**Graphical user interface, text, application

Description automatically generated**

**Purpose**

The network built demonstrates the usage of routing protocol BGP (Border Gateway Protocol) in order to route packets through a series of networks. BGP is typically used for external connections, which are typically on the large, wide area network scale. BGP requires more manual configuration to distribute information, which means that it has greater flexibility and control of routing than fully dynamic routing protocols like OSPF or EIGRP. This greater flexibility and control make BGP a solid choice for networks on larger scales with a larger scope of dependent users, such as the Internet.

**Background Information**

In this lab, the external routing protocol BGP’s configurations and operation were explore. BGP is often used to connect sites to other remote sites on larger scopes. BGP distinctively puts major emphasis on customizability and flexibility, making the role of the administrator greater. BGP is compatible with both IPv4 and IPv6 addressing.

The IPv4 addressing scheme works with a unique combination of 4 numbers from 0-255 (8 bits in binary) separated by dots in order to denote the IPv4 address. An example IPv4 address would be 192.168.0.1. However, different networks are separated from each other, and 4 simple numbers delimited by dots cannot identify what network the devices belong to. To accommodate this, the IPv4 addressing scheme uses a subnet mask to denote which part of the IPv4 address represents the network it belongs to, and which part of the address represents which host it is within that network. Since IPv4 addresses are binary based, the subnet mask separates network parts from host parts by denoting whether a certain bit belongs to the network or not. A sample subnet mask is 255.255.255.0, which donates that the first 3 numbers (24 bits) of the address belong to the network and the last number (8 bits) belongs to the host. Combined with the earlier 192.168.0.1 IPv4 address, the network address would be 192.168.0.0 and the host portion would be .1 within the network. This could also be written as 192.168.0.1/24 to show the IPv4 address and the subnet mask.

Because IPv4 addresses are only 32 bits long, there are constraints on the number of unique addresses available. IPv4 provides about 4 billion unique addresses, a number that is well within the scope of being all used up. Thus, IPv6 addressing was introduced, a 128-bit long address which has an astronomically larger address space. This helped solve the depletion of unique IPv4 addresses. They are represented in hexadecimal, meaning every digit represents a number from 0 to 15 as it is a base 16 number system. Groups of 4 hexadecimal digits are separated by colons and each represent 16 bits of the 128 bit-long address. If a group of hexadecimal digits does not have 4 digits, then there are leading 0s in that group of digits. A shorthand used in IPv6 addressing is using double colons in order to denote that until the next group of 4 hexadecimal digits, everything in between are all zeros. The last part of an IPv6 address is the network prefix, which signals how many of the 128 bits are used to distinguish the network portion and the host portion, like the subnet mask. By typical convention, the network portion would be 64 bits long and the host portion would be 64 bits long. A sample IPv6 address is 2001:0db8:acad:000a:0000:0000:0000:00ef/64. Notice that there are groups of 4 digits, and that there are the letters a, b, c, d, e, and f. These represents decimal 10, 11, 12, 13, 14, and 15 respectively. The slash followed by 64 signals the network prefix is 64 bits, meaning that the first 4 groups separated by colons belong to the network portion and the last 4 groups are used to identify hosts within that network. Using the shorthand mentioned before, this address can be shortened to 2001:db8:acad:a::ef/64. All the leading 0s of each group of 4 have been omitted and the long chain of 0s were replaced with a double colon. This keeps IPv6 addresses cleaner and shorter while still having the flexibility and access to the full 128-bit address-space.

With that in mind, BGP works with both IPv4 and IPv6. Compared to other routing protocols such as OSPF and EIGRP, it is generally considered as an external routing protocol rather than an internal routing protocol. This is due to its usage in connecting different organizations together rather than connecting destinations within the same organization. For example, a company with multiple floors may implement a network for each floor, and the resulting network would be connected using an internal routing protocol such as OSPF or EIGRP for internal connectivity. However, if this company had two different buildings in two cities that are connected through an Internet Service Provider, then the usage of BGP would be appropriate as it is connecting external sites to each other. Typically, BGP is used for routing across the internet and is mostly used by companies that need more specific routing and control to certain destinations.

A critical distinction between internal and external routing protocols is that internal routing protocols work within their own routing domains whereas external routing protocols route between different routing domains. A routing domain is a set of routers who are all in direct communication with one another and share information with each other. This would be routers that have close proximity with each other. However, external routing protocols focus on connecting routers that do not have direct communication with one another at a local level. In OSPF and EIGRP, the routing domain numbers were used across all the routers being connected because of their locality. As a result of the lack of direct communication, configuration of BGP would require the usage of separate routing domain numbers to signal those two routers are not in close contact with each other.

Another feature that makes BGP different than other routing protocols is the need to manually set up neighbor connections. OSPF and EIGRP automatically create and maintain router adjacencies so that they can exchange information. Contrarily, BGP requires the administrators to statically define the neighbors before they can share information routing information with each other. This manual configuration of neighbors is virtually creating a transport layer connection between the two routers to guarantee the secure exchange of information. The external nature of BGP makes it so that using Transport Control Protocol (TCP) is necessary for proper and reliable distribution of routing information can be accomplished.

External features that make BGP a better choice than using internal gateway protocols is that the manual configurations give it more control over specific vital connections. Companies regularly use BGP to connect to multiple Internet Service providers because of this stability and reliability. BGP also has a way of implementing load balancing across external links, making it even more desirable for redundancy and fault tolerance in the corporate sphere. Furthermore, it has lower network overhead than the internal gateway protocols as it is defined to handle more dedicated connections, making it scale better into the Internet scope.

The configuration process of BGP would require correct IPv4 and IPv6 addressing, a manual configuration of a BGP neighbor relationship between routers, an activation of the network to distribute information across, and redistribution of the internal gateway protocols on the two simulated company campuses. Once completed, full connectivity is created with each campus receiving external routes from the other campus through BGP.

**Lab Summary**

6 routers were connected in a straight line using copper cross-over cables. Each router was configured with both IPv4 and IPv6 addresses for dual-stack connectivity. Loopback addresses were configured for each router to simulate a potential connected LAN to each router. The topology was split into two sections, with 3 routers configured for OSPF and the other 3 with EIGRP. The middle routers between these two sections were configured for external BGP to redistribute the routing information between OSPF and EIGRP.

**Lab Commands**

**Router (config) # router bgp <AS Number>**

Enables BGP on the router and enters BGP configuration mode. The AS (autonomous system) number identifies the router’s BGP configuration group. When configuring external BGP, two connected routers should have different AS numbers to signal they are on different groups. Unlike EIGRP and OSPF, BGP only has one router protocol configuration mode for both IPv4 and IPv6.

**Router(config-router) #no bgp default ipv4-unicast**

Turns off the default BGP operating mode that only distributes across IPv4. In other words, this command enables BGP’s operation in IPv6. Required for dual-stack operation.

