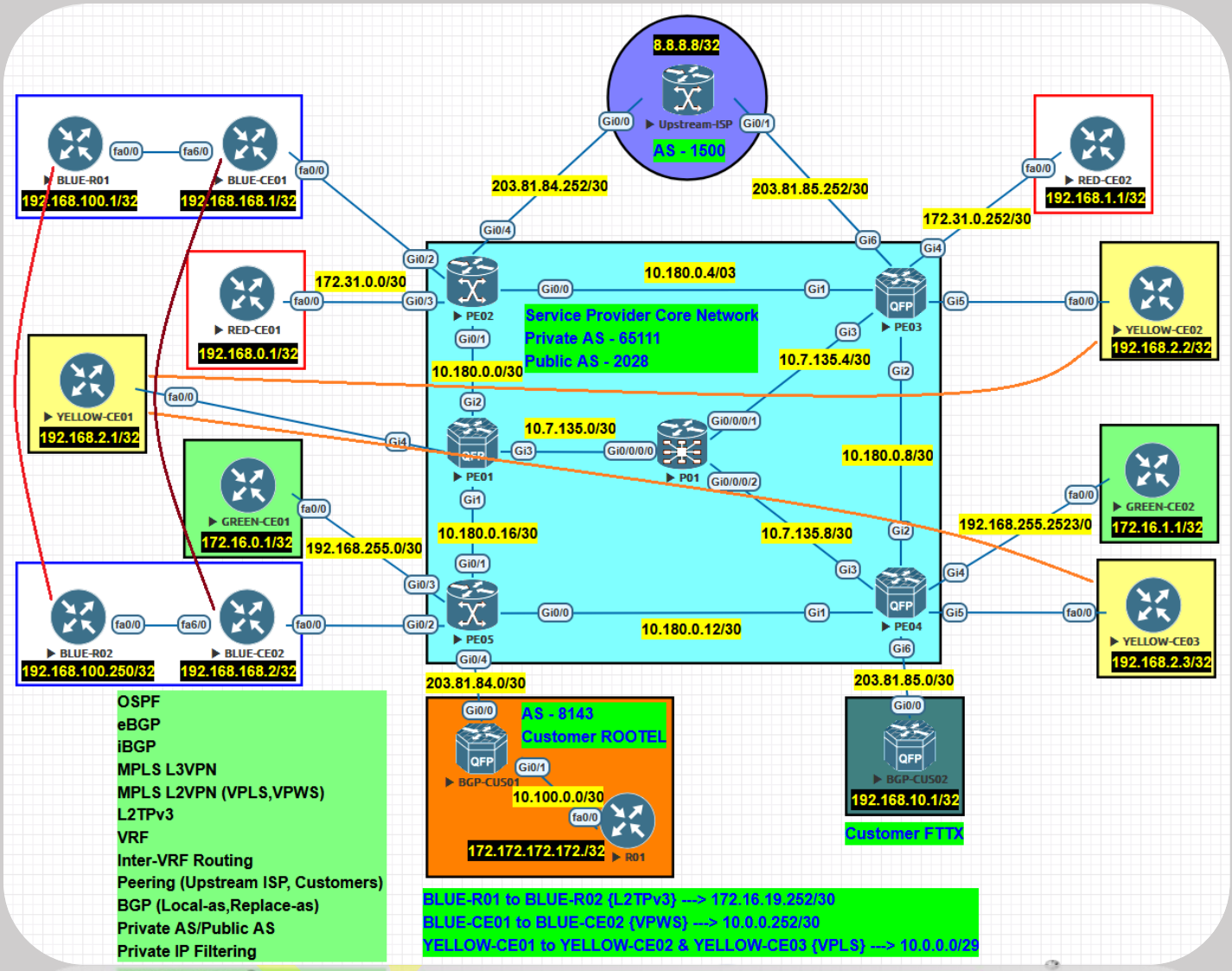
Service Provider MPLS VPNs and BGP Peering with ISPs and Customers [Full Lab]



Lab Requirements

1. OSPF must be configured as the IGP within the service provider core, and all P and PE loopback interfaces must be reachable via OSPF.

