subnets
O        12.12.12.0 [110/128] via 25.25.25.2, 02:25:41, Serial1/0
                    [110/128] via 15.15.15.1, 02:25:41, Serial1/3
     13.0.0.0/24 is subnetted, 1 subnets
O        13.13.13.0 [110/128] via 15.15.15.1, 02:25:41, Serial1/3
     14.0.0.0/24 is subnetted, 1 subnets
O        14.14.14.0 [110/128] via 15.15.15.1, 02:25:41, Serial1/3
     15.0.0.0/24 is subnetted, 1 subnets
C        15.15.15.0 is directly connected, Serial1/3
R5_P#
```

五 MPLS VPN 跨域配置实例

1 VRF to VRF 模式

1.1 网络拓扑图
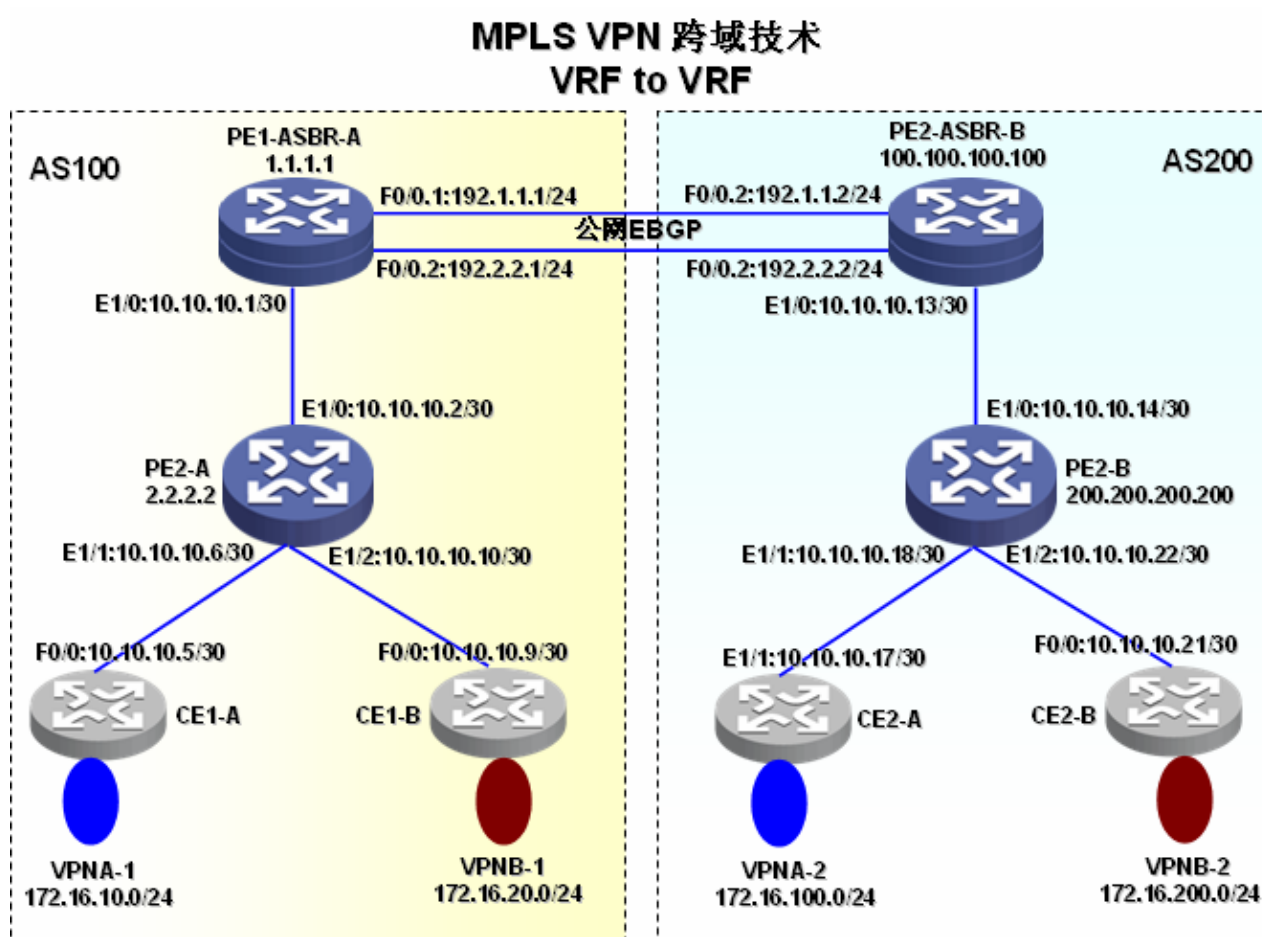
1.2 应用需求

采用 MPLS VPN 跨域的第一种方式（OptionA）：VRF to VRF 的模式来达到在不同 AS 域的同一个 VPN 的用户能够互相通信，即 VPNA-1 和 VPNA-2 之间，VPNB-1 和 VPNB-2 之间的用户能够互相通信。

1.3 设备配置

1.3.1 PE1-ASBR-A 设备配置

```
PE1-ASBR-A#
PE1-ASBR-A#show running
Building configuration...

Current configuration : 2139 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE1-ASBR-A
!
!
ip subnet-zero
!
!
!
ip vrf vpna
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpnb
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
```

```
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding vpna
 ip address 192.1.1.1 255.255.255.0
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding vpnb
 ip address 192.2.2.1 255.255.255.0
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 10.10.10.1 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 no ip address
```

```
  shutdown
  half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpnb
 redistribute connected
 neighbor 192.2.2.2 remote-as 200
 neighbor 192.2.2.2 activate
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpna
 redistribute connected
 neighbor 192.1.1.2 remote-as 200
 neighbor 192.1.1.2 activate
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
```

```
  exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

1.3.2　PE1-ASBR-B 设备配置

```
PE1-ASBR-B#show running
Building configuration...

Current configuration : 2200 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE1-ASBR-B
```

```
!
!
ip subnet-zero
!
!
!
ip vrf vpna
 rd 10:10
 route-target export 10:10
 route-target import 10:10
!
ip vrf vpnb
 rd 20:20
 route-target export 20:20
 route-target import 20:20
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 100.100.100.100 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
```

```
  ip vrf forwarding vpna
  ip address 192.1.1.2 255.255.255.0
!
interface FastEthernet0/0.2
  encapsulation dot1Q 2
  ip vrf forwarding vpnb
  ip address 192.2.2.2 255.255.255.0
!
interface FastEthernet0/1
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface Ethernet1/0
  ip address 10.10.10.13 255.255.255.252
  half-duplex
  mpls label protocol ldp
  tag-switching ip
!
interface Ethernet1/1
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/2
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/3
  no ip address
  shutdown
  half-duplex
!
router ospf 1
  router-id 100.100.100.100
  log-adjacency-changes
  network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 200
  no synchronization
  bgp log-neighbor-changes
  neighbor 200.200.200.200 remote-as 200
  neighbor 200.200.200.200 update-source Loopback0
```

```
   no auto-summary
   !
   address-family ipv4 vrf vpnb
   redistribute connected
   neighbor 192.2.2.1 remote-as 100
   neighbor 192.2.2.1 activate
   no auto-summary
   no synchronization
   exit-address-family
   !
   address-family ipv4 vrf vpna
   redistribute connected
   neighbor 192.1.1.1 remote-as 100
   neighbor 192.1.1.1 activate
   no auto-summary
   no synchronization
   exit-address-family
   !
   address-family vpnv4
   neighbor 200.200.200.200 activate
   neighbor 200.200.200.200 send-community extended
   no auto-summary
   exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
```

```
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.3 PE2-A 设备配置

```
PE2-A#show running
Building configuration...

Current configuration : 2156 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE2-A
!
!
ip subnet-zero
!
!
!
ip vrf vpna
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpnb
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
```

!

!

!

!

!

!

!

mta receive maximum-recipients 0

!

!

!

!

interface Loopback0

 ip address 2.2.2.2 255.255.255.255

!

interface FastEthernet0/0

 no ip address

 shutdown

 duplex auto

 speed auto

!

interface FastEthernet0/1

 no ip address

 shutdown

 duplex auto

 speed auto

!

interface Ethernet1/0

 ip address 10.10.10.2 255.255.255.252

 half-duplex

 mpls label protocol ldp

 tag-switching ip

!

interface Ethernet1/1

 ip vrf forwarding vpna

 ip address 10.10.10.6 255.255.255.252

 half-duplex

!

interface Ethernet1/2

 ip vrf forwarding vpnb

 ip address 10.10.10.10 255.255.255.252

 half-duplex

!

interface Ethernet1/3

 no ip address

```
 shutdown
 half-duplex
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 10 vrf vpna
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpnb
 redistribute connected
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpna
 redistribute connected
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community extended
 no auto-summary
 exit-address-family
!
```

```
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

1.3.4 PE2-B 设备配置

```
PE2-B#show running
Building configuration...

Current configuration : 2218 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE2-B
!
!
```

```
ip subnet-zero
!
!
!
ip vrf vpna
 rd 10:10
 route-target export 10:10
 route-target import 10:10
!
ip vrf vpnb
 rd 20:20
 route-target export 20:20
 route-target import 20:20
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 200.200.200.200 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
```

```
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 10.10.10.14 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip vrf forwarding vpna
 ip address 10.10.10.18 255.255.255.252
 half-duplex
!
interface Ethernet1/2
 ip vrf forwarding vpnb
 ip address 10.10.10.22 255.255.255.252
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 200.200.200.200
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 10 vrf vpna
 log-adjacency-changes
 redistribute bgp 200 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
 log-adjacency-changes
 redistribute bgp 200 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 200
 no synchronization
 bgp log-neighbor-changes
 neighbor 100.100.100.100 remote-as 200
 neighbor 100.100.100.100 update-source Loopback0
 no auto-summary
```

```
 !
 address-family ipv4 vrf vpnb
 redistribute connected
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpna
 redistribute connected
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 100.100.100.100 activate
 neighbor 100.100.100.100 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
```

```
 login
!
!
end
```

1.3.5　CE1-A 设备配置

```
CE1-A#show running
Building configuration...

Current configuration : 749 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE1-A
!
!
ip subnet-zero
!
!
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.10.1 255.255.255.0
!
```

```
interface FastEthernet0/0
 ip address 10.10.10.5 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.6 CE1-B 设备配置

CE1-B#show running
Building configuration...

Current configuration : 749 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE2-A
!
!
ip subnet-zero
!
!
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.20.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.9 255.255.255.252
 duplex auto
 speed auto
!

```
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.7 CE2-A 设备配置

```
CE2-A#show running
Building configuration...
```

```
Current configuration : 744 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE1-B
!
!
ip subnet-zero
!
!
!
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.100.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.17 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
```

```
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

1.3.8　CE2-B 设备配置

```
CE2-B#show running
Building configuration...

Current configuration : 744 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
```

```
hostname CE2-B
!
!
ip subnet-zero
!
!
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.200.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.21 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
```

!

!

!

call rsvp-sync

!

!

mgcp profile default

!

!

!

dial-peer cor custom

!

!

!

!

line con 0

  exec-timeout 0 0

line aux 0

line vty 0 4

  exec-timeout 0 0

  login

!

!

end

1.4　配置验证

1.4.1　PE1-ASBR-A 设备配置

PE1-ASBR-A#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	1	FULL/BDR	00:00:36	10.10.10.2	Ethernet1/0

PE1-ASBR-A#show 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, 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

```
        1.0.0.0/32 is subnetted, 1 subnets
C          1.1.1.1 is directly connected, Loopback0
        2.0.0.0/32 is subnetted, 1 subnets
O          2.2.2.2 [110/11] via 10.10.10.2, 01:54:22, Ethernet1/0
        10.0.0.0/30 is subnetted, 1 subnets
C          10.10.10.0 is directly connected, Ethernet1/0
PE1-ASBR-A#show ip bgp summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 1, main routing table version 1


Neighbor         V     AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
2.2.2.2          4    100    222     225       1     0    0 03:30:43        0
PE1-ASBR-A#show ip bgp vpnv4 vrf vpna summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 23, main routing table version 23
5 network entries and 6 paths using 989 bytes of memory
12 BGP path attribute entries using 720 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
4 BGP extended community entries using 128 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 10/0 prefixes, 12/0 paths, scan interval 15 secs


Neighbor         V     AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
192.1.1.2        4    200    121     121      23     0    0 01:54:13        3
PE1-ASBR-A#show ip bgp vpnv4 vrf vpnb summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 23, main routing table version 23
5 network entries and 6 paths using 989 bytes of memory
12 BGP path attribute entries using 720 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
4 BGP extended community entries using 128 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 10/0 prefixes, 12/0 paths, scan interval 15 secs


Neighbor         V     AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
192.2.2.2        4    200    123     122      23     0    0 01:55:23        3
PE1-ASBR-A#