**Router(config-router) #address-family <Address Family >**

Enters BGP address-family configuration mode. The address family parameter includes ipv4 and ipv6. Each brings the router to its respective configuration mode for either BGP for IPv4 or BGP IPv6. Once there, IP specific commands can be accessed.

**Router(config-router) # neighbor <IP Address> remote-as <Neighbor AS Number>**

Configures a BGP neighbor. The IP Address parameter can either be an IPv4 address or an IPv6 address. The Neighbor AS Number parameter requires the AS number of the adjacent router. This statically configures BGP to create a neighbor connection. This command must be entered correctly on both participating routers in order to form a neighbor connection. This command must be entered twice, once for IPv4 and once for IPv6, for dual stack operation.

**Router(config-router-af) #neighbor <IP Address> activate**

Activates the BGP neighbor connection. IP Address parameter is either an IPv4 or IPv6 address. Entered in either the IPv4 or IPv6 address family configuration mode to activate respective neighbor connections.

**Router(config-router-af) #network <IPv4 Address> mask <Subnet Mask>**

Activates an IPv4 network for BGP information distribution. Used in IPv4 address family configuration mode.

**Router(config-router-af) #network <IPv6 Address>**

Activates an IPv6 network for BGP information distribution. Used in IPv6 address family configuration mode.

**Router(config-router-af) #redistribute <protocol> <protocol number>**

Allows BGP to distribute information from a different protocol. Protocol parameter includes OSPF and EIGRP. Protocol number would be the process-id of OSPF or AS number of EIGRP. Entered in either the IPv4 or IPv6 address family configuration mode to allow the distribution for other protocols in the respective IP version.

**Router(config-router) #redistribute <protocol> <protocol number>**

Used in OSPF or EIGRP router configuration mode to allow them to distribute information from a different routing protocol. Protocol parameter includes BGP. Protocol number would be the AS number of the local BGP connection.

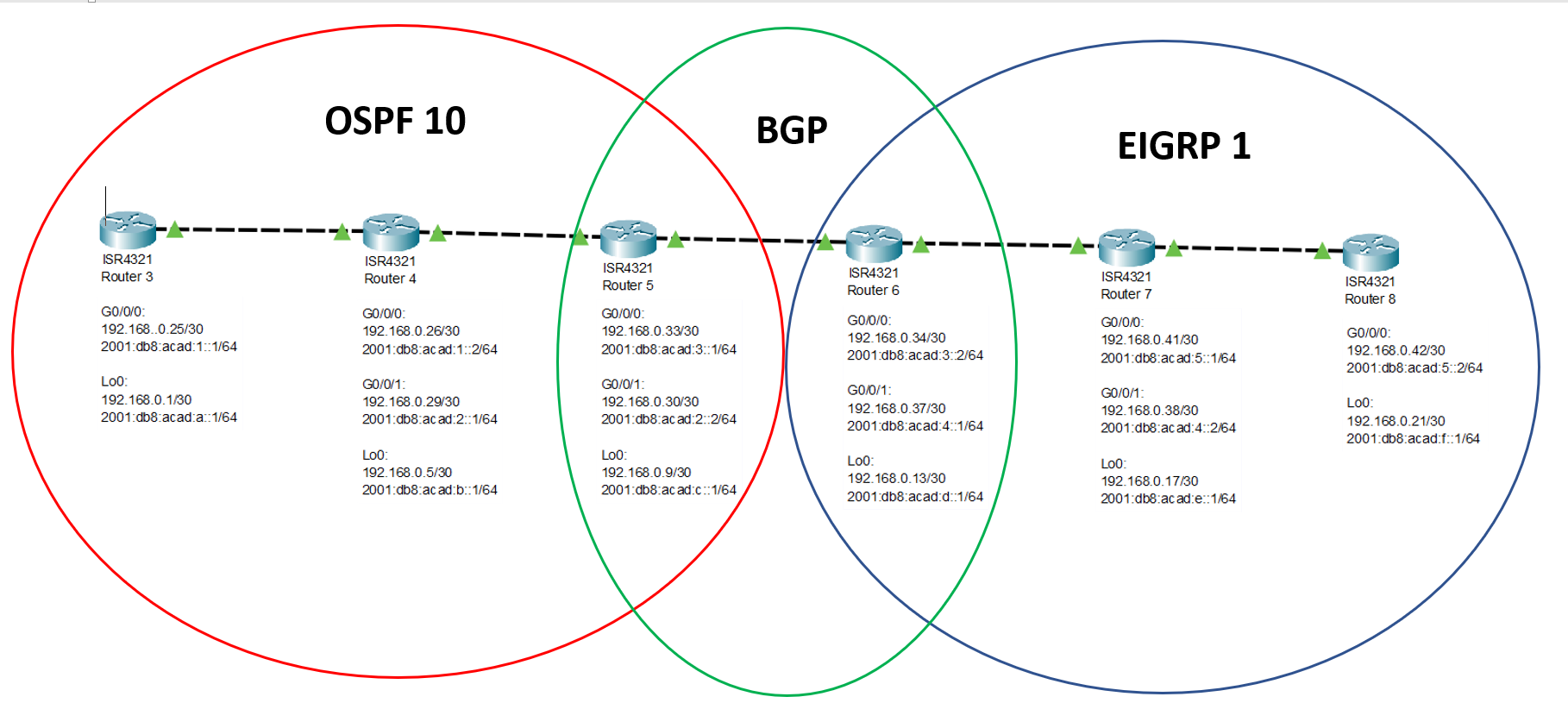
**Router# show ip protocols**

Shows all the configured IP protocols on the router.

**Router# show ipv6 protocols**

Shows all the configured IPv6 protocols on the router.

**Network Diagram with IP’s**



|  |  |  |  |
| --- | --- | --- | --- |
| **Router Name** | Interface | IPv4 Address | IPv6 Address |
| **R3** | G0/0/0 | 192.168.0.25/30 | 2001:db8:acad:1::1/64 |
|  | G0/0/1 | N/A | N/A |
|  | Loopback0 | 192.168.0.1/30 | 2001:db8:acad:a::1/64 |
|  |  |  |  |
| **R4** | G0/0/0 | 192.168.0.26/30 | 2001:db8:acad:1::2/64 |
|  | G0/0/1 | 192.168.0.29/30 | 2001:db8:acad:2::1/64 |
|  | Loopback0 | 192.168.0.5/30 | 2001:db8:acad:b::1/64 |
|  |  |  |  |
| **R5** | G0/0/0 | 192.168.0.33/30 | 2001:db8:acad:3::1/64 |
|  | G0/0/1 | 192.168.0.30/30 | 2001:db8:acad:2::2/64 |
|  | Loopback0 | 192.168.0.9/30 | 2001:db8:acad:c::1/64 |
|  |  |  |  |
| **R6** | G0/0/0 | 192.168.0.34/30 | 2001:db8:acad:3::2/64 |
|  | G0/0/1 | 192.168.0.37/30 | 2001:db8:acad:4::1/64 |
|  | Loopback0 | 192.168.0.13/30 | 2001:db8:acad:d::1/64 |
|  |  |  |  |
| **R7** | G0/0/0 | 192.168.0.41/30 | 2001:db8:acad:5::1/64 |
|  | G0/0/1 | 192.168.0.38/30 | 2001:db8:acad:4::2/64 |
|  | Loopback0 | 192.168.0.17/30 | 2001:db8:acad:e::1/64 |
|  |  |  |  |
| **R8** | G0/0/0 | 192.168.0.42/30 | 2001:db8:acad:5::2/64 |
|  | G0/0/1 | N/A | N/A |
|  | Loopback0 | 192.168.0.21/30 | 2001:db8:acad:f::1/64 |

