



Advanced Cisco Networking Academy: Designing a Multiprotocol Network with BGP

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Purpose

This lab is intended to teach the basics of the BGP routing protocol, and also provide insight as to how it works with other routing protocols such as OSPF and IS-IS. The lab teaches how to connect multiple separate autonomous systems with one routing protocol.

Background

Border Gateway Protocol, or BGP, is a routing protocol used to exchange routers in between routers on internal networks and on the internet. It was developed in 1989 by the Internet Engineering Task Force, or IETF, a group that develops standards and operates under the Internet Society non-profit organization. BGP for IPv4 was originally specified in RFC 1105, and BGP for IPv6 was originally specified in RFC 1654. The most recent version of the protocol, BGP-4, is specified in RFC 4271.

BGP uses TCP connections between routers on port 179 and sends hello messages every 30 seconds by default. Internal BGP, or iBGP, sends routing information between routers in the same autonomous system, while external BGP, or eBGP, sends information between autonomous systems. Confusingly, eBGP sounds very similar to EGP, or Exterior Gateway Protocol, which is the predecessor to BGP. BGP is mainly designed to allow routers managed by different companies to exchange routes with each other, which is why eBGP is much more commonly used than iBGP.

BGP routers go through 6 exchange states: Idle, Connect, Active, OpenSent, OpenConfirm, and Established. By default, if the protocol is given multiple routes to a destination, it will count the number of AS jumps to the destination between each route and use the route with the lowest number.

One of BGP's major vulnerabilities is that routers, by default, BGP-enabled routers will put any advertised routes into the routing table. While this is normally useful, it also leaves routers vulnerable to hijacking, and makes it somewhat trivial for a malicious actor to redirect traffic to their own servers by introducing a lower-metric route.

Open Shortest Path First is a routing protocol that uses link state advertisements to automatically build a network topology and provide end-to-end connectivity across networks. It was developed by the IETF. This lab uses both OSPFv2 and OSPFv3, which operate similarly but use IPv4 and IPv6 addresses respectively. OSPFv2 is specified in RFC 2328 and OSPFv3 is specified in RFC 5320.

OSPF-enabled routers can have two different types of relationships with each other: neighbor relationships and adjacencies. Neighbor relationships, which are automatically formed in P2P, broadcast, and point-to-multipoint networks, are formed using hello messages and simply inform routers of each other's existence on the network. Adjacencies are a more complex type of relationship that allows routers to exchange routing information with each other.

Intermediate System to Intermediate System, or IS-IS, is an interior gateway link-state routing protocol. Unlike most routing protocols, it was standardized by the International Standards Organization instead of the IETF. More specifically, it was

defined in ISO/IEC 10589:2002. IS-IS can send 4 types of packets: Hello PDUs, Link State PDUs, Complete Sequence Number PDUs, and Partial Sequence Number PDUs. IS-IS uses Dijkstra's algorithm, like OSPF, to find the optimal routes through a network.

Lab Summary

In this lab, we configured a BGP network across three companies: Company A (Arceus Architects), Company B (Blastoise Builders), and Company C (Charizard Construction). Each of these companies had their own internal network with a separate instance of a routing protocol. Companies A and B ran OSPF with a process ID of 1, in areas 0 and 1 respectively (despite sharing a process ID, these OSPF networks didn't communicate with each other). Company C ran the IS-IS protocol with an area tag of "char". The primary routers of each company were connected via BGP. They distributed routing information to BGP from the local routing protocol and vice versa, allowing all host routes to be accessible by any router on the network. Each of these routers were configured with their own BGP autonomous system number, meaning that the routers were connected to each other via eBGP.

Additionally, we configured optional characteristics of BGP through route maps. Through BGP, Company A was blocked from accessing the loopback address of the primary router of Company B (6.6.6.6), and Company C was given BGP routes with a metric of 444 instead of the default.

Lab Commands

Configuring BGP (Basic)

```
Router(config)#router bgp <as>
Enters BGP configuration mode. <as> represents the router's BGP autonomous system number.

Router(config-router)#bgp router-id <id>
Configures the router's BGP router ID.

Router(config-router)#neighbor <ip> remote-as <remote-as>
Configures an external BGP neighbor. IP can be IPv4 or IPv6. <remote-as> is the autonomous system number of the neighbor.

Router(config-router)#neighbor <ip> description <desc>
Configures a description for a neighbor.

Router(config-router)#address-family [ipv4|ipv6]
Enters address family configuration mode for the specified IP version.

Router(config-router-af)#network <network> mask <subnet-mask>
Configures the network where a neighbor can be found.

Router(config-router-af)#redistribute connected subnets
Redistributes networks from directly connected interfaces into BGP.

Router(config-router-af)#redistribute ospf <pid> metric <metric>
Redistributes information into BGP from OSPF using the given process ID.
Redistributed routes will be given the specified metric.

Router(config-router-af)#redistribute isis <tag> [level-1|level-2|level-1-2] metric <metric>
```

Redistributes information into BGP from IS-IS using the given area tag. Routes from level 1 (intra-area), level 2 (inter-area), or both levels can be redistributed. Redistributed routes will be given the specified metric.

```
Router(config-router-af) #neighbor <ip> activate
```

Activates a neighbor in address family configuration mode.