2. MPLS must be enabled on all core–facing interfaces, and end–to–end label–switched paths must exist between all PE routers.
3. iBGP must be established between PE routers within the service provider private AS–**65111**, using loopback interfaces as the update source.
4. An iBGP route–reflector architecture must be implemented. All non–route–reflector PE routers must establish iBGP sessions exclusively with the route reflector. **P01** shall operate as the **active route reflector**, while **PE01** shall be configured as the **standby route reflector**.
5. MPLS Layer–3 VPN services must be implemented using VRFs with unique Route Distinguishers and controlled Route Target import and export policies.
6. Customer sites assigned to the same VRF must have end–to–end IP connectivity across the MPLS backbone.
7. Inter–VRF routing must be implemented for **RED–CE01** and **GREEN–CE01**.
8. MPLS Layer–2 VPN services must be implemented using: **VPWS** between **BLUE–CE01 and BLUE–CE02**, and **VPLS** between **YELLOW–CE01 and YELLOW–CE02, YELLOW–CE03**, providing transparent Layer–2 connectivity between PE routers.
9. An additional Layer–2 VPN service must be implemented using **L2TPv3** between **BLUE–R01 and BLUE–R02**, providing point–to–point Layer–2 transport.
10. eBGP sessions must be established with external ISPs and customers using public Autonomous System numbers (**2028**).
11. The service provider private AS must connect to public AS peers using the BGP **local–as** and **replace–as** features.
12. The private AS number **must not appear** in the AS–PATH advertised to any external ISP or customer.
13. Public BGP peering must exchange only authorized public IP prefixes; internal service provider, VPN, and private prefixes must not be advertised externally.
14. Private IP address space must be filtered on all public–facing eBGP sessions.
15. External ISPs and customers must not receive the service provider internal routing table.

SERVICE PROVIDER CORE NETWORK

IGP: OSPF CONFIGURATION

hello interval is 3s, dead interval is 10s and network type is point-to-point

PE01

```
router ospf 65111
 router-id 172.16.30.1
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet1
 no passive-interface GigabitEthernet2
 no passive-interface GigabitEthernet3
 network 10.7.135.1 0.0.0.0 area 0
 network 10.180.0.2 0.0.0.0 area 0
 network 10.180.0.17 0.0.0.0 area 0
 network 172.16.30.1 0.0.0.0 area 0
!
```

PE02

```
router ospf 65111
 router-id 172.16.30.2
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet0/0
 no passive-interface GigabitEthernet0/1
 network 10.180.0.1 0.0.0.0 area 0
```

```
 network 10.180.0.5 0.0.0.0 area 0
 network 172.16.30.2 0.0.0.0 area 0
!
```

PE03

```
router ospf 65111
 router-id 172.16.30.3
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet1
 no passive-interface GigabitEthernet2
 no passive-interface GigabitEthernet3
 network 10.7.135.6 0.0.0.0 area 0
 network 10.180.0.6 0.0.0.0 area 0
 network 10.180.0.9 0.0.0.0 area 0
 network 172.16.30.3 0.0.0.0 area 0
!
```

PE04

```
router ospf 65111
 router-id 172.16.30.4
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet1
 no passive-interface GigabitEthernet2
 no passive-interface GigabitEthernet3
```

```
 network 10.7.135.10 0.0.0.0 area 0
 network 10.180.0.10 0.0.0.0 area 0
 network 10.180.0.14 0.0.0.0 area 0
 network 172.16.30.4 0.0.0.0 area 0
!
```

PE05

```
router ospf 65111
 router-id 172.16.30.5
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet0/0
 no passive-interface GigabitEthernet0/1
 network 10.180.0.13 0.0.0.0 area 0
 network 10.180.0.18 0.0.0.0 area 0
 network 172.16.30.5 0.0.0.0 area 0
!
```

P01

```
router ospf 65111
 router-id 172.16.30.254
 network point-to-point
 passive enable
 dead-interval 10
 hello-interval 3
 auto-cost reference-bandwidth 10000
```

```
 area 0
  interface Loopback2028
  !
  interface GigabitEthernet0/0/0/0
   passive disable
  !
  interface GigabitEthernet0/0/0/1
   passive disable
  !
  interface GigabitEthernet0/0/0/2
   passive disable
  !
```

MPLS CONFIGURATION

PE01

```
mpls ldp router–id Loopback2028 force
!
interface range gigabitEthernet 1–3
mpls ip
!
```

PE02

```
mpls ldp router–id Loopback2028 force
!
interface range gigabitEthernet 0/0–1
mpls ip
```

PE03

```
mpls ldp router–id Loopback2028 force
!
interface range gigabitEthernet 1–3
mpls ip
!
```

PE04

```
mpls ldp router–id Loopback2028 force
!
interface range gigabitEthernet 1–3
mpls ip
!
```