**Configurations**

**Router 3**

**R3#show running-config**

Current configuration : 1638 bytes

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R3

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214421BY

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.1 255.255.255.252

ipv6 address 2001:DB8:ACAD:A::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 192.168.0.25 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:1::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

no ip address

shutdown

negotiation auto

interface Serial0/1/0

interface Serial0/1/1

interface GigabitEthernet0/2/0

negotiation auto

interface GigabitEthernet0/2/1

negotiation auto

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

network 192.168.0.0 0.0.0.3 area 0

network 192.168.0.24 0.0.0.3 area 0

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**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

192.168.0.0/24 is variably subnetted, 13 subnets, 2 masks

C 192.168.0.0/30 is directly connected, Loopback0

L 192.168.0.1/32 is directly connected, Loopback0

O 192.168.0.5/32

[110/2] via 192.168.0.26, 01:13:44, GigabitEthernet0/0/0

O 192.168.0.9/32

[110/3] via 192.168.0.26, 01:13:44, GigabitEthernet0/0/0

O E2 192.168.0.12/30

[110/1] via 192.168.0.26, 01:03:48, GigabitEthernet0/0/0

O E2 192.168.0.16/30

[110/1] via 192.168.0.26, 01:03:21, GigabitEthernet0/0/0

O E2 192.168.0.20/30

[110/1] via 192.168.0.26, 01:03:21, GigabitEthernet0/0/0

C 192.168.0.24/30 is directly connected, GigabitEthernet0/0/0

L 192.168.0.25/32 is directly connected, GigabitEthernet0/0/0

O 192.168.0.28/30

[110/2] via 192.168.0.26, 01:13:44, GigabitEthernet0/0/0

O 192.168.0.32/30

[110/3] via 192.168.0.26, 01:03:48, GigabitEthernet0/0/0

O E2 192.168.0.36/30

[110/1] via 192.168.0.26, 01:03:48, GigabitEthernet0/0/0

O E2 192.168.0.40/30

[110/1] via 192.168.0.26, 01:03:21, GigabitEthernet0/0/0

**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

C 2001:DB8:ACAD:1::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:1::1/128 [0/0]

via GigabitEthernet0/0/0, receive

O 2001:DB8:ACAD:2::/64 [110/2]

via FE80::521C:B0FF:FE42:AF80, GigabitEthernet0/0/0

O 2001:DB8:ACAD:3::/64 [110/3]

via FE80::521C:B0FF:FE42:AF80, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:4::/64 [110/1]

via FE80::521C:B0FF:FE42:AF80, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:5::/64 [110/1]

via FE80::521C:B0FF:FE42:AF80, GigabitEthernet0/0/0

C 2001:DB8:ACAD:A::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:ACAD:A::1/128 [0/0]

via Loopback0, receive

O 2001:DB8:ACAD:B::1/128 [110/1]

via FE80::521C:B0FF:FE42:AF80, GigabitEthernet0/0/0

O 2001:DB8:ACAD:C::1/128 [110/2]

via FE80::521C:B0FF:FE42:AF80, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:D::/64 [110/1]

via FE80::521C:B0FF:FE42:AF80, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:E::/64 [110/1]

via FE80::521C:B0FF:FE42:AF80, GigabitEthernet0/0/0

OE2 2001:DB8:ACAD:F::/64 [110/1]

via FE80::521C:B0FF:FE42:AF80, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

**R3#show ip protocols**

\*\*\* IP Routing is NSF aware \*\*\*

Routing Protocol is "application"

Sending updates every 0 seconds

Invalid after 0 seconds, hold down 0, flushed after 0

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Maximum path: 32

Routing for Networks:

Routing Information Sources:

Gateway Distance Last Update

Distance: (default is 4)

Routing Protocol is "ospf 10"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Router ID 192.168.0.1

Number of areas in this router is 1. 1 normal 0 stub 0 nssa

Maximum path: 4

Routing for Networks:

192.168.0.0 0.0.0.3 area 0

192.168.0.24 0.0.0.3 area 0

Routing Information Sources:

Gateway Distance Last Update

192.168.0.9 110 01:03:31

192.168.0.5 110 01:13:54

Distance: (default is 110)

**R3#show ipv6 protocols**

IPv6 Routing Protocol is "connected"

IPv6 Routing Protocol is "application"

IPv6 Routing Protocol is "ND"

IPv6 Routing Protocol is "ospf 10"

Router ID 192.168.0.1

Number of areas: 1 normal, 0 stub, 0 nssa

Interfaces (Area 0):

Loopback0

GigabitEthernet0/0/0

Redistribution:

None

**Router 4**

**R4#show running-config**

Current configuration : 1798 bytes

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R4

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214913GF

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.5 255.255.255.252

ipv6 address 2001:DB8:ACAD:B::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 192.168.0.26 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:1::2/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

ip address 192.168.0.29 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:2::1/64

ipv6 ospf 10 area 0

interface Serial0/1/0

interface Serial0/1/1

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

network 192.168.0.4 0.0.0.3 area 0

network 192.168.0.24 0.0.0.3 area 0

network 192.168.0.28 0.0.0.3 area 0

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**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

