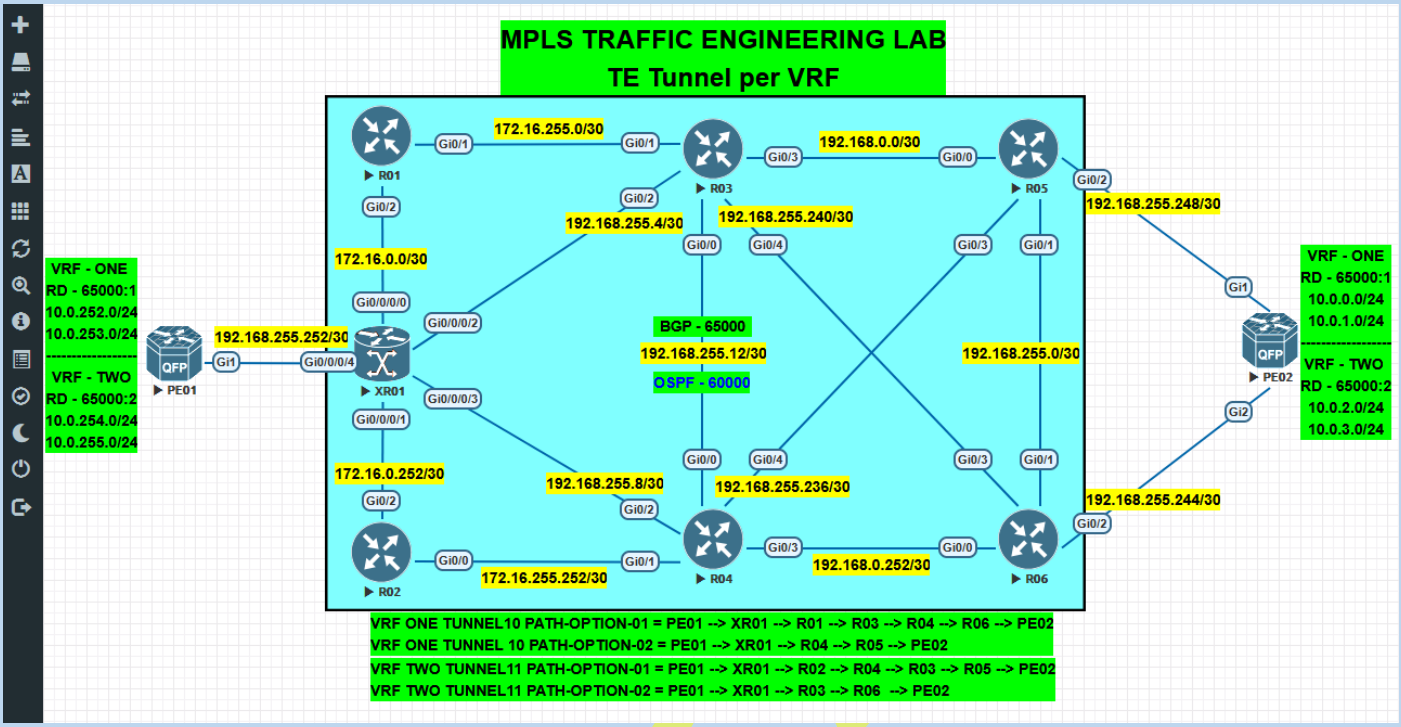
MPLS TRAFFIC ENGINEERING LAB
TE TUNNELS PER VRF



Lab Requirements

1. Configure TE Tunnels PE01 to PE02.
2. Each VRF must be routed through their dedicated tunnels according to their respective path-options.