Configuring OSPF

```
Router(config) #[ipv6] router ospf <pid>
```

Enters OSPF router configuration mode using the specified process ID. IPv4 and IPv6 have separate router configuration modes.

```
Router(config-router) #router-id <id>
```

Configures an OSPF router ID.

```
Router(config-router) #redistribute bgp <as> subnets
```

Redistributes routes into OSPF from BGP using the specified autonomous system number.

```
Router(config-if) #[ip|ipv6] ospf <pid> area <area>
```

Configures OSPF on an interface using the specified process ID and area.

Configuring IS-IS

```
Router(config) #router isis <tag>
```

Enters IS-IS configuration mode with the specified area tag.

```
Router(config-router) #net <net>
```

Configures an IS-IS Network Entity Title. This parameter works similarly to a router ID in other routing protocols.

```
Router(config-router) #metric-style wide
```

Configures IS-IS to use larger metrics in best-path calculations.

```
Router(config-router) #redistribute bgp <as>
```

Redistributes into IS-IS from the given BGP autonomous system number.

Configuring BGP (Optional Characteristics)

```
Router(config) #ip prefix-list <list> seq <number> [permit|deny]<ip>/<mask>
```

Configures a prefix list with the name <list> to permit or deny a certain range of IP addresses. Since a prefix list can consist of multiple lines, the sequence number determines the order in which the lines are read.

```
Router(config) #route-map <map-name> [permit|deny] <seq-number>
```

Configures a route map with the name <map-name> to permit or deny addresses. The sequence number determines the order in which the route map instructions are read.

```
Router(config-route-map) #set metric <metric>
```

Sets the metric of addresses permitted by the route map.

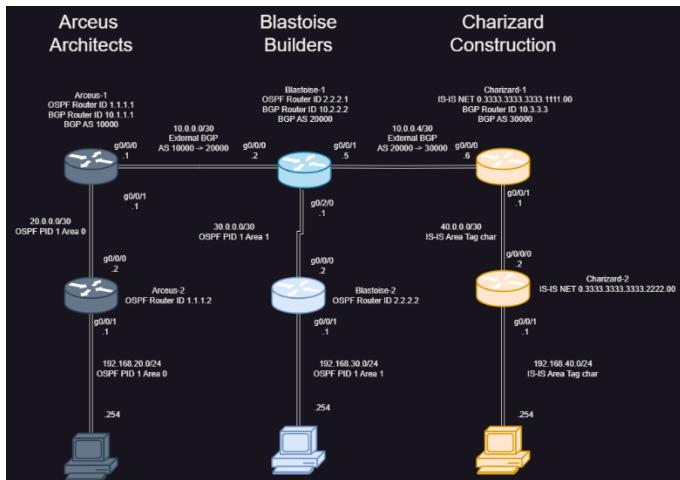
```
Router(config-route-map) #match ip address prefix-list <prefix-list>
```

Sets a route map to permit/deny addresses specified in a prefix list.

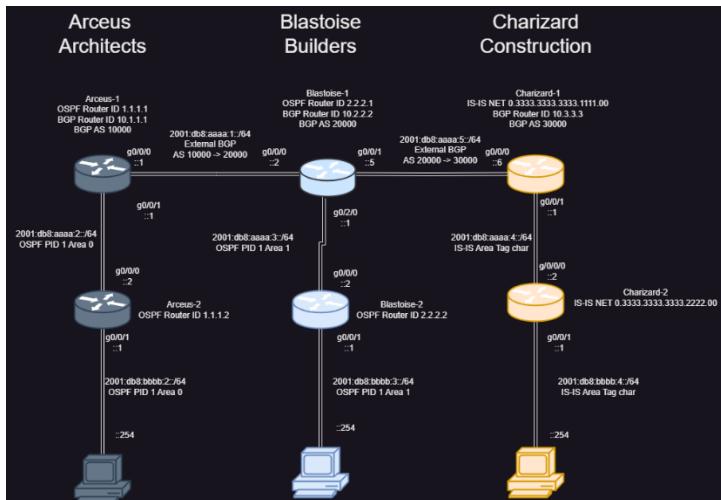
```
Router(config-router-af) #neighbor <ip> route-map <route-map> [in|out]
```

Sets the routes given to/from a BGP neighbor to be passed through a specific route map for filtering/manipulation.