PE05

```
mpls ldp router–id Loopback2028 force
!
interface range gigabitEthernet 0/0–1
mpls ip
!
```

P01

```
mpls ldp
 router–id 172.16.30.254
 interface GigabitEthernet0/0/0/0
 interface GigabitEthernet0/0/0/1
 interface GigabitEthernet0/0/0/2
```

MP-BGP CONFIGURATION

P01 (RR-ACTIVE)

```
router bgp 65111
 bgp router-id 172.16.30.254
 bgp cluster-id 172.16.30.254
 address-family ipv4 unicast
 !
 address-family vpnv4 unicast
 !
 neighbor-group CORE-RR
  remote-as 65111
  password neolwin!!!!
  update-source Loopback2028
  address-family ipv4 unicast
   route-policy LOCAL in
   route-reflector-client
  !
  address-family vpnv4 unicast
   route-policy LOCAL in
   route-reflector-client
  !
 neighbor 172.16.30.2
  use neighbor-group CORE-RR
  description PE02
```

```
 !
 neighbor 172.16.30.3
  use neighbor-group CORE-RR
  description PE03
 !
 neighbor 172.16.30.4
  use neighbor-group CORE-RR
  description PE04
 !
 neighbor 172.16.30.5
  use neighbor-group CORE-RR
  description PE05
!
route-policy LOCAL
  set local-preference 500
  pass
end-policy
!
```

PE01 (RR-STANDBY)

```
router bgp 65111
 bgp router-id 172.16.30.1
 bgp cluster-id 172.16.30.254
 neighbor CORE-RR peer-group
 neighbor CORE-RR remote-as 65111
```

```
neighbor CORE-RR password neolwin!!!!
neighbor CORE-RR update-source Loopback2028
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
!
address-family ipv4
 neighbor CORE-RR route-reflector-client
 neighbor 172.16.30.2 activate
 neighbor 172.16.30.3 activate
 neighbor 172.16.30.4 activate
 neighbor 172.16.30.5 activate
exit-address-family
!
address-family vpnv4
 neighbor CORE-RR send-community extended
 neighbor CORE-RR route-reflector-client
 neighbor 172.16.30.2 activate
 neighbor 172.16.30.3 activate
 neighbor 172.16.30.4 activate
 neighbor 172.16.30.5 activate
exit-address-family
!
```

PE02

```
router bgp 65111
 bgp router-id 172.16.30.2
 neighbor 172.16.30.1 remote-as 65111
 neighbor 172.16.30.1 password neolwin!!!!
 neighbor 172.16.30.1 update-source Loopback2028
 neighbor 172.16.30.254 remote-as 65111
 neighbor 172.16.30.254 password neolwin!!!!
 neighbor 172.16.30.254 update-source Loopback2028
!
 address-family ipv4
  neighbor 172.16.30.1 activate
  neighbor 172.16.30.254 activate
 exit-address-family
 !
 address-family vpnv4
  neighbor 172.16.30.1 activate
  neighbor 172.16.30.1 send-community extended
  neighbor 172.16.30.254 activate
  neighbor 172.16.30.254 send-community extended
 exit-address-family
 !
```

PE03

```
router bgp 65111
```

```
 bgp router-id 172.16.30.3
 neighbor 172.16.30.1 remote-as 65111
 neighbor 172.16.30.1 password neolwin!!!!
 neighbor 172.16.30.1 update-source Loopback2028
 neighbor 172.16.30.254 remote-as 65111
 neighbor 172.16.30.254 password neolwin!!!!
 neighbor 172.16.30.254 update-source Loopback2028
!
 address-family ipv4
  neighbor 172.16.30.1 activate
  neighbor 172.16.30.254 activate
exit-address-family
 !
 address-family vpnv4
  neighbor 172.16.30.1 activate
  neighbor 172.16.30.1 send-community extended
  neighbor 172.16.30.254 activate
  neighbor 172.16.30.254 send-community extended
 exit-address-family
 !
```

PE04

```
router bgp 65111
 bgp router-id 172.16.30.4
 neighbor 172.16.30.1 remote-as 65111
```

```
 neighbor 172.16.30.1 password neolwin!!!!
 neighbor 172.16.30.1 update-source Loopback2028
 neighbor 172.16.30.254 remote-as 65111
 neighbor 172.16.30.254 password neolwin!!!!
 neighbor 172.16.30.254 update-source Loopback2028
 !
 address-family ipv4
  neighbor 172.16.30.1 activate
  neighbor 172.16.30.254 activate
 exit-address-family
 !
 address-family vpnv4
  neighbor 172.16.30.1 activate
  neighbor 172.16.30.1 send-community extended
  neighbor 172.16.30.254 activate
  neighbor 172.16.30.254 send-community extended
 exit-address-family
 !
```