For VRF ONE,

Path-option 01 : **PE01 → XR01 → R01 → R03 → R04 → R06 → PE02**

Path-option 02 : **PE01 → XR01 → R04 → R05 → PE02**

Path-option 03 : **Dynamic**

For VRF TWO,

Path-option 01 : **PE01 → XR01 → R02 → R04 → R03 → R05 → PE02**

Path-option 02 : **PE01 → XR01 → R03 → R06 → PE02**

Path-option 03 : **Dynamic**

IGP: OSPF Configuration

hello interval is 3s, dead interval is 6s and network type is point-to-point

R01

```
router ospf 60000
router-id 172.16.30.1
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet0/1
 no passive-interface GigabitEthernet0/2
 network 172.16.0.1 0.0.0.0 area 0
 network 172.16.30.1 0.0.0.0 area 0
 network 172.16.255.1 0.0.0.0 area 0
!
```

R02

```
router ospf 60000
router-id 172.16.30.2
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet0/0
 no passive-interface GigabitEthernet0/2
 network 172.16.0.254 0.0.0.0 area 0
 network 172.16.30.2 0.0.0.0 area 0
```

```
 network 172.16.255.253 0.0.0.0 area
!
```

R03

```
router ospf 60000
router-id 172.16.30.3
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet0/0
 no passive-interface GigabitEthernet0/1
 no passive-interface GigabitEthernet0/2
 no passive-interface GigabitEthernet0/3
 no passive-interface GigabitEthernet0/4
 network 172.16.30.3 0.0.0.0 area 0
 network 172.16.255.2 0.0.0.0 area 0
 network 192.168.0.1 0.0.0.0 area 0
 network 192.168.255.6 0.0.0.0 area 0
 network 192.168.255.13 0.0.0.0 area 0
 network 192.168.255.241 0.0.0.0 area 0
!
```

R04

```
router ospf 60000
router-id 172.16.30.4
```

```
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet0/0
 no passive-interface GigabitEthernet0/1
 no passive-interface GigabitEthernet0/2
 no passive-interface GigabitEthernet0/3
 no passive-interface GigabitEthernet0/4
 network 172.16.30.4 0.0.0.0 area 0
 network 172.16.255.254 0.0.0.0 area 0
 network 192.168.0.253 0.0.0.0 area 0
 network 192.168.255.10 0.0.0.0 area 0
 network 192.168.255.14 0.0.0.0 area 0
 network 192.168.255.237 0.0.0.0 area 0
!
```

R05

```
router ospf 60000
router-id 172.16.30.5
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet0/0
 no passive-interface GigabitEthernet0/1
 no passive-interface GigabitEthernet0/2
```

```
 no passive-interface GigabitEthernet0/3
 no passive-interface GigabitEthernet0/4
 network 172.16.30.5 0.0.0.0 area 0
 network 192.168.0.2 0.0.0.0 area 0
 network 192.168.255.1 0.0.0.0 area 0
 network 192.168.255.238 0.0.0.0 area 0
 network 192.168.255.249 0.0.0.0 area 0
!
```

R06

```
router ospf 60000
 router-id 172.16.30.6
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet0/0
 no passive-interface GigabitEthernet0/1
 no passive-interface GigabitEthernet0/2
 no passive-interface GigabitEthernet0/3
 no passive-interface GigabitEthernet0/4
 network 172.16.30.6 0.0.0.0 area 0
 network 192.168.0.254 0.0.0.0 area 0
 network 192.168.255.2 0.0.0.0 area 0
 network 192.168.255.242 0.0.0.0 area 0
```

```
 network 192.168.255.245 0.0.0.0 area 0
!
```

PE01

```
router ospf 60000
 router-id 172.16.30.7
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet1
 network 10.10.10.1 0.0.0.0 area 0
 network 10.10.10.2 0.0.0.0 area 0
 network 10.137.137.137 0.0.0.0 area 0
 network 172.16.30.7 0.0.0.0 area 0
 network 192.168.255.253 0.0.0.0 area 0
!
```

PE02

```
router ospf 60000
 router-id 172.16.30.8
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet1
 no passive-interface GigabitEthernet2
 network 10.10.10.3 0.0.0.0 area 0
```

```
 network 10.10.10.4 0.0.0.0 area 0
 network 10.24.24.24 0.0.0.0 area 0
 network 172.16.30.8 0.0.0.0 area 0
 network 192.168.255.246 0.0.0.0 area 0
 network 192.168.255.250 0.0.0.0 area 0
!
```

XR01

```
router ospf 60000
 router-id 172.16.30.9
 network point-to-point
 passive enable
 dead-interval 6
 hello-interval 3
 auto-cost reference-bandwidth 10000
 area 0
  interface Loopback0
  !
  interface GigabitEthernet0/0/0/0
   passive disable
  !
  interface GigabitEthernet0/0/0/1
   passive disable
```

```
 !
 interface GigabitEthernet0/0/0/2
  passive disable
 !
 interface GigabitEthernet0/0/0/3
  passive disable
 !
 interface GigabitEthernet0/0/0/4
  passive disable
 !
```

Configure MPLS in Respective Interfaces

!

