Networking Academy: Internal Border Gateway Protocol

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Contents

Purpose

The purpose of this lab is to use Internal Border Gateway Protocol (iBGP) to share routes in and out of an autonomous system (AS) by establishing iBGP neighborships. Additionally, eBGP will be used to share route information between the other two AS's. As a part of this lab, knowledge about using route-reflectors, declaring iBGP neighbors, and using an interior gateway protocol (IGP) to help BGP packets get navigated between iBGP neighbors will be integral to setting up iBGP. For eBGP, skills about how to redistribute routes and how to use eBGP to route between AS's will be important for this lab. **Configurations of devices are available at the end of this document.**

Background Information

Border Gateway Protocol (BGP) was created in 1989 by Kirk Lougheed, Len Bosack and Yakov Rekhter. eBGP was designed to share routing information between autonomous systems (AS's), which are often owned by different organizations. iBGP is like a different flavor of eBGP; iBGP, instead of routing between AS's, provides routes within an AS. This means that iBGP neighbors will have the same AS number. Unlike eBGP, iBGP often needs to have an Interior Gateway Protocol (IGP) to help route the packets needed to establish iBGP neighborships. This is because if there are multiple routes to an iBGP neighbor as long as one route is valid to an interface, that interface will be used to set up the neighbor session the iBGP neighbor will stay up. As of now BGP has been updated since 2006 and supports both IPv6 and IPv4 neighbors.

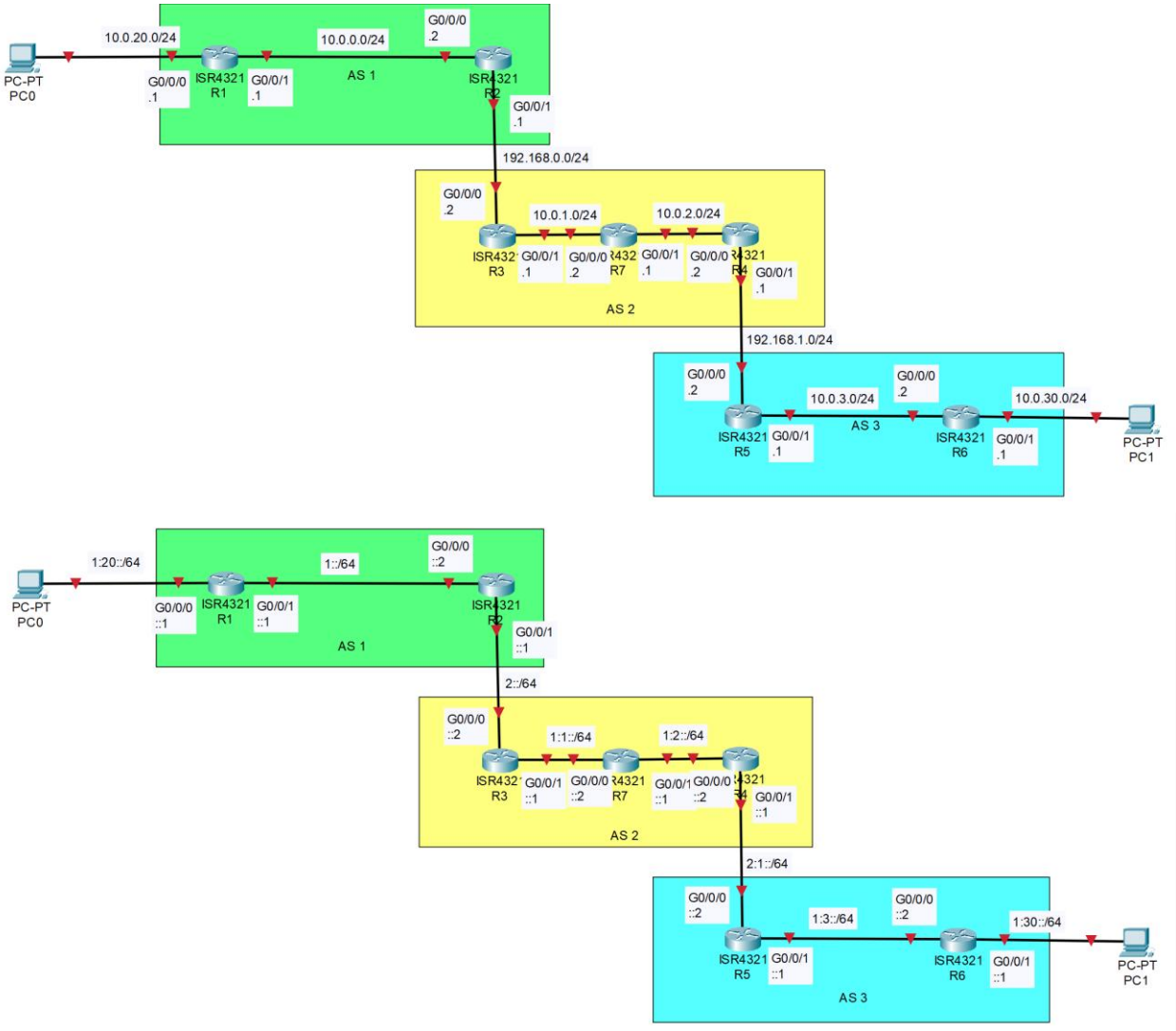
Route reflectors are a common part of iBGP configurations. The main purpose of a route reflector is to allow iBGP to no longer need a fully meshed network. Instead, a router running iBGP only needs to form a neighbor adjacency with the route reflector (RR). The rest of the routers are configured as clients and will send their route updates to the RR, which will then send updates to the clients.

Lab Summary

In this lab 3 AS's were set up with eBGP connecting the 3 AS's together. There are two host devices that are PCs and there are seven 4321 routers that are connected via ethernet. To allow host devices to communicate with each other, the routers needed IPv6 and IPv4 routes to redistribute in and out of eBGP. Additionally in the 2nd AS, iBGP is used to provide network connectivity between AS 1 and AS 3 with EIGRP serving as the routing protocol for the 2nd AS.

In the topology, R7—the router in the middle of the 2nd AS—acts as a route-reflector to neighbors: R3 and R4. This allows R7 to receive routes from R3 and R4, so that connectivity can be established between the 2 AS's. And when R7 receives routes, it will send updates to R3 and R4, which will provide end-to-end connectivity for the PCs. Further information related to the setup of this lab is available here: https://github.com/101zh/iBGPLab.

Network Diagram with IPs



Lab Commands

`router bgp` [*`autonomous-system-number`*]

- Creates and enters a configuration of an instance of BGP with the specified autonomous system number. (terminal configuration mode)

  `neighbor` [*`ip-address`*] **`update-source`** [*`interface`*]
  - Allows BGP neighbors to use the IP address from the specified interface on the neighbor to form a neighbor session.

  `address-family ipv4`
  - Enters IPv4 address-family configuration for BGP

    `neighbor` [*`ip-address`*] **`next-hop-self`**
    - Configures the router to advertise BGP routes with the local outbound interface address as the next hop address to the specified BGP neighbor.

    `neighbor` [*`ip-address`*] **`route-reflector-client`**

        - Configures the router as a BGP route reflector and configures the specified BGP neighbor as its route-reflector-client.

address-family ipv6

- Enters IPv6 address-family configuration for BGP

neighbor [*ip-address*] **next-hop-self**

- Configures the router to advertise BGP routes with the local outbound interface address as the next hop address to the specified BGP neighbor.

neighbor [*ip-address*] **route-reflector-client**

- Configures the router as a BGP route reflector and configures the specified BGP neighbor as its route-reflector-client.