PE05

```
router bgp 65111
 bgp router-id 172.16.30.5
 neighbor 172.16.30.1 remote-as 65111
 neighbor 172.16.30.1 password neolwin!!!!
 neighbor 172.16.30.1 update-source Loopback2028
```

```
 neighbor 172.16.30.254 remote-as 65111
 neighbor 172.16.30.254 password neolwin!!!!
 neighbor 172.16.30.254 update-source Loopback2028
!
 address-family ipv4
  neighbor 172.16.30.1 activate
  neighbor 172.16.30.254 activate
exit-address-family
 !
 address-family vpnv4
  neighbor 172.16.30.1 activate
  neighbor 172.16.30.1 send-community extended
  neighbor 172.16.30.254 activate
  neighbor 172.16.30.254 send-community extended
 exit-address-family
!
```

MPLS L3VPN CONFIGURATION

FOR VRF RED

PE-CE ROUTING

PE02

```
ip vrf RED
 rd 65111:111
 route-target export 65111:111
 route-target import 65111:111
```

```
interface GigabitEthernet0/3
 ip vrf forwarding RED
 ip address 172.31.0.1 255.255.255.252
!
router bgp 65111
address-family ipv4 vrf RED
  redistribute ospf 111 match internal external 1 external 2
 exit-address-family
!
router ospf 111 vrf RED
 router-id 192.168.0.2
 auto-cost reference-bandwidth 10000
 redistribute bgp 65111 subnets
 passive-interface default
 no passive-interface GigabitEthernet0/3
 network 172.31.0.1 0.0.0.0 area 0
!
```

RED-CE01

```
router ospf 111
 router-id 192.168.0.1
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface FastEthernet0/0
 network 172.31.0.2 0.0.0.0 area 0
```

```
 network 192.168.0.1 0.0.0.0 area 0
!
```

PE03

```
ip vrf RED
 rd 65111:111
 route-target export 65111:111
 route-target import 65111:111
!
interface GigabitEthernet4
 ip vrf forwarding RED
 ip address 172.31.0.253 255.255.255.252
!
router bgp 65111
address-family ipv4 vrf RED
  redistribute ospf 111 match internal external 1 external 2
 exit-address-family
!
router ospf 111 vrf RED
 router-id 192.168.1.2
 auto-cost reference-bandwidth 10000
 redistribute bgp 65111 subnets
 passive-interface default
 no passive-interface GigabitEthernet4
 network 172.31.0.253 0.0.0.0 area 0
```

RED-CE02

```
router ospf 111
 router-id 192.168.1.1
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface FastEthernet0/0
 network 172.31.0.254 0.0.0.0 area 0
 network 192.168.1.1 0.0.0.0 area 0
!
```

FOR VRF GREEN

PE-CE ROUTING

PE05

```
ip vrf GREEN
 rd 65111:2222
 route-target export 65111:2222
 route-target import 65111:2222
!
interface GigabitEthernet0/3
 ip vrf forwarding GREEN
 ip address 192.168.255.1 255.255.255.252
!
router bgp 65111
address-family ipv4 vrf GREEN
  redistribute ospf 2222 match internal external 1 external 2
```

```
 exit-address-family
!
router ospf 2222 vrf GREEN
 router-id 172.16.0.2
 auto-cost reference-bandwidth 10000
 redistribute bgp 65111 subnets
 passive-interface default
 no passive-interface GigabitEthernet0/3
 network 192.168.255.1 0.0.0.0 area 0
!
```

GREEN-CE01

```
router ospf 2222
 router-id 172.16.0.1
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface FastEthernet0/0
 network 172.16.0.1 0.0.0.0 area 0
 network 192.168.255.2 0.0.0.0 area 0
!
```

PE04

```
ip vrf GREEN
 rd 65111:2222
 route-target export 65111:2222
 route-target import 65111:2222
```

```
!
interface GigabitEthernet4
 ip vrf forwarding GREEN
 ip address 192.168.255.253 255.255.255.252
!
router bgp 65111
address-family ipv4 vrf GREEN
  redistribute ospf 2222 match internal external 1 external 2
 exit-address-family
!
router ospf 2222 vrf GREEN
 router-id 172.16.1.2
 auto-cost reference-bandwidth 10000
 redistribute bgp 65111 subnets
 passive-interface default
 no passive-interface GigabitEthernet4
 network 192.168.255.253 0.0.0.0 area 0
!
```