BGP Configuration

R01

```
router bgp 65000
 bgp router-id 172.16.30.1
 neighbor 172.16.30.8 remote-as 65000
 neighbor 172.16.30.8 password 1111
 neighbor 172.16.30.8 update-source Loopback0
 neighbor 172.16.30.9 remote-as 65000
 neighbor 172.16.30.9 password 1111
 neighbor 172.16.30.9 update-source Loopback0
```

```
!
address-family ipv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.9 activate
exit-address-family
!
address-family vpnv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.8 send-community extended
 neighbor 172.16.30.9 activate
 neighbor 172.16.30.9 send-community extended
exit-address-family
!
```

R02

```
router bgp 65000
 bgp router-id 172.16.30.2
 neighbor 172.16.30.8 remote-as 65000
 neighbor 172.16.30.8 password 1111
 neighbor 172.16.30.8 update-source Loopback0
 neighbor 172.16.30.9 remote-as 65000
 neighbor 172.16.30.9 password 1111
 neighbor 172.16.30.9 update-source Loopback0
```

```
!
address-family ipv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.9 activate
exit-address-family
!
address-family vpnv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.8 send-community extended
 neighbor 172.16.30.9 activate
 neighbor 172.16.30.9 send-community extended
exit-address-family
!
```

R03

```
router bgp 65000
 bgp router-id 172.16.30.3
 neighbor 172.16.30.8 remote-as 65000
 neighbor 172.16.30.8 password 1111
 neighbor 172.16.30.8 update-source Loopback0
 neighbor 172.16.30.9 remote-as 65000
 neighbor 172.16.30.9 password 1111
 neighbor 172.16.30.9 update-source Loopback0
```

```
!
address-family ipv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.9 activate
exit-address-family
!
address-family vpnv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.8 send-community extended
 neighbor 172.16.30.9 activate
 neighbor 172.16.30.9 send-community extended
exit-address-family
!
```

R04

```
router bgp 65000
 bgp router-id 172.16.30.4
 neighbor 172.16.30.8 remote-as 65000
 neighbor 172.16.30.8 password 1111
 neighbor 172.16.30.8 update-source Loopback0
 neighbor 172.16.30.9 remote-as 65000
 neighbor 172.16.30.9 password 1111
 neighbor 172.16.30.9 update-source Loopback0
```

```
!
address-family ipv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.9 activate
exit-address-family
!
address-family vpnv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.8 send-community extended
 neighbor 172.16.30.9 activate
 neighbor 172.16.30.9 send-community extended
exit-address-family
!
```

R05

```
router bgp 65000
 bgp router-id 172.16.30.5
 neighbor 172.16.30.8 remote-as 65000
 neighbor 172.16.30.8 password 1111
 neighbor 172.16.30.8 update-source Loopback0
 neighbor 172.16.30.9 remote-as 65000
 neighbor 172.16.30.9 password 1111
 neighbor 172.16.30.9 update-source Loopback0
```

```
!
address-family ipv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.9 activate
exit-address-family
!
address-family vpnv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.8 send-community extended
 neighbor 172.16.30.9 activate
 neighbor 172.16.30.9 send-community extended
exit-address-family
!
```

R06

```
router bgp 65000
 bgp router-id 172.16.30.6
 neighbor 172.16.30.8 remote-as 65000
 neighbor 172.16.30.8 password 1111
 neighbor 172.16.30.8 update-source Loopback0
 neighbor 172.16.30.9 remote-as 65000
 neighbor 172.16.30.9 password 1111
 neighbor 172.16.30.9 update-source Loopback0
```

```
!
address-family ipv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.9 activate
exit-address-family
!
address-family vpnv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.8 send-community extended
 neighbor 172.16.30.9 activate
 neighbor 172.16.30.9 send-community extended
exit-address-family
!
```