192.168.0.0/24 is variably subnetted, 14 subnets, 2 masks

O 192.168.0.1/32

[110/2] via 192.168.0.25, 01:13:06, GigabitEthernet0/0/0

C 192.168.0.4/30 is directly connected, Loopback0

L 192.168.0.5/32 is directly connected, Loopback0

O 192.168.0.9/32

[110/2] via 192.168.0.30, 01:13:26, GigabitEthernet0/0/1

O E2 192.168.0.12/30

[110/1] via 192.168.0.30, 01:03:10, GigabitEthernet0/0/1

O E2 192.168.0.16/30

[110/1] via 192.168.0.30, 01:02:43, GigabitEthernet0/0/1

O E2 192.168.0.20/30

[110/1] via 192.168.0.30, 01:02:43, GigabitEthernet0/0/1

C 192.168.0.24/30 is directly connected, GigabitEthernet0/0/0

L 192.168.0.26/32 is directly connected, GigabitEthernet0/0/0

C 192.168.0.28/30 is directly connected, GigabitEthernet0/0/1

L 192.168.0.29/32 is directly connected, GigabitEthernet0/0/1

O 192.168.0.32/30

[110/2] via 192.168.0.30, 01:03:10, GigabitEthernet0/0/1

O E2 192.168.0.36/30

[110/1] via 192.168.0.30, 01:03:10, GigabitEthernet0/0/1

O E2 192.168.0.40/30

[110/1] via 192.168.0.30, 01:02:43, GigabitEthernet0/0/1

**R4#show ipv6 route**

IPv6 Routing Table - default - 15 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 2001:DB8:ACAD:1::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:1::2/128 [0/0]

via GigabitEthernet0/0/0, receive

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:2::1/128 [0/0]

via GigabitEthernet0/0/1, receive

O 2001:DB8:ACAD:3::/64 [110/2]

via FE80::521C:B0FF:FE2C:4C81, GigabitEthernet0/0/1

OE2 2001:DB8:ACAD:4::/64 [110/1]

via FE80::521C:B0FF:FE2C:4C81, GigabitEthernet0/0/1

OE2 2001:DB8:ACAD:5::/64 [110/1]

via FE80::521C:B0FF:FE2C:4C81, GigabitEthernet0/0/1

O 2001:DB8:ACAD:A::1/128 [110/1]

via FE80::B6A8:B9FF:FE01:B510, GigabitEthernet0/0/0

C 2001:DB8:ACAD:B::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:ACAD:B::1/128 [0/0]

via Loopback0, receive

O 2001:DB8:ACAD:C::1/128 [110/1]

via FE80::521C:B0FF:FE2C:4C81, GigabitEthernet0/0/1

OE2 2001:DB8:ACAD:D::/64 [110/1]

via FE80::521C:B0FF:FE2C:4C81, GigabitEthernet0/0/1

OE2 2001:DB8:ACAD:E::/64 [110/1]

via FE80::521C:B0FF:FE2C:4C81, GigabitEthernet0/0/1

OE2 2001:DB8:ACAD:F::/64 [110/1]

via FE80::521C:B0FF:FE2C:4C81, GigabitEthernet0/0/1

L FF00::/8 [0/0]

via Null0, receive

**R4#show ip protocols**

\*\*\* IP Routing is NSF aware \*\*\*

Routing Protocol is "application"

Sending updates every 0 seconds

Invalid after 0 seconds, hold down 0, flushed after 0

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Maximum path: 32

Routing for Networks:

Routing Information Sources:

Gateway Distance Last Update

Distance: (default is 4)

Routing Protocol is "ospf 10"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Router ID 192.168.0.5

Number of areas in this router is 1. 1 normal 0 stub 0 nssa

Maximum path: 4

Routing for Networks:

192.168.0.4 0.0.0.3 area 0

192.168.0.24 0.0.0.3 area 0

192.168.0.28 0.0.0.3 area 0

Routing Information Sources:

Gateway Distance Last Update

192.168.0.9 110 01:02:54

192.168.0.1 110 01:13:17

Distance: (default is 110)

**R4#show ipv6 protocols**

IPv6 Routing Protocol is "connected"

IPv6 Routing Protocol is "application"

IPv6 Routing Protocol is "ND"

IPv6 Routing Protocol is "ospf 10"

Router ID 192.168.0.5

Number of areas: 1 normal, 0 stub, 0 nssa

Interfaces (Area 0):

Loopback0

GigabitEthernet0/0/1

GigabitEthernet0/0/0

Redistribution:

None

**Router 5**

**R5#show running-config**

Current configuration : 2387 bytes

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R5

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21482HYV

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.9 255.255.255.252

ipv6 address 2001:DB8:ACAD:C::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/0

ip address 192.168.0.33 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:3::1/64

ipv6 ospf 10 area 0

interface GigabitEthernet0/0/1

ip address 192.168.0.30 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:2::2/64

ipv6 ospf 10 area 0

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router ospf 10

redistribute bgp 1 subnets

network 192.168.0.8 0.0.0.3 area 0

network 192.168.0.28 0.0.0.3 area 0

network 192.168.0.32 0.0.0.3 area 0

router bgp 1

bgp log-neighbor-changes

no bgp default ipv4-unicast

neighbor 2001:DB8:ACAD:3::2 remote-as 2

neighbor 192.168.0.34 remote-as 2

address-family ipv4

network 192.168.0.32 mask 255.255.255.252

redistribute ospf 10

neighbor 192.168.0.34 activate

exit-address-family

address-family ipv6

redistribute connected

redistribute ospf 10

neighbor 2001:DB8:ACAD:3::2 activate

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router ospf 10

redistribute bgp 1

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**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

192.168.0.0/24 is variably subnetted, 14 subnets, 2 masks

O 192.168.0.1/32

[110/3] via 192.168.0.29, 00:54:18, GigabitEthernet0/0/1

O 192.168.0.5/32

[110/2] via 192.168.0.29, 00:54:18, GigabitEthernet0/0/1

C 192.168.0.8/30 is directly connected, Loopback0

L 192.168.0.9/32 is directly connected, Loopback0

B 192.168.0.12/30 [20/0] via 192.168.0.34, 00:54:18

B 192.168.0.16/30 [20/130816] via 192.168.0.34, 00:54:18

B 192.168.0.20/30 [20/131072] via 192.168.0.34, 00:54:18

O 192.168.0.24/30

[110/2] via 192.168.0.29, 00:54:18, GigabitEthernet0/0/1

C 192.168.0.28/30 is directly connected, GigabitEthernet0/0/1

L 192.168.0.30/32 is directly connected, GigabitEthernet0/0/1

C 192.168.0.32/30 is directly connected, GigabitEthernet0/0/0

L 192.168.0.33/32 is directly connected, GigabitEthernet0/0/0

B 192.168.0.36/30 [20/0] via 192.168.0.34, 00:54:18

B 192.168.0.40/30 [20/3072] via 192.168.0.34, 00:54:18

**R5#show ipv6 route**

IPv6 Routing Table - default - 15 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

