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Lab 9: BGP

Purpose

The purpose of this lab was to set up a network that employs multiple routing protocols that are connected by Border Gateway Protocols (BGP). The main type of BGP that was used is EBGP; our task was to explore how each BGP works in networks.

Background Information on Lab Concepts

Border Gateway Protocol (BGP): A standardized exterior gateway protocol that allows the exchange between Autonomous Systems (AS). BGP is a path vector protocol; it prioritizes weight, preference, locality of paths, and then the distance. Sometimes, however, it is sometimes classified as a distance vector routing protocol. BGP is a routing protocol that centers in the management of core routing protocols across various networks.

There are two primary types of BGP: IBGP and EBGP.

- IBGP (Internal BGP): A BGP that processes a single autonomous system.
    - The main requirement for this BGP is that peers must be in full mesh mode, meaning that a direct connection needs to be established between routes.
    - The administrative distance of IBGP is 200
- EBGP (Exterior BGP): A BGP that runs different autonomous systems.
    - The administrative distance of EBGP is 20.

The main difference between IBGP and EBGP is the way that a route is forwarded to another route. If a route is learned from EBGP, it will be redistributed to all IBGP and EBGP peers. On the other hand, if a route is learned from IBGP, it will be redistributed to only EBGP peers. Since IBGP establishes a full mesh topology, the speed of IBGP will be much faster than that of EBGP. In addition, when EBPG and IBGP are both configured on the same network, IBGP, whose administrative distance of the two BGP is lower, will have the priority.

As mentioned above, the route selection process for BGP involves quite a few steps besides the obvious routing processes.

1. Networking Layer Reachability Information (NLRI) must first be decided to reach Loc-RIB (Routing Information Base). The first step is to determine whether the next-hop has connectivity with the router running BGP. A reachable route must exist in the routing table of the router.
2. Then, BGP will determine which routes should go into Adj-RIB-In (unedited routing information that the router receives). Since there might exist various ways that a neighbor can send routes to the router, the neighbor level is prioritized; this means that a single route will be installed in the routing table.

3. The main BGP process will determine whether the Routing Information-Base contains any of the new routes are better than the old ones. If a route has a destination that other routes don't, that route is immediately removed from the Routing Information-Base.

Peer-to-peer network: A decentralized (meaning that there is no central device(s) controlling other peers) network in which the individual devices function establish a direct connection between each other. This network is the exact opposite of a client-server model which involves the distribution of information to client devices. A peer-to peer network includes devices that assume control over no devices. BGP is widely known as a protocol that supports peer-to-peer networks.

Lab Summary

The lab summary is slightly intricate; it is critical that one follows these directions precisely.

1. Configure static IP addresses for all devices in the network topology below.
2. Configuring RIP, EIGRP, and OSPF for each corresponding network below using the commands the network commands and the *no auto-summary* command. When issuing network commands, do not forget to incorporate the IP address of the loopbacks.
3. It is essential that one configure different routing commands before redistributing routes. Configure the central Switch with BGP, using the **SAME AUTONOMOUS SYSTEM NUMBER FOR ONLY** its interfaces (e.g interface fa0/0 and interface fa0/1 of R2must have the same Autonomous System number but a different Autonomous System number from interface fa0/0 and interface fa0/1 of R4. The reason for inputting same autonomous system numbers is that the BGP for the central Switch will act as the main BGP that will manage other routing protocols. As four interfaces have the BGP of the central Switch, nearby devices will recognize that BGP number as the central BGP. In this case, the autonomous system number of the central BGP was 4. Then, issue the network command for the BGP of the central Switch.
4. Go back to the routers with OSPF, RIP, and BGP. Keep in mind that EBGP is the primary BGP that is being used in this lab. As mentioned above, the benefit of using EBGP over IBGP is that EBGP allows a connection between two different Autonomous Systems, which in this case represent different enterprises.
5. Since only the interfaces connected to one router need to have the same Autonomous System numbers with each other but different Autonomous System numbers, select five different Autonomous system numbers that will represent each enterprise (router).
6. On the central BGP, issue the commands *neighbor [IP address of the neighbor, or directly connected router] remote-as [Autonomous System number of the neighbor],* and then add the additional command *neighbor [IP address of the neighbor] next-hop-self.* Since the router inside the Autonomous System does not have an additional route to the neighbor's address, this command is indispensable to advertising Autonomous Systems across BGP.
7. Repeat step 6 with the five different Autonomous Systems that were chosen in step 5: add in the commands *neighbor [IP address of the neighbor, or directly connected router] remote-as [Autonomous System number of the neighbor]* and *neighbor [IP address of the neighbor] next-hop-self* on every router.