PE01

```
router bgp 65000
 bgp router-id 172.16.30.7
 neighbor 172.16.30.8 remote-as 65000
 neighbor 172.16.30.8 password 1111
 neighbor 172.16.30.8 update-source Loopback0
 neighbor 172.16.30.9 remote-as 65000
 neighbor 172.16.30.9 password 1111
 neighbor 172.16.30.9 update-source Loopback0
```

```
!
address-family ipv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.9 activate
exit-address-family
!
address-family vpnv4
 neighbor 172.16.30.8 activate
 neighbor 172.16.30.8 send-community extended
 neighbor 172.16.30.9 activate
 neighbor 172.16.30.9 send-community extended
exit-address-family
!
address-family ipv4 vrf ONE
 redistribute connected
exit-address-family
!
address-family ipv4 vrf TWO
 redistribute connected
exit-address-family
!
```

PE02 [ROUTE-REFLECTOR]

```
router bgp 65000
 bgp router-id 172.16.30.8
 bgp cluster-id 172.16.30.9
 neighbor CORE-RR peer-group
 neighbor CORE-RR remote-as 65000
 neighbor CORE-RR password 1111
 neighbor CORE-RR update-source Loopback0
 neighbor 172.16.30.1 peer-group CORE-RR
 neighbor 172.16.30.2 peer-group CORE-RR
 neighbor 172.16.30.3 peer-group CORE-RR
 neighbor 172.16.30.4 peer-group CORE-RR
 neighbor 172.16.30.5 peer-group CORE-RR
 neighbor 172.16.30.6 peer-group CORE-RR
 neighbor 172.16.30.7 peer-group CORE-RR
 !
 address-family ipv4
  neighbor CORE-RR route-reflector-client
  neighbor 172.16.30.1 activate
  neighbor 172.16.30.2 activate
  neighbor 172.16.30.3 activate
  neighbor 172.16.30.4 activate
```

```
 neighbor 172.16.30.5 activate
 neighbor 172.16.30.6 activate
 neighbor 172.16.30.7 activate
exit-address-family
!
address-family vpnv4
 neighbor CORE-RR send-community extended
 neighbor CORE-RR route-reflector-client
 neighbor 172.16.30.1 activate
 neighbor 172.16.30.2 activate
 neighbor 172.16.30.3 activate
 neighbor 172.16.30.4 activate
 neighbor 172.16.30.5 activate
 neighbor 172.16.30.6 activate
 neighbor 172.16.30.7 activate
exit-address-family
!
address-family ipv4 vrf ONE
 redistribute connected
exit-address-family
!
address-family ipv4 vrf TWO
```

```
 redistribute connected
 exit-address-family
!
```

XR01 [ROUTE-REFLECTOR]

```
router bgp 65000
 bgp router-id 172.16.30.9
 bgp cluster-id 172.16.30.9
 address-family ipv4 unicast
 !
 address-family vpnv4 unicast
 !
 neighbor-group CORE-RR
  remote-as 65000
  password 1111
  update-source Loopback0
  address-family ipv4 unicast
   route-reflector-client
  !
  address-family vpnv4 unicast
   route-reflector-client
  !
!
```

```
neighbor 172.16.30.1
 use neighbor-group CORE-RR
!
neighbor 172.16.30.2
 use neighbor-group CORE-RR
!
neighbor 172.16.30.3
 use neighbor-group CORE-RR
!
neighbor 172.16.30.4
 use neighbor-group CORE-RR
!
neighbor 172.16.30.5
 use neighbor-group CORE-RR
!
neighbor 172.16.30.6
 use neighbor-group CORE-RR
!
neighbor 172.16.30.7
 use neighbor-group CORE-RR
!
```

Enable TE in Global

IOS XE

```
Router(config)# mpls traffic-eng tunnels
!
```

IOS XR

```
mpls traffic-eng
 interface GigabitEthernet0/0/0/0
 !
 interface GigabitEthernet0/0/0/1
 !
 interface GigabitEthernet0/0/0/2
 !
 interface GigabitEthernet0/0/0/3
 !
 interface GigabitEthernet0/0/0/4
 !
```