Problems

There were some problems that were met in this lab, but most of them were easily overcome. The first problem encountered was R7 not receiving the correct routes. After configuring R7 as a route-reflector, I got incorrect next-hop IP addresses for the routes in R7, which was quite puzzling. This was because iBGP doesn't always change the next-hop IP address when distributing routes to neighbors. We fixed this problem by manually configuring R3 and R4 to tell R7 that R3 and R4 were the next hop for R7.

Conclusion

Overall, the lab was successful; I was able to set up iBGP sessions successfully. Though I lacked knowledge of iBGP and the specifics of how it worked, I was ultimately able to set up IGPs and iBGP on top of those IGPs. Importantly, knowledge of eBGP greatly assisted the me as I was configuring iBGP.

Configurations

R1 Configuration

```
version 16.9
hostname R1
!
ipv6 unicast-routing
!
!
interface GigabitEthernet0/0/0
 ip address 10.0.20.1 255.255.255.0
 negotiation auto
 ipv6 address 1:20::1/64
 ipv6 ospf 1 area 0
!
interface GigabitEthernet0/0/1
 ip address 10.0.0.1 255.255.255.0
 negotiation auto
 ipv6 address 1::1/64
 ipv6 ospf 1 area 0
!
!
router ospf 1
```

```
 router-id 1.1.1.1
 network 10.0.0.0 0.0.0.255 area 0
 network 10.0.20.0 0.0.0.255 area 0
!
ipv6 router ospf 1
 router-id 1.1.1.1
!
!
end
```

R2 Configuration

```
version 16.9
hostname R2
!
ipv6 unicast-routing
!
!
interface GigabitEthernet0/0/0
 ip address 10.0.0.2 255.255.255.0
 negotiation auto
 ipv6 address 1::2/64
 ipv6 ospf 1 area 0
!
interface GigabitEthernet0/0/1
 ip address 192.168.0.1 255.255.255.0
 negotiation auto
 ipv6 address 2::1/64
 ipv6 ospf 1 area 0
!
!
router ospf 1
 router-id 2.2.2.2
 redistribute bgp 1 metric 10 subnets
 network 10.0.0.0 0.0.0.255 area 0
 network 192.168.0.0 0.0.0.255 area 0
!
router bgp 1
 bgp router-id 2.2.2.2
 bgp log-neighbor-changes
 neighbor 2::2 remote-as 2
 neighbor 192.168.0.2 remote-as 2
 !
 address-family ipv4
  redistribute connected
  redistribute ospf 1
  no neighbor 2::2 activate
  neighbor 192.168.0.2 activate
 exit-address-family
 !
 address-family ipv6
```

```
  redistribute connected
  redistribute ospf 1 metric 10
  neighbor 2::2 activate
 exit-address-family
!
ipv6 router ospf 1
 router-id 2.2.2.2
 redistribute bgp 1 metric 10
!
!
end
```

R3 Configuration

```
version 16.9
hostname R3
!
ipv6 unicast-routing
!
!
interface Loopback0
 ip address 3.3.3.3 255.255.255.255
 ipv6 address 100:3::3/128
 ipv6 eigrp 1
!
interface GigabitEthernet0/0/0
 ip address 192.168.0.2 255.255.255.0
 negotiation auto
 ipv6 address 2::2/64
 ipv6 eigrp 1
!
interface GigabitEthernet0/0/1
 ip address 10.0.1.1 255.255.255.0
 negotiation auto
 ipv6 address 1:1::1/64
 ipv6 eigrp 1
!
!
router eigrp 1
 network 3.3.3.3 0.0.0.0
 network 10.0.1.0 0.0.0.255
 network 192.168.0.0
 eigrp router-id 3.3.3.3
!
router bgp 2
 bgp router-id 3.3.3.3
 bgp log-neighbor-changes
 neighbor 2::1 remote-as 1
 neighbor 100:4::4 remote-as 2
 neighbor 100:4::4 update-source Loopback0
 neighbor 100:7::7 remote-as 2
```

```
 neighbor 100:7::7 update-source Loopback0
 neighbor 4.4.4.4 remote-as 2
 neighbor 4.4.4.4 update-source Loopback0
 neighbor 7.7.7.7 remote-as 2
 neighbor 7.7.7.7 update-source Loopback0
 neighbor 192.168.0.1 remote-as 1
 !
 address-family ipv4
  redistribute connected
  no neighbor 2::1 activate
  no neighbor 100:4::4 activate
  no neighbor 100:7::7 activate
  neighbor 4.4.4.4 activate
  neighbor 7.7.7.7 activate
  neighbor 7.7.7.7 next-hop-self
  neighbor 192.168.0.1 activate
 exit-address-family
 !
 address-family ipv6
  redistribute connected
  neighbor 2::1 activate
  neighbor 100:4::4 activate
  neighbor 100:7::7 activate
  neighbor 100:7::7 next-hop-self
 exit-address-family
!
ipv6 router eigrp 1
 eigrp router-id 3.3.3.3
!
!
end
```

R4 Configuration

```
version 16.9
hostname R4
!
ipv6 unicast-routing
!
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
 ipv6 address 100:4::4/128
 ipv6 eigrp 1
!
interface GigabitEthernet0/0/0
 ip address 10.0.2.2 255.255.255.0
 negotiation auto
 ipv6 address 1:2::2/64
 ipv6 eigrp 1
!
```

```
interface GigabitEthernet0/0/1
 ip address 192.168.1.1 255.255.255.0
 negotiation auto
 ipv6 address 2:1::1/64
 ipv6 eigrp 1
!
!
router eigrp 1
 network 4.4.4.4 0.0.0.0
 network 10.0.2.0 0.0.0.255
 network 192.168.1.0
 eigrp router-id 4.4.4.4
!
router bgp 2
 bgp router-id 4.4.4.4
 bgp log-neighbor-changes
 neighbor 2:1::2 remote-as 3
 neighbor 100:3::3 remote-as 2
 neighbor 100:3::3 update-source Loopback0
 neighbor 100:7::7 remote-as 2
 neighbor 100:7::7 update-source Loopback0
 neighbor 3.3.3.3 remote-as 2
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 7.7.7.7 remote-as 2
 neighbor 7.7.7.7 update-source Loopback0
 neighbor 192.168.1.2 remote-as 3
 !
 address-family ipv4
  redistribute connected
  no neighbor 2:1::2 activate
  no neighbor 100:3::3 activate
  no neighbor 100:7::7 activate
  neighbor 3.3.3.3 activate
  neighbor 7.7.7.7 activate
  neighbor 7.7.7.7 next-hop-self
  neighbor 192.168.1.2 activate
 exit-address-family
 !
 address-family ipv6
  redistribute connected
  neighbor 2:1::2 activate
  neighbor 100:3::3 activate
  neighbor 100:7::7 activate
  neighbor 100:7::7 next-hop-self
 exit-address-family
!
ipv6 router eigrp 1
 eigrp router-id 4.4.4.4
!
!
```

```
end
```