PE1-ASBR-A#show ip bgp vpnv4 vrf vpna labels
    Network          Next Hop      In label/Out label
Route Distinguisher: 1:1 (vpna)
    10.10.10.4/30    2.2.2.2          nolabel/18
    10.10.10.16/30   192.1.1.2        19/nolabel
```

172.16.10.1/32	2.2.2.2	nolabel/20
172.16.100.1/32	192.1.1.2	21/nolabel
192.1.1.0	192.1.1.2	18/nolabel
	0.0.0.0	18/aggregate(vpna)

PE1-ASBR-A#show ip bgp vpnv4 vrf vpnb labels

Network	Next Hop	In label/Out label
Route Distinguisher: 2:2 (vpnb)		
10.10.10.8/30	2.2.2.2	nolabel/19
10.10.10.20/30	192.2.2.2	20/nolabel
172.16.20.1/32	2.2.2.2	nolabel/21
172.16.200.1/32	192.2.2.2	22/nolabel
192.2.2.0	192.2.2.2	16/nolabel
	0.0.0.0	16/aggregate(vpnb)

PE1-ASBR-A#show ip bgp vpnv4 vrf vpna

BGP table version is 23, local router ID is 1.1.1.1

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

               r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (default for vrf vpna)					
*>i10.10.10.4/30	2.2.2.2	0	100	0	?
*> 10.10.10.16/30	192.1.1.2			0	200 ?
*>i172.16.10.1/32	2.2.2.2	11	100	0	?
*> 172.16.100.1/32	192.1.1.2			0	200 ?
* 192.1.1.0	192.1.1.2	0		0	200 ?
*>	0.0.0.0	0		32768	?

PE1-ASBR-A#show ip bgp vpnv4 vrf vpnb

BGP table version is 23, local router ID is 1.1.1.1

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

               r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 2:2 (default for vrf vpnb)					
*>i10.10.10.8/30	2.2.2.2	0	100	0	?
*> 10.10.10.20/30	192.2.2.2			0	200 ?
*>i172.16.20.1/32	2.2.2.2	11	100	0	?
*> 172.16.200.1/32	192.2.2.2			0	200 ?
* 192.2.2.0	192.2.2.2	0		0	200 ?
*>	0.0.0.0	0		32768	?

PE1-ASBR-A#show ip route vrf vpna

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, 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

172.16.0.0/32 is subnetted, 2 subnets

B   172.16.10.1 [200/11] via 2.2.2.2, 03:27:47

B   172.16.100.1 [20/0] via 192.1.1.2, 01:34:29

10.0.0.0/30 is subnetted, 2 subnets

B   10.10.10.4 [200/0] via 2.2.2.2, 03:32:01

B   10.10.10.16 [20/0] via 192.1.1.2, 01:37:41

C   192.1.1.0/24 is directly connected, FastEthernet0/0.1

PE1-ASBR-A#show ip route vrf vpnb

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, 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

172.16.0.0/32 is subnetted, 2 subnets

B   172.16.200.1 [20/0] via 192.2.2.2, 01:32:32

B   172.16.20.1 [200/11] via 2.2.2.2, 03:26:49

10.0.0.0/30 is subnetted, 2 subnets

B   10.10.10.8 [200/0] via 2.2.2.2, 03:32:04

B   10.10.10.20 [20/0] via 192.2.2.2, 01:36:41

C   192.2.2.0/24 is directly connected, FastEthernet0/0.2

PE1-ASBR-A#

1.4.2   PE1-ASBR-B 设备配置

PE1-ASBR-B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
200.200.200.200	1	FULL/BDR	00:00:30	10.10.10.14	Ethernet1/0

PE1-ASBR-B#show 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, 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

200.200.200.0/32 is subnetted, 1 subnets

O   200.200.200.200 [110/11] via 10.10.10.14, 01:42:47, Ethernet1/0

100.0.0.0/32 is subnetted, 1 subnets

C   100.100.100.100 is directly connected, Loopback0

10.0.0.0/30 is subnetted, 1 subnets

C   10.10.10.12 is directly connected, Ethernet1/0

PE1-ASBR-B#show ip bgp vpnv4 vrf vpna summary

BGP router identifier 100.100.100.100, local AS number 200

BGP table version is 21, main routing table version 21

5 network entries and 6 paths using 989 bytes of memory

12 BGP path attribute entries using 720 bytes of memory

1 BGP AS-PATH entries using 24 bytes of memory

4 BGP extended community entries using 128 bytes of memory

0 BGP route-map cache entries using 0 bytes of memory

0 BGP filter-list cache entries using 0 bytes of memory

BGP activity 10/0 prefixes, 12/0 paths, scan interval 15 secs

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
192.1.1.1	4	100	126	126	21	0	0	01:59:27	3

PE1-ASBR-B#show ip bgp vpnv4 vrf vpnb summary

BGP router identifier 100.100.100.100, local AS number 200

BGP table version is 21, main routing table version 21

5 network entries and 6 paths using 989 bytes of memory

12 BGP path attribute entries using 720 bytes of memory

1 BGP AS-PATH entries using 24 bytes of memory

4 BGP extended community entries using 128 bytes of memory

0 BGP route-map cache entries using 0 bytes of memory

0 BGP filter-list cache entries using 0 bytes of memory

BGP activity 10/0 prefixes, 12/0 paths, scan interval 15 secs

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
192.2.2.1	4	100	127	128	21	0	0	02:00:35	3

PE1-ASBR-B#show ip bgp vpnv4 vrf vpna labels ?

  | Output modifiers

PE1-ASBR-B#show ip bgp vpnv4 vrf vpna labels

Network	Next Hop	In label/Out label
Route Distinguisher: 10:10 (vpna)		
10.10.10.4/30	192.1.1.1	21/nolabel
10.10.10.16/30	200.200.200.200	nolabel/17
172.16.10.1/32	192.1.1.1	20/nolabel
172.16.100.1/32	200.200.200.200	nolabel/19
192.1.1.0	192.1.1.1	16/nolabel
	0.0.0.0	16/aggregate(vpna)

PE1-ASBR-B#show ip bgp vpnv4 vrf vpnb labels

Network	Next Hop	In label/Out label
Route Distinguisher: 20:20 (vpnb)		
10.10.10.8/30	192.2.2.1	17/nolabel
10.10.10.20/30	200.200.200.200	nolabel/18
172.16.20.1/32	192.2.2.1	18/nolabel
172.16.200.1/32	200.200.200.200	nolabel/20
192.2.2.0	192.2.2.1	19/nolabel
	0.0.0.0	19/aggregate(vpnb)

PE1-ASBR-B#show ip bgp vpnv4 vrf vpna
BGP table version is 21, local router ID is 100.100.100.100
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

	Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 10:10 (default for vrf vpna)						
*>	10.10.10.4/30	192.1.1.1			0	100 ?
*>i	10.10.10.16/30	200.200.200.200	0	100	0	?
*>	172.16.10.1/32	192.1.1.1			0	100 ?
*>i	172.16.100.1/32	200.200.200.200	11	100	0	?
*	192.1.1.0	192.1.1.1	0		0	100 ?
*>		0.0.0.0	0		32768	?

PE1-ASBR-B#show ip bgp vpnv4 vrf vpnb
BGP table version is 21, local router ID is 100.100.100.100
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

	Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 20:20 (default for vrf vpnb)						
*>	10.10.10.8/30	192.2.2.1			0	100 ?
*>i	10.10.10.20/30	200.200.200.200	0	100	0	?

*> 172.16.20.1/32	192.2.2.1				0 100 ?
*>i172.16.200.1/32	200.200.200.200	11	100		0 ?
* 192.2.2.0	192.2.2.1	0			0 100 ?
*>	0.0.0.0	0			32768 ?

PE1-ASBR-B#show ip route vrf vpna

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, 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

  172.16.0.0/32 is subnetted, 2 subnets

B   172.16.10.1 [20/0] via 192.1.1.1, 02:00:34

B   172.16.100.1 [200/11] via 200.200.200.200, 01:39:24

  10.0.0.0/30 is subnetted, 2 subnets

B   10.10.10.4 [20/0] via 192.1.1.1, 02:00:34

B   10.10.10.16 [200/0] via 200.200.200.200, 01:42:24

C 192.1.1.0/24 is directly connected, FastEthernet0/0.1

PE1-ASBR-B#show ip route vrf vpnb

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, 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

  172.16.0.0/32 is subnetted, 2 subnets

B   172.16.200.1 [200/11] via 200.200.200.200, 01:37:25

B   172.16.20.1 [20/0] via 192.2.2.1, 02:00:47

  10.0.0.0/30 is subnetted, 2 subnets

B   10.10.10.8 [20/0] via 192.2.2.1, 02:00:47

B   10.10.10.20 [200/0] via 200.200.200.200, 01:41:26

C 192.2.2.0/24 is directly connected, FastEthernet0/0.2

PE1-ASBR-B#

1.4.3 PE2-A 设备配置

PE2-A#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
172.16.20.1	1	FULL/BDR	00:00:34	10.10.10.9	Ethernet1/2
172.16.10.1	1	FULL/BDR	00:00:39	10.10.10.5	Ethernet1/1
1.1.1.1	1	FULL/DR	00:00:26	10.10.10.1	Ethernet1/0

PE2-A#show 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, 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

    1.0.0.0/32 is subnetted, 1 subnets

O   1.1.1.1 [110/11] via 10.10.10.1, 02:02:48, Ethernet1/0

    2.0.0.0/32 is subnetted, 1 subnets

C   2.2.2.2 is directly connected, Loopback0

    10.0.0.0/30 is subnetted, 1 subnets

C   10.10.10.0 is directly connected, Ethernet1/0

PE2-A#show ip bgp summary

BGP router identifier 2.2.2.2, local AS number 100

BGP table version is 1, main routing table version 1

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
1.1.1.1	4	100	234	231	1	0	0	03:39:05	0

PE2-A#show ip bgp vpnv4 vrf vpna summary

PE2-A#show ip bgp vpnv4 vrf vpnb summary

PE2-A#show ip bgp vpnv4 vrf vpna labels

Network	Next Hop	In label/Out label
Route Distinguisher: 1:1 (vpna)		
10.10.10.4/30	0.0.0.0	18/aggregate(vpna)
10.10.10.16/30	1.1.1.1	nolabel/19
172.16.10.1/32	10.10.10.5	20/nolabel
172.16.100.1/32	1.1.1.1	nolabel/21
192.1.1.0	1.1.1.1	nolabel/18

PE2-A#show ip bgp vpnv4 vrf vpnb labels

Network	Next Hop	In label/Out label
Route Distinguisher: 2:2 (vpnb)		
10.10.10.8/30	0.0.0.0	19/aggregate(vpnb)
10.10.10.20/30	1.1.1.1	nolabel/20
172.16.20.1/32	10.10.10.9	21/nolabel
172.16.200.1/32	1.1.1.1	nolabel/22
192.2.2.0	1.1.1.1	nolabel/16

PE2-A#show ip route vrf vpna
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, 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

     172.16.0.0/32 is subnetted, 2 subnets
O   172.16.10.1 [110/11] via 10.10.10.5, 03:35:04, Ethernet1/1
B   172.16.100.1 [200/0] via 1.1.1.1, 01:41:21
     10.0.0.0/30 is subnetted, 2 subnets
C   10.10.10.4 is directly connected, Ethernet1/1
B   10.10.10.16 [200/0] via 1.1.1.1, 01:44:36
B   192.1.1.0/24 [200/0] via 1.1.1.1, 02:03:38

PE2-A#show ip route vrf vpnb
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, 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

     172.16.0.0/32 is subnetted, 2 subnets
B   172.16.200.1 [200/0] via 1.1.1.1, 01:39:38
O   172.16.20.1 [110/11] via 10.10.10.9, 03:34:03, Ethernet1/2
     10.0.0.0/30 is subnetted, 2 subnets
C   10.10.10.8 is directly connected, Ethernet1/2
B   10.10.10.20 [200/0] via 1.1.1.1, 01:43:38
B   192.2.2.0/24 [200/0] via 1.1.1.1, 03:39:48

PE2-A#

1.4.4　PE2-B 设备配置

PE2-B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
172.16.200.1	1	FULL/BDR	00:00:36	10.10.10.21	Ethernet1/2
172.16.100.1	1	FULL/BDR	00:00:37	10.10.10.17	Ethernet1/1
100.100.100.100	1	FULL/DR	00:00:39	10.10.10.13	Ethernet1/0

PE2-B#show 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, 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

  200.200.200.0/32 is subnetted, 1 subnets

C 200.200.200.200 is directly connected, Loopback0

  100.0.0.0/32 is subnetted, 1 subnets

O 100.100.100.100 [110/11] via 10.10.10.13, 01:51:06, Ethernet1/0

  10.0.0.0/30 is subnetted, 1 subnets

C 10.10.10.12 is directly connected, Ethernet1/0

PE2-B#show ip bgp summary

BGP router identifier 200.200.200.200, local AS number 200

BGP table version is 1, main routing table version 1

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
100.100.100.100	4	200	120	122	1	0	0	01:48:50	0

PE2-B#show ip bgp vpnv4 vrf vpna summary

PE2-B#show ip bgp vpnv4 vrf vpnb summary

PE2-B#show ip bgp vpnv4 vrf vpna labels

Network	Next Hop	In label/Out label
Route Distinguisher: 10:10 (vpna)		
10.10.10.4/30	100.100.100.100	nolabel/21
10.10.10.16/30	0.0.0.0	17/aggregate(vpna)
172.16.10.1/32	100.100.100.100	nolabel/20
172.16.100.1/32	10.10.10.17	19/nolabel

192.1.1.0   100.100.100.100 nolabel/16

PE2-B#show ip bgp vpnv4 vrf vpnb labels
    Network   Next Hop   In label/Out label
Route Distinguisher: 20:20 (vpnb)
    10.10.10.8/30   100.100.100.100 nolabel/17
    10.10.10.20/30   0.0.0.0   18/aggregate(vpnb)
    172.16.20.1/32   100.100.100.100 nolabel/18
    172.16.200.1/32   10.10.10.21   20/nolabel
    192.2.2.0   100.100.100.100 nolabel/19

PE2-B#show ip vpnv4 vrf vpna
                   ^
% Invalid input detected at '^' marker.

PE2-B#show ip bgp vpnv4 vrf vpna
BGP table version is 21, local router ID is 200.200.200.200
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 10:10 (default for vrf vpna)
*>i10.10.10.4/30   100.100.100.100   100   0 100 ?
*> 10.10.10.16/30   0.0.0.0   0   32768 ?
*>i172.16.10.1/32   100.100.100.100   100   0 100 ?
*> 172.16.100.1/32   10.10.10.17   11   32768 ?
*>i192.1.1.0   100.100.100.100   0   100   0 ?
PE2-B#show ip bgp vpnv4 vrf vpnb
BGP table version is 21, local router ID is 200.200.200.200
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 20:20 (default for vrf vpnb)
*>i10.10.10.8/30   100.100.100.100   100   0 100 ?
*> 10.10.10.20/30   0.0.0.0   0   32768 ?
*>i172.16.20.1/32   100.100.100.100   100   0 100 ?
*> 172.16.200.1/32   10.10.10.21   11   32768 ?
*>i192.2.2.0   100.100.100.100   0   100   0 ?
PE2-B#show ip route vrf vpna
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, 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

172.16.0.0/32 is subnetted, 2 subnets
B   172.16.10.1 [200/0] via 100.100.100.100, 01:49:43
O   172.16.100.1 [110/11] via 10.10.10.17, 01:46:30, Ethernet1/1
10.0.0.0/30 is subnetted, 2 subnets
B   10.10.10.4 [200/0] via 100.100.100.100, 01:49:43
C   10.10.10.16 is directly connected, Ethernet1/1
B   192.1.1.0/24 [200/0] via 100.100.100.100, 01:49:43
PE2-B#show ip route vrf vpnb

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, 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

172.16.0.0/32 is subnetted, 2 subnets
O   172.16.200.1 [110/11] via 10.10.10.21, 01:44:34, Ethernet1/2
B   172.16.20.1 [200/0] via 100.100.100.100, 01:49:46
10.0.0.0/30 is subnetted, 2 subnets
B   10.10.10.8 [200/0] via 100.100.100.100, 01:49:46
C   10.10.10.20 is directly connected, Ethernet1/2
B   192.2.2.0/24 [200/0] via 100.100.100.100, 01:49:46
PE2-B#

1.4.5 CE1-A 设备配置

CE1-A#show ip ospf neighbor

Neighbor ID   Pri   State   Dead Time   Address   Interface
10.10.10.6   1   FULL/DR   00:00:31   10.10.10.6   FastEthernet0/
0
CE1-A#show 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, 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

    172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C   172.16.10.0/24 is directly connected, Loopback0
O E2   172.16.100.1/32 [110/1] via 10.10.10.6, 01:47:02, FastEthernet0/0
    10.0.0.0/30 is subnetted, 2 subnets
C   10.10.10.4 is directly connected, FastEthernet0/0
O E2   10.10.10.16 [110/1] via 10.10.10.6, 01:50:15, FastEthernet0/0
O E2 192.1.1.0/24 [110/1] via 10.10.10.6, 02:08:48, FastEthernet0/0
CE1-A#

CE1-A#traceroute
Protocol [ip]:
Target IP address: 172.16.100.1
Source address: 172.16.10.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.100.1

  1 10.10.10.6 164 msec 260 msec 240 msec
  2 192.1.1.1 [MPLS: Label 21 Exp 0] 504 msec 524 msec 552 msec
  3 192.1.1.2 480 msec 764 msec 480 msec
  4 10.10.10.18 [MPLS: Label 19 Exp 0] 792 msec 884 msec 856 msec
  5 10.10.10.17 1128 msec 1056 msec 1196 msec
CE1-A#

1.4.6　CE1-B 设备配置

CE2-A#show ip ospf neighbor

Neighbor ID   Pri   State   Dead Time   Address   Interface

| 10.10.10.10 | 1 | FULL/DR | 00:00:35 | 10.10.10.10 | FastEthernet0/0 |

CE2-A#show 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, 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

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks

O E2   172.16.200.1/32 [110/1] via 10.10.10.10, 01:45:46, FastEthernet0/0

C   172.16.20.0/24 is directly connected, Loopback0

     10.0.0.0/30 is subnetted, 2 subnets

C   10.10.10.8 is directly connected, FastEthernet0/0

O E2   10.10.10.20 [110/1] via 10.10.10.10, 01:49:46, FastEthernet0/0

O E2 192.2.2.0/24 [110/1] via 10.10.10.10, 03:39:51, FastEthernet0/0

CE1-B#

CE1-B#traceroute

Protocol [ip]:

Target IP address: 172.16.200.1

Source address: 172.16.20.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.200.1

  1 10.10.10.10 272 msec 168 msec 192 msec

  2 192.2.2.1 [MPLS: Label 22 Exp 0] 480 msec 572 msec 288 msec

  3 192.2.2.2 528 msec 620 msec 696 msec

  4 10.10.10.22 [MPLS: Label 20 Exp 0] 1104 msec 2312 msec 2124 msec

  5 10.10.10.21 1008 msec 1340 msec 1320 msec

CE1-B#

1.4.7　CE1-B 设备配置

CE1-B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.10.10.18	1	FULL/DR	00:00:33	10.10.10.18	FastEthernet0/0

CE1-B#show 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, 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

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks

O E2   172.16.10.1/32 [110/1] via 10.10.10.18, 01:49:36, FastEthernet0/0

C   172.16.100.0/24 is directly connected, Loopback0

     10.0.0.0/30 is subnetted, 2 subnets

O E2   10.10.10.4 [110/1] via 10.10.10.18, 01:49:36, FastEthernet0/0

C   10.10.10.16 is directly connected, FastEthernet0/0

O E2 192.1.1.0/24 [110/1] via 10.10.10.18, 01:49:36, FastEthernet0/0

CE2-A#

CE2-A#traceroute

Protocol [ip]:

Target IP address: 172.16.10.1

Source address: 172.16.100.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.10.1

  1 10.10.10.18 148 msec 772 msec 792 msec

  2 192.1.1.2 [MPLS: Label 20 Exp 0] 828 msec 1472 msec 1256 msec

  3 192.1.1.1 1788 msec 1052 msec 528 msec

4 10.10.10.6 [MPLS: Label 20 Exp 0] 892 msec 968 msec 796 msec

5 10.10.10.5 840 msec 1100 msec 1320 msec

CE2-A#

1.4.8 CE2-B 设备配置

CE2-B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.10.10.22	1	FULL/DR	00:00:39	10.10.10.22	FastEthernet0/0

CE2-B#show 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, 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

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks

C   172.16.200.0/24 is directly connected, Loopback0

O E2   172.16.20.1/32 [110/1] via 10.10.10.22, 01:48:31, FastEthernet0/0

     10.0.0.0/30 is subnetted, 2 subnets

O E2   10.10.10.8 [110/1] via 10.10.10.22, 01:48:31, FastEthernet0/0

C   10.10.10.20 is directly connected, FastEthernet0/0

O E2 192.2.2.0/24 [110/1] via 10.10.10.22, 01:48:31, FastEthernet0/0

CE2-B#

CE2-B#traceroute

Protocol [ip]:

Target IP address: 172.16.20.1

Source address: 172.16.200.1

Numeric display [n]:

Timeout in seconds [3]:

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.20.1

1 10.10.10.22 296 msec 260 msec 192 msec

2 192.2.2.2 [MPLS: Label 18 Exp 0] 408 msec 452 msec 312 msec

3 192.2.2.1 672 msec 860 msec 744 msec

4 10.10.10.10 [MPLS: Label 21 Exp 0] 864 msec 1004 msec 696 msec

5 10.10.10.9 1104 msec 1244 msec 1328 msec

CE2-B#

2 单跳 MP-EBGP（不改变下一跳）模式

2.1 网络拓扑图
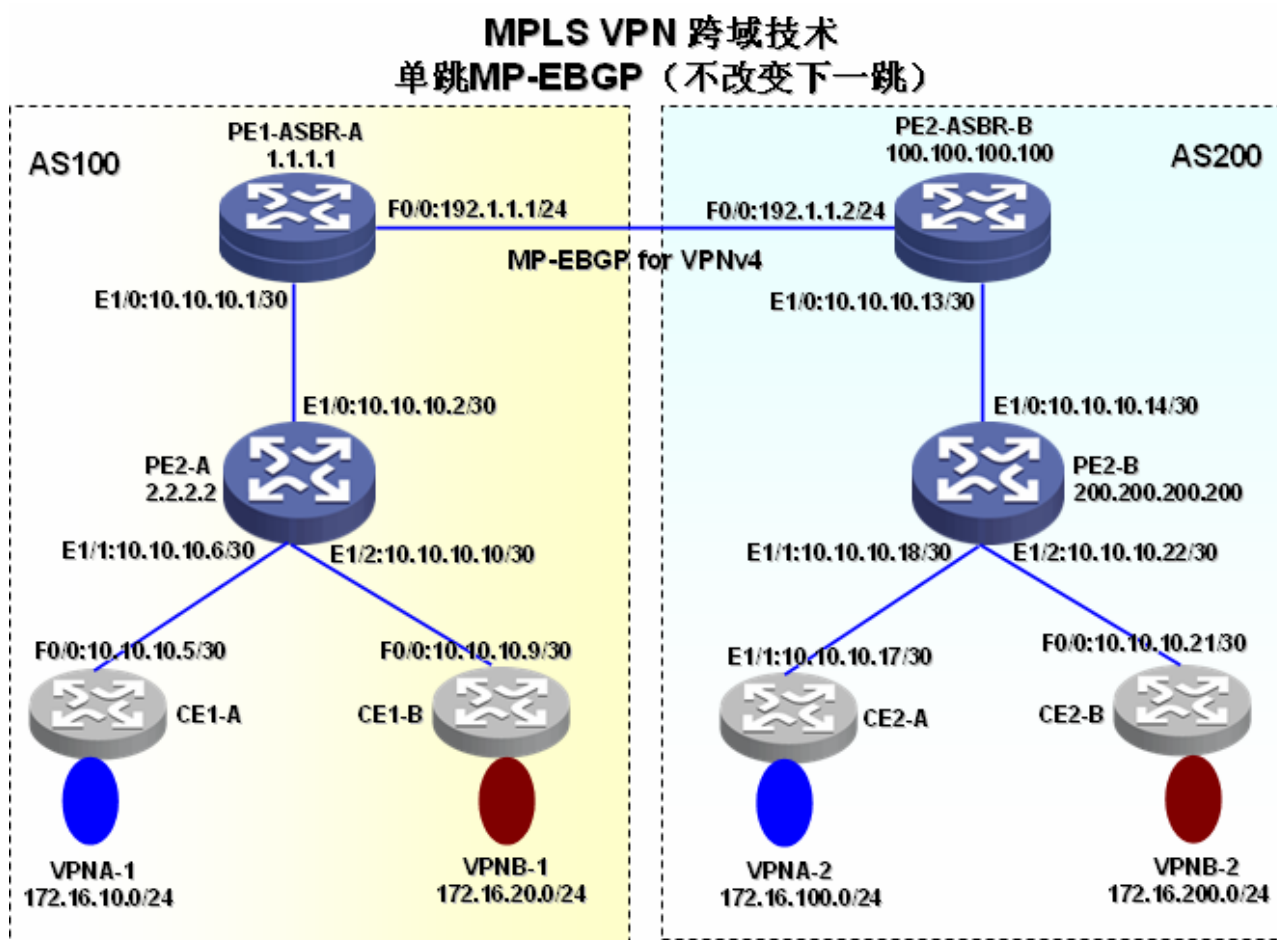
2.2 应用需求

采用 MPLS VPN 跨域的第二种方式（OptionB）：单跳 MP-EBGP（不改变下一跳方式）来达到在不同 AS 域的同一个 VPN 的用户能够互相通信，即 VPNA-1 和 VPNA-2 之间，VPNB-1 和 VPNB-2 之间的用户能够互相通信。

2.3 设备配置

2.3.1 PE1-ASBR-A 设备配置

PE1-ASBR-A#show running
Building configuration...

Current configuration : 1662 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE1-ASBR-A
!
!
ip subnet-zero
!
!
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!