RSVP Configuration and Enable TE in Interface Level

IOS XE

```
interface GigabitEthernet-/-
mpls traffic-eng tunnels
ip rsvp bandwidth percent 80
!
```

IOS XR

```
rsvp
 interface GigabitEthernet0/0/0/0
  bandwidth percentage 80
 !
 interface GigabitEthernet0/0/0/1
  bandwidth percentage 80
 !
 interface GigabitEthernet0/0/0/2
  bandwidth percentage 80
 !
 interface GigabitEthernet0/0/0/3
  bandwidth percentage 80
 !
 interface GigabitEthernet0/0/0/4
  bandwidth percentage 80
 !
```

Enable TE in IGP: OSPF

IOS XE

```
router ospf 60000
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

IOS XR

```
router ospf 60000
mpls traffic-eng router-id Loopback0
area 0
  mpls traffic-eng
!
```

Preparation of Explicit Path List

PE01

```
ip explicit-path name PATH-01 enable
 next-address 192.168.255.254
 next-address 172.16.0.1
 next-address 172.16.255.2
 next-address 192.168.255.14
 next-address 192.168.0.254
 next-address 192.168.255.246
!
ip explicit-path name PATH-02 enable
 next-address 192.168.255.254
 next-address 192.168.255.10
 next-address 192.168.255.238
 next-address 192.168.255.250
!
```

```
ip explicit-path name PATH-03 enable
 next-address 192.168.255.254
 next-address 172.16.0.254
 next-address 172.16.255.254
 next-address 192.168.255.13
 next-address 192.168.0.2
 next-address 192.168.255.250
!
ip explicit-path name PATH-04 enable
 next-address 192.168.255.254
 next-address 192.168.255.6
 next-address 192.168.255.242
 next-address 192.168.255.246
!
```

Configuring TE Tunnels

PE01

```
interface Tunnel10
 ip unnumbered Loopback0
 tunnel mode mpls traffic-eng
 tunnel destination 172.16.30.8
 tunnel mpls traffic-eng bandwidth 250000
 tunnel mpls traffic-eng path-option 1 explicit name PATH-01
```

```
 tunnel mpls traffic-eng path-option 2 explicit name PATH-02
 tunnel mpls traffic-eng path-option 3 dynamic
!
interface Tunnel11
 ip unnumbered Loopback0
 tunnel mode mpls traffic-eng
 tunnel destination 172.16.30.8
 tunnel mpls traffic-eng bandwidth 250000
 tunnel mpls traffic-eng path-option 1 explicit name PATH-03
 tunnel mpls traffic-eng path-option 2 explicit name PATH-04
 tunnel mpls traffic-eng path-option 3 dynamic
!
PE01(config)# mpls traffic-eng reoptimize timers frequency 3
!
```

Loopback Configuration for BGP Next-hop

PE01

```
interface Loopback1
 ip address 10.10.10.1 255.255.255.255
!
interface Loopback2
 ip address 10.10.10.2 255.255.255.255
!
```

PE02

```
interface Loopback1
 ip address 10.10.10.3 255.255.255.255
!
interface Loopback2
 ip address 10.10.10.4 255.255.255.255
!
```

Configuring BGP Next-hop in VRF

PE01 & PE02

```
ip vrf ONE
 rd 65000:1
 route-target both 65000:1
 bgp next-hop Loopback1
!
ip vrf TWO
 rd 65000:2
 route-target both 65000:2
 bgp next-hop Loopback2
!
```

Routing over TE Tunnels

PE01

```
ip route 10.10.10.3 255.255.255.255 Tunnel10
```

ip route 10.10.10.4 255.255.255.255 Tunnel11

!

Verification

VPNv4 Routes at PE01