8. Since different routing protocols cannot communicate with each other as of now, redistribution of OSPF, RIP, EIGRP, and BGP is required. On routers that run two different protocols at the same time, issue the command *redistribute [routing protocol]*. On EIGRP, issue the command *redistribute bgp [Autonomous system number of the BGP] metric [metric settings]* to configure the metrics for EIGRP. When redistributing BGP, add the Autonomous System number to the word *bgp.* On OSPF, add the command *default-information* to propagate any default routes.
9. Ping across various end devices. If a route does not show up, issue the command *show ip route* and check which networks are missing.

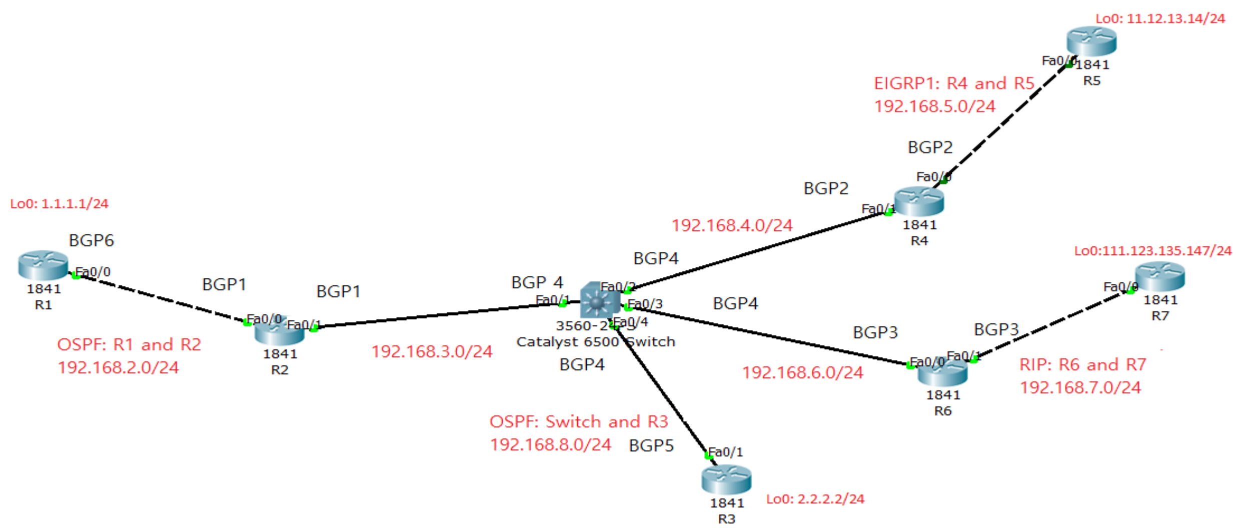
Lab Commands

Router (config-router)# redistribute bgp [Autonomous System number of the BGP protocol adjacent to OSPF, RIP, or BGP]	This command is for **OSPF, RIP, AND BGP ONLY.** EIGRP has a separate command for redistribution. This command redistributes BGP to a protocol adjacent to OSPF
Router (config)# router bgp [Autonomous System number]	Allows the user to enter the configuration mode for BGP
Router (config-router)# network [network number]	Configures the network address of the network that BGP is configured in.
Router (config-router)# neighbor [IP address of the neighbor] remote-as [Autonomous System Number of the neighbor]	Establishes a connection between the current router and its neighbor by identifying its Autonomous System number.
Router (config-router)# neighbor [IP address of the neighbor] next-hop-self	Notifies the router of the IP address of the next hop. In EBGP, it is crucial that this command is issued; it sets the current router as the next hop address of the owner of the IP address in the command. To conserve network resources, this command is indispensable.
Router (config)# router ospf [number]	Allows the user to enter the configuration mode for OSPF
Router (config-router)# default-information originate	Sends a default route to the network via OSPF
Router (config-router)# network [network number] [wild card mask] area [area number]	Configures the network address of the network that OSPF is configured in.
Router (config)# router rip	Allows the user to enter the configuration mode for RIP
Router (config-router)# no auto-summary	Eliminates the summary of the subnet masks that prevents the emerging of routes in the routing table in stubby areas.
Router (config-router)# version 2	Sets the version of RIP as 2.
Router (config-router)# network [network number]	Configure Make sure to put the loopback address
Router (config)# router eigrp [autonomous system number]	Allows the user to enter the configuration mode for RIP