R5 Configuration

```
version 16.9
hostname R5
!
ipv6 unicast-routing
!
!
interface GigabitEthernet0/0/0
 ip address 192.168.1.2 255.255.255.0
 ip router isis
 negotiation auto
 ipv6 address 2:1::2/64
 ipv6 router isis
!
interface GigabitEthernet0/0/1
 ip address 10.0.3.1 255.255.255.0
 ip router isis
 negotiation auto
 ipv6 address 1:3::1/64
 ipv6 router isis
!
!
router isis
 net 49.0012.0000.0000.0005.00
 is-type level-1
 metric-style wide
 log-adjacency-changes
 redistribute bgp 3 metric 30 level-1
 !
 address-family ipv6
  redistribute bgp 3 metric 30 level-1
 exit-address-family
!
router bgp 3
 bgp router-id 5.5.5.5
 bgp log-neighbor-changes
 no bgp default ipv4-unicast
 neighbor 2:1::1 remote-as 2
 neighbor 192.168.1.1 remote-as 2
 !
 address-family ipv4
  redistribute connected
  redistribute isis level-1 metric 10
  neighbor 192.168.1.1 activate
 exit-address-family
 !
 address-family ipv6
  redistribute connected
```

```
  redistribute isis metric 10 level-1
  neighbor 2:1::1 activate
 exit-address-family
!
!
end
```

R6 Configuration

```
version 16.9
hostname R6
!
ipv6 unicast-routing
!
!
interface GigabitEthernet0/0/0
 ip address 10.0.3.2 255.255.255.0
 ip router isis
 negotiation auto
 ipv6 address 1:3::2/64
 ipv6 router isis
!
interface GigabitEthernet0/0/1
 ip address 10.0.30.1 255.255.255.0
 ip router isis
 negotiation auto
 ipv6 address 1:30::1/64
 ipv6 router isis
!
!
router isis
 net 49.0012.0000.0000.0006.00
 is-type level-1
 metric-style wide
 log-adjacency-changes
!
!
end
```

R7 Configuration

```
version 16.9
hostname R7
!
ipv6 unicast-routing
!
!
interface Loopback0
 ip address 7.7.7.7 255.255.255.255
 ipv6 address 100:7::7/128
 ipv6 eigrp 1
!
interface GigabitEthernet0/0/0
```

```
 ip address 10.0.1.2 255.255.255.0
 negotiation auto
 ipv6 address 1:1::2/64
 ipv6 eigrp 1
!
interface GigabitEthernet0/0/1
 ip address 10.0.2.1 255.255.255.0
 negotiation auto
 ipv6 address 1:2::1/64
 ipv6 eigrp 1
!
!
router eigrp 1
 network 7.7.7.7 0.0.0.0
 network 10.0.1.0 0.0.0.255
 network 10.0.2.0 0.0.0.255
 eigrp router-id 7.7.7.7
!
router bgp 2
 bgp router-id 7.7.7.7
 bgp log-neighbor-changes
 neighbor 100:3::3 remote-as 2
 neighbor 100:3::3 update-source Loopback0
 neighbor 100:4::4 remote-as 2
 neighbor 100:4::4 update-source Loopback0
 neighbor 3.3.3.3 remote-as 2
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 4.4.4.4 remote-as 2
 neighbor 4.4.4.4 update-source Loopback0
 !
 address-family ipv4
  no neighbor 100:3::3 activate
  no neighbor 100:4::4 activate
  neighbor 3.3.3.3 activate
  neighbor 3.3.3.3 route-reflector-client
  neighbor 4.4.4.4 activate
  neighbor 4.4.4.4 route-reflector-client
 exit-address-family
 !
 address-family ipv6
  neighbor 100:3::3 activate
  neighbor 100:3::3 route-reflector-client
  neighbor 100:4::4 activate
  neighbor 100:4::4 route-reflector-client
 exit-address-family
!
!
ipv6 router eigrp 1
 eigrp router-id 7.7.7.7
!
```

```
!
end
```

Routes

R1 Routing Table

```
R1#show ip route
Codes: L - local, 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, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
O E2     3.3.3.3 [110/10] via 10.0.0.2, 01:14:33, GigabitEthernet0/0/1
      4.0.0.0/32 is subnetted, 1 subnets
O E2     4.4.4.4 [110/10] via 10.0.0.2, 01:12:41, GigabitEthernet0/0/1
      10.0.0.0/8 is variably subnetted, 8 subnets, 2 masks
C        10.0.0.0/24 is directly connected, GigabitEthernet0/0/1
L        10.0.0.1/32 is directly connected, GigabitEthernet0/0/1
O E2     10.0.1.0/24 [110/10] via 10.0.0.2, 01:14:33, GigabitEthernet0/0/1
O E2     10.0.2.0/24 [110/10] via 10.0.0.2, 01:12:41, GigabitEthernet0/0/1
O E2     10.0.3.0/24 [110/10] via 10.0.0.2, 01:12:41, GigabitEthernet0/0/1
C        10.0.20.0/24 is directly connected, GigabitEthernet0/0/0
L        10.0.20.1/32 is directly connected, GigabitEthernet0/0/0
O E2     10.0.30.0/24 [110/10] via 10.0.0.2, 01:12:41, GigabitEthernet0/0/1
O     192.168.0.0/24 [110/2] via 10.0.0.2, 01:14:37, GigabitEthernet0/0/1
O E2  192.168.1.0/24 [110/10] via 10.0.0.2, 01:12:41, GigabitEthernet0/0/1

R1#show ipv6 route
IPv6 Routing Table - default - 13 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, a - Application
C   1::/64 [0/0]
     via GigabitEthernet0/0/1, directly connected
L   1::1/128 [0/0]
     via GigabitEthernet0/0/1, receive
OE2 1:1::/64 [110/10]
     via FE80::CE7F:76FF:FE6A:B5E0, GigabitEthernet0/0/1
```

```
OE2 1:2::/64 [110/10]
     via FE80::CE7F:76FF:FE6A:B5E0, GigabitEthernet0/0/1
OE2 1:3::/64 [110/10]
     via FE80::CE7F:76FF:FE6A:B5E0, GigabitEthernet0/0/1
C   1:20::/64 [0/0]
     via GigabitEthernet0/0/0, directly connected
L   1:20::1/128 [0/0]
     via GigabitEthernet0/0/0, receive
OE2 1:30::/64 [110/10]
     via FE80::CE7F:76FF:FE6A:B5E0, GigabitEthernet0/0/1
O   2::/64 [110/2]
     via FE80::CE7F:76FF:FE6A:B5E0, GigabitEthernet0/0/1
OE2 2:1::/64 [110/10]
     via FE80::CE7F:76FF:FE6A:B5E0, GigabitEthernet0/0/1
OE2 100:3::3/128 [110/10]
     via FE80::CE7F:76FF:FE6A:B5E0, GigabitEthernet0/0/1
OE2 100:4::4/128 [110/10]
     via FE80::CE7F:76FF:FE6A:B5E0, GigabitEthernet0/0/1
L   FF00::/8 [0/0]
     via Null0, receive
```

R2 Routing Table

```
R2#show ip route
Codes: L - local, 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, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
B        3.3.3.3 [20/0] via 192.168.0.2, 01:20:04
      4.0.0.0/32 is subnetted, 1 subnets
B        4.4.4.4 [20/0] via 192.168.0.2, 01:18:12
      10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
C        10.0.0.0/24 is directly connected, GigabitEthernet0/0/0
L        10.0.0.2/32 is directly connected, GigabitEthernet0/0/0
B        10.0.1.0/24 [20/0] via 192.168.0.2, 01:20:04
B        10.0.2.0/24 [20/0] via 192.168.0.2, 01:18:12
B        10.0.3.0/24 [20/0] via 192.168.0.2, 01:18:12
O        10.0.20.0/24 [110/2] via 10.0.0.1, 01:11:27, GigabitEthernet0/0/0
B        10.0.30.0/24 [20/0] via 192.168.0.2, 01:18:12
      192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
```

```
C        192.168.0.0/24 is directly connected, GigabitEthernet0/0/1
L        192.168.0.1/32 is directly connected, GigabitEthernet0/0/1
B     192.168.1.0/24 [20/0] via 192.168.0.2, 01:18:12
```