O 2001:DB8:ACAD:1::/64 [110/2]

via FE80::521C:B0FF:FE42:AF81, GigabitEthernet0/0/1

C 2001:DB8:ACAD:2::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:2::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:3::1/128 [0/0]

via GigabitEthernet0/0/0, receive

B 2001:DB8:ACAD:4::/64 [20/0]

via FE80::227:90FF:FEC7:8DB0, GigabitEthernet0/0/0

B 2001:DB8:ACAD:5::/64 [20/3072]

via FE80::227:90FF:FEC7:8DB0, GigabitEthernet0/0/0

O 2001:DB8:ACAD:A::1/128 [110/2]

via FE80::521C:B0FF:FE42:AF81, GigabitEthernet0/0/1

O 2001:DB8:ACAD:B::1/128 [110/1]

via FE80::521C:B0FF:FE42:AF81, GigabitEthernet0/0/1

C 2001:DB8:ACAD:C::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:ACAD:C::1/128 [0/0]

via Loopback0, receive

B 2001:DB8:ACAD:D::/64 [20/0]

via FE80::227:90FF:FEC7:8DB0, GigabitEthernet0/0/0

B 2001:DB8:ACAD:E::/64 [20/130816]

via FE80::227:90FF:FEC7:8DB0, GigabitEthernet0/0/0

B 2001:DB8:ACAD:F::/64 [20/131072]

via FE80::227:90FF:FEC7:8DB0, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

**R5#show ip protocols**

\*\*\* IP Routing is NSF aware \*\*\*

Routing Protocol is "application"

Sending updates every 0 seconds

Invalid after 0 seconds, hold down 0, flushed after 0

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Maximum path: 32

Routing for Networks:

Routing Information Sources:

Gateway Distance Last Update

Distance: (default is 4)

Routing Protocol is "ospf 10"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Router ID 192.168.0.9

It is an autonomous system boundary router

Redistributing External Routes from,

bgp 1, includes subnets in redistribution

Number of areas in this router is 1. 1 normal 0 stub 0 nssa

Maximum path: 4

Routing for Networks:

192.168.0.8 0.0.0.3 area 0

192.168.0.28 0.0.0.3 area 0

192.168.0.32 0.0.0.3 area 0

Routing Information Sources:

Gateway Distance Last Update

192.168.0.1 110 00:54:27

192.168.0.5 110 00:54:27

Distance: (default is 110)

Routing Protocol is "bgp 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

IGP synchronization is disabled

Automatic route summarization is disabled

Redistributing: ospf 10 (internal)

Neighbor(s):

Address FiltIn FiltOut DistIn DistOut Weight RouteMap

192.168.0.31

192.168.0.34

Maximum path: 1

Routing Information Sources:

Gateway Distance Last Update

Gateway Distance Last Update

192.168.0.34 20 00:54:30

Distance: external 20 internal 200 local 200

**R5#show ipv6 protocols**

IPv6 Routing Protocol is "connected"

IPv6 Routing Protocol is "application"

IPv6 Routing Protocol is "ND"

IPv6 Routing Protocol is "ospf 10"

Router ID 192.168.0.9

Autonomous system boundary router

Number of areas: 1 normal, 0 stub, 0 nssa

Interfaces (Area 0):

Loopback0

GigabitEthernet0/0/0

GigabitEthernet0/0/1

Redistribution:

Redistributing protocol bgp 1

IPv6 Routing Protocol is "bgp 1"

IGP synchronization is disabled

Redistribution:

Redistributing protocol connected

Redistributing protocol ospf 10 (internal)

Neighbor(s):

Address FiltIn FiltOut Weight RoutemapIn RoutemapOut

2001:DB8:ACAD:3::2

**Router 6**

**R6#show running-config**

Current configuration : 2220 bytes

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R6

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214333H6

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.13 255.255.255.252

ipv6 address 2001:DB8:ACAD:D::1/64

ipv6 eigrp 1

interface GigabitEthernet0/0/0

ip address 192.168.0.34 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:3::2/64

ipv6 eigrp 1

interface GigabitEthernet0/0/1

ip address 192.168.0.37 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:4::1/64

ipv6 eigrp 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

interface Vlan1

no ip address

shutdown

router eigrp 1

variance 3

network 192.168.0.12 0.0.0.3

network 192.168.0.32 0.0.0.3

network 192.168.0.36 0.0.0.3

redistribute bgp 2 metric 1000000 1 255 1 1500

router bgp 2

bgp log-neighbor-changes

no bgp default ipv4-unicast

neighbor 2001:DB8:ACAD:3::1 remote-as 1

neighbor 192.168.0.33 remote-as 1

address-family ipv4

network 192.168.0.32 mask 255.255.255.252

redistribute eigrp 1

neighbor 192.168.0.33 activate

exit-address-family

address-family ipv6

redistribute connected

redistribute eigrp 1

network 2001:DB8:ACAD:3::/64

neighbor 2001:DB8:ACAD:3::1 activate

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router eigrp 1

redistribute bgp 2 metric 1000000 1 255 1 1500

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R6#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

192.168.0.0/24 is variably subnetted, 14 subnets, 2 masks

B 192.168.0.1/32 [20/3] via 192.168.0.33, 01:02:14

B 192.168.0.5/32 [20/2] via 192.168.0.33, 01:02:14

B 192.168.0.8/30 [20/0] via 192.168.0.33, 01:02:14

C 192.168.0.12/30 is directly connected, Loopback0

L 192.168.0.13/32 is directly connected, Loopback0

D 192.168.0.16/30

[90/130816] via 192.168.0.38, 01:02:08, GigabitEthernet0/0/1

D 192.168.0.20/30

[90/131072] via 192.168.0.38, 01:02:08, GigabitEthernet0/0/1

B 192.168.0.24/30 [20/2] via 192.168.0.33, 01:02:14

B 192.168.0.28/30 [20/0] via 192.168.0.33, 01:02:14

C 192.168.0.32/30 is directly connected, GigabitEthernet0/0/0

L 192.168.0.34/32 is directly connected, GigabitEthernet0/0/0

C 192.168.0.36/30 is directly connected, GigabitEthernet0/0/1

L 192.168.0.37/32 is directly connected, GigabitEthernet0/0/1

D 192.168.0.40/30

[90/3072] via 192.168.0.38, 01:02:08, GigabitEthernet0/0/1

**R6#show ipv6 route**

IPv6 Routing Table - default - 15 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 2001:DB8:ACAD:1::/64 [20/2]

via FE80::521C:B0FF:FE2C:4C80, GigabitEthernet0/0/0

B 2001:DB8:ACAD:2::/64 [20/0]

via FE80::521C:B0FF:FE2C:4C80, GigabitEthernet0/0/0

C 2001:DB8:ACAD:3::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:3::2/128 [0/0]

via GigabitEthernet0/0/0, receive

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:4::1/128 [0/0]

via GigabitEthernet0/0/1, receive

D 2001:DB8:ACAD:5::/64 [90/3072]

via FE80::B6A8:B9FF:FE01:AE51, GigabitEthernet0/0/1

B 2001:DB8:ACAD:A::1/128 [20/2]

via FE80::521C:B0FF:FE2C:4C80, GigabitEthernet0/0/0

B 2001:DB8:ACAD:B::1/128 [20/1]

via FE80::521C:B0FF:FE2C:4C80, GigabitEthernet0/0/0

B 2001:DB8:ACAD:C::/64 [20/0]

via FE80::521C:B0FF:FE2C:4C80, GigabitEthernet0/0/0

C 2001:DB8:ACAD:D::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:ACAD:D::1/128 [0/0]

via Loopback0, receive

D 2001:DB8:ACAD:E::/64 [90/130816]

via FE80::B6A8:B9FF:FE01:AE51, GigabitEthernet0/0/1

D 2001:DB8:ACAD:F::/64 [90/131072]

via FE80::B6A8:B9FF:FE01:AE51, GigabitEthernet0/0/1

L FF00::/8 [0/0]

via Null0, receive

**R6#show ip protocols**

\*\*\* IP Routing is NSF aware \*\*\*

Routing Protocol is "application"