GREEN-CE02

```
router ospf 2222
 router-id 172.16.1.1
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface FastEthernet0/0
```

```
 network 172.16.1.1 0.0.0.0 area 0
 network 192.168.255.254 0.0.0.0 area 0
!
```

INTER-VRF ROUTING BETWEEN PE02 AND PE05 FOR VRF RED AND VRF GREEN

PE02

```
ip vrf RED
 rd 65111:111
 route-target import 65111:2222
!
```

PE05

```
ip vrf GREEN
 rd 65111:2222
 route-target import 65111:111
!
```

MPLS L2VPN CONFIGURATION

VPWS CONFIGURATION (PE02 – PE05) FOR BLUE SITE

PE02

```
pseudowire-class VPWS
 encapsulation mpls
!
interface GigabitEthernet0/2
xconnect 172.16.30.5 100 pw-class VPWS
!
```

PE05

```
pseudowire-class VPWS
 encapsulation mpls
!
interface GigabitEthernet0/2
xconnect 172.16.30.2 100 pw-class VPWS
!
```

VPLS CONFIGURATION (PE01 – PE03 & PE04) FOR YELLOW SITE

PE01

```
l2vpn vfi context VPLS
 vpn id 24
 member 172.16.30.3 encapsulation mpls
 member 172.16.30.4 encapsulation mpls
!
interface GigabitEthernet4
 service instance 1 ethernet
  encapsulation untagged
 !
bridge-domain 24
 member GigabitEthernet4 service-instance 1
 member vfi VPLS
!
```

PE03

```
l2vpn vfi context VPLS
```

```
 vpn id 24
 member 172.16.30.1 encapsulation mpls
!
interface GigabitEthernet5
service instance 1 ethernet
  encapsulation untagged
 !
bridge-domain 24
 member GigabitEthernet5 service-instance 1
 member vfi VPLS
!
```

PE04

```
l2vpn vfi context VPLS
 vpn id 24
 member 172.16.30.1 encapsulation mpls
!
interface GigabitEthernet5
service instance 1 ethernet
  encapsulation untagged
 !
bridge-domain 24
 member GigabitEthernet5 service-instance 1
 member vfi VPLS
!
```

L2TPv3 CONFIGURATION (BLUE-CE01 – BLUE-CE02) FOR BLUE-R01 & BLUE-R02

BLUE-CE01

```
ip route 192.168.168.2 255.255.255.255 10.0.0.254
!
pseudowire-class L2TPV3
 encapsulation l2tpv3
 ip local interface Loopback0
!
interface FastEthernet6/0
xconnect 192.168.168.2 100 pw-class L2TPV3
!
```

BLUE-CE02

```
ip route 192.168.168.1 255.255.255.255 10.0.0.253
!
pseudowire-class L2TPV3
 encapsulation l2tpv3
 ip local interface Loopback0
!
interface FastEthernet6/0
xconnect 192.168.168.1 100 pw-class L2TPV3
!
```

BGP PEERING WITH UPSTREAM ISP AND ENTERPRISE CUSTOMER

WITH UPSTREAM ISP

UPSTREAM-ISP

```
router bgp 1500
 bgp router-id 8.8.8.8
 network 8.8.8.8 mask 255.255.255.255
 network 203.81.84.252 mask 255.255.255.252
 network 203.81.85.252 mask 255.255.255.252
 neighbor 203.81.84.254 remote-as 2028
 neighbor 203.81.84.254 password neolwin!!!!
 neighbor 203.81.85.254 remote-as 2028
 neighbor 203.81.85.254 password neolwin!!!!
!
```

PE02

```
router bgp 65111
 neighbor 203.81.84.253 remote-as 1500
 neighbor 203.81.84.253 local-as 2028 no-prepend replace-as
 neighbor 203.81.84.253 password neolwin!!!!
 !
 address-family ipv4
  neighbor 172.16.30.1 next-hop-self
  neighbor 172.16.30.254 next-hop-self
  neighbor 203.81.84.253 activate
 exit-address-family
```