```
interface FastEthernet0/0
 ip address 192.1.1.1 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 10.10.10.1 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 redistribute connected subnets
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 10.10.10.0 0.0.0.3 area 0.0.0.0
 default-information originate
!
router bgp 100
 no synchronization
 no bgp default route-target filter
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
```

```
  neighbor 2.2.2.2 update-source Loopback0
  neighbor 192.1.1.2 remote-as 200
  no auto-summary
  !
  address-family vpnv4
  neighbor 2.2.2.2 activate
  neighbor 2.2.2.2 send-community extended
  neighbor 192.1.1.2 activate
  neighbor 192.1.1.2 send-community both
  no auto-summary
  exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

2.3.2　PE1-ASBR-B 设备配置

PE1-ASBR-B#show running

Building configuration...

Current configuration : 1720 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE1-ASBR-B
!
!
ip subnet-zero
!
!
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 100.100.100.100 255.255.255.255
!
interface FastEthernet0/0
 ip address 192.1.1.2 255.255.255.0
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address

```
  shutdown
  duplex auto
  speed auto
!
interface Ethernet1/0
  ip address 10.10.10.13 255.255.255.252
  half-duplex
  mpls label protocol ldp
  tag-switching ip
!
interface Ethernet1/1
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/2
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/3
  no ip address
  shutdown
  half-duplex
!
router ospf 1
  router-id 100.100.100.100
  log-adjacency-changes
  redistribute connected subnets
  network 10.10.10.12 0.0.0.3 area 0.0.0.0
  network 100.100.100.100 0.0.0.0 area 0.0.0.0
  default-information originate
!
router bgp 200
  no synchronization
  no bgp default route-target filter
  bgp log-neighbor-changes
  neighbor 192.1.1.1 remote-as 100
  neighbor 200.200.200.200 remote-as 200
  neighbor 200.200.200.200 update-source Loopback0
  no auto-summary
  !
  address-family vpnv4
  neighbor 192.1.1.1 activate
  neighbor 192.1.1.1 send-community both
```

```
   neighbor 200.200.200.200 activate
   neighbor 200.200.200.200 send-community extended
   no auto-summary
   exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

2.3.3 PE2-A 设备配置

```
PE2-A#show running
Building configuration...

Current configuration : 2188 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
```

```
no service password-encryption
!
hostname PE2-A
!
!
ip subnet-zero
!
!
!
ip vrf vpna
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpnb
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
```

```
  speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 10.10.10.2 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip vrf forwarding vpna
 ip address 10.10.10.6 255.255.255.252
 half-duplex
!
interface Ethernet1/2
 ip vrf forwarding vpnb
 ip address 10.10.10.10 255.255.255.252
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 10 vrf vpna
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
```

```
  no synchronization
  no bgp default route-target filter
  bgp log-neighbor-changes
  neighbor 1.1.1.1 remote-as 100
  neighbor 1.1.1.1 update-source Loopback0
  no auto-summary
  !
  address-family ipv4 vrf vpnb
  redistribute connected
  redistribute ospf 20
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family ipv4 vrf vpna
  redistribute connected
  redistribute ospf 10
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family vpnv4
  neighbor 1.1.1.1 activate
  neighbor 1.1.1.1 send-community both
  no auto-summary
  exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
```

```
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

2.3.4 PE2-B 设备配置

```
PE2-B#show running
Building configuration...

Current configuration : 2238 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE2-B
!
!
ip subnet-zero
!
!
!
ip vrf vpna
  rd 1:1
  route-target export 1:1
  route-target import 1:1
!
ip vrf vpnb
  rd 2:2
  route-target export 2:2
  route-target import 2:2
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
```

```
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 200.200.200.200 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 10.10.10.14 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip vrf forwarding vpna
 ip address 10.10.10.18 255.255.255.252
 half-duplex
!
interface Ethernet1/2
 ip vrf forwarding vpnb
 ip address 10.10.10.22 255.255.255.252
 half-duplex
```

```
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 200.200.200.200
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 10 vrf vpna
 log-adjacency-changes
 redistribute bgp 200 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
 log-adjacency-changes
 redistribute bgp 200 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 200
 no synchronization
 no bgp default route-target filter
 bgp log-neighbor-changes
 neighbor 100.100.100.100 remote-as 200
 neighbor 100.100.100.100 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpnb
 redistribute connected
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpna
 redistribute connected
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 100.100.100.100 activate
```

```
  neighbor 100.100.100.100 send-community both
  no auto-summary
  exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

2.3.5 CE1-A 设备配置

```
CE1-A#show running
Building configuration...

Current configuration : 749 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
```

```
!
hostname CE1-A
!
!
ip subnet-zero
!
!
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.10.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.5 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
```

!

!

!

!

!

call rsvp-sync

!

!

mgcp profile default

!

!

!

dial-peer cor custom

!

!

!

!

line con 0

  exec-timeout 0 0

line aux 0

line vty 0 4

  exec-timeout 0 0

  login

!

!

end

2.3.6 CE2-A 设备配置

CE2-A#show running

Building configuration...

Current configuration : 744 bytes

!

version 12.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname CE2-A

!

!

ip subnet-zero

!

!

!

!

!

!

!

!

!

!

!

!

!

!

mta receive maximum-recipients 0

!

!

!

!

interface Loopback0

 ip address 172.16.100.1 255.255.255.0

!

interface FastEthernet0/0

 ip address 10.10.10.17 255.255.255.252

 duplex auto

 speed auto

!

interface FastEthernet0/1

 no ip address

 shutdown

 duplex auto

 speed auto

!

router ospf 1

 log-adjacency-changes

 network 0.0.0.0 255.255.255.255 area 0.0.0.0

!

ip classless

ip http server

!

!

!

!

!

call rsvp-sync

!

```
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

2.3.7　CE1-B 设备配置

```
CE1-B#show running
Building configuration...

Current configuration : 749 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE1-B
!
!
ip subnet-zero
!
!
!
ip cef
!
!
!
!
```

```
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.20.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.9 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
```

!

!

!

!

line con 0

  exec-timeout 0 0

line aux 0

line vty 0 4

  exec-timeout 0 0

  login

!

!

end

2.3.8 CE2-B 设备配置

CE2-B#show running

Building configuration...

Current configuration : 744 bytes

!

version 12.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname CE2-B

!

!

ip subnet-zero

!

!

!

!

!

!

!

!

!

!

!

!

!

!

```
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.200.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.21 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
```

line vty 0 4

exec-timeout 0 0

login

!

!

end

2.4 配置验证

2.4.1 PE1-ASBR-A 配置验证

PE1-ASBR-A#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	1	FULL/BDR	00:00:33	10.10.10.2	Ethernet1/0

PE1-ASBR-A#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets

C   1.1.1.1 is directly connected, Loopback0

     2.0.0.0/32 is subnetted, 1 subnets

O   2.2.2.2 [110/11] via 10.10.10.2, 00:17:42, Ethernet1/0

     10.0.0.0/30 is subnetted, 1 subnets

C   10.10.10.0 is directly connected, Ethernet1/0

     192.1.1.0/24 is variably subnetted, 2 subnets, 2 masks

C   192.1.1.0/24 is directly connected, FastEthernet0/0

C   192.1.1.2/32 is directly connected, FastEthernet0/0

PE1-ASBR-A#show ip bgp summary

BGP router identifier 1.1.1.1, local AS number 100

BGP table version is 1, main routing table version 1

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2.2.2.2	4	100	29	25	1	0	0	00:17:44	0
192.1.1.2	4	200	28	28	1	0	0	00:20:05	0

PE1-ASBR-A#show ip bgp vpnv4 all

BGP table version is 9, local router ID is 1.1.1.1

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1					
*>i10.10.10.4/30	2.2.2.2	0	100	0	?
*> 10.10.10.16/30	192.1.1.2			0	200 ?
*>i172.16.10.1/32	2.2.2.2	11	100	0	?
*> 172.16.100.1/32	192.1.1.2			0	200 ?
Route Distinguisher: 2:2					
*>i10.10.10.8/30	2.2.2.2	0	100	0	?
*> 10.10.10.20/30	192.1.1.2			0	200 ?
*>i172.16.20.1/32	2.2.2.2	11	100	0	?
*> 172.16.200.1/32	192.1.1.2			0	200 ?

PE1-ASBR-A#

PE1-ASBR-A#show ip bgp vpnv4 rd 1:1 labels

Network	Next Hop	In label/Out label
Route Distinguisher: 1:1		
10.10.10.4/30	2.2.2.2	18/19
10.10.10.16/30	192.1.1.2	nolabel/18
172.16.10.1/32	2.2.2.2	20/21
172.16.100.1/32	192.1.1.2	nolabel/20

PE1-ASBR-A#show ip bgp vpnv4 rd 2:2 labels

Network	Next Hop	In label/Out label
Route Distinguisher: 2:2		
10.10.10.8/30	2.2.2.2	19/20
10.10.10.20/30	192.1.1.2	nolabel/19
172.16.20.1/32	2.2.2.2	21/22
172.16.200.1/32	192.1.1.2	nolabel/21

PE1-ASBR-A#

PE1-ASBR-A#show tag-switching forwarding-table

Local tag	Outgoing tag or VC	Prefix or Tunnel Id	Bytes tag switched	Outgoing interface	Next Hop
16	Pop tag	192.1.1.2/32	1180	Fa0/0	192.1.1.2
17	Pop tag	2.2.2.2/32	0	Et1/0	10.10.10.2
18	19	1:1:10.10.10.4/30	\		
			590	Et1/0	10.10.10.2
19	20	2:2:10.10.10.8/30	\		
			590	Et1/0	10.10.10.2

20	21	1:1:172.16.10.1/32	\			
			0	Et1/0	10.10.10.2	
21	22	2:2:172.16.20.1/32	\			
			0	Et1/0	10.10.10.2	

PE1-ASBR-A#

2.4.2 PE2-ASBR-B 配置验证

PE1-ASBR-B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
200.200.200.200	1	FULL/BDR	00:00:35	10.10.10.14	Ethernet1/0

PE1-ASBR-B#show 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, 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

     200.200.200.0/32 is subnetted, 1 subnets

O   200.200.200.200 [110/11] via 10.10.10.14, 00:19:27, Ethernet1/0

     100.0.0.0/32 is subnetted, 1 subnets

C   100.100.100.100 is directly connected, Loopback0

     10.0.0.0/30 is subnetted, 1 subnets

C   10.10.10.12 is directly connected, Ethernet1/0

     192.1.1.0/24 is variably subnetted, 2 subnets, 2 masks

C   192.1.1.0/24 is directly connected, FastEthernet0/0

C   192.1.1.1/32 is directly connected, FastEthernet0/0

PE1-ASBR-B#show ip bgp summary

BGP router identifier 100.100.100.100, local AS number 200

BGP table version is 1, main routing table version 1

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
192.1.1.1	4	100	31	31	1	0	0	00:23:59	0
200.200.200.200	4	200	31	27	1	0	0	00:19:21	0

PE1-ASBR-B#show ip bgp vpnv4 all

BGP table version is 9, local router ID is 100.100.100.100

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

            r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1					
*> 10.10.10.4/30	192.1.1.1			0 100	?
*>i10.10.10.16/30	200.200.200.200	0	100	0	?
*> 172.16.10.1/32	192.1.1.1			0 100	?
*>i172.16.100.1/32	200.200.200.200	11	100	0	?
Route Distinguisher: 2:2					
*> 10.10.10.8/30	192.1.1.1			0 100	?
*>i10.10.10.20/30	200.200.200.200	0	100	0	?
*> 172.16.20.1/32	192.1.1.1			0 100	?
*>i172.16.200.1/32	200.200.200.200	11	100	0	?