```
PE01#sh ip bgp vpnv4 all | be Network
     Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 65000:1 (default for vrf ONE)
 *>i 10.0.0.0/24      10.10.10.3               0    100      0 ?
 *>i 10.0.1.0/24      10.10.10.3               0    100      0 ?
 *>  10.0.252.0/24    0.0.0.0                  0         32768 ?
 *>  10.0.253.0/24    0.0.0.0                  0         32768 ?
Route Distinguisher: 65000:2 (default for vrf TWO)
 *>i 10.0.2.1/32      10.10.10.4               0    100      0 ?
 *>i 10.0.3.1/32      10.10.10.4               0    100      0 ?
 *>  10.0.254.1/32    0.0.0.0                  0         32768 ?
 *>  10.0.255.1/32    0.0.0.0                  0         32768 ?
PE01#
```

TE Tunnels

TE Tunnel 10

```
Name: PE01_t10                           (Tunnel10) Destination: 172.16.30.8
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
    path option 1, type explicit PATH-01 (Basis for Setup, path weight 60)
    path option 2, type explicit PATH-02
    path option 3, type dynamic

  Config Parameters:
    Bandwidth: 250000   kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: disabled LockDown: disabled Loadshare: 250000 [8000] bw-based
    auto-bw: disabled
  Active Path Option Parameters:
    State: explicit path option 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled
```

```
RSVP Signalling Info:
     Src 172.16.30.7, Dst 172.16.30.8, Tun_Id 10, Tun_Instance 265
  RSVP Path Info:
    My Address: 192.168.255.253
    Explicit Route: 192.168.255.254 172.16.0.1 172.16.255.2 192.168.255.14
                    192.168.0.254 192.168.255.246 172.16.30.8
```

TE Tunnel 11

```
Name: PE01_t11                            (Tunnel11) Destination: 172.16.30.8
  Status:
    Admin: up          Oper: up     Path: valid       Signalling: connected
    path option 1, type explicit PATH-03 (Basis for Setup, path weight 60)
    path option 2, type explicit PATH-04
    path option 3, type dynamic

  Config Parameters:
    Bandwidth: 250000   kbps (Global)  Priority: 7  7   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute: disabled LockDown: disabled Loadshare: 250000 [8000] bw-based
    auto-bw: disabled
  Active Path Option Parameters:
    State: explicit path option 1 is active
    BandwidthOverride: disabled  LockDown: disabled  Verbatim: disabled
```

```
RSVP Signalling Info:
     Src 172.16.30.7, Dst 172.16.30.8, Tun_Id 11, Tun_Instance 82
  RSVP Path Info:
    My Address: 192.168.255.253
    Explicit Route: 192.168.255.254 172.16.0.254 172.16.255.254 192.168.255.13
                    192.168.0.2 192.168.255.250 172.16.30.8
```

Traceroute Results for Each VRFs

For VRF ONE

```
PE01#traceroute vrf ONE 10.0.0.1
Type escape sequence to abort.
Tracing the route to 10.0.0.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.255.254 [MPLS: Labels 24022/34 Exp 0] 16 msec 11 msec 9 msec
  2 172.16.0.1 [MPLS: Labels 38/34 Exp 0] 10 msec 10 msec 8 msec
  3 172.16.255.2 [MPLS: Labels 43/34 Exp 0] 10 msec 10 msec 8 msec
  4 192.168.255.14 [MPLS: Labels 43/34 Exp 0] 9 msec 10 msec 10 msec
  5 192.168.0.254 [MPLS: Labels 39/34 Exp 0] 11 msec 12 msec 10 msec
  6 10.0.0.1 12 msec *  11 msec
PE01#
```

For VRF TWO

```
PE01#traceroute vrf TWO 10.0.3.1
Type escape sequence to abort.
Tracing the route to 10.0.3.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.255.254 [MPLS: Labels 24021/37 Exp 0] 11 msec 9 msec 9 msec
  2 172.16.0.254 [MPLS: Labels 44/37 Exp 0] 9 msec 11 msec 11 msec
  3 172.16.255.254 [MPLS: Labels 42/37 Exp 0] 9 msec 9 msec 10 msec
  4 192.168.255.13 [MPLS: Labels 42/37 Exp 0] 10 msec 9 msec 10 msec
  5 192.168.0.2 [MPLS: Labels 43/37 Exp 0] 9 msec 10 msec 9 msec
  6 10.0.3.1 12 msec *  11 msec
PE01#
```

Ko Lwin (Network)