Sending updates every 0 seconds

Invalid after 0 seconds, hold down 0, flushed after 0

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Maximum path: 32

Routing for Networks:

Routing Information Sources:

Gateway Distance Last Update

Distance: (default is 4)

Routing Protocol is "eigrp 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Default networks flagged in outgoing updates

Default networks accepted from incoming updates

Redistributing: bgp 2

EIGRP-IPv4 Protocol for AS(1)

Metric weight K1=1, K2=0, K3=1, K4=0, K5=0

Soft SIA disabled

NSF-aware route hold timer is 240

EIGRP NSF disabled

NSF signal timer is 20s

NSF converge timer is 120s

Router-ID: 192.168.0.13

Topology : 0 (base)

Active Timer: 3 min

Distance: internal 90 external 170

Maximum path: 4

Maximum hopcount 100

Maximum metric variance 3

Automatic Summarization: disabled

Maximum path: 4

Routing for Networks:

192.168.0.12/30

192.168.0.32/30

192.168.0.36/30

Routing Information Sources:

Gateway Distance Last Update

192.168.0.38 90 01:02:22

Distance: internal 90 external 170

Routing Protocol is "bgp 2"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

IGP synchronization is disabled

Automatic route summarization is disabled

Redistributing: eigrp 1

Neighbor(s):

Address FiltIn FiltOut DistIn DistOut Weight RouteMap

192.168.0.33

Maximum path: 1

Routing Information Sources:

Gateway Distance Last Update

192.168.0.33 20 01:02:29

Distance: external 20 internal 200 local 200

**R6#show ipv6 protocols**

IPv6 Routing Protocol is "connected"

IPv6 Routing Protocol is "application"

IPv6 Routing Protocol is "ND"

IPv6 Routing Protocol is "bgp 2"

IGP synchronization is disabled

Redistribution:

Redistributing protocol connected

Redistributing protocol eigrp 1

Neighbor(s):

Address FiltIn FiltOut Weight RoutemapIn RoutemapOut

2001:DB8:ACAD:3::1

IPv6 Routing Protocol is "eigrp 1"

EIGRP-IPv6 Protocol for AS(1)

Metric weight K1=1, K2=0, K3=1, K4=0, K5=0

Soft SIA disabled

NSF-aware route hold timer is 240

EIGRP NSF disabled

NSF signal timer is 20s

NSF converge timer is 120s

Router-ID: 192.168.0.13

Topology : 0 (base)

Active Timer: 3 min

Distance: internal 90 external 170

Maximum path: 16

Maximum hopcount 100

Maximum metric variance 1

Interfaces:

Loopback0

GigabitEthernet0/0/0

GigabitEthernet0/0/1

Redistribution:

Redistributing protocol bgp 2 with metric 1000000 1 255 1 1500

**Router 7**

**R7#show running-config**

Current configuration : 1588 bytes

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R7

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420HY

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.17 255.255.255.252

ipv6 address 2001:DB8:ACAD:E::1/64

ipv6 eigrp 1

interface GigabitEthernet0/0/0

ip address 192.168.0.41 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:5::1/64

ipv6 eigrp 1

interface GigabitEthernet0/0/1

ip address 192.168.0.38 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:4::2/64

ipv6 eigrp 1

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router eigrp 1

variance 3

network 192.168.0.16 0.0.0.3

network 192.168.0.36 0.0.0.3

network 192.168.0.40 0.0.0.3

ip forward-protocol nd

no ip http server

no ip http secure-server

ipv6 router eigrp 1

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**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

192.168.0.0/24 is variably subnetted, 14 subnets, 2 masks

D EX 192.168.0.1/32

[170/3072] via 192.168.0.37, 00:46:42, GigabitEthernet0/0/1

D EX 192.168.0.5/32

[170/3072] via 192.168.0.37, 00:46:42, GigabitEthernet0/0/1

D EX 192.168.0.8/30

[170/3072] via 192.168.0.37, 00:46:42, GigabitEthernet0/0/1

D 192.168.0.12/30

[90/130816] via 192.168.0.37, 01:02:49, GigabitEthernet0/0/1

C 192.168.0.16/30 is directly connected, Loopback0

L 192.168.0.17/32 is directly connected, Loopback0

D 192.168.0.20/30

[90/130816] via 192.168.0.42, 01:11:15, GigabitEthernet0/0/0

D EX 192.168.0.24/30

[170/3072] via 192.168.0.37, 00:46:42, GigabitEthernet0/0/1

D EX 192.168.0.28/30

[170/3072] via 192.168.0.37, 00:46:42, GigabitEthernet0/0/1

D 192.168.0.32/30

[90/3072] via 192.168.0.37, 01:02:49, GigabitEthernet0/0/1

C 192.168.0.36/30 is directly connected, GigabitEthernet0/0/1

L 192.168.0.38/32 is directly connected, GigabitEthernet0/0/1

C 192.168.0.40/30 is directly connected, GigabitEthernet0/0/0

L 192.168.0.41/32 is directly connected, GigabitEthernet0/0/0

**R7#show ipv6 route**

IPv6 Routing Table - default - 15 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