PE1-ASBR-B#show ip bgp vpnv4 rd 1:1 labels

Network	Next Hop	In label/Out label
Route Distinguisher: 1:1		
10.10.10.4/30	192.1.1.1	nolabel/18
10.10.10.16/30	200.200.200.200	18/19
172.16.10.1/32	192.1.1.1	nolabel/20
172.16.100.1/32	200.200.200.200	20/21

PE1-ASBR-B#show ip bgp vpnv4 rd 2:2 labels

Network	Next Hop	In label/Out label
Route Distinguisher: 2:2		
10.10.10.8/30	192.1.1.1	nolabel/19
10.10.10.20/30	200.200.200.200	19/20
172.16.20.1/32	192.1.1.1	nolabel/21
172.16.200.1/32	200.200.200.200	21/22

PE1-ASBR-B#show tag for

PE1-ASBR-B#show tag forwarding-table

Local tag	Outgoing tag or VC	Prefix or Tunnel Id	Bytes tag switched	Outgoing interface	Next Hop
16	Pop tag	192.1.1.1/32	1180	Fa0/0	192.1.1.1
17	Pop tag	200.200.200.200/32 \			
			0	Et1/0	10.10.10.14
18	19	1:1:10.10.10.16/30 \			
			0	Et1/0	10.10.10.14
19	20	2:2:10.10.10.20/30 \			
			0	Et1/0	10.10.10.14
20	21	1:1:172.16.100.1/32 \			
			590	Et1/0	10.10.10.14
21	22	2:2:172.16.200.1/32 \			
			590	Et1/0	10.10.10.14

PE1-ASBR-B#

2.4.3 PE2-A 配置验证

PE2-A#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
172.16.20.1	1	FULL/BDR	00:00:34	10.10.10.9	Ethernet1/2
172.16.10.1	1	FULL/BDR	00:00:30	10.10.10.5	Ethernet1/1
1.1.1.1	1	FULL/DR	00:00:37	10.10.10.1	Ethernet1/0

PE2-A#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets

O   1.1.1.1 [110/11] via 10.10.10.1, 00:24:06, Ethernet1/0

     2.0.0.0/32 is subnetted, 1 subnets

C   2.2.2.2 is directly connected, Loopback0

     10.0.0.0/30 is subnetted, 1 subnets

C   10.10.10.0 is directly connected, Ethernet1/0

     192.1.1.0/24 is variably subnetted, 2 subnets, 2 masks

O E2   192.1.1.0/24 [110/20] via 10.10.10.1, 00:24:06, Ethernet1/0

O E2   192.1.1.2/32 [110/20] via 10.10.10.1, 00:24:06, Ethernet1/0

PE2-A#show ip bgp vpnv4 vrf vpna summary

PE2-A#show ip bgp vpnv4 vrf vpna

BGP table version is 17, local router ID is 2.2.2.2

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

            r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (default for vrf vpna)					
*> 10.10.10.4/30	0.0.0.0	0		32768	?
*>i10.10.10.16/30	192.1.1.2		100	0	200 ?
*> 172.16.10.1/32	10.10.10.5	11		32768	?
*>i172.16.100.1/32	192.1.1.2		100	0	200 ?

PE2-A#show ip bgp vpnv4 vrf vpna labels

Network	Next Hop	In label/Out label

Route Distinguisher: 1:1 (vpna)

10.10.10.4/30	0.0.0.0	19/aggregate(vpna)
10.10.10.16/30	192.1.1.2	nolabel/18
172.16.10.1/32	10.10.10.5	21/nolabel
172.16.100.1/32	192.1.1.2	nolabel/20

PE2-A#show ip bgp vpnv4 vrf vpnb

BGP table version is 17, local router ID is 2.2.2.2

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

              r RIB-failure

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

Network	Next Hop	Metric LocPrf Weight Path

Route Distinguisher: 2:2 (default for vrf vpnb)

*> 10.10.10.8/30	0.0.0.0	0		32768 ?	
*>i10.10.10.20/30	192.1.1.2		100	0 200 ?	
*> 172.16.20.1/32	10.10.10.9	11		32768 ?	
*>i172.16.200.1/32	192.1.1.2		100	0 200 ?	

PE2-A#show ip bgp vpnv4 vrf vpnb labels

Network	Next Hop	In label/Out label

Route Distinguisher: 2:2 (vpnb)

10.10.10.8/30	0.0.0.0	20/aggregate(vpnb)
10.10.10.20/30	192.1.1.2	nolabel/19
172.16.20.1/32	10.10.10.9	22/nolabel
172.16.200.1/32	192.1.1.2	nolabel/21

PE2-A#show tag forwarding-table

Local tag	Outgoing tag or VC	Prefix or Tunnel Id	Bytes tag switched	Outgoing interface	Next Hop
16	Pop tag	1.1.1.1/32	0	Et1/0	10.10.10.1
17	Pop tag	192.1.1.0/24	0	Et1/0	10.10.10.1
18	16	192.1.1.2/32	0	Et1/0	10.10.10.1
19	Aggregate	10.10.10.4/30[V]	520		
20	Aggregate	10.10.10.8/30[V]	520		
21	Untagged	172.16.10.1/32[V]	0	Et1/1	10.10.10.5
22	Untagged	172.16.20.1/32[V]	0	Et1/2	10.10.10.9

PE2-A#

2.4.4 PE2-B 配置验证

PE2-B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface

172.16.200.1	1	FULL/BDR	00:00:34	10.10.10.21	Ethernet1/2
172.16.100.1	1	FULL/BDR	00:00:37	10.10.10.17	Ethernet1/1
100.100.100.100	1	FULL/DR	00:00:35	10.10.10.13	Ethernet1/0

PE2-B#show 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, 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

    200.200.200.0/32 is subnetted, 1 subnets

C   200.200.200.200 is directly connected, Loopback0

    100.0.0.0/32 is subnetted, 1 subnets

O   100.100.100.100 [110/11] via 10.10.10.13, 00:27:32, Ethernet1/0

    10.0.0.0/30 is subnetted, 1 subnets

C   10.10.10.12 is directly connected, Ethernet1/0

    192.1.1.0/24 is variably subnetted, 2 subnets, 2 masks

O E2   192.1.1.0/24 [110/20] via 10.10.10.13, 00:27:32, Ethernet1/0

O E2   192.1.1.1/32 [110/20] via 10.10.10.13, 00:27:32, Ethernet1/0

PE2-B#show ip bgp summary

BGP router identifier 200.200.200.200, local AS number 200

BGP table version is 1, main routing table version 1

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
100.100.100.100	4	200	35	39	1	0	0	00:27:30	0

PE2-B#show ip vpnv4 vrf vpna

         ^

% Invalid input detected at '^' marker.

PE2-B#show ip bgp vpnv4 vrf vpna

BGP table version is 17, local router ID is 200.200.200.200

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

        r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (default for vrf vpna)					
*>i10.10.10.4/30	192.1.1.1		100	0	100 ?
*> 10.10.10.16/30	0.0.0.0	0		32768	?
*>i172.16.10.1/32	192.1.1.1		100	0	100 ?
*> 172.16.100.1/32	10.10.10.17	11		32768	?

```
PE2-B#show ip bgp vpnv4 vrf vpna labels
    Network           Next Hop        In label/Out label
Route Distinguisher: 1:1 (vpna)
    10.10.10.4/30     192.1.1.1       nolabel/18
    10.10.10.16/30    0.0.0.0         19/aggregate(vpna)
    172.16.10.1/32    192.1.1.1       nolabel/20
    172.16.100.1/32   10.10.10.17     21/nolabel


PE2-B#show ip bgp vpnv4 vrf vpnb
BGP table version is 17, local router ID is 200.200.200.200
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete


    Network           Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 2:2 (default for vrf vpnb)
*>i10.10.10.8/30     192.1.1.1                  100       0 100 ?
*> 10.10.10.20/30    0.0.0.0              0          32768 ?
*>i172.16.20.1/32    192.1.1.1                  100       0 100 ?
*> 172.16.200.1/32   10.10.10.21         11         32768 ?
PE2-B#show ip bgp vpnv4 vrf vpnb labels
    Network           Next Hop        In label/Out label
Route Distinguisher: 2:2 (vpnb)
    10.10.10.8/30     192.1.1.1       nolabel/19
    10.10.10.20/30    0.0.0.0         20/aggregate(vpnb)
    172.16.20.1/32    192.1.1.1       nolabel/21
    172.16.200.1/32   10.10.10.21     22/nolabel


PE2-B#show tag for
PE2-B#show tag forwarding-table
Local   Outgoing     Prefix              Bytes tag  Outgoing    Next Hop
tag     tag or VC    or Tunnel Id        switched   interface
16      Pop tag      100.100.100.100/32     \
                                        0          Et1/0       10.10.10.13
17      Pop tag      192.1.1.0/24        0          Et1/0       10.10.10.13
18      16           192.1.1.1/32        0          Et1/0       10.10.10.13
19      Aggregate    10.10.10.16/30[V] 0
20      Aggregate    10.10.10.20/30[V] 0
21      Untagged     172.16.100.1/32[V]     \
                                        570        Et1/1       10.10.10.17
22      Untagged     172.16.200.1/32[V]     \
                                        570        Et1/2       10.10.10.21
PE2-B#
```

2.4.5 CE1-A 配置验证

CE1-A#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.10.10.6	1	FULL/DR	00:00:37	10.10.10.6	FastEthernet0/0

CE1-A#show 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, 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

  172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks

C   172.16.10.0/24 is directly connected, Loopback0

O IA 172.16.100.1/32 [110/2] via 10.10.10.6, 00:21:47, FastEthernet0/0

  10.0.0.0/30 is subnetted, 2 subnets

C   10.10.10.4 is directly connected, FastEthernet0/0

O IA 10.10.10.16 [110/2] via 10.10.10.6, 00:27:18, FastEthernet0/0

CE1-A#tracer

CE1-A#traceroute

Protocol [ip]:

Target IP address: 172.16.100.1

Source address: 172.16.10.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.100.1

 1 10.10.10.6 704 msec 324 msec 216 msec

 2 10.10.10.1 [MPLS: Labels 16/20 Exp 0] 2112 msec 3404 msec 2136 msec

 3 192.1.1.2 [MPLS: Label 20 Exp 0] 1896 msec 2372 msec 2400 msec

 4 10.10.10.18 [MPLS: Label 21 Exp 0] 1140 msec 908 msec 1272 msec

 5 10.10.10.17 1128 msec 992 msec 1008 msec

CE1-A#

2.4.6 CE2-A 配置验证

CE2-A#show ip ospf neighbor

Neighbor ID   Pri   State   Dead Time   Address   Interface
10.10.10.18   1   FULL/DR   00:00:36   10.10.10.18   FastEthernet0/
0
CE2-A#show 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, 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

        172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O IA   172.16.10.1/32 [110/2] via 10.10.10.18, 00:31:39, FastEthernet0/0
C   172.16.100.0/24 is directly connected, Loopback0
        10.0.0.0/30 is subnetted, 2 subnets
O IA   10.10.10.4 [110/2] via 10.10.10.18, 00:31:39, FastEthernet0/0
C   10.10.10.16 is directly connected, FastEthernet0/0
CE2-A#traceroute
Protocol [ip]:
Target IP address: 172.16.10.1
Source address: 172.16.100.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 172.16.10.1

  1 10.10.10.18 188 msec 528 msec 364 msec
  2 10.10.10.13 [MPLS: Labels 16/20 Exp 0] 2252 msec 3260 msec 2472 msec
  3 192.1.1.1 [MPLS: Label 20 Exp 0] 1944 msec 3596 msec 2088 msec
  4 10.10.10.6 [MPLS: Label 21 Exp 0] 768 msec 2340 msec 1160 msec

5 10.10.10.5 1080 msec 1136 msec 864 msec

CE2-A#

2.4.7　CE1-B 配置验证

CE1-B#show ip ospf neighbor

Neighbor ID   Pri   State   Dead Time   Address   Interface

10.10.10.10   1   FULL/DR   00:00:36   10.10.10.10   FastEthernet0/

0

CE1-B#show 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, 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

   172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks

O IA 172.16.200.1/32 [110/2] via 10.10.10.10, 00:26:49, FastEthernet0/0

C   172.16.20.0/24 is directly connected, Loopback0

   10.0.0.0/30 is subnetted, 2 subnets

C   10.10.10.8 is directly connected, FastEthernet0/0

O IA 10.10.10.20 [110/2] via 10.10.10.10, 00:32:16, FastEthernet0/0

CE1-B#traceroute

Protocol [ip]:

Target IP address: 172.16.200.1

Source address: 172.16.20.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.200.1

 1 10.10.10.10 260 msec 472 msec 172 msec

 2 10.10.10.1 [MPLS: Labels 16/21 Exp 0] 1944 msec 4984 msec 2320 msec

 3 192.1.1.2 [MPLS: Label 21 Exp 0] 2136 msec 3296 msec 1872 msec

4 10.10.10.22 [MPLS: Label 22 Exp 0] 1176 msec 884 msec 1032 msec

5 10.10.10.21 816 msec 1328 msec 1104 msec

CE1-B#

2.4.8 CE2-B 配置验证

CE2-B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.10.10.22	1	FULL/DR	00:00:31	10.10.10.22	FastEthernet0/0

CE2-B#show 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, 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

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks

C   172.16.200.0/24 is directly connected, Loopback0

O IA   172.16.20.1/32 [110/2] via 10.10.10.22, 00:32:16, FastEthernet0/0

     10.0.0.0/30 is subnetted, 2 subnets

O IA   10.10.10.8 [110/2] via 10.10.10.22, 00:32:16, FastEthernet0/0

C   10.10.10.20 is directly connected, FastEthernet0/0

CE2-B#traceroute

Protocol [ip]:

Target IP address: 172.16.20.1

Source address: 172.16.200.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.20.1

1 10.10.10.22 356 msec 1348 msec 448 msec

2 10.10.10.13 [MPLS: Labels 16/21 Exp 0] 2112 msec 2152 msec 3732 msec

3 192.1.1.1 [MPLS: Label 21 Exp 0] 4660 msec 3888 msec 3756 msec

4 10.10.10.10 [MPLS: Label 22 Exp 0] 1132 msec 884 msec 1080 msec

5 10.10.10.9 1056 msec 1172 msec 1368 msec

CE2-B#

3 单跳 MP-EBGP（改变下一跳）模式

3.1 网络拓扑图
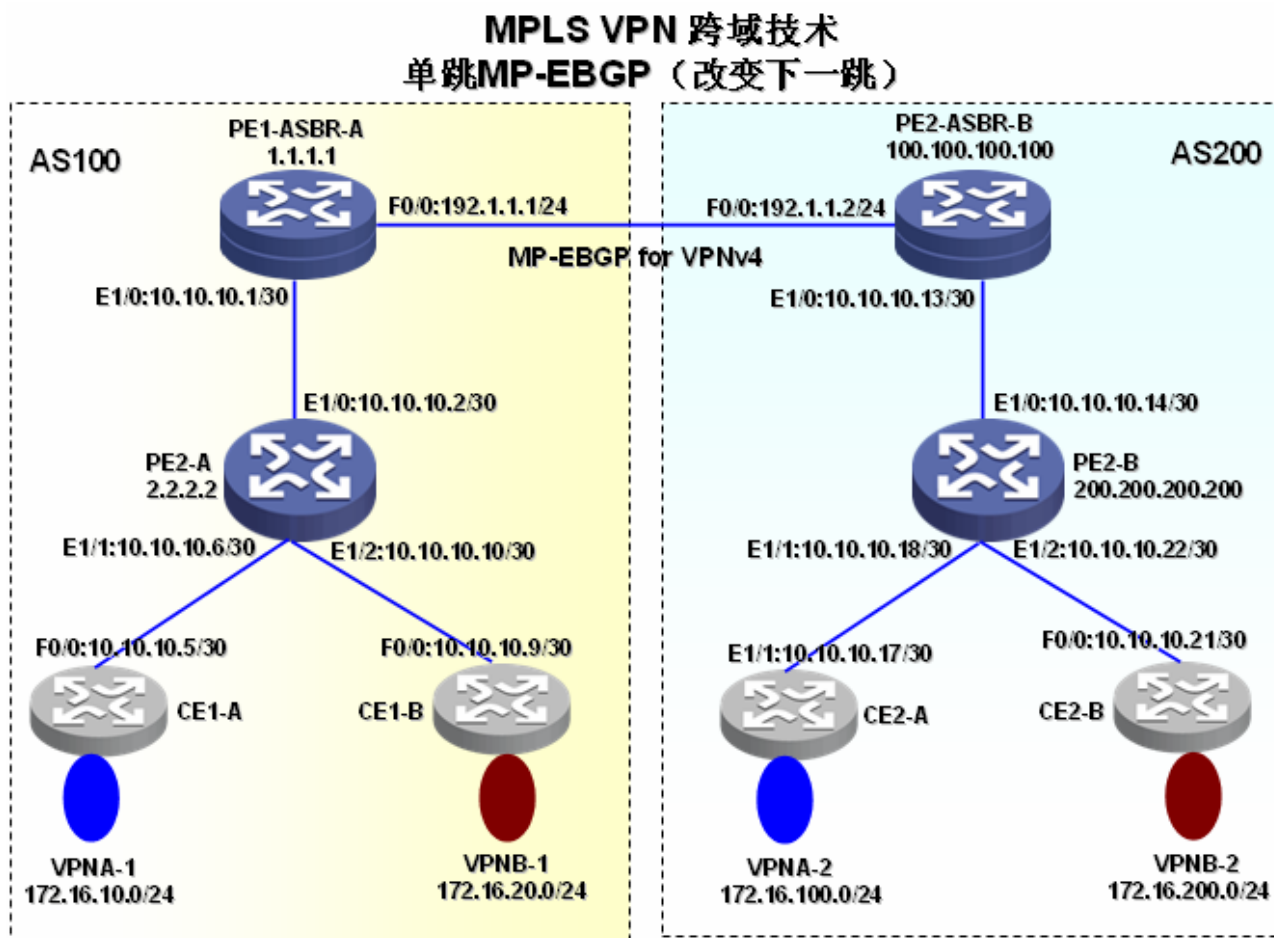
3.2 应用需求

采用 MPLS VPN 跨域的第二种方式（OptionB）：单跳 MP-EBGP（改变下一跳方式）来达到在不同 AS 域的同一个 VPN 的用户能够互相通信，即 VPNA-1 和 VPNA-2 之间，VPNB-1 和 VPNB-2 之间的用户能够互相通信。

3.3 设备配置

3.3.1 PE1-ASBR-A 设备配置

PE1-ASBR-A#show running
Building configuration...