PE03

```
router bgp 65111
 neighbor 203.81.85.253 remote-as 1500
 neighbor 203.81.85.253 local-as 2028 no-prepend replace-as
 neighbor 203.81.85.253 password neolwin!!!!
 !
 address-family ipv4
  neighbor 172.16.30.1 next-hop-self
  neighbor 172.16.30.254 next-hop-self
  neighbor 203.81.85.253 activate
 exit-address-family
 !
```

WITH ENTERPRISE CUSTOMER

PE05

```
router bgp 65111
 neighbor 203.81.84.2 remote-as 8143
 neighbor 203.81.84.2 local-as 2028 no-prepend replace-as
 neighbor 203.81.84.2 password neolwin!!!!
 !
 address-family ipv4
  network 203.81.84.0 mask 255.255.255.252
  neighbor 203.81.84.2 activate
 exit-address-family
!
```

BGP-CUS01

```
router bgp 8143
 bgp router-id 203.81.84.2
 network 172.172.172.172 mask 255.255.255.255
 neighbor 203.81.84.1 remote-as 2028
 neighbor 203.81.84.1 password neolwin!!!!
!
router ospf 8143
 router-id 10.100.0.1
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface GigabitEthernet0/1
 network 10.100.0.1 0.0.0.0 area 0
 default-information originate always
!
```

R01

```
router ospf 8143
 router-id 172.172.172.172
 auto-cost reference-bandwidth 10000
 passive-interface default
 no passive-interface FastEthernet0/0
 network 10.100.0.2 0.0.0.0 area 0
 network 172.172.172.172 0.0.0.0 area 0
!
```

WITH ENTERPRISE CUSTOMER WITHOUT BGP

PE04

router bgp **65111**

address-family ipv4

network 203.81.85.0 mask 255.255.255.252

exit-address-family

!

BGP-CUS02

ip route 0.0.0.0 0.0.0.0 203.81.85.1

!

ip access-list extended **NAT-ACL**

permit ip host 192.168.10.1 any

!

ip nat inside source list **NAT-ACL** interface **GigabitEthernet0/0 overload**

!

interface **GigabitEthernet0/0**

ip address 203.81.85.2 255.255.255.252

ip nat outside

!

PRIVATE IP FILTERING AT CUSTOMER-FACING PE

PE05

ip prefix-list **PRIVATE-IPS** seq 10 permit 10.0.0.0/8 le 32

ip prefix-list **PRIVATE-IPS** seq 20 permit 172.16.0.0/12 le 32

ip prefix-list **PRIVATE-IPS** seq 30 permit 192.168.0.0/16 le 32

!

route-map **PRIVATE** deny 10

match ip address prefix-list **PRIVATE-IPS**

route-map **PRIVATE** permit 100

!

router bgp **65111**

address-family ipv4

neighbor **203.81.84.2** route-map **PRIVATE** in

!

PING AND TRACEROUTE RESULTS

RED-CE01

```
RED-CE01#ping 192.168.1.1 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.0.1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
RED-CE01#traceroute 192.168.1.1 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 172.31.0.1 60 msec 56 msec 48 msec
  2 172.31.0.253 [MPLS: Label 28 Exp 0] 48 msec 60 msec 52 msec
  3 172.31.0.254 52 msec *  28 msec
```

RED-CE02

```
RED-CE02#ping 192.168.0.1 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.0.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
RED-CE02#traceroute 192.168.0.1 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.0.1
VRF info: (vrf in name/id, vrf out name/id)
  1 172.31.0.253 80 msec 52 msec 48 msec
  2 172.31.0.1 [MPLS: Label 28 Exp 0] 52 msec 56 msec 56 msec
  3 172.31.0.2 52 msec *  48 msec
```

GREEN-CE01

```
GREEN-CE01#ping 172.16.1.1 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 172.16.1.1, timeout is 2 seconds:
Packet sent with a source address of 172.16.0.1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
GREEN-CE01#traceroute 172.16.1.1 source lo0
Type escape sequence to abort.
Tracing the route to 172.16.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.255.1 52 msec 56 msec 52 msec
  2 192.168.255.253 [MPLS: Label 27 Exp 0] 48 msec 56 msec 52 msec
  3 192.168.255.254 52 msec *  36 msec
```

GREEN-CE02

```
GREEN-CE02#ping 172.16.0.1 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 172.16.0.1, timeout is 2 seconds:
Packet sent with a source address of 172.16.1.1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
GREEN-CE02#traceroute 172.16.0.1 source lo0
Type escape sequence to abort.
Tracing the route to 172.16.0.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.255.253 80 msec 56 msec 52 msec
  2 192.168.255.1 [MPLS: Label 28 Exp 0] 52 msec 52 msec 56 msec
  3 192.168.255.2 60 msec *  32 msec
```