Network Diagram (IPv4)



Network Diagram (IPv6)



Configurations

Arceus-1:

```

version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Arceus-1
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
  address-family ipv4
  exit-address-family

```

```
address-family ipv6
exit-address-family
no aaa new-model
no ip domain lookup
login on-success log
subscriber templating
vtp domain cisco
vtp mode transparent
ipv6 unicast-routing
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn FLM240608PJ
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
mode none
interface GigabitEthernet0/0/0
ip address 10.0.0.1 255.255.255.252
negotiation auto
ipv6 address 2001:DB8:AAAA:1::1/64
interface GigabitEthernet0/0/1
ip address 20.0.0.1 255.255.255.252
ip ospf 1 area 0
negotiation auto
ipv6 address 2001:DB8:AAAA:2::1/64
ipv6 ospf 1 area 0
interface GigabitEthernet0/1/0
no ip address
shutdown
negotiation auto
interface GigabitEthernet0/1/1
no ip address
shutdown
negotiation auto
interface GigabitEthernet0
vrf forwarding Mgmt-intf
no ip address
shutdown
negotiation auto
router ospf 1
router-id 1.1.1.1
redistribute bgp 10000 subnets
router bgp 10000
bgp router-id 10.1.1.1
bgp log-neighbor-changes
neighbor 10.0.0.2 remote-as 20000
neighbor 10.0.0.2 description blastoise
```

```

neighbor 2001:DB8:AAAA:1::2 remote-as 20000
neighbor 2001:DB8:AAAA:1::2 description blastoisev6
address-family ipv4
  network 10.0.0.0 mask 255.255.255.252
  redistribute ospf 1 metric 10
  neighbor 10.0.0.2 activate
  neighbor 2001:DB8:AAAA:1::2 activate
exit-address-family
address-family ipv6
  redistribute ospf 1 metric 10
  neighbor 2001:DB8:AAAA:1::2 activate
exit-address-family
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
ipv6 router ospf 1
  router-id 1.1.1.1
  default-information originate
  redistribute bgp 10000
control-plane
banner motd ^CUnauthorized access is illegal. Gotta catch em
all!^C
line con 0
  login
  transport input none
  stopbits 1
line aux 0
  stopbits 1
line vty 0 4
  login
line vty 5 15
  login
end

```

Arceus-2:

```

version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Arceus-2
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
  address-family ipv4

```

```
exit-address-family
address-family ipv6
exit-address-family
no aaa new-model
no ip domain lookup
login on-success log
subscriber templating
vtp domain cisco
vtp mode transparent
ipv6 unicast-routing
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn FLM240608H7
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
mode none
interface GigabitEthernet0/0/0
ip address 20.0.0.2 255.255.255.252
ip ospf 1 area 0
negotiation auto
ipv6 address 2001:DB8:AAAA:2::2/64
ipv6 ospf 1 area 0
interface GigabitEthernet0/0/1
ip address 192.168.20.1 255.255.255.0
ip ospf 1 area 0
negotiation auto
ipv6 address 2001:DB8:BBBB:2::1/64
ipv6 ospf 1 area 0
interface GigabitEthernet0
vrf forwarding Mgmt-intf
no ip address
shutdown
negotiation auto
router ospf 1
router-id 1.1.1.2
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
ipv6 router ospf 1
router-id 1.1.1.2
control-plane
banner motd ^CUnauthorized access is illegal. Gotta catch em
all!^C
line con 0
```

```
login
transport input none
stopbits 1
line aux 0
stopbits 1
line vty 0 4
login
line vty 5 15
login
end
```