Current configuration : 1649 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE1-ASBR-A
!
!
ip subnet-zero
!
!
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!

```
interface FastEthernet0/0
 ip address 192.1.1.1 255.255.255.0
 duplex auto
 speed auto
 tag-switching ip
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 10.10.10.1 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 10.10.10.0 0.0.0.3 area 0.0.0.0
!
router bgp 100
 no synchronization
 no bgp default route-target filter
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
```

```
 neighbor 192.1.1.2 remote-as 200
 no auto-summary
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 next-hop-self
 neighbor 2.2.2.2 send-community extended
 neighbor 192.1.1.2 activate
 neighbor 192.1.1.2 send-community both
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

3.3.2 PE1-ASBR-B 设备配置

PE1-ASBR-B#show running

Building configuration...

Current configuration : 1715 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE1-ASBR-B
!
!
ip subnet-zero
!
!
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 100.100.100.100 255.255.255.255
!
interface FastEthernet0/0
 ip address 192.1.1.2 255.255.255.0
 duplex auto
 speed auto
 tag-switching ip
!
interface FastEthernet0/1

```
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface Ethernet1/0
  ip address 10.10.10.13 255.255.255.252
  half-duplex
  mpls label protocol ldp
  tag-switching ip
!
interface Ethernet1/1
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/2
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/3
  no ip address
  shutdown
  half-duplex
!
router ospf 1
  router-id 100.100.100.100
  log-adjacency-changes
  network 10.10.10.12 0.0.0.3 area 0.0.0.0
  network 100.100.100.100 0.0.0.0 area 0.0.0.0
!
router bgp 200
  no synchronization
  no bgp default route-target filter
  bgp log-neighbor-changes
  neighbor 192.1.1.1 remote-as 100
  neighbor 200.200.200.200 remote-as 200
  neighbor 200.200.200.200 update-source Loopback0
  no auto-summary
  !
  address-family vpnv4
  neighbor 192.1.1.1 activate
  neighbor 192.1.1.1 send-community both
  neighbor 200.200.200.200 activate
```

```
  neighbor 200.200.200.200 next-hop-self
  neighbor 200.200.200.200 send-community extended
  no auto-summary
  exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

3.3.3　PE2-A 设备配置

```
PE2-A#show running
Building configuration...

Current configuration : 2188 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
```

```
no service password-encryption
!
hostname PE2-A
!
!
ip subnet-zero
!
!
!
ip vrf vpna
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpnb
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
```

```
  speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 10.10.10.2 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip vrf forwarding vpna
 ip address 10.10.10.6 255.255.255.252
 half-duplex
!
interface Ethernet1/2
 ip vrf forwarding vpnb
 ip address 10.10.10.10 255.255.255.252
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 10 vrf vpna
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
 log-adjacency-changes
 redistribute bgp 100 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
```

```
  no synchronization
  no bgp default route-target filter
  bgp log-neighbor-changes
  neighbor 1.1.1.1 remote-as 100
  neighbor 1.1.1.1 update-source Loopback0
  no auto-summary
  !
  address-family ipv4 vrf vpnb
  redistribute connected
  redistribute ospf 20
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family ipv4 vrf vpna
  redistribute connected
  redistribute ospf 10
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family vpnv4
  neighbor 1.1.1.1 activate
  neighbor 1.1.1.1 send-community both
  no auto-summary
  exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
```

```
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

3.3.4 PE2-B 设备配置

```
PE2-B#show running
Building configuration...

Current configuration : 2238 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE2-B
!
!
ip subnet-zero
!
!
!
ip vrf vpna
  rd 1:1
  route-target export 1:1
  route-target import 1:1
!
ip vrf vpnb
  rd 2:2
  route-target export 2:2
  route-target import 2:2
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
```

```
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 200.200.200.200 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 10.10.10.14 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip vrf forwarding vpna
 ip address 10.10.10.18 255.255.255.252
 half-duplex
!
interface Ethernet1/2
 ip vrf forwarding vpnb
 ip address 10.10.10.22 255.255.255.252
 half-duplex
```

```
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 200.200.200.200
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 10 vrf vpna
 log-adjacency-changes
 redistribute bgp 200 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
 log-adjacency-changes
 redistribute bgp 200 subnets
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 200
 no synchronization
 no bgp default route-target filter
 bgp log-neighbor-changes
 neighbor 100.100.100.100 remote-as 200
 neighbor 100.100.100.100 update-source Loopback0
 no auto-summary
 !
 address-family ipv4 vrf vpnb
 redistribute connected
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpna
 redistribute connected
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 100.100.100.100 activate
```

```
  neighbor 100.100.100.100 send-community both
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

3.3.5 CE1-A 设备配置

```
CE1-A#show running
Building configuration...

Current configuration : 749 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
```

```
!
hostname CE1-A
!
!
ip subnet-zero
!
!
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.10.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.5 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
```

!

!

!

!

!

call rsvp-sync

!

!

mgcp profile default

!

!

!

dial-peer cor custom

!

!

!

!

line con 0

  exec-timeout 0 0

line aux 0

line vty 0 4

  exec-timeout 0 0

  login

!

!

end

3.3.6 CE2-A 设备配置

CE2-A#show running

Building configuration...

Current configuration : 744 bytes

!

version 12.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname CE2-A

!

!

ip subnet-zero

!

!
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.100.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.17 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!

!

mgcp profile default

!

!

!

dial-peer cor custom

!

!

!

!

line con 0

  exec-timeout 0 0

line aux 0

line vty 0 4

  exec-timeout 0 0

  login

!

!

end

3.3.7　CE1-B 设备配置

CE1-B#show running

Building configuration...

Current configuration : 749 bytes

!

version 12.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname CE1-B

!

!

ip subnet-zero

!

!

!

ip cef

!

!

!

!

```
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.20.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.9 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
```

```
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end
```

3.3.8 CE2-B 设备配置

```
CE2-B#show running
Building configuration...

Current configuration : 744 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname CE2-B
!
!
ip subnet-zero
!
!
!
!
!
!
!
!
!
!
!
!
!
!
```

```
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 172.16.200.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.10.10.21 255.255.255.252
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 1
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
```

line vty 0 4

  exec-timeout 0 0

  login

!

!

end

3.4　配置验证

3.4.1　PE1-ASBR-A 配置验证

PE1-ASBR-A#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	1	FULL/DR	00:00:37	10.10.10.2	Ethernet1/0

PE1-ASBR-A#show 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, 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

    1.0.0.0/32 is subnetted, 1 subnets

C   1.1.1.1 is directly connected, Loopback0

    2.0.0.0/32 is subnetted, 1 subnets

O   2.2.2.2 [110/11] via 10.10.10.2, 00:13:37, Ethernet1/0

    10.0.0.0/30 is subnetted, 1 subnets

C   10.10.10.0 is directly connected, Ethernet1/0

    192.1.1.0/24 is variably subnetted, 2 subnets, 2 masks

C   192.1.1.0/24 is directly connected, FastEthernet0/0

C   192.1.1.2/32 is directly connected, FastEthernet0/0

PE1-ASBR-A#show ip bgp summary

BGP router identifier 1.1.1.1, local AS number 100

BGP table version is 1, main routing table version 1

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2.2.2.2	4	100	54	48	1	0	0	00:11:02	0
192.1.1.2	4	200	54	55	1	0	0	00:10:37	0

PE1-ASBR-A#show ip bgp vpnv4 all

BGP table version is 9, local router ID is 1.1.1.1

Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
                r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 1:1
*>i10.10.10.4/30   2.2.2.2   0   100   0 ?
*> 10.10.10.16/30   192.1.1.2   0 200 ?
*>i172.16.10.1/32   2.2.2.2   11   100   0 ?
*> 172.16.100.1/32 192.1.1.2   0 200 ?
Route Distinguisher: 2:2
*>i10.10.10.8/30   2.2.2.2   0   100   0 ?
*> 10.10.10.20/30   192.1.1.2   0 200 ?
*>i172.16.20.1/32   2.2.2.2   11   100   0 ?
*> 172.16.200.1/32 192.1.1.2   0 200 ?
PE1-ASBR-A#show ip bgp vpnv4 rd 1:1 labels
   Network   Next Hop   In label/Out label
Route Distinguisher: 1:1
   10.10.10.4/30   2.2.2.2   22/17
   10.10.10.16/30   192.1.1.2   27/26
   172.16.10.1/32   2.2.2.2   23/18
   172.16.100.1/32 192.1.1.2   28/27

PE1-ASBR-A#show ip bgp vpnv4 rd 2:2 labels
   Network   Next Hop   In label/Out label
Route Distinguisher: 2:2
   10.10.10.8/30   2.2.2.2   24/23
   10.10.10.20/30   192.1.1.2   26/28
   172.16.20.1/32   2.2.2.2   25/24
   172.16.200.1/32 192.1.1.2   29/29

PE1-ASBR-A#

3.4.2 PE1-ASBR-B 配置验证

PE1-ASBR-B#show ip ospf neighbor

Neighbor ID   Pri   State   Dead Time   Address   Interface
200.200.200.200   1   FULL/DR   00:00:32   10.10.10.14   Ethernet1/0
PE1-ASBR-B#show 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

Gateway of last resort is not set

200.200.200.0/32 is subnetted, 1 subnets

O   200.200.200.200 [110/11] via 10.10.10.14, 00:17:27, Ethernet1/0

100.0.0.0/32 is subnetted, 1 subnets

C   100.100.100.100 is directly connected, Loopback0

10.0.0.0/30 is subnetted, 1 subnets

C   10.10.10.12 is directly connected, Ethernet1/0

192.1.1.0/24 is variably subnetted, 2 subnets, 2 masks

C   192.1.1.0/24 is directly connected, FastEthernet0/0

C   192.1.1.1/32 is directly connected, FastEthernet0/0

PE1-ASBR-B#show ip bgp summary

BGP router identifier 100.100.100.100, local AS number 200

BGP table version is 1, main routing table version 1

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
192.1.1.1	4	100	57	56	1	0	0	00:12:46	0
200.200.200.200	4	200	52	55	1	0	0	00:13:08	0

PE1-ASBR-B#show ip vpnv4 all

                      ^

% Invalid input detected at '^' marker.

PE1-ASBR-B#show ip bgp vpnv4 all

BGP table version is 13, local router ID is 100.100.100.100

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

              r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1					
*> 10.10.10.4/30	192.1.1.1			0	100 ?
*>i10.10.10.16/30	200.200.200.200	0	100	0	?
*> 172.16.10.1/32	192.1.1.1			0	100 ?
*>i172.16.100.1/32	200.200.200.200	11	100	0	?
Route Distinguisher: 2:2					
*> 10.10.10.8/30	192.1.1.1			0	100 ?
*>i10.10.10.20/30	200.200.200.200	0	100	0	?
*> 172.16.20.1/32	192.1.1.1			0	100 ?
*>i172.16.200.1/32	200.200.200.200	11	100	0	?

PE1-ASBR-B#show ip bgp vpnv4 rd 1:1 labels

   Network   Next Hop   In label/Out label

Route Distinguisher: 1:1

10.10.10.4/30	192.1.1.1	22/22
10.10.10.16/30	200.200.200.200	26/18
172.16.10.1/32	192.1.1.1	23/23
172.16.100.1/32	200.200.200.200	27/17

PE1-ASBR-B#show ip bgp vpnv4 rd 2:2 labels

Network	Next Hop	In label/Out label

Route Distinguisher: 2:2

10.10.10.8/30	192.1.1.1	24/24
10.10.10.20/30	200.200.200.200	28/24
172.16.20.1/32	192.1.1.1	25/25
172.16.200.1/32	200.200.200.200	29/23

PE1-ASBR-B#

3.4.3　PE2-A 配置验证

PE2-A#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
172.16.20.1	1	FULL/BDR	00:00:31	10.10.10.9	Ethernet1/2
172.16.10.1	1	FULL/BDR	00:00:31	10.10.10.5	Ethernet1/1
1.1.1.1	1	FULL/BDR	00:00:33	10.10.10.1	Ethernet1/0

PE2-A#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets

O   1.1.1.1 [110/11] via 10.10.10.1, 00:19:36, Ethernet1/0

     2.0.0.0/32 is subnetted, 1 subnets

C   2.2.2.2 is directly connected, Loopback0

     10.0.0.0/30 is subnetted, 1 subnets

C   10.10.10.0 is directly connected, Ethernet1/0

PE2-A#show ip bgp summary

BGP router identifier 2.2.2.2, local AS number 100

BGP table version is 1, main routing table version 1

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
1.1.1.1	4	100	93	105	1	0	0	00:16:57	0

PE2-A#show ip bgp vpnv4 vrf vpna

BGP table version is 17, local router ID is 2.2.2.2

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

          r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (default for vrf vpna)					
*> 10.10.10.4/30	0.0.0.0	0		32768	?
*>i10.10.10.16/30	1.1.1.1		100	0	200 ?
*> 172.16.10.1/32	10.10.10.5	11		32768	?
*>i172.16.100.1/32	1.1.1.1		100	0	200 ?

PE2-A#show ip bgp vpnv4 vrf vpnb

BGP table version is 17, local router ID is 2.2.2.2

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

          r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 2:2 (default for vrf vpnb)					
*> 10.10.10.8/30	0.0.0.0	0		32768	?
*>i10.10.10.20/30	1.1.1.1		100	0	200 ?
*> 172.16.20.1/32	10.10.10.9	11		32768	?
*>i172.16.200.1/32	1.1.1.1		100	0	200 ?