R3 Routing Table

```
R3#show ip route
Codes: L - local, 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, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      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
D        4.4.4.4 [90/131072] via 10.0.1.2, 01:15:33, GigabitEthernet0/0/1
      7.0.0.0/32 is subnetted, 1 subnets
D        7.7.7.7 [90/130816] via 10.0.1.2, 01:15:33, GigabitEthernet0/0/1
      10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
B        10.0.0.0/24 [20/0] via 192.168.0.1, 01:15:31
C        10.0.1.0/24 is directly connected, GigabitEthernet0/0/1
L        10.0.1.1/32 is directly connected, GigabitEthernet0/0/1
D        10.0.2.0/24 [90/3072] via 10.0.1.2, 01:15:33, GigabitEthernet0/0/1
B        10.0.3.0/24 [200/0] via 192.168.1.2, 00:47:56
B        10.0.20.0/24 [20/2] via 192.168.0.1, 01:06:30
B        10.0.30.0/24 [200/10] via 192.168.1.2, 00:44:02
      192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.0.0/24 is directly connected, GigabitEthernet0/0/0
L        192.168.0.2/32 is directly connected, GigabitEthernet0/0/0
D     192.168.1.0/24 [90/3328] via 10.0.1.2, 01:15:33, GigabitEthernet0/0/1

R3#show ipv6 route
IPv6 Routing Table - default - 14 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, a - Application
B   1::/64 [20/0]
     via FE80::CE7F:76FF:FE6A:B5E1, GigabitEthernet0/0/0
C   1:1::/64 [0/0]
     via GigabitEthernet0/0/1, directly connected
```

```
L   1:1::1/128 [0/0]
     via GigabitEthernet0/0/1, receive
D   1:2::/64 [90/3072]
     via FE80::227:90FF:FED5:FB60, GigabitEthernet0/0/1
B   1:3::/64 [200/0]
     via 2:1::2
B   1:20::/64 [20/10]
     via FE80::CE7F:76FF:FE6A:B5E1, GigabitEthernet0/0/0
B   1:30::/64 [200/10]
     via 2:1::2
C   2::/64 [0/0]
     via GigabitEthernet0/0/0, directly connected
L   2::2/128 [0/0]
     via GigabitEthernet0/0/0, receive
D   2:1::/64 [90/3328]
     via FE80::227:90FF:FED5:FB60, GigabitEthernet0/0/1
LC  100:3::3/128 [0/0]
     via Loopback0, receive
D   100:4::4/128 [90/131072]
     via FE80::227:90FF:FED5:FB60, GigabitEthernet0/0/1
D   100:7::7/128 [90/130816]
     via FE80::227:90FF:FED5:FB60, GigabitEthernet0/0/1
L   FF00::/8 [0/0]
     via Null0, receive
```

R4 Routing Table

```
R4#show ip route
Codes: L - local, 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, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
D        3.3.3.3 [90/131072] via 10.0.2.1, 01:19:02, GigabitEthernet0/0/0
      4.0.0.0/32 is subnetted, 1 subnets
C        4.4.4.4 is directly connected, Loopback0
      7.0.0.0/32 is subnetted, 1 subnets
D        7.7.7.7 [90/130816] via 10.0.2.1, 01:19:27, GigabitEthernet0/0/0
      10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
B        10.0.0.0/24 [200/0] via 192.168.0.1, 00:51:29
D        10.0.1.0/24 [90/3072] via 10.0.2.1, 01:19:07, GigabitEthernet0/0/0
C        10.0.2.0/24 is directly connected, GigabitEthernet0/0/0
```

```
L        10.0.2.2/32 is directly connected, GigabitEthernet0/0/0
B        10.0.3.0/24 [20/0] via 192.168.1.2, 01:20:11
B        10.0.20.0/24 [200/2] via 192.168.0.1, 00:51:29
B        10.0.30.0/24 [20/10] via 192.168.1.2, 00:47:34
D     192.168.0.0/24 [90/3328] via 10.0.2.1, 01:19:02, GigabitEthernet0/0/0
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/0/1
L        192.168.1.1/32 is directly connected, GigabitEthernet0/0/1
```

R5 Routing Table

```
R5#show ip route
Codes: L - local, 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, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
B        3.3.3.3 [20/0] via 192.168.1.1, 01:15:39
      4.0.0.0/32 is subnetted, 1 subnets
B        4.4.4.4 [20/0] via 192.168.1.1, 01:18:39
      10.0.0.0/8 is variably subnetted, 7 subnets, 2 masks
B        10.0.0.0/24 [20/0] via 192.168.1.1, 01:15:39
B        10.0.1.0/24 [20/0] via 192.168.1.1, 01:15:39
B        10.0.2.0/24 [20/0] via 192.168.1.1, 01:17:39
C        10.0.3.0/24 is directly connected, GigabitEthernet0/0/1
L        10.0.3.1/32 is directly connected, GigabitEthernet0/0/1
B        10.0.20.0/24 [20/0] via 192.168.1.1, 01:08:29
i L1     10.0.30.0/24 [115/20] via 10.0.3.2, 00:46:27, GigabitEthernet0/0/1
B     192.168.0.0/24 [20/0] via 192.168.1.1, 01:15:39
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, GigabitEthernet0/0/0
L        192.168.1.2/32 is directly connected, GigabitEthernet0/0/0

R5#show ipv6 route
IPv6 Routing Table - default - 13 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, a - Application
B   1::/64 [20/0]
```

```
     via FE80::2F8:2CFF:FE7F:7191, GigabitEthernet0/0/0
B    1:1::/64 [20/0]
     via FE80::2F8:2CFF:FE7F:7191, GigabitEthernet0/0/0
B    1:2::/64 [20/0]
     via FE80::2F8:2CFF:FE7F:7191, GigabitEthernet0/0/0
C    1:3::/64 [0/0]
     via GigabitEthernet0/0/1, directly connected
L    1:3::1/128 [0/0]
     via GigabitEthernet0/0/1, receive
B    1:20::/64 [20/0]
     via FE80::2F8:2CFF:FE7F:7191, GigabitEthernet0/0/0
I1   1:30::/64 [115/20]
     via FE80::B6A8:B9FF:FE01:B2D0, GigabitEthernet0/0/1
B    2::/64 [20/0]
     via FE80::2F8:2CFF:FE7F:7191, GigabitEthernet0/0/0
C    2:1::/64 [0/0]
     via GigabitEthernet0/0/0, directly connected
L    2:1::2/128 [0/0]
     via GigabitEthernet0/0/0, receive
B    100:3::3/128 [20/0]
     via FE80::2F8:2CFF:FE7F:7191, GigabitEthernet0/0/0
B    100:4::4/128 [20/0]
     via FE80::2F8:2CFF:FE7F:7191, GigabitEthernet0/0/0
L    FF00::/8 [0/0]
     via Null0, receive
```