EX 2001:DB8:ACAD:1::/64 [170/3072]

via FE80::227:90FF:FEC7:8DB1, GigabitEthernet0/0/1

EX 2001:DB8:ACAD:2::/64 [170/3072]

via FE80::227:90FF:FEC7:8DB1, GigabitEthernet0/0/1

D 2001:DB8:ACAD:3::/64 [90/3072]

via FE80::227:90FF:FEC7:8DB1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:4::/64 [0/0]

via GigabitEthernet0/0/1, directly connected

L 2001:DB8:ACAD:4::2/128 [0/0]

via GigabitEthernet0/0/1, receive

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:5::1/128 [0/0]

via GigabitEthernet0/0/0, receive

EX 2001:DB8:ACAD:A::1/128 [170/3072]

via FE80::227:90FF:FEC7:8DB1, GigabitEthernet0/0/1

EX 2001:DB8:ACAD:B::1/128 [170/3072]

via FE80::227:90FF:FEC7:8DB1, GigabitEthernet0/0/1

EX 2001:DB8:ACAD:C::/64 [170/3072]

via FE80::227:90FF:FEC7:8DB1, GigabitEthernet0/0/1

D 2001:DB8:ACAD:D::/64 [90/130816]

via FE80::227:90FF:FEC7:8DB1, GigabitEthernet0/0/1

C 2001:DB8:ACAD:E::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:ACAD:E::1/128 [0/0]

via Loopback0, receive

D 2001:DB8:ACAD:F::/64 [90/130816]

via FE80::B6A8:B9FF:FE47:92C0, GigabitEthernet0/0/0

L FF00::/8 [0/0]

via Null0, receive

**R7#show ip protocols**

\*\*\* IP Routing is NSF aware \*\*\*

Routing Protocol is "application"

Sending updates every 0 seconds

Invalid after 0 seconds, hold down 0, flushed after 0

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Maximum path: 32

Routing for Networks:

Routing Information Sources:

Gateway Distance Last Update

Distance: (default is 4)

Routing Protocol is "eigrp 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Default networks flagged in outgoing updates

Default networks accepted from incoming updates

EIGRP-IPv4 Protocol for AS(1)

Metric weight K1=1, K2=0, K3=1, K4=0, K5=0

Soft SIA disabled

NSF-aware route hold timer is 240

EIGRP NSF disabled

NSF signal timer is 20s

NSF converge timer is 120s

Router-ID: 192.168.0.17

Topology : 0 (base)

Active Timer: 3 min

Distance: internal 90 external 170

Maximum path: 4

Maximum hopcount 100

Maximum metric variance 3

Automatic Summarization: disabled

Maximum path: 4

Routing for Networks:

192.168.0.16/30

192.168.0.36/30

192.168.0.40/30

Routing Information Sources:

Gateway Distance Last Update

192.168.0.42 90 00:46:54

192.168.0.37 90 00:46:54

Distance: internal 90 external 170

**R7#show ipv6 protocols**

IPv6 Routing Protocol is "connected"

IPv6 Routing Protocol is "application"

IPv6 Routing Protocol is "ND"

IPv6 Routing Protocol is "eigrp 1"

EIGRP-IPv6 Protocol for AS(1)

Metric weight K1=1, K2=0, K3=1, K4=0, K5=0

Soft SIA disabled

NSF-aware route hold timer is 240

EIGRP NSF disabled

NSF signal timer is 20s

NSF converge timer is 120s

Router-ID: 192.168.0.17

Topology : 0 (base)

Active Timer: 3 min

Distance: internal 90 external 170

Maximum path: 16

Maximum hopcount 100

Maximum metric variance 1

Interfaces:

Loopback0

GigabitEthernet0/0/0

GigabitEthernet0/0/1

Redistribution:

None

**Router 8**

**R8#show running-config**

Current configuration : 1524 bytes

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

hostname R8

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

ipv6 unicast-routing

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420QQ

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface Loopback0

ip address 192.168.0.21 255.255.255.252

ipv6 address 2001:DB8:ACAD:F::1/64

ipv6 eigrp 1

interface GigabitEthernet0/0/0

ip address 192.168.0.42 255.255.255.252

negotiation auto

ipv6 address 2001:DB8:ACAD:5::2/64

ipv6 eigrp 1

interface GigabitEthernet0/0/1

no ip address

shutdown

negotiation auto

interface Serial0/1/0

interface Serial0/1/1

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router eigrp 1

variance 3

network 192.168.0.20 0.0.0.3

network 192.168.0.40 0.0.0.3

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

ipv6 router eigrp 1

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R8#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

192.168.0.0/24 is variably subnetted, 13 subnets, 2 masks

D EX 192.168.0.1/32

[170/3328] via 192.168.0.41, 00:47:20, GigabitEthernet0/0/0

D EX 192.168.0.5/32

[170/3328] via 192.168.0.41, 00:47:20, GigabitEthernet0/0/0

D EX 192.168.0.8/30

[170/3328] via 192.168.0.41, 00:47:20, GigabitEthernet0/0/0

D 192.168.0.12/30

[90/131072] via 192.168.0.41, 01:03:27, GigabitEthernet0/0/0

D 192.168.0.16/30

[90/130816] via 192.168.0.41, 01:11:47, GigabitEthernet0/0/0

C 192.168.0.20/30 is directly connected, Loopback0

L 192.168.0.21/32 is directly connected, Loopback0

D EX 192.168.0.24/30

[170/3328] via 192.168.0.41, 00:47:20, GigabitEthernet0/0/0

D EX 192.168.0.28/30

[170/3328] via 192.168.0.41, 00:47:20, GigabitEthernet0/0/0

D 192.168.0.32/30

[90/3328] via 192.168.0.41, 01:03:27, GigabitEthernet0/0/0

D 192.168.0.36/30

[90/3072] via 192.168.0.41, 01:03:36, GigabitEthernet0/0/0

C 192.168.0.40/30 is directly connected, GigabitEthernet0/0/0

L 192.168.0.42/32 is directly connected, GigabitEthernet0/0/0

**R8#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

EX 2001:DB8:ACAD:1::/64 [170/3328]

via FE80::B6A8:B9FF:FE01:AE50, GigabitEthernet0/0/0

EX 2001:DB8:ACAD:2::/64 [170/3328]

via FE80::B6A8:B9FF:FE01:AE50, GigabitEthernet0/0/0

D 2001:DB8:ACAD:3::/64 [90/3328]

via FE80::B6A8:B9FF:FE01:AE50, GigabitEthernet0/0/0

D 2001:DB8:ACAD:4::/64 [90/3072]

via FE80::B6A8:B9FF:FE01:AE50, GigabitEthernet0/0/0

C 2001:DB8:ACAD:5::/64 [0/0]

via GigabitEthernet0/0/0, directly connected

L 2001:DB8:ACAD:5::2/128 [0/0]

via GigabitEthernet0/0/0, receive

EX 2001:DB8:ACAD:A::1/128 [170/3328]

via FE80::B6A8:B9FF:FE01:AE50, GigabitEthernet0/0/0

EX 2001:DB8:ACAD:B::1/128 [170/3328]

via FE80::B6A8:B9FF:FE01:AE50, GigabitEthernet0/0/0

EX 2001:DB8:ACAD:C::/64 [170/3328]

via FE80::B6A8:B9FF:FE01:AE50, GigabitEthernet0/0/0

D 2001:DB8:ACAD:D::/64 [90/131072]

via FE80::B6A8:B9FF:FE01:AE50, GigabitEthernet0/0/0

D 2001:DB8:ACAD:E::/64 [90/130816]

via FE80::B6A8:B9FF:FE01:AE50, GigabitEthernet0/0/0

C 2001:DB8:ACAD:F::/64 [0/0]

via Loopback0, directly connected

L 2001:DB8:ACAD:F::1/128 [0/0]

via Loopback0, receive

L FF00::/8 [0/0]

via Null0, receive

**R8#show ip protocols**

\*\*\* IP Routing is NSF aware \*\*\*

Routing Protocol is "application"