Router (config-router)# redistribute bgp [Autonomous system number of the BGP] metric	Redistributes BGP according to the metric settings.

[metric settings]	
Router (config-router)# network [network number]	Configures the network address of the network that EIGRP is configured in.
Router (config-router)# no auto-summary	Eliminates the summary of the subnet masks that prevents the emerging of routes in the routing table in stubby areas.

*For all end routers, add a network statement that can incorporate the loopback interfaces.

Network Diagram with IP's



Configurations

R1

```
R1#sh run
!
hostname R1
!
!
!
!
vlan internal allocation policy
ascending
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
 no shutdown
!
interface FastEthernet0/0
 ip address 192.168.2.2 255.255.255.0
 duplex auto
 speed auto
 no shutdown
!
router ospf 1
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0
 network 192.168.2.0 0.0.0.255 area 0
!
router bgp 6
 no synchronization
 bgp log-neighbor-changes
 neighbor 192.168.2.1 remote-as 1
 no auto-summary
!
!
!
ip http server
no ip http secure-server
!
no cdp run
!
!
!
line con 0
line aux 0
line vty 0 4
 login
!
scheduler allocate 20000 1000
```

```
!
end
```

R2

```
R2#sh run
!
hostname R2
!
boot-start-marker
boot-end-marker
!
!
!
no aaa new-model
!
memory-size iomem 10
!
no ipv6 cef
ip source-route
ip cef
!
!
!
!
interface GigabitEthernet0/0
 ip address 192.168.2.1 255.255.255.0
 duplex auto
 speed auto
 no shutdown
!
interface GigabitEthernet0/1
 ip address 192.168.3.2 255.255.255.0
 duplex auto
 speed auto
 no shutdown
!
router ospf 1
 redistribute bgp 1
 network 192.168.2.0 0.0.0.255 area 0
 default-information originate
!
router bgp 1
 bgp log-neighbor-changes
 network 192.168.3.0
 redistribute ospf 1
 neighbor 192.168.2.2 remote-as 6
 neighbor 192.168.3.1 remote-as 4
 neighbor 192.168.3.1 next-hop-self
!
!
!
line con 0
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output pad telnet rlogin
lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 login
 transport input all
!
scheduler allocate 20000 1000
end
```

R3

```
R3#sh run
!
hostname R3
!
voice-card 0
!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
 no shutdown
!
!
interface GigabitEthernet0/1
 ip address 192.168.8.2 255.255.255.0
 duplex auto
 speed auto
 no shutdown
!
!
router ospf 2
 network 2.2.2.2 0.0.0.0 area 0
 network 192.168.8.0 0.0.0.255 area 0
!
router bgp 5
 bgp log-neighbor-changes
 neighbor 192.168.8.1 remote-as 4
!
!
!
!
line con 0
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport output pad telnet rlogin
lapb-ta mop udptn v120 ssh
 stopbits 1
line vty 0 4
 login
 transport input all
!
scheduler allocate 20000 1000
!
end
```