YELLOW-CE01

```
YELLOW-CE01#ping 192.168.2.2 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.2.2, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
YELLOW-CE01#ping 192.168.2.3 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.2.3, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
YELLOW-CE01#traceroute 192.168.2.2 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.2.2
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.0.2 60 msec *  40 msec
```

```
YELLOW-CE01#traceroute 192.168.2.3 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.2.3
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.0.3 56 msec *  44 msec
```

YELLOW-CE02

```
YELLOW-CE02#ping 192.168.2.1 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.2
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
YELLOW-CE02#ping 192.168.2.3 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.2.3, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.2
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
YELLOW-CE02#traceroute 192.168.2.1 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.2.1
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.0.1 56 msec *  48 msec
```

```
YELLOW-CE02#traceroute 192.168.2.3 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.2.3
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.0.1 56 msec 52 msec 52 msec
  2 10.0.0.3 52 msec *  56 msec
```

YELLOW-CE03

```
YELLOW-CE03#ping 192.168.2.1 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.3
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
YELLOW-CE03#ping 192.168.2.2 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.2.2, timeout is 2 seconds:
Packet sent with a source address of 192.168.2.3
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
YELLOW-CE03#traceroute 192.168.2.1 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.2.1
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.0.1 56 msec *  44 msec
```

```
YELLOW-CE03#traceroute 192.168.2.2 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.2.2
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.0.1 56 msec 52 msec 48 msec
  2 10.0.0.2 52 msec *  32 msec
```

BLUE-CE01

```
BLUE-CE01#ping 192.168.168.2 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.168.2, timeout is 2 seconds:
Packet sent with a source address of 192.168.168.1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
BLUE-CE01#traceroute 192.168.168.2 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.168.2
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.0.254 36 msec *  48 msec
```

BLUE-CE02

```
BLUE-CE02#ping 192.168.168.1 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.168.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.168.2
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
BLUE-CE02#traceroute 192.168.168.1 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.168.1
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.0.253 56 msec *  52 msec
```

BLUE-R01

```
BLUE-R01#ping 192.168.100.250 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.100.250, timeout is 2 seconds:
Packet sent with a source address of 192.168.100.1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
BLUE-R01#traceroute 192.168.100.250
Type escape sequence to abort.
Tracing the route to 192.168.100.250
VRF info: (vrf in name/id, vrf out name/id)
  1 172.16.19.254 56 msec *  40 msec
```

BLUE-R02

```
BLUE-R02#ping 192.168.100.1 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 192.168.100.1, timeout is 2 seconds:
Packet sent with a source address of 192.168.100.250
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
BLUE-R02#traceroute 192.168.100.1 source lo0
Type escape sequence to abort.
Tracing the route to 192.168.100.1
VRF info: (vrf in name/id, vrf out name/id)
  1 172.16.19.253 52 msec *  120 msec
```

R01(BGP-CUS01)

```
R01#ping 8.8.8.8 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 8.8.8.8, timeout is 2 seconds:
Packet sent with a source address of 172.172.172.172
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
R01#traceroute 8.8.8.8 source lo0
Type escape sequence to abort.
Tracing the route to 8.8.8.8
VRF info: (vrf in name/id, vrf out name/id)
  1 10.100.0.1 56 msec 52 msec 56 msec
  2 203.81.84.1 48 msec 52 msec 52 msec
  3 10.180.0.14 [MPLS: Label 17 Exp 0] 52 msec 52 msec 52 msec
  4 10.180.0.9 56 msec 56 msec 52 msec
  5 203.81.85.253 56 msec *  32 msec
```

BGP-CUS02

```
BGP-CUS02#ping 8.8.8.8 source lo0 repeat 100
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 8.8.8.8, timeout is 2 seconds:
Packet sent with a source address of 192.168.10.1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
BGP-CUS02#traceroute 8.8.8.8 source lo0
Type escape sequence to abort.
Tracing the route to 8.8.8.8
VRF info: (vrf in name/id, vrf out name/id)
  1 203.81.85.1 8 msec 4 msec 3 msec
  2 10.180.0.9 6 msec 6 msec 4 msec
  3 203.81.85.253 12 msec *  10 msec
```