Sending updates every 0 seconds

Invalid after 0 seconds, hold down 0, flushed after 0

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Maximum path: 32

Routing for Networks:

Routing Information Sources:

Gateway Distance Last Update

Distance: (default is 4)

Routing Protocol is "eigrp 1"

Outgoing update filter list for all interfaces is not set

Incoming update filter list for all interfaces is not set

Default networks flagged in outgoing updates

Default networks accepted from incoming updates

EIGRP-IPv4 Protocol for AS(1)

Metric weight K1=1, K2=0, K3=1, K4=0, K5=0

Soft SIA disabled

NSF-aware route hold timer is 240

EIGRP NSF disabled

NSF signal timer is 20s

NSF converge timer is 120s

Router-ID: 192.168.0.21

Topology : 0 (base)

Active Timer: 3 min

Distance: internal 90 external 170

Maximum path: 4

Maximum hopcount 100

Maximum metric variance 3

Automatic Summarization: disabled

Maximum path: 4

Routing for Networks:

192.168.0.20/30

192.168.0.40/30

Routing Information Sources:

Gateway Distance Last Update

192.168.0.41 90 00:47:59

Distance: internal 90 external 170

**R8#show ipv6 protocols**

IPv6 Routing Protocol is "connected"

IPv6 Routing Protocol is "application"

IPv6 Routing Protocol is "ND"

IPv6 Routing Protocol is "eigrp 1"

EIGRP-IPv6 Protocol for AS(1)

Metric weight K1=1, K2=0, K3=1, K4=0, K5=0

Soft SIA disabled

NSF-aware route hold timer is 240

EIGRP NSF disabled

NSF signal timer is 20s

NSF converge timer is 120s

Router-ID: 192.168.0.21

Topology : 0 (base)

Active Timer: 3 min

Distance: internal 90 external 170

Maximum path: 16

Maximum hopcount 100

Maximum metric variance 1

Interfaces:

Loopback0

GigabitEthernet0/0/0

Redistribution:

None

**Connectivity Tests**

**IPv4 Pings**

R3#ping 192.168.0.1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.5

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.5, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.9

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.9, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.13

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.13, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.17

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.17, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.21

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.21, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.25

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.25, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.26

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.26, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.29

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.29, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.30

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.30, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.33

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.33, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.34

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.34, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.37

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.37, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.38

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.38, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.41

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.41, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 192.168.0.42

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 192.168.0.42, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

**IPv6 Pings**

R3#ping 2001:db8:acad:a::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:A::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:b::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:B::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/8 ms

R3#ping 2001:db8:acad:c::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:C::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:d::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:D::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:e::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:E::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:f::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:F::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:1::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:1::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:1::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:1::2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/3/12 ms

R3#ping 2001:db8:acad:2::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:2::2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/9 ms

R3#ping 2001:db8:acad:2::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:2::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:3::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:3::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:3::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:3::2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 2/4/6 ms

R3#ping 2001:db8:acad:4::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:4::2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/6 ms

R3#ping 2001:db8:acad:4::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:4::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:5::1

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:5::1, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

R3#ping 2001:db8:acad:5::2

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2001:DB8:ACAD:5::2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/9 ms

**Problems**

During the configuration, the IPv4 connectivity experienced no issues, but the IPv6 configuration had multiple issues. The first was that the middle BGP routers did not have IPv6 routes to networks directly connected to the other BGP router. More specifically, router 5 did not have routes to networks directly connected to router 6, such as the loopback address of router 6. Because the only routes missing were the directly connected routes of the other router BGP router, the problem seemed to be with BGP being unable to communicate the directly connected routes. The proposed solution was to run the **redistribute connected** command in BGP configuration mode so that BGP can send its directly connected routes to the other BGP router. This fixed the BGP routers’ routing tables and gave them full routing operability.

The second problem arises when examining the IPv6 routing tables of not the BGP routers but the internal routers for either the OSPF side of the network or EIGRP side of the network. None of the internal routers had external routes from the other side. Because this was only a problem with the IPv6 routing table, the command **no bgp default ipv4-unicast** was entered to enable BGP’s distribution of IPv6 information. This proved to have no impact on the routing tables. Next, the problem seemed to possibly be a redistribution error, however BGP had already been configured properly on the BGP routers to have full routing tables. Thus, the next plausible issue was that there was a failure of redistribution into the OSPF and EIGRP networks. The command **redistribute bgp** **<AS number>** was missing on both BGP routers. A quick configuration of this fixed this issue for the OSPF side.

Despite the **redistribute bgp <AS number>** command, internal EIGRP routers still didn’t have any external routes. The above redistribute command was used in the IPv4 network, however when applied to the IPv6 EIGRP network, the same effect of flooding BGP routes into the internal EIGRP routers did not happen. The solution was that instead of the simple redistribute command, EIGRP needed to have a manually configured metric for it to accept the route. Thus, the extended redistribute command **redistribute bgp <AS number> metric <bandwidth> <delay> <reliability> <load> <MTU>** was entered into the BGP/EIGRP edge router. The exact command entered was **redistribute bgp 2 metric 1000000 1 255 1 1500** to signify a gigabit ethernet link with least delay, greatest reliability, least load, and a default MTU. Afterwards, the internal EIGRP routers had received a full routing table.

A problem others experienced that I troubleshooted was that the internal routers on both the OSPF and EIGRP side were missing the specific route to the network between the two BGP routers. The solution was that the middle route is a connected route for both the OSPF and EIGRP edge routers, thus enabling that connected network for simple OSPF and EIGRP advertisement into the respective internal networks restored connectivity.

Another problem others experienced was that their BGP connection had not redistributed any routes even after typing the correct redistribute commands. Upon examination of the running configurations, it was found that the BGP routers had the same autonomous system number, signaling that they were forming an internal BGP neighbor relationship. Thus, the reconfiguration of the BGP routers to use different autonomous system numbers restored the external redistribution ability.

**Conclusion**

This lab demonstrated the usefulness of BGP as an external routing protocol. Its manual configurations of neighbors, focus on dedicated connections, and control make it a widely used protocol for external connections such as to and through the Internet. It can form reliable connections between sites and tunnel internal routing protocols such as OSPF or EIGRP across external networks. Despite requiring more manual configuration to set up routing protocol connections than internal routing protocols, it proves to be one of the most scalable options for connecting large organizations together without large network overhead.