R6 Routing Table

```
Codes: L - local, 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, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
i L1     3.3.3.3 [115/40] via 10.0.3.1, 01:16:16, GigabitEthernet0/0/0
      4.0.0.0/32 is subnetted, 1 subnets
i L1     4.4.4.4 [115/40] via 10.0.3.1, 01:19:14, GigabitEthernet0/0/0
      10.0.0.0/8 is variably subnetted, 8 subnets, 2 masks
i L1     10.0.0.0/24 [115/40] via 10.0.3.1, 01:16:16, GigabitEthernet0/0/0
i L1     10.0.1.0/24 [115/40] via 10.0.3.1, 01:16:16, GigabitEthernet0/0/0
i L1     10.0.2.0/24 [115/40] via 10.0.3.1, 01:18:16, GigabitEthernet0/0/0
C        10.0.3.0/24 is directly connected, GigabitEthernet0/0/0
L        10.0.3.2/32 is directly connected, GigabitEthernet0/0/0
```

```
i L1     10.0.20.0/24 [115/40] via 10.0.3.1, 01:09:06, GigabitEthernet0/0/0
C        10.0.30.0/24 is directly connected, GigabitEthernet0/0/1
L        10.0.30.1/32 is directly connected, GigabitEthernet0/0/1
i L1  192.168.0.0/24 [115/40] via 10.0.3.1, 01:16:16, GigabitEthernet0/0/0
i L1  192.168.1.0/24 [115/20] via 10.0.3.1, 01:19:14, GigabitEthernet0/0/0
```

R7 Routing Table

```
R7#show ip route
Codes: L - local, 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, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static
route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

      3.0.0.0/32 is subnetted, 1 subnets
D        3.3.3.3 [90/130816] via 10.0.1.1, 01:19:41, GigabitEthernet0/0/0
      4.0.0.0/32 is subnetted, 1 subnets
D        4.4.4.4 [90/130816] via 10.0.2.2, 01:20:09, GigabitEthernet0/0/1
      7.0.0.0/32 is subnetted, 1 subnets
C        7.7.7.7 is directly connected, Loopback0
      10.0.0.0/8 is variably subnetted, 8 subnets, 2 masks
B        10.0.0.0/24 [200/0] via 3.3.3.3, 01:17:50
C        10.0.1.0/24 is directly connected, GigabitEthernet0/0/0
L        10.0.1.2/32 is directly connected, GigabitEthernet0/0/0
C        10.0.2.0/24 is directly connected, GigabitEthernet0/0/1
L        10.0.2.1/32 is directly connected, GigabitEthernet0/0/1
B        10.0.3.0/24 [200/0] via 4.4.4.4, 01:17:50
B        10.0.20.0/24 [200/2] via 3.3.3.3, 01:10:41
B        10.0.30.0/24 [200/10] via 4.4.4.4, 00:48:13
D     192.168.0.0/24 [90/3072] via 10.0.1.1, 01:19:41, GigabitEthernet0/0/0
D     192.168.1.0/24 [90/3072] via 10.0.2.2, 01:20:09, GigabitEthernet0/0/1

R7#show ipv6 route
IPv6 Routing Table - default - 14 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
       ND - ND Default, NDp - ND Prefix, DCE - Destination, NDr - Redirect
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2, a - Application
B   1::/64 [200/0]
     via 100:3::3
C   1:1::/64 [0/0]
```

```
     via GigabitEthernet0/0/0, directly connected
L    1:1::2/128 [0/0]
     via GigabitEthernet0/0/0, receive
C    1:2::/64 [0/0]
     via GigabitEthernet0/0/1, directly connected
L    1:2::1/128 [0/0]
     via GigabitEthernet0/0/1, receive
B    1:3::/64 [200/0]
     via 100:4::4
B    1:20::/64 [200/10]
     via 100:3::3
B    1:30::/64 [200/10]
     via 100:4::4
D    2::/64 [90/3072]
     via FE80::B6A8:B9FF:FE01:B751, GigabitEthernet0/0/0
D    2:1::/64 [90/3072]
     via FE80::2F8:2CFF:FE7F:7190, GigabitEthernet0/0/1
D    100:3::3/128 [90/130816]
     via FE80::B6A8:B9FF:FE01:B751, GigabitEthernet0/0/0
D    100:4::4/128 [90/130816]
     via FE80::2F8:2CFF:FE7F:7190, GigabitEthernet0/0/1
LC   100:7::7/128 [0/0]
     via Loopback0, receive
L    FF00::/8 [0/0]
     via Null0, receive
```

BGP Debug Info

R3 BGP routing tables

```
R3#show ip bgp
BGP table version is 30, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-
Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>  3.3.3.3/32       0.0.0.0                  0         32768 ?
 r>i 4.4.4.4/32       4.4.4.4                  0    100      0 ?
 r i                  4.4.4.4                  0    100      0 ?
 *>  10.0.0.0/24      192.168.0.1              0             0 1 ?
 *>  10.0.1.0/24      0.0.0.0                  0         32768 ?
 r>i 10.0.2.0/24      4.4.4.4                  0    100      0 ?
 r i                  4.4.4.4                  0    100      0 ?
 *>i 10.0.3.0/24      192.168.1.2              0    100      0 3 ?
 * i                  4.4.4.4                  0    100      0 3 ?
 *>  10.0.20.0/24     192.168.0.1              2             0 1 ?
```

```
 * i 10.0.30.0/24     4.4.4.4                10    100      0 3 ?
 *>i                  192.168.1.2            10    100      0 3 ?
 *   192.168.0.0      192.168.0.1             0             0 1 ?
 *>                   0.0.0.0                 0         32768 ?
     Network          Next Hop            Metric LocPrf Weight Path
 r>i 192.168.1.0      4.4.4.4                 0    100      0 ?
 r i                  4.4.4.4                 0    100      0 ?

R3#show bgp ipv6 unicast
BGP table version is 51, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-
Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>  1::/64           2::1                    0             0 1 ?
 *>  1:1::/64         ::                      0         32768 ?
 r>i 1:2::/64         100:4::4                0    100      0 ?
 r i                  100:4::4                0    100      0 ?
 *>i 1:3::/64         2:1::2                  0    100      0 3 ?
 * i                  100:4::4                0    100      0 3 ?
 *>  1:20::/64        2::1                   10             0 1 ?
 * i 1:30::/64        100:4::4               10    100      0 3 ?
 *>i                  2:1::2                 10    100      0 3 ?
 *   2::/64           2::1                    0             0 1 ?
 *>                   ::                      0         32768 ?
 r>i 2:1::/64         100:4::4                0    100      0 ?
 r i                  100:4::4                0    100      0 ?
 *>  100:3::3/128     ::                      0         32768 ?
     Network          Next Hop            Metric LocPrf Weight Path
 r>i 100:4::4/128     100:4::4                0    100      0 ?
 r i                  100:4::4                0    100      0 ?
```