UPSTREAM-ISP

```
      172.172.0.0/32 is subnetted, 1 subnets
B        172.172.172.172 [20/0] via 203.81.84.254, 03:21:56
      203.81.84.0/24 is variably subnetted, 3 subnets, 2 masks
B        203.81.84.0/30 [20/0] via 203.81.84.254, 03:21:56
      203.81.85.0/24 is variably subnetted, 3 subnets, 2 masks
B        203.81.85.0/30 [20/0] via 203.81.85.254, 03:22:38
UPSTREAM-ISP#
```

```
     Network          Next Hop            Metric LocPrf Weight Path
 *>  8.8.8.8/32       0.0.0.0                  0         32768 i
 *   172.172.172.172/32
                       203.81.85.254                          0 2028 8143 i
 *>                    203.81.84.254                        0 2028 8143 i
 *   203.81.84.0/30    203.81.85.254                        0 2028 i
 *>                    203.81.84.254                        0 2028 i
 *>  203.81.84.252/30 0.0.0.0                  0         32768 i
 *   203.81.85.0/30    203.81.84.254                        0 2028 i
 *>                    203.81.85.254                        0 2028 i
 *>  203.81.85.252/30 0.0.0.0                  0         32768 i
UPSTREAM-ISP#
```

IP ADDRESSING ASSIGNMENT

P01

Loopback2028	172.16.30.254
GigabitEthernet0/0/0/0	10.7.135.2
GigabitEthernet0/0/0/1	10.7.135.5
GigabitEthernet0/0/0/2	10.7.135.9

PE01

GigabitEthernet1	10.180.0.17
GigabitEthernet2	10.180.0.2
GigabitEthernet3	10.7.135.1
Loopback2028	172.16.30.1

PE02

GigabitEthernet0/0	10.180.0.5
GigabitEthernet0/1	10.180.0.1
GigabitEthernet0/3	172.31.0.1
GigabitEthernet0/4	203.81.84.254
Loopback2028	172.16.30.2

PE03

GigabitEthernet1	10.180.0.6
GigabitEthernet2	10.180.0.9
GigabitEthernet3	10.7.135.6
GigabitEthernet4	172.31.0.253
GigabitEthernet6	203.81.85.254
Loopback2028	172.16.30.3

PE04

GigabitEthernet1	10.180.0.14
GigabitEthernet2	10.180.0.10
GigabitEthernet3	10.7.135.10
GigabitEthernet4	192.168.255.253
GigabitEthernet6	203.81.85.1
Loopback2028	172.16.30.4

PE05

GigabitEthernet0/0	10.180.0.13
GigabitEthernet0/1	10.180.0.18
GigabitEthernet0/3	192.168.255.1
GigabitEthernet0/4	203.81.84.1
Loopback2028	172.16.30.5

UPSTREAM-ISP

GigabitEthernet0/0	203.81.84.253
GigabitEthernet0/1	203.81.85.253
Loopback0	8.8.8.8

BGP-CUS01

GigabitEthernet0/0	203.81.84.2
GigabitEthernet0/1	10.100.0.1

R01

FastEthernet0/0	10.100.0.2
Loopback0	172.172.172.172

BGP-CUS02

GigabitEthernet0/0	203.81.85.2
Loopback0	192.168.10.1

RED-CE01

FastEthernet0/0	172.31.0.2
Loopback0	192.168.0.1

RED-CE02

FastEthernet0/0	172.31.0.254

Loopback0	192.168.1.1
GREEN-CE01	
FastEthernet0/0	192.168.255.2
Loopback0	172.16.0.1
GREEN-CE02	
FastEthernet0/0	192.168.255.254
Loopback0	172.16.1.1
YELLOW-CE01	
FastEthernet0/0	10.0.0.1
Loopback0	192.168.2.1
YELLOW-CE02	
FastEthernet0/0	10.0.0.2
Loopback0	192.168.2.2
YELLOW-CE03	
FastEthernet0/0	10.0.0.3
Loopback0	192.168.2.3
BLUE-CE01	
FastEthernet0/0	10.0.0.253
Loopback0	192.168.168.1
BLUE-R01	
FastEthernet0/0	172.16.19.253
Loopback0	192.168.100.1
BLUE-CE02	

FastEthernet0/0	10.0.0.254
Loopback0	192.168.168.2

BLUE-R02

FastEthernet0/0	172.16.19.254
Loopback0	192.168.100.250

Ko Lwin (Network)

January 18, 2026 (SUN) | 16:15