R4

```
R4#sh run
Building configuration...

Current configuration : 1771 bytes
!
version 12.4
no service timestamps debug uptime
no service timestamps log uptime
no service password-encryption
!
hostname R4
!
```

```
boot-start-marker
boot-end-marker
!
logging message-counter syslog
!
no aaa new-model
memory-size iomem 10
no network-clock-participate slot 1
!
dot11 syslog
ip source-route
!
!
ip cef
!
!
no ipv6 cef
!
multilink bundle-name authenticated
!
!
interface FastEthernet0/0
 ip address 192.168.6.1 255.255.255.0
 duplex auto
 speed auto
 no shutdown
!
interface FastEthernet0/1
 ip address 192.168.4.2 255.255.255.0
 duplex auto
 speed auto
 no shutdown
!
!
router eigrp 1
 redistribute bgp 2 metric 1 255 1 150
1500
 network 192.168.6.0
 no auto-summary
!
router bgp 2
 no synchronization
 bgp log-neighbor-changes
 network 192.168.4.0
 redistribute eigrp 1
 neighbor 192.168.4.1 remote-as 4
 neighbor 192.168.4.1 next-hop-self
 no auto-summary
!
!
!
!
!
!
!
line con 0
line aux 0
line vty 0 4
 login
!
scheduler allocate 20000 1000
end
```

R5

```
R5#sh run
Building configuration...


Current configuration : 1307 bytes
!
! Last configuration change at 18:03:50
UTC Tue Mar 18 2014
!
version 15.0
no service timestamps debug uptime
no service timestamps log uptime
no service password-encryption
!
hostname R5
!
boot-start-marker
boot-end-marker
!
!
no aaa new-model
!
!
!
memory-size iomem 10
!
no ipv6 cef
ip source-route
ip cef
!
!
!
!
!
multilink bundle-name authenticated
!
!
!
!
!
!
!
voice-card 0
!
!
!
!
!
!
license udi pid CISCO2901/K9 sn
FTX152885A3
license accept end user agreement
license boot module c2900 technology-
package securityk9
license boot module c2900 technology-
package uck9
!
!
!
redundancy
!
!
!
```

```
!
!
!
!
!
!
interface Loopback0
 ip address 11.12.13.14 255.255.255.255
 no shutdown
!
interface GigabitEthernet0/0
 ip address 192.168.6.2 255.255.255.0
 duplex auto
 speed auto
 no shutdown
!
!
!
!
router eigrp 1
 network 11.0.0.0
 network 192.168.6.0
 redistribute bgp 2
!
ip forward-protocol nd
!
no ip http server
no ip http secure-server
!
!
!
!
gatekeeper
 shutdown
!
!
line con 0
line aux 0
line vty 0 4
 login
!
scheduler allocate 20000 1000
end
```

R6

```
R6#sh run
Building configuration...


Current configuration : 1492 bytes
!
! Last configuration change at 17:13:16
UTC Tue Mar 18 2014
!
version 15.0
no service timestamps debug uptime
no service timestamps log uptime
no service password-encryption
!
hostname R6
!
boot-start-marker
boot-end-marker
!
!
no aaa new-model
!
!
!
memory-size iomem 10
!
no ipv6 cef
ip source-route
!
!
!
!
!
!
license udi pid CISCO2901/K9 sn
FTX1528859Z
license accept end user agreement
license boot module c2900 technology-
package securityk9
license boot module c2900 technology-
package uck9
!
!
!
redundancy
!
!
!
!
!
!
!
!
!
interface GigabitEthernet0/0
 ip address 192.168.5.2 255.255.255.0
 duplex auto
 speed auto
 no shutdown
 !
!
interface GigabitEthernet0/1
 ip address 192.168.7.1 255.255.255.0
 duplex auto
 speed auto
 no shutdown
 !
!
!
router rip
 version 2
 redistribute bgp 3
 network 192.168.7.0
 default-information originate
 no auto-summary
!
router bgp 3
 no synchronization
 bgp log-neighbor-changes
 network 192.168.5.0
 redistribute rip
 neighbor 192.168.5.1 remote-as 4
```

```
 neighbor 192.168.5.1 next-hop-self
 no auto-summary
!
!
line con 0
line aux 0
line vty 0 4
 login
!
scheduler allocate 20000 1000
end
```