R3 BGP neighbors

```
R3#show ip bgp neighbors
BGP neighbor is 4.4.4.4,  remote AS 2, internal link
  BGP version 4, remote router ID 4.4.4.4
  BGP state = Established, up for 00:48:43
  Last read 00:00:48, last write 00:00:07, hold time is 180, keepalive
interval is 60 seconds
  Neighbor sessions:
    1 active, is not multisession capable (disabled)
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
```

```
  Enhanced Refresh Capability: advertised and received
  Multisession Capability:
  Stateful switchover support enabled: NO for session 1
 Message statistics:
  InQ depth is 0
  OutQ depth is 0

                      Sent       Rcvd
  Opens:                 1          1
  Notifications:         0          0
  Updates:               4          6
  Keepalives:           55         53
  Route Refresh:         0          0
  Total:                60         60
 Do log neighbor state changes (via global configuration)
 Default minimum time between advertisement runs is 0 seconds

For address family: IPv4 Unicast
 Session: 4.4.4.4
 BGP table version 30, neighbor version 30/0
 Output queue size : 0
 Index 3, Advertise bit 2
 3 update-group member
 Slow-peer detection is disabled
 Slow-peer split-update-group dynamic is disabled
                             Sent       Rcvd
 Prefix activity:            ----       ----
  Prefixes Current:             5          5 (Consumes 600 bytes)
  Prefixes Total:               5          6
  Implicit Withdraw:            0          0
  Explicit Withdraw:            0          1
  Used as bestpath:           n/a          5
  Used as multipath:          n/a          0

                               Outbound    Inbound
 Local Policy Denied Prefixes:  --------    -------
  Bestpath from this peer:             8        n/a
  Bestpath from iBGP peer:             6        n/a
  Total:                              14          0
 Number of NLRIs in the update sent: max 3, min 0
 Last detected as dynamic slow peer: never
 Dynamic slow peer recovered: never
 Refresh Epoch: 1
 Last Sent Refresh Start-of-rib: never
 Last Sent Refresh End-of-rib: never
 Last Received Refresh Start-of-rib: never
 Last Received Refresh End-of-rib: never
                                  Sent       Rcvd
       Refresh activity:          ----       ----
         Refresh Start-of-RIB       0          0
```

```
          Refresh End-of-RIB           0          0

  Address tracking is enabled, the RIB does have a route to 4.4.4.4
  Connections established 1; dropped 0
  Last reset never
  Interface associated: (none) (peering address NOT in same link)
  Transport(tcp) path-mtu-discovery is enabled
  Graceful-Restart is disabled
  SSO is disabled
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 255
Local host: 3.3.3.3, Local port: 13645
Foreign host: 4.4.4.4, Foreign port: 179
Connection tableid (VRF): 0
Maximum output segment queue size: 50

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

Event Timers (current time is 0x510147):
Timer          Starts    Wakeups            Next
Retrans            57          0             0x0
TimeWait            0          0             0x0
AckHold            57         53             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger         2037       2036        0x51043B
DeadWait            0          0             0x0
Linger              0          0             0x0
ProcessQ            0          0             0x0

iss:  649618873  snduna:  649620185  sndnxt:  649620185
irs: 4068377976  rcvnxt: 4068379338

sndwnd:  15073  scale:      0  maxrcvwnd:  16384
rcvwnd:  15023  scale:      0  delrcvwnd:   1361

SRTT: 1000 ms, RTTO: 1007 ms, RTV: 7 ms, KRTT: 0 ms
minRTT: 1 ms, maxRTT: 1000 ms, ACK hold: 200 ms
uptime: 2930235 ms, Sent idletime: 13607 ms, Receive idletime: 13405 ms
Status Flags: active open
Option Flags: nagle, path mtu capable
IP Precedence value : 6

Datagrams (max data segment is 1460 bytes):
Rcvd: 113 (out of order: 0), with data: 57, total data bytes: 1361
Sent: 113 (retransmit: 0, fastretransmit: 0, partialack: 0, Second
Congestion: 0), with data: 57, total data bytes: 1311

 Packets received in fast path: 0, fast processed: 0, slow path: 0
```

```
 fast lock acquisition failures: 0, slow path: 0
TCP Semaphore      0x7F3B33068C18  FREE

BGP neighbor is 7.7.7.7,  remote AS 2, internal link
  BGP version 4, remote router ID 7.7.7.7
  BGP state = Established, up for 01:14:30
  Last read 00:00:33, last write 00:00:09, hold time is 180, keepalive
interval is 60 seconds
  Neighbor sessions:
    1 active, is not multisession capable (disabled)
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
    Enhanced Refresh Capability: advertised and received
    Multisession Capability:
    Stateful switchover support enabled: NO for session 1
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:                8         13
    Keepalives:            82         81
    Route Refresh:          0          0
    Total:                 91         95
  Do log neighbor state changes (via global configuration)
  Default minimum time between advertisement runs is 0 seconds

 For address family: IPv4 Unicast
  Session: 7.7.7.7
  BGP table version 30, neighbor version 30/0
  Output queue size : 0
  Index 2, Advertise bit 1
  2 update-group member
  NEXT_HOP is always this router for eBGP paths
  Slow-peer detection is disabled
  Slow-peer split-update-group dynamic is disabled
                                 Sent       Rcvd
  Prefix activity:               ----       ----
    Prefixes Current:               5          5 (Consumes 600 bytes)
    Prefixes Total:                 7          6
    Implicit Withdraw:              0          0
    Explicit Withdraw:              2          1
    Used as bestpath:             n/a          0
    Used as multipath:            n/a          0

                                   Outbound    Inbound
```

```
  Local Policy Denied Prefixes:    --------    -------
    NEXT_HOP is us:                      n/a          7
    Bestpath from this peer:              11        n/a
    Bestpath from iBGP peer:               8        n/a
    Total:                                19          7
  Number of NLRIs in the update sent: max 3, min 0
  Last detected as dynamic slow peer: never
  Dynamic slow peer recovered: never
  Refresh Epoch: 1
  Last Sent Refresh Start-of-rib: never
  Last Sent Refresh End-of-rib: never
  Last Received Refresh Start-of-rib: never
  Last Received Refresh End-of-rib: never
                                     Sent       Rcvd
        Refresh activity:            ----       ----
          Refresh Start-of-RIB        0          0
          Refresh End-of-RIB          0          0

  Address tracking is enabled, the RIB does have a route to 7.7.7.7
  Connections established 1; dropped 0
  Last reset never
  Interface associated: (none) (peering address NOT in same link)
  Transport(tcp) path-mtu-discovery is enabled
  Graceful-Restart is disabled
  SSO is disabled
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 255
Local host: 3.3.3.3, Local port: 40694
Foreign host: 7.7.7.7, Foreign port: 179
Connection tableid (VRF): 0
Maximum output segment queue size: 50

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

Event Timers (current time is 0x5115BF):
Timer          Starts    Wakeups            Next
Retrans            88          0             0x0
TimeWait            0          0             0x0
AckHold            88         83             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger         3637       3636        0x511988
DeadWait            0          0             0x0
Linger              0          0             0x0
ProcessQ            0          0             0x0

iss:  737779630  snduna:  737781631  sndnxt:  737781631
irs:  301366267  rcvnxt:  301368649
```

```
sndwnd:  15852  scale:      0  maxrcvwnd:  16384
rcvwnd:  15472  scale:      0  delrcvwnd:    912

SRTT: 1000 ms, RTTO: 1003 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 1 ms, maxRTT: 1000 ms, ACK hold: 200 ms
uptime: 4474220 ms, Sent idletime: 13253 ms, Receive idletime: 13053 ms
Status Flags: active open
Option Flags: nagle, path mtu capable
IP Precedence value : 6

Datagrams (max data segment is 1460 bytes):
Rcvd: 173 (out of order: 0), with data: 89, total data bytes: 2381
Sent: 176 (retransmit: 0, fastretransmit: 0, partialack: 0, Second
Congestion: 0), with data: 88, total data bytes: 2000

 Packets received in fast path: 0, fast processed: 0, slow path: 0
 fast lock acquisition failures: 0, slow path: 0
TCP Semaphore      0x7F3B33068F18  FREE

BGP neighbor is 192.168.0.1,  remote AS 1, external link
  BGP version 4, remote router ID 2.2.2.2
  BGP state = Established, up for 01:16:26
  Last read 00:00:56, last write 00:00:09, hold time is 180, keepalive
interval is 60 seconds
  Neighbor sessions:
    1 active, is not multisession capable (disabled)
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
    Enhanced Refresh Capability: advertised and received
    Multisession Capability:
    Stateful switchover support enabled: NO for session 1
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:               14          7
    Keepalives:            83         83
    Route Refresh:          0          0
    Total:                 98         91
  Do log neighbor state changes (via global configuration)
  Default minimum time between advertisement runs is 30 seconds

 For address family: IPv4 Unicast
  Session: 192.168.0.1
  BGP table version 30, neighbor version 30/0
```

```
  Output queue size : 0
  Index 1, Advertise bit 0
  1 update-group member
  Slow-peer detection is disabled
  Slow-peer split-update-group dynamic is disabled
                               Sent       Rcvd
  Prefix activity:             ----       ----
    Prefixes Current:             8          3 (Consumes 360 bytes)
    Prefixes Total:              19          5
    Implicit Withdraw:           11          0
    Explicit Withdraw:            0          2
    Used as bestpath:           n/a          2
    Used as multipath:          n/a          0

                                 Outbound    Inbound
  Local Policy Denied Prefixes:  --------    -------
    Bestpath from this peer:            4        n/a
    Total:                              4          0
  Number of NLRIs in the update sent: max 3, min 0
  Last detected as dynamic slow peer: never
  Dynamic slow peer recovered: never
  Refresh Epoch: 1
  Last Sent Refresh Start-of-rib: never
  Last Sent Refresh End-of-rib: never
  Last Received Refresh Start-of-rib: never
  Last Received Refresh End-of-rib: never
                                    Sent       Rcvd
        Refresh activity:           ----       ----
          Refresh Start-of-RIB       0          0
          Refresh End-of-RIB         0          0

  Address tracking is enabled, the RIB does have a route to 192.168.0.1
  Connections established 1; dropped 0
  Last reset never
  External BGP neighbor configured for connected checks (single-hop no-
disable-connected-check)
  Interface associated: GigabitEthernet0/0/0 (peering address in same link)
  Transport(tcp) path-mtu-discovery is enabled
  Graceful-Restart is disabled
  SSO is disabled
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 1
Local host: 192.168.0.2, Local port: 179
Foreign host: 192.168.0.1, Foreign port: 45460
Connection tableid (VRF): 0
Maximum output segment queue size: 50

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

Event Timers (current time is 0x512C97):
```

```
Timer          Starts    Wakeups            Next
Retrans            90          0             0x0
TimeWait            0          0             0x0
AckHold            89         85             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0
Linger              0          0             0x0
ProcessQ            0          0             0x0

iss: 2746823984  snduna: 2746826327  sndnxt: 2746826327
irs: 1937309002  rcvnxt: 1937310953

sndwnd:  15510  scale:      0  maxrcvwnd:  16384
rcvwnd:  15909  scale:      0  delrcvwnd:    475

SRTT: 1000 ms, RTTO: 1003 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 1 ms, maxRTT: 1000 ms, ACK hold: 200 ms
uptime: 4590934 ms, Sent idletime: 2909 ms, Receive idletime: 3109 ms
Status Flags: passive open, gen tcbs
Option Flags: nagle, path mtu capable
IP Precedence value : 6

Datagrams (max data segment is 1460 bytes):
Rcvd: 181 (out of order: 0), with data: 90, total data bytes: 1950
Sent: 180 (retransmit: 0, fastretransmit: 0, partialack: 0, Second
Congestion: 0), with data: 91, total data bytes: 2342

 Packets received in fast path: 0, fast processed: 0, slow path: 0
 fast lock acquisition failures: 0, slow path: 0
TCP Semaphore      0x7F3B33069098  FREE
```