PE2-A#show ip bgp vpnv4 vrf vpna labels

Network	Next Hop	In label/Out label
Route Distinguisher: 1:1 (vpna)		
10.10.10.4/30	0.0.0.0	17/aggregate(vpna)
10.10.10.16/30	1.1.1.1	nolabel/27
172.16.10.1/32	10.10.10.5	18/nolabel
172.16.100.1/32	1.1.1.1	nolabel/28

PE2-A#show ip bgp vpnv4 vrf vpnb labels

Network	Next Hop	In label/Out label
Route Distinguisher: 2:2 (vpnb)		
10.10.10.8/30	0.0.0.0	23/aggregate(vpnb)
10.10.10.20/30	1.1.1.1	nolabel/26
172.16.20.1/32	10.10.10.9	24/nolabel
172.16.200.1/32	1.1.1.1	nolabel/29

PE2-A#show ip route vrf vpna

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, 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

172.16.0.0/32 is subnetted, 2 subnets

O   172.16.10.1 [110/11] via 10.10.10.5, 00:36:40, Ethernet1/1

B   172.16.100.1 [200/0] via 1.1.1.1, 00:18:18

10.0.0.0/30 is subnetted, 2 subnets

C   10.10.10.4 is directly connected, Ethernet1/1

B   10.10.10.16 [200/0] via 1.1.1.1, 00:18:18

PE2-A#show ip route vrf vpnb

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, 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

172.16.0.0/32 is subnetted, 2 subnets

B   172.16.200.1 [200/0] via 1.1.1.1, 00:18:21

O   172.16.20.1 [110/11] via 10.10.10.9, 00:36:43, Ethernet1/2

10.0.0.0/30 is subnetted, 2 subnets

C   10.10.10.8 is directly connected, Ethernet1/2

B   10.10.10.20 [200/0] via 1.1.1.1, 00:18:21

PE2-A#

3.4.4 PE2-B 配置验证

PE2-B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
172.16.200.1	1	FULL/BDR	00:00:32	10.10.10.21	Ethernet1/2
172.16.100.1	1	FULL/BDR	00:00:39	10.10.10.17	Ethernet1/1
100.100.100.100	1	FULL/BDR	00:00:38	10.10.10.13	Ethernet1/0

PE2-B#show 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, 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


        200.200.200.0/32 is subnetted, 1 subnets
C          200.200.200.200 is directly connected, Loopback0
        100.0.0.0/32 is subnetted, 1 subnets
O          100.100.100.100 [110/11] via 10.10.10.13, 00:29:02, Ethernet1/0
        10.0.0.0/30 is subnetted, 1 subnets
C          10.10.10.12 is directly connected, Ethernet1/0
```

PE2-B#show ip bgp summary

BGP router identifier 200.200.200.200, local AS number 200

BGP table version is 1, main routing table version 1

```
Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
100.100.100.100 4    200    105     108        1    0    0 00:25:03         0
```

PE2-B#show ip bgp vpnv4 vrf vpna

BGP table version is 17, local router ID is 200.200.200.200

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

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

```
    Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 1:1 (default for vrf vpna)
*>i10.10.10.4/30    100.100.100.100             100      0 100 ?
*> 10.10.10.16/30   0.0.0.0                0          32768 ?
*>i172.16.10.1/32   100.100.100.100             100      0 100 ?
*> 172.16.100.1/32  10.10.10.17           11          32768 ?
```

PE2-B#show ip bgp vpnv4 vrf vpa labels

%Unknown VRF

PE2-B#show ip bgp vpnv4 vrf vpna labels

```
    Network          Next Hop       In label/Out label
Route Distinguisher: 1:1 (vpna)
    10.10.10.4/30    100.100.100.100 nolabel/22
    10.10.10.16/30   0.0.0.0         18/aggregate(vpna)
    172.16.10.1/32   100.100.100.100 nolabel/23
    172.16.100.1/32  10.10.10.17     17/nolabel
```


PE2-B#show ip bgp vpnv4 vrf vpnb

BGP table version is 17, local router ID is 200.200.200.200

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

                  r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 2:2 (default for vrf vpnb)					
*>i10.10.10.8/30	100.100.100.100		100	0	100 ?
*> 10.10.10.20/30	0.0.0.0	0		32768	?
*>i172.16.20.1/32	100.100.100.100		100	0	100 ?
*> 172.16.200.1/32	10.10.10.21	11		32768	?

PE2-B#show ip bgp vpnv4 vrf vpnb labels

Network	Next Hop	In label/Out label
Route Distinguisher: 2:2 (vpnb)		
10.10.10.8/30	100.100.100.100	nolabel/24
10.10.10.20/30	0.0.0.0	24/aggregate(vpnb)
172.16.20.1/32	100.100.100.100	nolabel/25
172.16.200.1/32	10.10.10.21	23/nolabel

PE2-B#show ip route vrf vpna

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, 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

     172.16.0.0/32 is subnetted, 2 subnets

B   172.16.10.1 [200/0] via 100.100.100.100, 00:25:01

O   172.16.100.1 [110/11] via 10.10.10.17, 00:42:46, Ethernet1/1

     10.0.0.0/30 is subnetted, 2 subnets

B   10.10.10.4 [200/0] via 100.100.100.100, 00:25:01

C   10.10.10.16 is directly connected, Ethernet1/1

PE2-B#show ip route vrf vpnb

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, 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

   172.16.0.0/32 is subnetted, 2 subnets
O   172.16.200.1 [110/11] via 10.10.10.21, 00:42:50, Ethernet1/2
B   172.16.20.1 [200/0] via 100.100.100.100, 00:25:04
   10.0.0.0/30 is subnetted, 2 subnets
B   10.10.10.8 [200/0] via 100.100.100.100, 00:25:04
C   10.10.10.20 is directly connected, Ethernet1/2
PE2-B#

3.4.5　CE1-A 配置验证

CE1-A#show ip ospf neighbor

Neighbor ID   Pri   State   Dead Time   Address   Interface
10.10.10.6   1   FULL/DR   00:00:37   10.10.10.6   FastEthernet0/
0
CE1-A#show 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, 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

   172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C   172.16.10.0/24 is directly connected, Loopback0
O IA   172.16.100.1/32 [110/2] via 10.10.10.6, 00:25:56, FastEthernet0/0
   10.0.0.0/30 is subnetted, 2 subnets
C   10.10.10.4 is directly connected, FastEthernet0/0
O IA   10.10.10.16 [110/2] via 10.10.10.6, 00:25:56, FastEthernet0/0
CE1-A#
CE1-A#traceroute
Protocol [ip]:
Target IP address: 172.16.100.1
Source address: 172.16.10.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.100.1

  1 10.10.10.6 236 msec 440 msec 564 msec

  2 10.10.10.1 [MPLS: Label 28 Exp 0] 2136 msec 1916 msec 2064 msec

  3 192.1.1.2 [MPLS: Label 27 Exp 0] 1968 msec 2348 msec 2256 msec

  4 10.10.10.18 [MPLS: Label 17 Exp 0] 1056 msec 1316 msec 1080 msec

  5 10.10.10.17 1224 msec 1652 msec 1344 msec

CE1-A#

3.4.6 CE2-A 配置验证

CE2-A#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.10.10.18	1	FULL/DR	00:00:38	10.10.10.18	FastEthernet0/0

CE2-A#show 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, 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

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks

O IA   172.16.10.1/32 [110/2] via 10.10.10.18, 00:32:51, FastEthernet0/0

C   172.16.100.0/24 is directly connected, Loopback0

     10.0.0.0/30 is subnetted, 2 subnets

O IA   10.10.10.4 [110/2] via 10.10.10.18, 00:32:51, FastEthernet0/0

C   10.10.10.16 is directly connected, FastEthernet0/0

CE2-A#traceroute

Protocol [ip]:

Target IP address: 172.16.10.1

Source address: 172.16.100.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.10.1

```
  1 10.10.10.18 224 msec 308 msec 168 msec
  2 10.10.10.13 [MPLS: Label 23 Exp 0] 2160 msec 5456 msec 4656 msec
  3 192.1.1.1 [MPLS: Label 23 Exp 0] 3120 msec 2036 msec 1992 msec
  4 10.10.10.6 [MPLS: Label 18 Exp 0] 816 msec 968 msec 948 msec
  5 10.10.10.5 1248 msec 1052 msec 1200 msec
CE2-A#
```

3.4.7　CE1-B 配置验证

CE1-B#show ip ospf neighbor

```
Neighbor ID       Pri   State           Dead Time    Address        Interface
10.10.10.10       1     FULL/DR         00:00:34     10.10.10.10     FastEthernet0/
0
```
CE1-B#show 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, 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

```
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O IA      172.16.200.1/32 [110/2] via 10.10.10.10, 00:29:19, FastEthernet0/0
C          172.16.20.0/24 is directly connected, Loopback0
     10.0.0.0/30 is subnetted, 2 subnets
C          10.10.10.8 is directly connected, FastEthernet0/0
O IA      10.10.10.20 [110/2] via 10.10.10.10, 00:29:19, FastEthernet0/0
```
CE1-B#traceroute

Protocol [ip]:

Target IP address: 172.16.200.1

Source address: 172.16.20.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.200.1

  1 10.10.10.10 624 msec 164 msec 192 msec

  2 10.10.10.1 [MPLS: Label 29 Exp 0] 2112 msec 2376 msec 2156 msec

  3 192.1.1.2 [MPLS: Label 29 Exp 0] 2184 msec 2372 msec 2120 msec

  4 10.10.10.22 [MPLS: Label 23 Exp 0] 1020 msec 3136 msec 3252 msec

  5 10.10.10.21 1200 msec 896 msec 1320 msec

CE1-B#

3.4.8　CE2-B 配置验证

CE2-B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
10.10.10.22	1	FULL/DR	00:00:30	10.10.10.22	FastEthernet0/0

CE2-B#show 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, 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

      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks

C   172.16.200.0/24 is directly connected, Loopback0

O IA   172.16.20.1/32 [110/2] via 10.10.10.22, 00:36:48, FastEthernet0/0

      10.0.0.0/30 is subnetted, 2 subnets

O IA   10.10.10.8 [110/2] via 10.10.10.22, 00:36:48, FastEthernet0/0

C   10.10.10.20 is directly connected, FastEthernet0/0

CE2-B#traceroute

Protocol [ip]:

Target IP address: 172.16.20.1

Source address: 172.16.200.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 172.16.20.1

  1 10.10.10.22 200 msec 212 msec 192 msec

  2 10.10.10.13 [MPLS: Label 25 Exp 0] 2136 msec 2060 msec 2184 msec

  3 192.1.1.1 [MPLS: Label 25 Exp 0] 2088 msec 2552 msec 1984 msec

  4 10.10.10.10 [MPLS: Label 24 Exp 0] 792 msec 1976 msec 744 msec

  5 10.10.10.9 936 msec 1096 msec 1056 msec

CE2-B#

3 多跳 MP-EBGP（不改变下一跳）模式

3.1 网络拓扑图

MPLS VPN 跨域技术
Multi-Hop-EBGP（不改变私网路由下一跳）
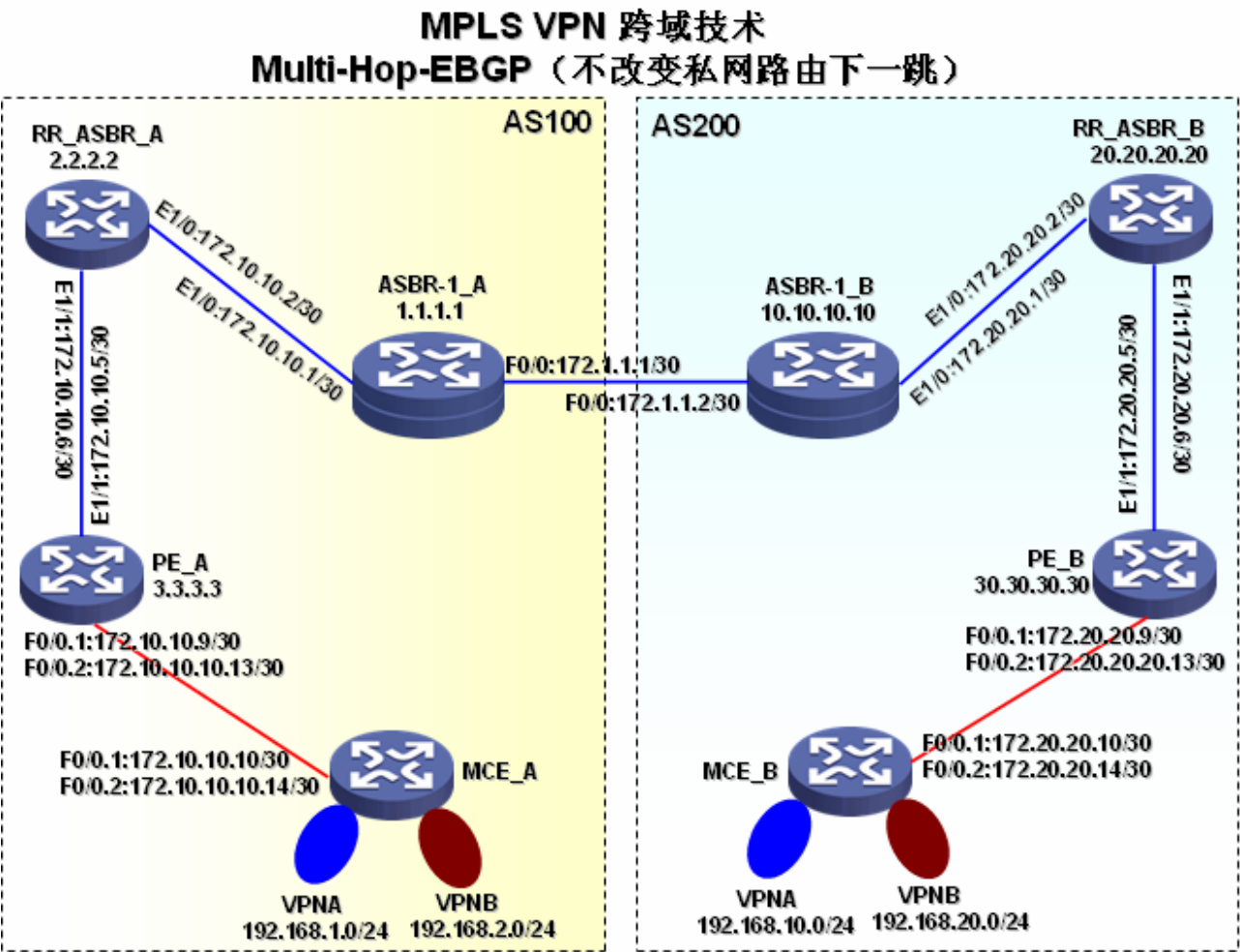
3.2 应用需求

采用 MPLS VPN 跨域的第三种方式（OptionC）：多跳 MP-EBGP（改变下一跳方式）来达到在不同 AS 域的同一个 VPN 的用户能够互相通信，即 VPNA-1 和 VPNA-2 之间，VPNB-1 和 VPNB-2 之间的用户能够互相通信。

3.3　设备配置及配置验证

3.3.1　ASBR_1_A 设备配置及配置验证

Building configuration...

Current configuration : 1790 bytes

!

version 12.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname ASBR_1_A

!

!

ip subnet-zero

!

!

no ip domain lookup

!

ip cef

mpls label protocol ldp

tag-switching tdp router-id Loopback0 force

!

!

!

!

!

!

!

!

!

!

!

mta receive maximum-recipients 0

!

!

!

!

interface Loopback0

 ip address 1.1.1.1 255.255.255.255

!

```
interface FastEthernet0/0
 ip address 172.1.1.1 255.255.255.252
 duplex auto
 speed auto
 mpls label protocol ldp
 tag-switching ip
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 172.10.10.1 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 1.1.1.1
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 172.10.10.0 0.0.0.3 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp log-neighbor-changes
 network 2.2.2.2 mask 255.255.255.255
 network 3.3.3.3 mask 255.255.255.255
```

```
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 neighbor 2.2.2.2 next-hop-self
 neighbor 2.2.2.2 send-label
 neighbor 172.1.1.2 remote-as 200
 neighbor 172.1.1.2 route-map bgp200 out
 neighbor 172.1.1.2 send-label
 no auto-summary
!
ip classless
ip http server
!
!
access-list 101 permit ip host 2.2.2.2 any
access-list 101 permit ip host 3.3.3.3 any
!
route-map bgp200 permit 200
 match ip address 101
 set mpls-label
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end

ASBR_1_A#show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.2.2	1	FULL/BDR	00:00:31	172.10.10.2	Ethernet1/0

ASBR_1_A#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets

C   1.1.1.1 is directly connected, Loopback0

     2.0.0.0/32 is subnetted, 1 subnets

O   2.2.2.2 [110/11] via 172.10.10.2, 00:28:00, Ethernet1/0

     3.0.0.0/32 is subnetted, 1 subnets

O   3.3.3.3 [110/21] via 172.10.10.2, 00:28:00, Ethernet1/0

     20.0.0.0/32 is subnetted, 1 subnets

B   20.20.20.20 [20/11] via 172.1.1.2, 00:25:18

     172.1.0.0/16 is variably subnetted, 2 subnets, 2 masks

C   172.1.1.0/30 is directly connected, FastEthernet0/0

C   172.1.1.2/32 is directly connected, FastEthernet0/0

     172.10.0.0/30 is subnetted, 2 subnets

O   172.10.10.4 [110/20] via 172.10.10.2, 00:28:00, Ethernet1/0

C   172.10.10.0 is directly connected, Ethernet1/0

     30.0.0.0/32 is subnetted, 1 subnets

B   30.30.30.30 [20/21] via 172.1.1.2, 00:25:18

ASBR_1_A#show ip bgp summary

BGP router identifier 1.1.1.1, local AS number 100

BGP table version is 5, main routing table version 5

4 network entries and 4 paths using 596 bytes of memory

4 BGP path attribute entries using 240 bytes of memory

1 BGP AS-PATH entries using 24 bytes of memory

0 BGP route-map cache entries using 0 bytes of memory

0 BGP filter-list cache entries using 0 bytes of memory

BGP activity 4/0 prefixes, 4/0 paths, scan interval 60 secs

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2.2.2.2	4	100	25	29	5	0	0	00:21:34	0
172.1.1.2	4	200	30	31	5	0	0	00:25:25	2

ASBR_1_A#

3.3.2 ASBR_1_B 设备配置及配置验证

Building configuration...