R7

```
R7#sh run
Building configuration...


Current configuration : 1534 bytes
!
! Last configuration change at 18:23:18
UTC Tue Mar 18 2014
version 15.2
no service timestamps debug uptime
no service timestamps log uptime
no service password-encryption
!
hostname R7
!
boot-start-marker
boot-end-marker
!
!
!
no aaa new-model
!
ip cef
!
!
!
!


!
!
!
!
no ipv6 cef
!
multilink bundle-name authenticated
!
!
!
!
!
!
!
voice-card 0
!
!
!
!
line vty 0 4
 login
 transport input all
!
!
!
!
license udi pid CISCO2901/K9 sn
FTX180180LT
license accept end user agreement
license boot module c2900 technology-
package securityk9
license boot module c2900 technology-
package uck9
!
!
!
!
!
!
!
!
interface Loopback1
 ip address 111.123.135.147
255.255.255.255
 no shutdown
!
interface Embedded-Service-Engine0/0
 no ip address
 shutdown
!
interface GigabitEthernet0/0
 ip address 192.168.7.2 255.255.255.0
 duplex auto
 speed auto
 no shutdown
!
!
!
router rip
 version 2
 network 111.0.0.0
 network 192.168.7.0
 no auto-summary
!
ip forward-protocol nd

!
gatekeeper
 shutdown
!
!
!
line con 0
line aux 0
line 2
 no activation-character
 no exec
 transport preferred none
 transport output pad telnet rlogin
lapb-ta mop udptn v120 ssh
 stopbits 1


!
scheduler allocate 20000 1000
!
```

```
end
```

S1

```
S1#sh run
!
hostname S1
!
boot-start-marker
boot-end-marker
!
!
!
!
no aaa new-model
system mtu routing 1500
authentication mac-move permit
ip subnet-zero
ip routing
!
!
!
!
!
!
!
!
spanning-tree mode pvst
spanning-tree etherchannel guard
misconfig
spanning-tree extend system-id
!
vlan internal allocation policy
ascending
!
!
!
!
interface FastEthernet0/1
 no switchport
 ip address 192.168.3.1 255.255.255.0
 no shutdown
!
interface FastEthernet0/2
 no switchport
 ip address 192.168.4.1 255.255.255.0
 no shutdown
!
interface FastEthernet0/3
 no switchport
 ip address 192.168.5.1 255.255.255.0
 no shutdown
!
interface FastEthernet0/4
 no switchport
 ip address 192.168.8.1 255.255.255.0
 ip ospf mtu-ignore
 no shutdown
!
router ospf 2
 log-adjacency-changes
 redistribute bgp 4
 network 192.168.8.0 0.0.0.255 area 0
 default-information originate
!
router bgp 4
 no synchronization
 bgp log-neighbor-changes
 network 192.168.3.0
 network 192.168.4.0
 network 192.168.5.0
 network 192.168.8.0
 redistribute ospf 2 match internal
 neighbor 192.168.3.2 remote-as 1
 neighbor 192.168.3.2 next-hop-self
 neighbor 192.168.4.2 remote-as 2
 neighbor 192.168.4.2 next-hop-self
 neighbor 192.168.5.2 remote-as 3
 neighbor 192.168.5.2 next-hop-self
 neighbor 192.168.8.2 remote-as 5
 neighbor 192.168.8.2 next-hop-self
 no auto-summary
!
ip classless
ip http server
ip http secure-server
!
!
!
!
line con 0
line vty 0 4
 login
line vty 5 15
 login
!
end
```