R4 BGP routing tables

```
BGP table version is 29, local router ID is 4.4.4.4
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-
Filter,
              x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 r>i 3.3.3.3/32       3.3.3.3                  0    100      0 ?
 r i                  3.3.3.3                  0    100      0 ?
 *>  4.4.4.4/32       0.0.0.0                  0         32768 ?
 *>i 10.0.0.0/24      192.168.0.1              0    100      0 1 ?
 * i                  3.3.3.3                  0    100      0 1 ?
```

```
 r>i 10.0.1.0/24      3.3.3.3                  0    100      0 ?
 r i                  3.3.3.3                  0    100      0 ?
 *>  10.0.2.0/24      0.0.0.0                  0         32768 ?
 *>  10.0.3.0/24      192.168.1.2              0             0 3 ?
 *>i 10.0.20.0/24     192.168.0.1              2    100      0 1 ?
 * i                  3.3.3.3                  2    100      0 1 ?
 *>  10.0.30.0/24     192.168.1.2             10             0 3 ?
 r>i 192.168.0.0      3.3.3.3                  0    100      0 ?
 r i                  3.3.3.3                  0    100      0 ?
     Network          Next Hop            Metric LocPrf Weight Path
 *   192.168.1.0      192.168.1.2              0             0 3 ?
 *>                   0.0.0.0                  0         32768 ?
```