Blastoise-1:

```
version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Blastoise-1
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
  address-family ipv4
  exit-address-family
  address-family ipv6
  exit-address-family
no aaa new-model
no ip domain lookup
login on-success log
subscriber templating
ipv6 unicast-routing
multilink bundle-name authenticated
crypto pki trustpoint TP-self-signed-2517694527
  enrollment selfsigned
  subject-name cn=IOS-Self-Signed-Certificate-2517694527
  revocation-check none
  rsakeypair TP-self-signed-2517694527
crypto pki certificate chain TP-self-signed-2517694527
  certificate self-signed 01
    30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101
  05050030
    31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D
  43657274
    69666963 6174652D 32353137 36393435 3237301E 170D3234 31303137
  32323238
    34305A17 0D333030 31303130 30303030 305A3031 312F302D 06035504
  03132649
```

```
4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32
35313736
    39343532 37308201 22300D06 092A8648 86F70D01 01010500 0382010F
00308201
    0A028201 0100A93A 5525F64C 9B52036B AA80055A C1CF0AB1 A76988AD
F35C3DF2
    BE91E9A5 E42A570E 7D4FE4A0 03569F42 462DEDA9 20F685A7 F6BED6F6
CD249286
    A92D8070 3ECAB612 EF0CA141 02E2DAAD E003A137 169C3E39 6265A127
FA6F0580
    47C64278 11C70901 EE5FEB02 CE4F0153 755BBC94 15603A6D 9D5F754E
3A2FF28E
    4D91CD4C 06406C6F EBC061BA 0E8156B3 3A597354 CC234FC1 6C509250
F97A9B02
    4C15AA98 948FF47A 61435C2F FAE59347 6830DEF8 9DFDC9CB 8881BCBA
63C009C9
    F1EAD5E2 4CE1F3C0 4FE491AC EFC5EA9A B82184F7 7A66BA43 BE7A3EDE
0C206747
    2FD3543A 3A853102 BD1E0E59 3DCF55F2 C4F16284 54E9D97C 15E79A30
B920AC4B
    C6C3756C 4E530203 010001A3 53305130 0F060355 1D130101 FF040530
030101FF
    301F0603 551D2304 18301680 1467E9AC A5E499F5 50E7FA98 FA6B12C9
639A8C0B
    18301D06 03551D0E 04160414 67E9ACA5 E499F550 E7FA98FA 6B12C963
9A8C0B18
    300D0609 2A864886 F70D0101 05050003 82010100 A853FB28 9EF515FB
BF8F237D
    A8919865 F52A012C 007F24E1 21CE1DBE EA5CC63B 3DC84139 75592551
71838E67
    43E0924E B45DAAD3 3144D2EE 2D15BF15 153CD230 92B7958E 6843CD20
A42780AA
    222DAF7D 8926DC75 FF0188EB C22A209D 2078ABDD 815DD3A5 684648A1
C7A4FF53
    82CD26E0 366B367E 70118FE5 2004B346 835321D7 A16B2BD7 D61D50B3
D4A75B9A
    78315986 66458573 B376F554 AB1726B4 50688D23 7D8E9360 F3477713
78D29CC4
    B4F4C8B2 1EC01B3A 7468AFEB ED0C2F4B 27609492 0BD014C5 450F8AC6
BB0737D2
    3DD3A856 6E8FF1BA DE68C96D 346AEF09 D853286D FD48E7CE E1CE90E0
08E9D749
    51EDC47C 4E9EE5B4 AD2579BA 56D6DF3F 274C1EEC
        quit
license udi pid ISR4321/K9 sn FDO214414VU
no license smart enable
diagnostic bootup level minimal
```

```

spanning-tree extend system-id
redundancy
  mode none
interface Loopback0
  ip address 6.6.6.6 255.255.255.255
interface GigabitEthernet0/0/0
  ip address 10.0.0.2 255.255.255.252
  negotiation auto
  ipv6 address 2001:DB8:AAAA:1::2/64
interface GigabitEthernet0/0/1
  ip address 10.0.0.5 255.255.255.252
  negotiation auto
  ipv6 address 2001:DB8:AAAA:5::5/64
interface Serial0/1/0
interface Serial0/1/1
interface GigabitEthernet0/2/0
  ip address 30.0.0.1 255.255.255.252
  ip ospf 1 area 1
  negotiation auto
  ipv6 address 2001:DB8:AAAA:3::1/64
  ipv6 ospf 1 area 1
interface GigabitEthernet0/2/1
  negotiation auto
interface GigabitEthernet0
  vrf forwarding Mgmt-intf
  no ip address
  shutdown
  negotiation auto
router ospf 1
  router-id 2.2.2.1
  redistribute connected subnets
  redistribute bgp 20000 metric 10 subnets
router bgp 20000
  bgp router-id 10.2.2.2
  bgp log-neighbor-changes
  neighbor 10.0.0.1 remote-as 10000
  neighbor 10.0.0.1 description arceus
  neighbor 10.0.0.6 remote-as 30000
  neighbor 10.0.0.6 description charizard
  neighbor 2001:DB8:AAAA:1::1 remote-as 10000
  neighbor 2001:DB8:AAAA:5::6 remote-as 30000
  address-family ipv4
    network 10.0.0.0 mask 255.255.255.252
    network 10.0.0.4 mask 255.255.255.252
    redistribute connected
    redistribute ospf 1
    neighbor 10.0.0.1 activate