Current configuration : 1814 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ASBR_1_B
!
!
ip subnet-zero
!
!
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 10.10.10.10 255.255.255.255
!
interface FastEthernet0/0
 ip address 172.1.1.2 255.255.255.252
 duplex auto
 speed auto

```
 mpls label protocol ldp
 tag-switching ip
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 172.20.20.1 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 10.10.10.10
 log-adjacency-changes
 network 10.10.10.10 0.0.0.0 area 0.0.0.0
 network 172.20.20.0 0.0.0.3 area 0.0.0.0
!
router bgp 200
 no synchronization
 bgp log-neighbor-changes
 network 20.20.20.20 mask 255.255.255.255
 network 30.30.30.30 mask 255.255.255.255
 neighbor 20.20.20.20 remote-as 200
 neighbor 20.20.20.20 update-source Loopback0
 neighbor 20.20.20.20 next-hop-self
 neighbor 20.20.20.20 send-label
```

```
  neighbor 172.1.1.1 remote-as 100
  neighbor 172.1.1.1 route-map bgp100 out
  neighbor 172.1.1.1 send-label
  no auto-summary
!
ip classless
ip http server
!
!
access-list 101 permit ip host 20.20.20.20 any
access-list 101 permit ip host 30.30.30.30 any
!
route-map bgp100 permit 100
  match ip address 101
  set mpls-label
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end


ASBR_1_B#show ip ospf neighbor


Neighbor ID      Pri    State           Dead Time    Address          Interface
20.20.20.20        1    FULL/BDR        00:00:31     172.20.20.2      Ethernet1/0
ASBR_1_B#show 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, 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

      2.0.0.0/32 is subnetted, 1 subnets
B   2.2.2.2 [20/11] via 172.1.1.1, 00:26:07
      3.0.0.0/32 is subnetted, 1 subnets
B   3.3.3.3 [20/21] via 172.1.1.1, 00:26:07
      20.0.0.0/32 is subnetted, 1 subnets
O   20.20.20.20 [110/11] via 172.20.20.2, 00:28:30, Ethernet1/0
      172.1.0.0/16 is variably subnetted, 2 subnets, 2 masks
C   172.1.1.0/30 is directly connected, FastEthernet0/0
C   172.1.1.1/32 is directly connected, FastEthernet0/0
      172.20.0.0/30 is subnetted, 2 subnets
O   172.20.20.4 [110/20] via 172.20.20.2, 00:28:30, Ethernet1/0
C   172.20.20.0 is directly connected, Ethernet1/0
      10.0.0.0/32 is subnetted, 1 subnets
C   10.10.10.10 is directly connected, Loopback0
      30.0.0.0/32 is subnetted, 1 subnets
O   30.30.30.30 [110/21] via 172.20.20.2, 00:28:31, Ethernet1/0
ASBR_1_B#show ip bgp summary
BGP router identifier 10.10.10.10, local AS number 200
BGP table version is 5, main routing table version 5
4 network entries and 4 paths using 596 bytes of memory
4 BGP path attribute entries using 240 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 4/0 prefixes, 4/0 paths, scan interval 60 secs

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
20.20.20.20	4	200	25	29	5	0	0	00:21:36	0
172.1.1.1	4	100	32	32	5	0	0	00:26:11	2

ASBR_1_B#

3.3.3 RR_ASBR_A 设备配置及配置验证

RR_ASBR_A#show ru

Building configuration...

Current configuration : 1987 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname RR_ASBR_A
!
!
ip subnet-zero
!
!
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!

```
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 172.10.10.2 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 ip address 172.10.10.6 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
 no synchronization
 bgp router-id 2.2.2.2
 no bgp default route-target filter
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 1.1.1.1 send-label
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 3.3.3.3 route-reflector-client
 neighbor 3.3.3.3 send-label
```

```
 neighbor 20.20.20.20 remote-as 200
 neighbor 20.20.20.20 ebgp-multihop 255
 neighbor 20.20.20.20 update-source Loopback0
 no auto-summary
 !
 address-family vpnv4
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 route-reflector-client
 neighbor 3.3.3.3 send-community extended
 neighbor 20.20.20.20 activate
 neighbor 20.20.20.20 next-hop-unchanged
 neighbor 20.20.20.20 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end

RR_ASBR_A#show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
3.3.3.3	1	FULL/BDR	00:00:27	172.10.10.5	Ethernet1/1
1.1.1.1	1	FULL/DR	00:00:34	172.10.10.1	Ethernet1/0

RR_ASBR_A#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets

O   1.1.1.1 [110/11] via 172.10.10.1, 01:03:43, Ethernet1/0

     2.0.0.0/32 is subnetted, 1 subnets

C   2.2.2.2 is directly connected, Loopback0

     3.0.0.0/32 is subnetted, 1 subnets

O   3.3.3.3 [110/11] via 172.10.10.5, 01:03:44, Ethernet1/1

     20.0.0.0/32 is subnetted, 1 subnets

B   20.20.20.20 [200/11] via 1.1.1.1, 00:23:47

     172.10.0.0/30 is subnetted, 2 subnets

C   172.10.10.4 is directly connected, Ethernet1/1

C   172.10.10.0 is directly connected, Ethernet1/0

     30.0.0.0/32 is subnetted, 1 subnets

B   30.30.30.30 [200/21] via 1.1.1.1, 00:23:47

RR_ASBR_A#show ip bgp summary

BGP router identifier 2.2.2.2, local AS number 100

BGP table version is 5, main routing table version 5

3 network entries and 3 paths using 447 bytes of memory

9 BGP path attribute entries using 540 bytes of memory

1 BGP AS-PATH entries using 24 bytes of memory

4 BGP extended community entries using 160 bytes of memory

0 BGP route-map cache entries using 0 bytes of memory

0 BGP filter-list cache entries using 0 bytes of memory

BGP activity 11/0 prefixes, 11/0 paths, scan interval 60 secs

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
1.1.1.1	4	100	75	69	5	0	0	00:23:56	3
3.3.3.3	4	100	76	71	5	0	0	01:03:44	0
20.20.20.20	4	200	32	32	5	0	0	00:22:51	0

RR_ASBR_A#show ip bgp vpnv4 all

BGP table version is 9, local router ID is 2.2.2.2

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

r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1					
*>i172.10.10.8/30	3.3.3.3	0	100	0	?
*> 172.20.20.8/30	30.30.30.30			0	200 ?
*>i192.168.1.1/32	3.3.3.3	2	100	0	?
*> 192.168.10.1/32	30.30.30.30			0	200 ?
Route Distinguisher: 2:2					
*>i172.10.10.12/30	3.3.3.3	0	100	0	?
*> 172.20.20.12/30	30.30.30.30			0	200 ?
*>i192.168.2.1/32	3.3.3.3	2	100	0	?
*> 192.168.20.1/32	30.30.30.30			0	200 ?

RR_ASBR_A#show ip bgp vpnv4 rd 1:1 labels

Network	Next Hop	In label/Out label
Route Distinguisher: 1:1		
172.10.10.8/30	3.3.3.3	nolabel/19
172.20.20.8/30	30.30.30.30	nolabel/19
192.168.1.1/32	3.3.3.3	nolabel/21
192.168.10.1/32	30.30.30.30	nolabel/21

RR_ASBR_A#show ip bgp vpnv4 rd 2:2 labels

Network	Next Hop	In label/Out label
Route Distinguisher: 2:2		
172.10.10.12/30	3.3.3.3	nolabel/20
172.20.20.12/30	30.30.30.30	nolabel/20
192.168.2.1/32	3.3.3.3	nolabel/22
192.168.20.1/32	30.30.30.30	nolabel/22

RR_ASBR_A#

3.3.4 RR_ASBR_B 设备配置及配置验证

RR_ARBR_B#show running

Building configuration...

Current configuration : 1947 bytes

!

version 12.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

```
!
hostname RR_ARBR_B
!
!
ip subnet-zero
!
!
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 20.20.20.20 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 172.20.20.2 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
```

```
!
interface Ethernet1/1
 ip address 172.20.20.6 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
 no ip address
 shutdown
 half-duplex
!
router ospf 1
 router-id 20.20.20.20
 log-adjacency-changes
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 200
 no synchronization
 bgp router-id 20.20.20.20
 no bgp default route-target filter
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 ebgp-multihop 255
 neighbor 2.2.2.2 update-source Loopback0
 neighbor 10.10.10.10 remote-as 200
 neighbor 10.10.10.10 update-source Loopback0
 neighbor 10.10.10.10 send-label
 neighbor 30.30.30.30 remote-as 200
 neighbor 30.30.30.30 update-source Loopback0
 neighbor 30.30.30.30 route-reflector-client
 neighbor 30.30.30.30 send-label
 no auto-summary
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 next-hop-unchanged
 neighbor 2.2.2.2 send-community extended
 neighbor 30.30.30.30 activate
 neighbor 30.30.30.30 route-reflector-client
```

```
 neighbor 30.30.30.30 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end


RR_ARBR_B#show ip ospf neighbor


Neighbor ID      Pri    State            Dead Time    Address          Interface
30.30.30.30       1     FULL/BDR          00:00:35     172.20.20.5       Ethernet1/1
10.10.10.10       1     FULL/DR           00:00:30     172.20.20.1       Ethernet1/0
RR_ARBR_B#show 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, 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


      2.0.0.0/32 is subnetted, 1 subnets
B         2.2.2.2 [200/11] via 10.10.10.10, 00:24:23
      3.0.0.0/32 is subnetted, 1 subnets
B         3.3.3.3 [200/21] via 10.10.10.10, 00:24:23
      20.0.0.0/32 is subnetted, 1 subnets
C         20.20.20.20 is directly connected, Loopback0
      172.20.0.0/30 is subnetted, 2 subnets
C         172.20.20.4 is directly connected, Ethernet1/1
C         172.20.20.0 is directly connected, Ethernet1/0
      10.0.0.0/32 is subnetted, 1 subnets
O         10.10.10.10 [110/11] via 172.20.20.1, 01:03:13, Ethernet1/0
      30.0.0.0/32 is subnetted, 1 subnets
O         30.30.30.30 [110/11] via 172.20.20.5, 01:03:13, Ethernet1/1
RR_ARBR_B#show ip bgp summary
BGP router identifier 20.20.20.20, local AS number 200
BGP table version is 5, main routing table version 5
3 network entries and 3 paths using 447 bytes of memory
9 BGP path attribute entries using 540 bytes of memory
1 BGP AS-PATH entries using 24 bytes of memory
4 BGP extended community entries using 160 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP activity 11/0 prefixes, 11/0 paths, scan interval 60 secs
```

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2.2.2.2	4	100	34	34	5	0	0	00:24:17	0
10.10.10.10	4	200	73	68	5	0	0	00:24:28	3
30.30.30.30	4	200	75	71	5	0	0	01:03:15	0

```
RR_ARBR_B#show ip bgp vpnv4 all
BGP table version is 9, local router ID is 20.20.20.20
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1					
*> 172.10.10.8/30	3.3.3.3			0	100 ?
*>i172.20.20.8/30	30.30.30.30	0	100	0	?
*> 192.168.1.1/32	3.3.3.3			0	100 ?
*>i192.168.10.1/32	30.30.30.30	2	100	0	?
Route Distinguisher: 2:2					

*> 172.10.10.12/30	3.3.3.3				0 100 ?
*>i172.20.20.12/30	30.30.30.30	0	100	0 ?	
*> 192.168.2.1/32	3.3.3.3				0 100 ?
*>i192.168.20.1/32	30.30.30.30	2	100	0 ?	

RR_ARBR_B#show ip bgp vpnv4 rd 1:1 labels

```
   Network           Next Hop        In label/Out label
Route Distinguisher: 1:1
   172.10.10.8/30    3.3.3.3         nolabel/19
   172.20.20.8/30    30.30.30.30     nolabel/19
   192.168.1.1/32    3.3.3.3         nolabel/21
   192.168.10.1/32   30.30.30.30     nolabel/21


RR_ARBR_B#show ip bgp vpnv4 rd 2:2 labels
   Network           Next Hop        In label/Out label
Route Distinguisher: 2:2
   172.10.10.12/30   3.3.3.3         nolabel/20
   172.20.20.12/30   30.30.30.30     nolabel/20
   192.168.2.1/32    3.3.3.3         nolabel/22
   192.168.20.1/32   30.30.30.30     nolabel/22


RR_ARBR_B#
```

3.3.5 PE_A 设备配置及配置验证

```
PE_A#show running
Building configuration...

Current configuration : 2427 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname PE_A
!
!
ip subnet-zero
!
!
!
ip vrf vpna
 rd 1:1
 route-target export 1:1
```

```
   route-target import 1:1
!
ip vrf vpnb
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
mpls label protocol ldp
tag-switching tdp router-id Loopback0 force
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding vpna
 ip address 172.10.10.9 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding vpnb
 ip address 172.10.10.13 255.255.255.252
!
interface FastEthernet0/1
```

```
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface Ethernet1/0
  ip address 172.10.10.5 255.255.255.252
  half-duplex
  mpls label protocol ldp
  tag-switching ip
!
interface Ethernet1/1
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/2
  no ip address
  shutdown
  half-duplex
!
interface Ethernet1/3
  no ip address
  shutdown
  half-duplex
!
router ospf 1
  router-id 3.3.3.3
  log-adjacency-changes
  network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 10 vrf vpna
  log-adjacency-changes
  redistribute connected subnets
  redistribute bgp 100 subnets
  network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
  log-adjacency-changes
  redistribute connected subnets
  redistribute bgp 100 subnets
  network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 100
  no synchronization
```

```
 bgp router-id 3.3.3.3
 bgp log-neighbor-changes
 neighbor 2.2.2.2 remote-as 100
 neighbor 2.2.2.2 update-source Loopback0
 neighbor 2.2.2.2 send-label
 no auto-summary
 !
 address-family ipv4 vrf vpnb
 redistribute connected
 redistribute ospf 20
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family ipv4 vrf vpna
 redistribute connected
 redistribute ospf 10
 no auto-summary
 no synchronization
 exit-address-family
 !
 address-family vpnv4
 neighbor 2.2.2.2 activate
 neighbor 2.2.2.2 send-community extended
 no auto-summary
 exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
```

```
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end

PE_A#show ip ospf neighbor

Neighbor ID      Pri   State           Dead Time    Address          Interface
192.168.2.1       1    FULL/BDR        00:00:31     172.10.10.14     FastEthernet0/
0.2
192.168.1.1       1    FULL/BDR        00:00:31     172.10.10.10     FastEthernet0/
0.1
2.2.2.2           1    FULL/DR         00:00:37     172.10.10.6      Ethernet1/0
PE_A#show 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, 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