Show IP Routes

R1

```
R1#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, 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

Gateway of last resort is not set

     1.0.0.0/32 is subnetted, 1 subnets
C       1.1.1.1 is directly connected, Loopback0
     2.0.0.0/32 is subnetted, 1 subnets
B       2.2.2.2 [20/0] via 192.168.2.1, 00:25:29
B    192.168.8.0/24 [20/0] via 192.168.2.1, 00:25:29
B    192.168.4.0/24 [20/0] via 192.168.2.1, 00:25:29
     111.0.0.0/32 is subnetted, 1 subnets
B       111.123.135.147 [20/0] via 192.168.2.1, 00:25:29
B    192.168.5.0/24 [20/0] via 192.168.2.1, 00:25:29
B    192.168.6.0/24 [20/0] via 192.168.2.1, 00:25:29
     11.0.0.0/32 is subnetted, 1 subnets
B       11.12.13.14 [20/0] via 192.168.2.1, 00:25:30
B    192.168.7.0/24 [20/0] via 192.168.2.1, 00:25:30
C    192.168.2.0/24 is directly connected, FastEthernet0/0
B    192.168.3.0/24 [20/0] via 192.168.2.1, 00:25:30
```

R2

```
R2#sh 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
       + - replicated route, % - next hop override

Gateway of last resort is not set

      1.0.0.0/32 is subnetted, 1 subnets
O        1.1.1.1 [110/2] via 192.168.2.2, 1d00h, GigabitEthernet0/0
      2.0.0.0/32 is subnetted, 1 subnets
B        2.2.2.2 [20/2] via 192.168.3.1, 20:34:21
      11.0.0.0/32 is subnetted, 1 subnets
B        11.12.13.14 [20/0] via 192.168.3.1, 1d00h
      111.0.0.0/32 is subnetted, 1 subnets
B        111.123.135.147 [20/0] via 192.168.3.1, 1d00h
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.2.0/24 is directly connected, GigabitEthernet0/0
L        192.168.2.1/32 is directly connected, GigabitEthernet0/0
      192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.3.0/24 is directly connected, GigabitEthernet0/1
L        192.168.3.2/32 is directly connected, GigabitEthernet0/1
B     192.168.4.0/24 [20/0] via 192.168.3.1, 1d00h
B     192.168.5.0/24 [20/0] via 192.168.3.1, 1d00h
B     192.168.6.0/24 [20/0] via 192.168.3.1, 1d00h
B     192.168.7.0/24 [20/0] via 192.168.3.1, 1d00h
B     192.168.8.0/24 [20/0] via 192.168.3.1, 00:15:05
```

R3

```
R3#sh 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
       + - replicated route, % - next hop override

Gateway of last resort is not set

      1.0.0.0/32 is subnetted, 1 subnets
B        1.1.1.1 [20/0] via 192.168.8.1, 00:34:09
      2.0.0.0/32 is subnetted, 1 subnets
C        2.2.2.2 is directly connected, Loopback0
      11.0.0.0/32 is subnetted, 1 subnets
B        11.12.13.14 [20/0] via 192.168.8.1, 00:34:09
      111.0.0.0/32 is subnetted, 1 subnets
B        111.123.135.147 [20/0] via 192.168.8.1, 00:34:09
B     192.168.2.0/24 [20/0] via 192.168.8.1, 00:34:09
B     192.168.3.0/24 [20/0] via 192.168.8.1, 00:34:09
B     192.168.4.0/24 [20/0] via 192.168.8.1, 00:34:09
B     192.168.5.0/24 [20/0] via 192.168.8.1, 00:34:09
B     192.168.6.0/24 [20/0] via 192.168.8.1, 00:34:09
B     192.168.7.0/24 [20/0] via 192.168.8.1, 00:34:09
      192.168.8.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.8.0/24 is directly connected, GigabitEthernet0/1
L        192.168.8.2/32 is directly connected, GigabitEthernet0/1
```