```

```

neighbor 10.0.0.1 route-map DLM out
neighbor 10.0.0.6 activate
neighbor 10.0.0.6 route-map set-mlp out
neighbor 2001:DB8:AAAA:1::1 activate
neighbor 2001:DB8:AAAA:5::6 activate
exit-address-family
address-family ipv6
    redistribute ospf 1 metric 10
    neighbor 2001:DB8:AAAA:1::1 activate
    neighbor 2001:DB8:AAAA:5::6 activate
exit-address-family
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
ip prefix-list DENY-LOOP seq 5 deny 6.6.6.6/32
ip prefix-list DENY-LOOP seq 10 permit 0.0.0.0/0 le 32
ipv6 router ospf 1
    router-id 2.2.2.1
    redistribute bgp 20000 metric 10
route-map set-mlp permit 10
    set metric 444
route-map DLM permit 10
    match ip address prefix-list DENY-LOOP
control-plane
banner motd ^CUnauthorized access is illegal. Gotta catch em
all!^C
line con 0
    transport input none
    stopbits 1
line aux 0
    stopbits 1
line vty 0 4
    login
line vty 5 15
    login
end

```

Blastoise-2:

```

version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Blastoise-2
boot-start-marker

```

```

boot-end-marker
vrf definition Mgmt-intf
  address-family ipv4
  exit-address-family
  address-family ipv6
  exit-address-family
no aaa new-model
no ip domain lookup
login on-success log
subscriber templating
vtp domain cisco
vtp mode transparent
ipv6 unicast-routing
multilink bundle-name authenticated
crypto pki trustpoint TP-self-signed-4013003437
  enrollment selfsigned
  subject-name cn=IOS-Self-Signed-Certificate-4013003437
  revocation-check none
  rsakeypair TP-self-signed-4013003437
crypto pki certificate chain TP-self-signed-4013003437
  certificate self-signed 01
    30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101
05050030
    31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D
43657274
    69666963 6174652D 34303133 30303334 3337301E 170D3234 31303136
31383530
    31305A17 0D333030 31303130 30303030 305A3031 312F302D 06035504
03132649
    4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D34
30313330
    30333433 37308201 22300D06 092A8648 86F70D01 01010500 0382010F
00308201
    0A028201 01009C67 BB2B8A07 F4E602AB AD379B80 420A7C5B 17022984
F00AD6AA
    D34C9C2B 8C1F5870 AFF57D8B F977D570 697B0A54 34998615 1A5F08A7
9E73BF25
    E5E27D68 FBD16FFC A710041E A0DE3CA4 EB5910F5 B1F8D7D9 8E8AFF59
9001CEFD
    F549AC1B 43BAAD63 927960DE D445FF4D 0886B987 2E83B0F8 B48522D7
D92BDE38
    596BA26A 1123514A 3EEB9682 A71BB1E8 6111F9F4 384A7D7F 29AF09E8
548A0015
    39E03643 F2486E75 211833E5 9A6C3458 9398F248 D385C318 09C77505
62BFDC68
    95D9C5FB 99255D65 33B6EBF8 F11E61E5 3CC67C07 81265645 4A838BDB
41B57341

```

```

F13E7241 7824649A C5C2B5B5 08219892 8C88C271 E134BE1E A3DB42E6
D4678372
    B62D31D9 84270203 010001A3 53305130 0F060355 1D130101 FF040530
030101FF
    301F0603 551D2304 18301680 140B006E 1C7C3866 28FBD494 A8BE2898
BA743916
    30301D06 03551D0E 04160414 0B006E1C 7C386628 FBD494A8 BE2898BA
74391630
    300D0609 2A864886 F70D0101 05050003 82010100 92000D94 6D9A98C7
C343BC16
    912850DF 3DFEF890 9107A683 44198A4B C7890930 DD020F13 7C65D011
CFACEEDA
    FB404A89 48253B22 C1AE783B 712A82F1 F02C3901 61637783 10F8DE58
52B064BD
    BD4EC243 FDBEF43F F28D343E 07D638C1 0E8D99A8 589AAF8A 18B289A7
B92BE087
    9B250DE7 1D4DE0C2 30F240FB 938924CA 753CEB1C 004AAD46 79C5E8EE
5E595282
    73ACB529 C0834F6E 8B43F07B EDA05D7F 03A2A6D3 FE6E7F61 6D5038B5
59CEBB76
    D47385B4 E606A202 946A2974 67BE51F6 39C54DBA 3A212F7F A5EC2CA9
E27BDE27
    6E1BE92B 2EA181A0 6BA9B8CA 7ED50BB7 828FEA7B CD297BEE D827E193
E8DFD13F
    D6FA96D3 1699B97E D60B3EF1 A4B93A29 4D9AE97D
        quit
license udi pid ISR4321/K9 sn FDO21482HZX
license boot level appxk9
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
mode none
interface GigabitEthernet0/0/0
    ip address 30.0.0.2 255.255.255.252
    ip ospf 1 area 1
    negotiation auto
    ipv6 address 2001:DB8:AAAA:3::2/64
    ipv6 ospf 1 area 1
interface GigabitEthernet0/0/1
    ip address 192.168.30.1 255.255.255.0
    ip ospf 1 area 1
    negotiation auto
    ipv6 address 2001:DB8:BBBB:3::1/64
    ipv6 ospf 1 area 1
interface Serial0/1/0
    no ip address