R7 BGP neighbors

```
R7# show ip bgp neighbors
BGP neighbor is 3.3.3.3,  remote AS 2, internal link
  BGP version 4, remote router ID 3.3.3.3
  BGP state = Established, up for 01:19:05
  Last read 00:00:31, last write 00:00:45, hold time is 180, keepalive
interval is 60 seconds
  Neighbor sessions:
    1 active, is not multisession capable (disabled)
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
    Enhanced Refresh Capability: advertised and received
    Multisession Capability:
    Stateful switchover support enabled: NO for session 1
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

                         Sent       Rcvd
    Opens:                  1          1
    Notifications:          0          0
    Updates:               13          8
    Keepalives:            86         87
    Route Refresh:          0          0
    Total:                100         96
  Do log neighbor state changes (via global configuration)
  Default minimum time between advertisement runs is 0 seconds

 For address family: IPv4 Unicast
  Session: 3.3.3.3
  BGP table version 17, neighbor version 17/0
  Output queue size : 0
  Index 1, Advertise bit 0
  Route-Reflector Client
```

```
  1 update-group member
  Slow-peer detection is disabled
  Slow-peer split-update-group dynamic is disabled
                               Sent       Rcvd
  Prefix activity:             ----       ----
    Prefixes Current:            10          5 (Consumes 680 bytes)
    Prefixes Total:              13          7
    Implicit Withdraw:            0          0
    Explicit Withdraw:            3          2
    Used as bestpath:           n/a          5
    Used as multipath:          n/a          0
    Used as secondary:          n/a          0

                                 Outbound    Inbound
  Local Policy Denied Prefixes:  --------    -------
    Total:                              0          0
  Number of NLRIs in the update sent: max 3, min 0
  Last detected as dynamic slow peer: never
  Dynamic slow peer recovered: never
  Refresh Epoch: 1
  Last Sent Refresh Start-of-rib: never
  Last Sent Refresh End-of-rib: never
  Last Received Refresh Start-of-rib: never
  Last Received Refresh End-of-rib: never
                                     Sent       Rcvd
        Refresh activity:            ----       ----
          Refresh Start-of-RIB        0          0
          Refresh End-of-RIB          0          0

  Address tracking is enabled, the RIB does have a route to 3.3.3.3
  Route to peer address reachability Up: 1; Down: 0
    Last notification 01:19:07
  Connections established 1; dropped 0
  Last reset never
  Interface associated: (none) (peering address NOT in same link)
  Transport(tcp) path-mtu-discovery is enabled
  Graceful-Restart is disabled
  SSO is disabled
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 255
Local host: 7.7.7.7, Local port: 179
Foreign host: 3.3.3.3, Foreign port: 40694
Connection tableid (VRF): 0
Maximum output segment queue size: 50

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

Event Timers (current time is 0x591FA6):
Timer          Starts    Wakeups            Next
Retrans            93          0             0x0
```

```
TimeWait            0          0             0x0
AckHold            92         85             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0
Linger              0          0             0x0
ProcessQ            0          0             0x0

iss:  301366267  snduna:  301368744  sndnxt:  301368744
irs:  737779630  rcvnxt:  737781726

sndwnd:  15377  scale:      0  maxrcvwnd:  16384
rcvwnd:  15757  scale:      0  delrcvwnd:    627

SRTT: 1000 ms, RTTO: 1003 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 1 ms, maxRTT: 1000 ms, ACK hold: 200 ms
uptime: 4745303 ms, Sent idletime: 30958 ms, Receive idletime: 31158 ms
Status Flags: passive open, gen tcbs
Option Flags: nagle, path mtu capable
IP Precedence value : 6

Datagrams (max data segment is 1460 bytes):
Rcvd: 186 (out of order: 0), with data: 93, total data bytes: 2095
Sent: 183 (retransmit: 0, fastretransmit: 0, partialack: 0, Second
Congestion: 0), with data: 94, total data bytes: 2476

 Packets received in fast path: 0, fast processed: 0, slow path: 0
 fast lock acquisition failures: 0, slow path: 0
TCP Semaphore      0x7F56320AD5B8  FREE

BGP neighbor is 4.4.4.4,  remote AS 2, internal link
  BGP version 4, remote router ID 4.4.4.4
  BGP state = Established, up for 01:19:03
  Last read 00:00:15, last write 00:00:16, hold time is 180, keepalive
interval is 60 seconds
  Neighbor sessions:
    1 active, is not multisession capable (disabled)
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
    Enhanced Refresh Capability: advertised and received
    Multisession Capability:
    Stateful switchover support enabled: NO for session 1
  Message statistics:
    InQ depth is 0
    OutQ depth is 0
```

```
                        Sent       Rcvd
  Opens:                   1          1
  Notifications:           0          0
  Updates:                13          6
  Keepalives:             86         87
  Route Refresh:           0          0
  Total:                 100         94
 Do log neighbor state changes (via global configuration)
 Default minimum time between advertisement runs is 0 seconds

For address family: IPv4 Unicast
 Session: 4.4.4.4
 BGP table version 17, neighbor version 17/0
 Output queue size : 0
 Index 1, Advertise bit 0
 Route-Reflector Client
 1 update-group member
 Slow-peer detection is disabled
 Slow-peer split-update-group dynamic is disabled
                               Sent       Rcvd
 Prefix activity:              ----       ----
   Prefixes Current:             10          5 (Consumes 680 bytes)
   Prefixes Total:               13          6
   Implicit Withdraw:             0          0
   Explicit Withdraw:             3          1
   Used as bestpath:            n/a          5
   Used as multipath:           n/a          0
   Used as secondary:           n/a          0

                                  Outbound    Inbound
 Local Policy Denied Prefixes:    --------    -------
   Total:                                0          0
 Number of NLRIs in the update sent: max 3, min 0
 Last detected as dynamic slow peer: never
 Dynamic slow peer recovered: never
 Refresh Epoch: 1
 Last Sent Refresh Start-of-rib: never
 Last Sent Refresh End-of-rib: never
 Last Received Refresh Start-of-rib: never
 Last Received Refresh End-of-rib: never
                                     Sent       Rcvd
       Refresh activity:             ----       ----
         Refresh Start-of-RIB         0          0
         Refresh End-of-RIB           0          0

 Address tracking is enabled, the RIB does have a route to 4.4.4.4
 Route to peer address reachability Up: 1; Down: 0
   Last notification 01:19:07
 Connections established 1; dropped 0
 Last reset never
```

```
  Interface associated: (none) (peering address NOT in same link)
  Transport(tcp) path-mtu-discovery is enabled
  Graceful-Restart is disabled
  SSO is disabled
Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled, Mininum incoming TTL 0, Outgoing TTL 255
Local host: 7.7.7.7, Local port: 179
Foreign host: 4.4.4.4, Foreign port: 50067
Connection tableid (VRF): 0
Maximum output segment queue size: 50

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

Event Timers (current time is 0x591FA7):
Timer          Starts    Wakeups            Next
Retrans            93          0             0x0
TimeWait            0          0             0x0
AckHold            90         83             0x0
SendWnd             0          0             0x0
KeepAlive           0          0             0x0
GiveUp              0          0             0x0
PmtuAger            0          0             0x0
DeadWait            0          0             0x0
Linger              0          0             0x0
ProcessQ            0          0             0x0

iss: 3122058340  snduna: 3122060817  sndnxt: 3122060817
irs: 3524892970  rcvnxt: 3524894978

sndwnd:  15377  scale:      0  maxrcvwnd:  16384
rcvwnd:  15852  scale:      0  delrcvwnd:    532

SRTT: 1000 ms, RTTO: 1003 ms, RTV: 3 ms, KRTT: 0 ms
minRTT: 1 ms, maxRTT: 1000 ms, ACK hold: 200 ms
uptime: 4743875 ms, Sent idletime: 15196 ms, Receive idletime: 15396 ms
Status Flags: passive open, gen tcbs
Option Flags: nagle, path mtu capable
IP Precedence value : 6

Datagrams (max data segment is 1460 bytes):
Rcvd: 183 (out of order: 0), with data: 91, total data bytes: 2007
Sent: 181 (retransmit: 0, fastretransmit: 0, partialack: 0, Second
Congestion: 0), with data: 94, total data bytes: 2476

 Packets received in fast path: 0, fast processed: 0, slow path: 0
 fast lock acquisition failures: 0, slow path: 0
TCP Semaphore      0x7F56320AD4E8  FREE
```

R7 BGP routing tables

```
R7#show ip bgp
```

```
BGP table version is 17, local router ID is 7.7.7.7
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-
Filter,
              x best-external, a additional-path, c RIB-compressed,
              t secondary path, L long-lived-stale,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 r>i  3.3.3.3/32       3.3.3.3                  0    100      0 ?
 r>i  4.4.4.4/32       4.4.4.4                  0    100      0 ?
 *>i  10.0.0.0/24      3.3.3.3                  0    100      0 1 ?
 r>i  10.0.1.0/24      3.3.3.3                  0    100      0 ?
 r>i  10.0.2.0/24      4.4.4.4                  0    100      0 ?
 *>i  10.0.3.0/24      4.4.4.4                  0    100      0 3 ?
 *>i  10.0.20.0/24     3.3.3.3                  2    100      0 1 ?
 *>i  10.0.30.0/24     4.4.4.4                 10    100      0 3 ?
 r>i  192.168.0.0      3.3.3.3                  0    100      0 ?
 r>i  192.168.1.0      4.4.4.4                  0    100      0 ?

BGP table version is 17, local router ID is 7.7.7.7
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
              r RIB-failure, S Stale, m multipath, b backup-path, f RT-
Filter,
              x best-external, a additional-path, c RIB-compressed,
              t secondary path, L long-lived-stale,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

     Network          Next Hop            Metric LocPrf Weight Path
 *>i  1::/64           100:3::3                 0    100      0 1 ?
 r>i  1:1::/64         100:3::3                 0    100      0 ?
 r>i  1:2::/64         100:4::4                 0    100      0 ?
 *>i  1:3::/64         100:4::4                 0    100      0 3 ?
 *>i  1:20::/64        100:3::3                10    100      0 1 ?
 *>i  1:30::/64        100:4::4                10    100      0 3 ?
 r>i  2::/64           100:3::3                 0    100      0 ?
 r>i  2:1::/64         100:4::4                 0    100      0 ?
 r>i  100:3::3/128     100:3::3                 0    100      0 ?
 r>i  100:4::4/128     100:4::4                 0    100      0 ?
```