R4

```
R4#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, 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

Gateway of last resort is not set

     1.0.0.0/32 is subnetted, 1 subnets
B       1.1.1.1 [20/0] via 192.168.4.1, 1d00h
     2.0.0.0/32 is subnetted, 1 subnets
B       2.2.2.2 [20/2] via 192.168.4.1, 20:38:52
B    192.168.8.0/24 [20/0] via 192.168.4.1, 1d00h
C    192.168.4.0/24 is directly connected, FastEthernet0/1
     111.0.0.0/32 is subnetted, 1 subnets
B       111.123.135.147 [20/0] via 192.168.4.1, 1d00h
B    192.168.5.0/24 [20/0] via 192.168.4.1, 1d00h
C    192.168.6.0/24 is directly connected, FastEthernet0/0
     11.0.0.0/32 is subnetted, 1 subnets
D       11.12.13.14 [90/156160] via 192.168.6.2, 1d00h, FastEthernet0/0
B    192.168.7.0/24 [20/0] via 192.168.4.1, 1d00h
B    192.168.2.0/24 [20/0] via 192.168.4.1, 1d00h
B    192.168.3.0/24 [20/0] via 192.168.4.1, 1d00h
```

R5

```
R5#sh 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, + - replicated route

Gateway of last resort is not set

      1.0.0.0/32 is subnetted, 1 subnets
D EX     1.1.1.1 [170/2560067840] via 192.168.6.1, 1d00h, GigabitEthernet0/0
      2.0.0.0/32 is subnetted, 1 subnets
D EX     2.2.2.2
           [170/2560067840] via 192.168.6.1, 20:40:14, GigabitEthernet0/0
      11.0.0.0/32 is subnetted, 1 subnets
C        11.12.13.14 is directly connected, Loopback0
      111.0.0.0/32 is subnetted, 1 subnets
D EX     111.123.135.147
           [170/2560067840] via 192.168.6.1, 1d00h, GigabitEthernet0/0
D EX  192.168.2.0/24
           [170/2560067840] via 192.168.6.1, 1d00h, GigabitEthernet0/0
D EX  192.168.3.0/24
           [170/2560067840] via 192.168.6.1, 1d00h, GigabitEthernet0/0
D EX  192.168.4.0/24
           [170/2560067840] via 192.168.6.1, 1d00h, GigabitEthernet0/0
D EX  192.168.5.0/24
           [170/2560067840] via 192.168.6.1, 1d00h, GigabitEthernet0/0
      192.168.6.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.6.0/24 is directly connected, GigabitEthernet0/0
L        192.168.6.2/32 is directly connected, GigabitEthernet0/0
D EX  192.168.7.0/24
           [170/2560067840] via 192.168.6.1, 1d00h, GigabitEthernet0/0
D EX  192.168.8.0/24
           [170/2560067840] via 192.168.6.1, 1d00h, GigabitEthernet0/0
```

R6

```
R6#sh 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, + - replicated route

Gateway of last resort is not set

      1.0.0.0/32 is subnetted, 1 subnets
B        1.1.1.1 [20/0] via 192.168.5.1, 1d00h
      2.0.0.0/32 is subnetted, 1 subnets
B        2.2.2.2 [20/2] via 192.168.5.1, 20:41:35
      11.0.0.0/32 is subnetted, 1 subnets
B        11.12.13.14 [20/0] via 192.168.5.1, 1d00h
      111.0.0.0/32 is subnetted, 1 subnets
R        111.123.135.147 [120/1] via 192.168.7.2, 00:00:04, GigabitEthernet0/1
B     192.168.2.0/24 [20/0] via 192.168.5.1, 1d00h
B     192.168.3.0/24 [20/0] via 192.168.5.1, 1d00h
B     192.168.4.0/24 [20/0] via 192.168.5.1, 1d00h
      192.168.5.0/24 is variably subnetted, 2 subnets, 2 masks
```

```
C        192.168.5.0/24 is directly connected, GigabitEthernet0/0
L        192.168.5.2/32 is directly connected, GigabitEthernet0/0
B     192.168.6.0/24 [20/0] via 192.168.5.1, 1d00h
      192.168.7.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.7.0/24 is directly connected, GigabitEthernet0/1
L        192.168.7.1/32 is directly connected, GigabitEthernet0/1
B     192.168.8.0/24 [20/0] via 192.168.5.1, 1d00h
```