```

```

shutdown
interface Serial0/1/1
  no ip address
  shutdown
interface GigabitEthernet0
  vrf forwarding Mgmt-intf
  no ip address
  shutdown
  negotiation auto
router ospf 1
  router-id 2.2.2.2
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
ipv6 router ospf 1
  router-id 2.2.2.2
control-plane
banner motd ^CUnauthorized access is illegal. Gotta catch em
all!^C
line con 0
  login
  transport input none
  stopbits 1
line aux 0
  stopbits 1
line vty 0 4
  login
line vty 5 15
  login
end

```

Charizard-1:

```

version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Charizard-1
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
  address-family ipv4
  exit-address-family
  address-family ipv6

```

```

exit-address-family
no aaa new-model
no ip domain lookup
login on-success log
subscriber templating
vtp domain cisco
vtp mode transparent
ipv6 unicast-routing
multilink bundle-name authenticated
crypto pki trustpoint TP-self-signed-4288135047
enrollment selfsigned
subject-name cn=IOS-Self-Signed-Certificate-4288135047
revocation-check none
rsakeypair TP-self-signed-4288135047
crypto pki certificate chain TP-self-signed-4288135047
certificate self-signed 01
    30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101
05050030
    31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D
43657274
    69666963 6174652D 34323838 31333530 3437301E 170D3234 31303135
31383339
    32365A17 0D333030 31303130 30303030 305A3031 312F302D 06035504
03132649
    4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D34
32383831
    33353034 37308201 22300D06 092A8648 86F70D01 01010500 0382010F
00308201
    0A028201 0100A32D 673D9BC9 F7A8F395 87B84E74 F1018C65 74FD2725
058676A3
    D8C69749 95E33C1A 49BBCE59 42CE95E0 6777A327 1EAD8D86 58F437DD
6B6F2E74
    C401DEA4 576D2ADA 2728A349 3D7794BD 219F632E C2DB84B3 39949994
D6CD06E7
    1C3B1096 ED72583A EA0DA1B5 32374183 24A209CD 83F6ECA7 2AD14480
49ECE6EA
    13E6C5C1 35DA16DC 8151751E 5F055987 75C42F57 0F5CDE5B 6B8A0806
9AA5C9B2
    D1E4B2D9 33A55C32 947FFD54 91BE3577 4BE9846F 122E70C2 E3F56AE7
CBB6F9F5
    AABBEEB5 43D0DB19 D13B84A3 3099B9B8 ED4E4A1C 836F2948 37CF7855
B98405EE
    EE375CD3 FC0D32E1 2689CE84 F6486624 AB9739AE AAFED849 E66A5836
6D3C5F4F
    2A559EC3 18D50203 010001A3 53305130 0F060355 1D130101 FF040530
030101FF

```

```

301F0603 551D2304 18301680 14625807 A78404D2 F24691C4 BF66C260
D55D973A
F3301D06 03551D0E 04160414 625807A7 8404D2F2 4691C4BF 66C260D5
5D973AF3
300D0609 2A864886 F70D0101 05050003 82010100 64224FCB 09F85DD4
3AA1D42E
133B1645 47526647 765B90FB 9E4C9115 652EC94F 2DEC0677 2F5FDDD4
0ABD917B
8867EC76 A40996C4 74E4EB11 24C2B71F 5420D0B2 BD9AB713 E60C33ED
0602B33C
0692C156 13960457 54589FEF 0C819B6B E1B21728 5755673D 4EF79D77
A270A3B5
331F6AE7 A10B064E 3A6DB5D5 E90953D7 88AD0420 63D69C58 4DF60D90
66CC83C4
CDE3916B 6E115FE6 8CA67714 D2935FDA 0B83997D EBF73C5D 136661F4
7B9E6C32
25FFBAD8 DA0B2C7A 76DA852C CD90466A 5691F49C 344E9E64 6C63CB53
C5518377
75FD3194 634627BE 0569576C 152009DE C1CD0E68 492D8C87 CF70F661
B7CD9B6F
098442A2 07942B63 192A0CFD FB86857B 330D2B2C
quit
license udi pid ISR4321/K9 sn FLM2406090M
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
mode none
interface GigabitEthernet0/0/0
ip address 10.0.0.6 255.255.255.252
negotiation auto
ipv6 address 2001:DB8:AAAA:5::6/64
interface GigabitEthernet0/0/1
ip address 40.0.0.1 255.255.255.252
ip router isis char
negotiation auto
ipv6 address 2001:DB8:AAAA:4::1/64
ipv6 router isis char
interface GigabitEthernet0
vrf forwarding Mgmt-intf
no ip address
shutdown
negotiation auto
router isis char
net 00.0033.3333.3333.3311.1100
metric-style wide
redistribute bgp 30000