     1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/21] via 172.10.10.6, 01:07:41, Ethernet1/0
     2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/11] via 172.10.10.6, 01:07:41, Ethernet1/0
     3.0.0.0/32 is subnetted, 1 subnets
C        3.3.3.3 is directly connected, Loopback0
     20.0.0.0/32 is subnetted, 1 subnets
B        20.20.20.20 [200/11] via 1.1.1.1, 00:27:02
     172.10.0.0/30 is subnetted, 2 subnets
C        172.10.10.4 is directly connected, Ethernet1/0
O        172.10.10.0 [110/20] via 172.10.10.6, 01:07:41, Ethernet1/0
     30.0.0.0/32 is subnetted, 1 subnets
B        30.30.30.30 [200/21] via 1.1.1.1, 00:27:03
PE_A#show ip bgp vpvn4 vrf vpna
                      ^
```

% Invalid input detected at '^' marker.

PE_A#show ip bgp vpnv4 vrf vpna

BGP table version is 17, local router ID is 3.3.3.3

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

                 r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (default for vrf vpna)					
*> 172.10.10.8/30	0.0.0.0	0		32768	?
*>i172.20.20.8/30	30.30.30.30		100	0	200 ?
*> 192.168.1.1/32	172.10.10.10	2		32768	?
*>i192.168.10.1/32	30.30.30.30		100	0	200 ?

PE_A#show ip bgp vpnv4 vrf vpna labels

Network	Next Hop	In label/Out label
Route Distinguisher: 1:1 (vpna)		
172.10.10.8/30	0.0.0.0	19/aggregate(vpna)
172.20.20.8/30	30.30.30.30	nolabel/19
192.168.1.1/32	172.10.10.10	21/nolabel
192.168.10.1/32	30.30.30.30	nolabel/21

PE_A#show ip bgp vpnv4 vrf vpnb

BGP table version is 17, local router ID is 3.3.3.3

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

                 r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 2:2 (default for vrf vpnb)					
*> 172.10.10.12/30	0.0.0.0	0		32768	?
*>i172.20.20.12/30	30.30.30.30		100	0	200 ?
*> 192.168.2.1/32	172.10.10.14	2		32768	?
*>i192.168.20.1/32	30.30.30.30		100	0	200 ?

PE_A#show ip bgp vpnv4 vrf vpnb labels

Network	Next Hop	In label/Out label
Route Distinguisher: 2:2 (vpnb)		
172.10.10.12/30	0.0.0.0	20/aggregate(vpnb)
172.20.20.12/30	30.30.30.30	nolabel/20
192.168.2.1/32	172.10.10.14	22/nolabel
192.168.20.1/32	30.30.30.30	nolabel/22

PE_A#

3.3.6　PE_B 设备配置及配置验证

PE_B#show running

Building configuration...

Current configuration : 2459 bytes

!

version 12.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname PE_B

!

!

ip subnet-zero

!

!

!

ip vrf vpna

 rd 1:1

 route-target export 1:1

 route-target import 1:1

!

ip vrf vpnb

 rd 2:2

 route-target export 2:2

 route-target import 2:2

!

ip cef

mpls label protocol ldp

tag-switching tdp router-id Loopback0 force

!

!

!

!

!

!

!

!

!

!

!

!

mta receive maximum-recipients 0

```
!
!
!
!
interface Loopback0
 ip address 30.30.30.30 255.255.255.255
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding vpna
 ip address 172.20.20.9 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding vpnb
 ip address 172.20.20.13 255.255.255.252
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
interface Ethernet1/0
 ip address 172.20.20.5 255.255.255.252
 half-duplex
 mpls label protocol ldp
 tag-switching ip
!
interface Ethernet1/1
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/2
 no ip address
 shutdown
 half-duplex
!
interface Ethernet1/3
```

```
  no ip address
  shutdown
  half-duplex
!
router ospf 10 vrf vpna
  log-adjacency-changes
  redistribute connected subnets
  redistribute bgp 200 subnets
  network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
  log-adjacency-changes
  redistribute connected subnets
  redistribute bgp 200 subnets
  network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 1
  router-id 30.30.30.30
  log-adjacency-changes
  network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router bgp 200
  no synchronization
  bgp router-id 30.30.30.30
  bgp log-neighbor-changes
  neighbor 20.20.20.20 remote-as 200
  neighbor 20.20.20.20 update-source Loopback0
  neighbor 20.20.20.20 send-label
  no auto-summary
  !
  address-family ipv4 vrf vpnb
  redistribute connected
  redistribute ospf 20
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family ipv4 vrf vpna
  redistribute connected
  redistribute ospf 10
  no auto-summary
  no synchronization
  exit-address-family
  !
  address-family vpnv4
```

```
  neighbor 20.20.20.20 activate
  neighbor 20.20.20.20 send-community extended
  no auto-summary
  exit-address-family
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  exec-timeout 0 0
  login
!
!
end


PE_B#show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
20.20.20.20	1	FULL/DR	00:00:37	172.20.20.6	Ethernet1/0
192.168.20.1	1	FULL/BDR	00:00:33	172.20.20.14	FastEthernet0/0.2
192.168.10.1	1	FULL/BDR	00:00:33	172.20.20.10	FastEthernet0/0.1

```
PE_B#show 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, 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

2.0.0.0/32 is subnetted, 1 subnets

B   2.2.2.2 [200/11] via 10.10.10.10, 00:28:01

3.0.0.0/32 is subnetted, 1 subnets

B   3.3.3.3 [200/21] via 10.10.10.10, 00:28:00

20.0.0.0/32 is subnetted, 1 subnets

O   20.20.20.20 [110/11] via 172.20.20.6, 01:07:08, Ethernet1/0

172.20.0.0/30 is subnetted, 2 subnets

C   172.20.20.4 is directly connected, Ethernet1/0

O   172.20.20.0 [110/20] via 172.20.20.6, 01:07:08, Ethernet1/0

10.0.0.0/32 is subnetted, 1 subnets

O   10.10.10.10 [110/21] via 172.20.20.6, 01:07:08, Ethernet1/0

30.0.0.0/32 is subnetted, 1 subnets

C   30.30.30.30 is directly connected, Loopback0

PE_B#show ip bgp summary

BGP router identifier 30.30.30.30, local AS number 200

BGP table version is 3, main routing table version 3

2 network entries and 2 paths using 298 bytes of memory

8 BGP path attribute entries using 480 bytes of memory

1 BGP rrinfo entries using 24 bytes of memory

1 BGP AS-PATH entries using 24 bytes of memory

4 BGP extended community entries using 160 bytes of memory

0 BGP route-map cache entries using 0 bytes of memory

0 BGP filter-list cache entries using 0 bytes of memory

BGP activity 10/0 prefixes, 10/0 paths, scan interval 60 secs

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
20.20.20.20	4	200	74	79	3	0	0	01:07:00	2

PE_B#show ip bgp vpnv4 vrf vpna

BGP table version is 17, local router ID is 30.30.30.30

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

r RIB-failure

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

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1:1 (default for vrf vpna)					
*>i172.10.10.8/30	3.3.3.3		100	0	100 ?
*> 172.20.20.8/30	0.0.0.0	0		32768	?

*>i192.168.1.1/32	3.3.3.3		100	0 100 ?

```
*>i192.168.1.1/32   3.3.3.3                          100        0 100 ?
*> 192.168.10.1/32  172.20.20.10           2              32768 ?
PE_B#show ip bgp vpnv4 vrf vpna labels
   Network            Next Hop         In label/Out label
Route Distinguisher: 1:1 (vpna)
   172.10.10.8/30     3.3.3.3          nolabel/19
   172.20.20.8/30     0.0.0.0          19/aggregate(vpna)
   192.168.1.1/32     3.3.3.3          nolabel/21
   192.168.10.1/32    172.20.20.10     21/nolabel


PE_B#show ip bgp vpnv4 vrf vpnb
BGP table version is 17, local router ID is 30.30.30.30
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure
Origin codes: i - IGP, e - EGP, ? - incomplete


   Network            Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 2:2 (default for vrf vpnb)
*>i172.10.10.12/30   3.3.3.3                          100        0 100 ?
*> 172.20.20.12/30   0.0.0.0                0              32768 ?
*>i192.168.2.1/32    3.3.3.3                          100        0 100 ?
*> 192.168.20.1/32   172.20.20.14           2              32768 ?
PE_B#show ip bgp vpnv4 vrf vpnb labels
   Network            Next Hop         In label/Out label
Route Distinguisher: 2:2 (vpnb)
   172.10.10.12/30    3.3.3.3          nolabel/20
   172.20.20.12/30    0.0.0.0          20/aggregate(vpnb)
   192.168.2.1/32     3.3.3.3          nolabel/22
   192.168.20.1/32    172.20.20.14     22/nolabel


PE_B#
```

3.3.7 MCE_A 设备配置及配置验证

```
MCE_A#show running
Building configuration...


Current configuration : 1367 bytes
!
version 12.2
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
```

```
hostname MCE_A
!
!
ip subnet-zero
!
!
!
ip vrf vpna
 rd 1:1
 route-target export 1:1
 route-target import 1:1
!
ip vrf vpnb
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback1
 ip vrf forwarding vpna
 ip address 192.168.1.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpnb
 ip address 192.168.2.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex auto
```

```
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding vpna
 ip address 172.10.10.10 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding vpnb
 ip address 172.10.10.14 255.255.255.252
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 10 vrf vpna
 log-adjacency-changes
 capability vrf-lite
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
 log-adjacency-changes
 capability vrf-lite
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
```

```
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
end
```

MCE_A#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
172.10.10.13	1	FULL/DR	00:00:31	172.10.10.13	FastEthernet0/0.2
172.10.10.9	1	FULL/DR	00:00:31	172.10.10.9	FastEthernet0/0.1

MCE_A#show 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, 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

MCE_A#show ip route vrf vpna
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, 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

     192.168.10.0/32 is subnetted, 1 subnets
O IA   192.168.10.1 [110/2] via 172.10.10.9, 00:08:42, FastEthernet0/0.1
     172.10.0.0/30 is subnetted, 1 subnets
C   172.10.10.8 is directly connected, FastEthernet0/0.1

```
        172.20.0.0/30 is subnetted, 1 subnets
O IA       172.20.20.8 [110/2] via 172.10.10.9, 00:08:42, FastEthernet0/0.1
C      192.168.1.0/24 is directly connected, Loopback1
MCE_A#show ip route vrf vpnb
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, 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


        172.10.0.0/30 is subnetted, 1 subnets
C           172.10.10.12 is directly connected, FastEthernet0/0.2
        172.20.0.0/30 is subnetted, 1 subnets
O IA       172.20.20.12 [110/2] via 172.10.10.13, 00:08:44, FastEthernet0/0.2
        192.168.20.0/32 is subnetted, 1 subnets
O IA       192.168.20.1 [110/2] via 172.10.10.13, 00:08:44, FastEthernet0/0.2
C      192.168.2.0/24 is directly connected, Loopback2
MCE_A#traceroute vrf vpna
Protocol [ip]:
Target IP address: 192.168.10.1
Source address: 192.168.1.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.10.1


  1 172.10.10.9 2280 msec 356 msec 96 msec
  2 172.10.10.6 [MPLS: Labels 16/21/21 Exp 0] 2712 msec 2768 msec 2736 msec
  3 172.10.10.1 [MPLS: Labels 21/21 Exp 0] 2328 msec 2552 msec 2664 msec
  4 172.1.1.2 [MPLS: Labels 19/21 Exp 0] 2616 msec 2516 msec 2664 msec
  5 172.20.20.2 [MPLS: Labels 17/21 Exp 0] 2904 msec 2868 msec 2880 msec
  6 172.20.20.9 [MPLS: Label 21 Exp 0] 1632 msec 1228 msec 1560 msec
  7 172.20.20.10 1464 msec 1404 msec 2016 msec
MCE_A#traceroute
Protocol [ip]:
MCE_A#traceroute vrf vpnb
```

Protocol [ip]:

Target IP address: 192.168.20.1

Source address: 192.168.2.1

Numeric display [n]:

Timeout in seconds [3]: 10

Probe count [3]:

Minimum Time to Live [1]:

Maximum Time to Live [30]:

Port Number [33434]:

Loose, Strict, Record, Timestamp, Verbose[none]:

Type escape sequence to abort.

Tracing the route to 192.168.20.1

  1 172.10.10.13 276 msec 228 msec 216 msec

  2 172.10.10.6 [MPLS: Labels 16/21/22 Exp 0] 2556 msec 1992 msec 1800 msec

  3 172.10.10.1 [MPLS: Labels 21/22 Exp 0] 1276 msec 2544 msec 2656 msec

  4 172.1.1.2 [MPLS: Labels 19/22 Exp 0] 2568 msec 4428 msec 2928 msec

  5 172.20.20.2 [MPLS: Labels 17/22 Exp 0] 2688 msec 2504 msec 2544 msec

  6 172.20.20.13 [MPLS: Label 22 Exp 0] 1344 msec 1340 msec 1632 msec

  7 172.20.20.14 1704 msec 2040 msec 1464 msec

MCE_A#

3.3.8 MCE_B 设备配置及配置验证

MCE_B#show running

Building configuration...

Current configuration : 1369 bytes

!

version 12.2

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

!

hostname MCE_B

!

!

ip subnet-zero

!

!

!

ip vrf vpna

 rd 1:1

 route-target export 1:1

```
  route-target import 1:1
!
ip vrf vpnb
 rd 2:2
 route-target export 2:2
 route-target import 2:2
!
ip cef
!
!
!
!
!
!
!
!
!
!
!
mta receive maximum-recipients 0
!
!
!
!
interface Loopback1
 ip vrf forwarding vpna
 ip address 192.168.10.1 255.255.255.0
!
interface Loopback2
 ip vrf forwarding vpnb
 ip address 192.168.20.1 255.255.255.0
!
interface FastEthernet0/0
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/0.1
 encapsulation dot1Q 1 native
 ip vrf forwarding vpna
 ip address 172.20.20.10 255.255.255.252
!
interface FastEthernet0/0.2
 encapsulation dot1Q 2
 ip vrf forwarding vpnb
```

```
 ip address 172.20.20.14 255.255.255.252
!
interface FastEthernet0/1
 no ip address
 shutdown
 duplex auto
 speed auto
!
router ospf 10 vrf vpna
 log-adjacency-changes
 capability vrf-lite
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
router ospf 20 vrf vpnb
 log-adjacency-changes
 capability vrf-lite
 network 0.0.0.0 255.255.255.255 area 0.0.0.0
!
ip classless
ip http server
!
!
!
!
!
call rsvp-sync
!
!
mgcp profile default
!
!
!
dial-peer cor custom
!
!
!
!
line con 0
 exec-timeout 0 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 login
!
!
```

end

MCE_B#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
172.20.20.13	1	FULL/DR	00:00:34	172.20.20.13	FastEthernet0/0.2
172.20.20.9	1	FULL/DR	00:00:34	172.20.20.9	FastEthernet0/0.1

MCE_B#show 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, 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

MCE_B#show ip route vrf vpna
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, 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

C   192.168.10.0/24 is directly connected, Loopback1
     172.10.0.0/30 is subnetted, 1 subnets
O IA   172.10.10.8 [110/2] via 172.20.20.9, 00:14:05, FastEthernet0/0.1
     172.20.0.0/30 is subnetted, 1 subnets
C   172.20.20.8 is directly connected, FastEthernet0/0.1
     192.168.1.0/32 is subnetted, 1 subnets
O IA   192.168.1.1 [110/2] via 172.20.20.9, 00:14:05, FastEthernet0/0.1
MCE_B#show ip route vrf vpnb
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, 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

     172.10.0.0/30 is subnetted, 1 subnets
O IA   172.10.10.12 [110/2] via 172.20.20.13, 00:14:07, FastEthernet0/0.2
     172.20.0.0/30 is subnetted, 1 subnets
C   172.20.20.12 is directly connected, FastEthernet0/0.2
C   192.168.20.0/24 is directly connected, Loopback2
     192.168.2.0/32 is subnetted, 1 subnets
O IA   192.168.2.1 [110/2] via 172.20.20.13, 00:14:07, FastEthernet0/0.2
MCE_B#traceroute vrf vpna
Protocol [ip]:
Target IP address: 192.168.1.1
Source address: 192.168.10.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.1.1

  1 172.20.20.9 868 msec 272 msec 216 msec
  2 172.20.20.6 [MPLS: Labels 16/21/21 Exp 0] 2472 msec 2552 msec 2784 msec
  3 172.20.20.1 [MPLS: Labels 21/21 Exp 0] 2760 msec 2940 msec 2808 msec
  4 172.1.1.1 [MPLS: Labels 19/21 Exp 0] 2592 msec 2868 msec 2496 msec
  5 172.10.10.2 [MPLS: Labels 17/21 Exp 0] 2688 msec 4416 msec 2472 msec
  6 172.10.10.9 [MPLS: Label 21 Exp 0] 1452 msec 1388 msec 1384 msec
  7 172.10.10.10 1760 msec 1840 msec 1724 msec
MCE_B#traceroute vrf vpnb
Protocol [ip]:
Target IP address: 192.168.2.1
Source address: 192.168.20.1
Numeric display [n]:
Timeout in seconds [3]: 10
Probe count [3]:
Minimum Time to Live [1]:
Maximum Time to Live [30]:
Port Number [33434]:
Loose, Strict, Record, Timestamp, Verbose[none]:
Type escape sequence to abort.
Tracing the route to 192.168.2.1

1 172.20.20.13 336 msec 204 msec 240 msec

2 172.20.20.6 [MPLS: Labels 16/21/22 Exp 0] 2856 msec 2496 msec 2796 msec

3 172.20.20.1 [MPLS: Labels 21/22 Exp 0] 2520 msec 2744 msec 2688 msec

4 172.1.1.1 [MPLS: Labels 19/22 Exp 0] 2592 msec 4012 msec 2688 msec

5 172.10.10.2 [MPLS: Labels 17/22 Exp 0] 3176 msec 2412 msec 2700 msec

6 172.10.10.13 [MPLS: Label 22 Exp 0] 1392 msec 2956 msec 1368 msec

7 172.10.10.14 1580 msec 1644 msec 1776 msec

MCE_B#