R7

```
R7#sh 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
       + - replicated route, % - next hop override

Gateway of last resort is 192.168.7.1 to network 0.0.0.0

R*    0.0.0.0/0 [120/1] via 192.168.7.1, 00:00:15, GigabitEthernet0/0
      111.0.0.0/32 is subnetted, 1 subnets
C        111.123.135.147 is directly connected, Loopback1
      192.168.7.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.7.0/24 is directly connected, GigabitEthernet0/0
L        192.168.7.2/32 is directly connected, GigabitEthernet0/0
```

S1

```
S1#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, 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

Gateway of last resort is not set

     1.0.0.0/32 is subnetted, 1 subnets
B       1.1.1.1 [20/2] via 192.168.3.2, 23:59:01
     2.0.0.0/32 is subnetted, 1 subnets
O       2.2.2.2 [110/2] via 192.168.8.2, 20:26:34, FastEthernet0/4
C    192.168.8.0/24 is directly connected, FastEthernet0/4
C    192.168.4.0/24 is directly connected, FastEthernet0/2
     111.0.0.0/32 is subnetted, 1 subnets
B       111.123.135.147 [20/1] via 192.168.5.2, 1d00h
C    192.168.5.0/24 is directly connected, FastEthernet0/3
B    192.168.6.0/24 [20/0] via 192.168.4.2, 1d00h
     11.0.0.0/32 is subnetted, 1 subnets
B       11.12.13.14 [20/156160] via 192.168.4.2, 1d00h
B    192.168.7.0/24 [20/0] via 192.168.5.2, 1d00h
B    192.168.2.0/24 [20/0] via 192.168.3.2, 1d00h
C    192.168.3.0/24 is directly connected, FastEthernet0/1
```

Problem

As intricate as the lab topology was, having to set up 8 different intermediary devices with 4 different routing protocols, I had a few problems in this lab.

Redistribution was the major problem in this lab. Although I set up correct BGP network statements, the absence of redistribution commands prevented a route from showing up on the routing table. After a few troubleshooting attempts, I was finally able to redistribute one routing protocol (OSPF) to BGP; however, I still could not ping any loopbacks and had to continue my research. I finally realized that a statement for incorporating the loopback address to the routing protocols was not inserted, and therefore had to add different statements to all end routers that were attached to loopback interfaces.

The major cause of this problem was simple: setting up 4 different routing protocols, some of them being used more than once at different locations, was too much to keep track of. As the central Switch, connected by 4 different routers – each of which had different routing protocols that took a considerable amount of time to check whether a redistribution command had been implemented – had to use different autonomous system numbers, redistributing different Autonomous Systems complicated the process.

Also, insufficient research also impeded me from proceeding with my lab. As mentioned in Background Information and Lab Concepts, there are two different types of BGP: IBGP and EBGP. Without knowing what those are, I started issuing commands from websites that did not fully contain information on BGP: I used EBGP on one end and IBGP on the other end and hence could not ensure connectivity across the network. This lack of background knowledge made me end up using same and different autonomous numbers in various networks, having implemented both IBGP and EBGP in different places.

Conclusion

Overall, I managed to configure BGP so that it can control three other routing protocols near it. Although I had considerable difficulty redistributing different routes and was confused by the concepts of IBGP and EGBP, connectivity was established between all loopbacks that were attached to each end router. I acquired a skill to manage connectivity between different routers (enterprises) using a new routing protocol that I have not learned before; this skill will be crucial to me as a CCNP when having to deal with routing with other companies.