```

```

address-family ipv6
  redistribute bgp 30000 metric 10
exit-address-family
router bgp 30000
  bgp router-id 10.3.3.3
  bgp log-neighbor-changes
  neighbor 10.0.0.5 remote-as 20000
  neighbor 10.0.0.5 description blastoise
  neighbor 2001:DB8:AAAA:5::5 remote-as 20000
  neighbor 2001:DB8:AAAA:5::5 description blastoise6
address-family ipv4
  network 10.0.0.4 mask 255.255.255.252
  redistribute connected
  redistribute isis char level-1 metric 10
  neighbor 10.0.0.5 activate
  neighbor 2001:DB8:AAAA:5::5 activate
exit-address-family
address-family ipv6
  redistribute isis char metric 10 level-1
  neighbor 2001:DB8:AAAA:5::5 activate
exit-address-family
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
control-plane
banner motd ^CUnauthorized access is illegal. Gotta catch em
all!^C
line con 0
  transport input none
  stopbits 1
line aux 0
  stopbits 1
line vty 0 4
  login
line vty 5 15
  login
end

```

Charizard-2:

```

version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Charizard-2

```

```

boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
  address-family ipv4
  exit-address-family
  address-family ipv6
  exit-address-family
no aaa new-model
no ip domain lookup
login on-success log
subscriber templating
vtp domain cisco
vtp mode transparent
ipv6 unicast-routing
multilink bundle-name authenticated
crypto pki trustpoint TP-self-signed-2105456491
  enrollment selfsigned
  subject-name cn=IOS-Self-Signed-Certificate-2105456491
  revocation-check none
  rsakeypair TP-self-signed-2105456491
crypto pki certificate chain TP-self-signed-2105456491
  certificate self-signed 01
    30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101
05050030
    31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D
43657274
    69666963 6174652D 32313035 34353634 3931301E 170D3233 30363036
31383232
    32395A17 0D333030 31303130 30303030 305A3031 312F302D 06035504
03132649
    4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32
31303534
    35363439 31308201 22300D06 092A8648 86F70D01 01010500 0382010F
00308201
    0A028201 0100876A 184F35C6 0E929121 EE3811A8 28E1A40F FD6DDB23
539E0D71
    8E7E6090 3554D474 46DF5C06 8E68CDAC B1FF1F90 ACF8D30E 20CD2F18
A3D2A9D8
    AC5627B9 D2163758 C17AEB01 07A8C0CF 3C9C8CF9 ED7074F9 02991FB8
1E7409DD
    74AEB5A2 40DC020A 5DE53722 7FFD0381 BD09A39C 11C123E4 BE55D472
1607DBD8
    987513C4 03E13D0D B539E73B 7DF22B0C 7C34FEC8 89133906 8F3BB98B
6D8AD20E
    0A490E56 48B00F73 80D3F9E9 A8B16B4D 64A6C0B4 C5C65E75 8FEAF49C
2B49687F

```

```

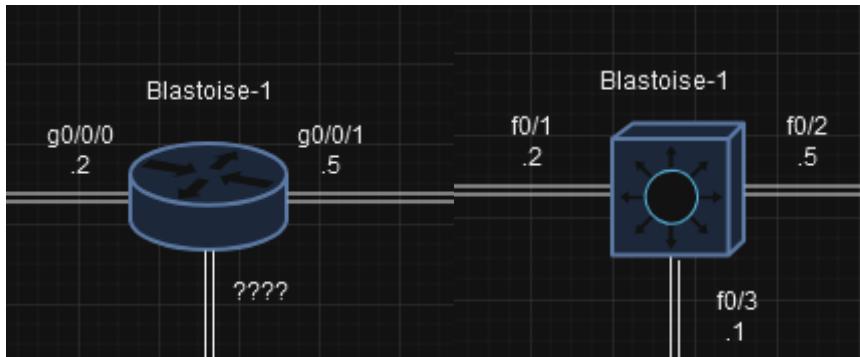
B150A1EC 6873780E 1AADEF00 CE9F01A6 17C6382D 4D71B2E6 1E4C78DA
5A46E715
    3EE04254 0DC6B096 180F1EF5 FC4BE073 C1B9221D 3A4C9F87 C15B7860
0EF18D3E
    54B842D5 0ABD0203 010001A3 53305130 0F060355 1D130101 FF040530
030101FF
    301F0603 551D2304 18301680 1440DDFF E73B2EAD ED3921BA A11AEE2E
6D45A59B
    59301D06 03551D0E 04160414 40DDFFE7 3B2EADED 3921BAA1 1AEE2E6D
45A59B59
    300D0609 2A864886 F70D0101 05050003 82010100 5B8F2495 D377BC11
0B345122
    96F7CB9A 8003892D F80D3933 C744DFE8 D0C85690 A020EF0C D378F115
D2DFFBD5
    7A915909 82581749 596387CB B7E832DF CBD3E80B 9C03DB26 DA183114
57E74C7D
    27386F78 F616A79F 984C1F31 CEEBFC5A A7899161 15D25D18 0E3E64C0
1451C28A
    E591F4F3 121F95BC E482E801 2886D58F 4B704519 75E997BC 751FCFA9
8C0FD4B5
    707B872B BAAE459F A94760DE 290E7468 C566D6E4 C2E9AB64 DCD64D7E
E4C533E1
    02C26C97 342238B1 985B5E18 A43B10B3 69E0A5ED 30796592 C66037AE
DAFA667A
    782B7257 3E033740 86EB13DD 6D60C50E C84D2F03 0CF888C6 D1356561
7DB99621
    79DC8347 077D1D63 E20BC2A1 AF6EC6E2 81F3D397
        quit
license udi pid ISR4321/K9 sn FDO21482DWJ
license boot level appxk9
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
    mode none
interface GigabitEthernet0/0/0
    ip address 40.0.0.2 255.255.255.252
    ip router isis char
    negotiation auto
    ipv6 address 2001:DB8:AAAA:4::2/64
    ipv6 router isis char
interface GigabitEthernet0/0/1
    ip address 192.168.40.1 255.255.255.0
    ip router isis char
    negotiation auto
    ipv6 address 2001:DB8:BBBB:4::1/64
    ipv6 router isis char

```

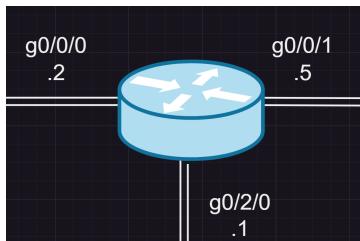
```
interface Serial0/1/0
    no ip address
    shutdown
interface Serial0/1/1
    no ip address
    shutdown
interface GigabitEthernet0
    vrf forwarding Mgmt-intf
    no ip address
    shutdown
    negotiation auto
router isis char
    net 00.0033.3333.3333.3322.2200
    metric-style wide
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
control-plane
banner motd ^CUnauthorized access is illegal. Gotta catch em
all!^C
line con 0
    transport input none
    stopbits 1
line aux 0
    stopbits 1
line vty 0 4
    login
line vty 5 15
    login
end
```

Problems

In my lab's original design, I used two routers for Company B (*Blastoise Builders*). This created a problem, as the *Blastoise-1* router had three connections that it had to manage and only two physical ports. Originally, to solve this problem, I made *Blastoise-1* a Layer 3 switch instead of a router.



For some reason, the Layer 3 switch had numerous problems redistributing routes across BGP and eventually became too much of an obstacle to our lab. At this point, I reintroduced the sixth router into the network and gave it an ethernet expansion card to fit up to four connections at once.



I received the following string of error messages from BGP. This was fixed by adding network statements in the BGP config (see Lab Commands).

```
*Oct  3 21:58:38.556: %BGP-5-NBR_RESET: Neighbor 10.0.0.5 active reset (BGP Notification received)
*Oct  3 21:58:38.557: %BGP-5-ADJCHANGE: neighbor 10.0.0.5 active Down BGP Notification received
*Oct  3 21:58:38.557: %BGP_SESSION-5-ADJCHANGE: neighbor 10.0.0.5 IPv4 Unicast topology base removed from session BGP Notification received
Charizard-1(config)#
*Oct  3 21:58:44.455: %BGP-3-NOTIFICATION: received from neighbor 10.0.0.5 passive 2/2 (peer in wrong AS) 2 bytes 4E20
*Oct  3 21:58:44.455: %BGP-5-NBR_RESET: Neighbor 10.0.0.5 passive reset (BGP Notification received)
*Oct  3 21:58:44.456: %BGP-5-ADJCHANGE: neighbor 10.0.0.5 passive Down BGP Notification received
```

Originally, I tried to route traffic between hosts with default routes. This didn't work due to our central router having to route traffic three different ways, making it impossible to have a single default route. I could have statically configured routes, but this would have defeated the point of using routing protocols. Instead, I fixed this by learning and implementing route redistribution.

Conclusion

This lab taught me critical routing skills by demonstrating how different routing protocols communicate and exemplifying the importance of route redistribution for a fully functional network. I'm grateful to have learned so much about BGP, a protocol which is very common for connecting routers on the modern Internet. I hope to use these valuable skills in the future if I need to connect multiple independent autonomous systems, which is likely to be a requirement in a networking career.