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Configuring a BGP Network

in GNS3 (IPv6)

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Purpose

The networking infrastructure of the world is supported by BGP. If it were not for BGP, none of us would be able to google “sushi places near me” and get convenient responses out of nowhere in mere milliseconds. In this paper, I go over my process of configuring BGP and provide some background information along the way. Since IPv6 is becoming more prominent, it seemed reasonable to try and configure BGP in IPv6. This lab was also a great introduction to GNS3— freelance software capable of emulating real cisco device operating systems.

Background Information

Routing

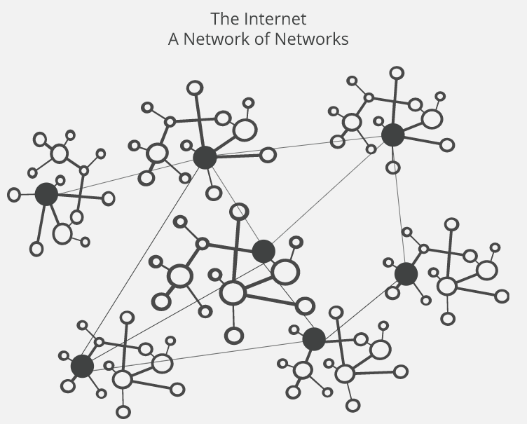
Routing is a significant process in networking as it allows hosts on different IP networks to connect to each other. *Border Gateway Protocol* (BGP) is a routing protocol simplifying the process of creating routes by using algorithms to figure out the directions automatically. In networking, routes are ultimately just *directions* for packets.

There are two options when dealing with traffic on a network; you can configure *static routes*, or you can set up a *routing protocol*. I like to think of static routes as absolute directions drawn onto a map, set in stone and unchangeable. The map can’t be altered unless it is manually redrawn. If you were to follow the map, you might find some of the routes to be outdated.

It would be nice if routes were adaptable, if they could update based on the fastest paths available. This is the difference between *static routing* and *routing protocols*. Routing protocols update their routing directions automatically based on information sent from neighbors. This is the magic of routing protocols: automatic updates and directions – like google maps – for packets.

What is BGP?

*Border Gateway Protocol* is the most popular external routing protocol, commonly used by ISPs (Internet Service Providers) to route customer traffic. Without BGP, the internet would not function nearly as well, if at all. Think of BGP as the postal service that delivers a letter to the recipient in the fastest and most efficient manner possible. When someone submits data across the internet, BGP is responsible for choosing the best path out of all preexisting available paths, which usually means passing through autonomous systems.



*An example of Autonomous systems and their local networks*

So, what are autonomous systems? *Autonomous Systems* (AS) are a collection of routers, each with their own lesser hierarchy of routers that eventually connects to local networks. Each autonomous system is aware of other autonomous system(s) and can broadly determine where to route traffic based on which autonomous system holds the desired destination. ASes typically belong to ISPs (Internet service providers) or other large high-tech organizations, such as tech companies, universities, or scientific institutions. The internet is run under a collection of autonomous systems.

Kingdom Analogy

I suppose one could think of an autonomous system as a form of kingdom. Each kingdom has a ruler that dictates certain policies that the underlying citizens and infrastructure abide to. For example, if a kingdom is landlocked, it likely has a high demand for fish and salt. Therefore, a *policy* is implemented where all traders from the nearest port town have free access to and from the kingdom. Different autonomous systems often have these unique routing *policies*.

There are many paths and roads in the kingdom internally, so much so that if one goes down, alternate routes are readily available. Some kingdoms have routes bridging them, but often a traveler (packet) will have to journey through multiple kingdoms to reach their desired destination. In other words, a packet may have to pass through multiple ASes to reach its destination.

Each AS is assigned a unique, 32-bit number, the *Autonomous System Number* (ASN). These numbers differentiate what “kingdom” a router falls under. Routers with the same AS are part of the same kingdom.

Internal and External BGP

As I vaguely covered in my analogy, there are two types of BGP: *internal BGP* (within kingdoms) and *external BGP* (between kingdoms).

*External BGP* (eBGP) is the bridge that connects autonomous systems, where neighbors can broadly exchange network prefixes to learn more about each other’s networks.

*Internal BGP* (iBGP) is a TCP based protocol to help advertise and support eBGP routes. The kicker: iBGP alone does not do any routing. To route, one needs an IP based protocol. So why bother with iBGP at all?

Consider an old, flimsy wooden bridge. Driving a cargo truck across would collapse the bridge. But now, with iBGP, that bridge is reinforced with a concrete foundation, metal bearings, and arches to brace the heavy loads. BGP is the only protocol designed to support the hundreds of thousands of routes that make up the internet. As of writing this, the size of the full IPv4 BGP routing table is around 800,000 prefixes without even accounting for IPv6. For reference, the average OSPF router would suffer at around 6000 prefixes. Therefore, iBGP is often used in conjunction with an IGP; the IGP does the local routing whilst iBGP contains the major routing table.

Both internal and external BGP sessions establish neighbors based on a peering system. You define a peer with a neighbor statement: for example, *neighbor 10.0.0.1 remote-as 100* states that there is a router connected, *10.0.0.1* running under ASN *100*. The neighbor *10.0.0.1* would need to define this router as a neighbor for a complete peer adjacency to form. Once both routers point to each other, they are peered. Networks are advertised with network statements: for example, *network 10.0.0.0 mask 255.255.255.0* will add the prefix *10.0.0.0/24* to the routing table. Other routers will direct traffic for *10.0.0.0/24* towards the router with the network statement.

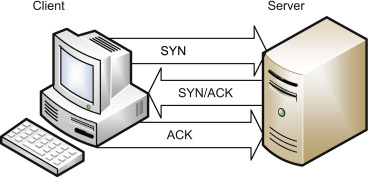
How does BGP function?

The main purpose BGP serves is forwarding traffic to an external network in the most efficient manner possible. Some factors that determine the best path are:

1. The path with the highest *weight*. This is a user defined variable.
2. The path with the highest*LOCAL\_PREF*. Local preference determines which path is preferred when leaving a local AS.
3. The path with the highest*AS\_PATH*. The main purpose of *AS\_PATH* is to prevent infinite routing table updates. It is rather complicated, but essentially if a router goes down in a network, then this might cause the other routers to falsely change their paths, resulting in an infinite loop of changing paths. This can only happen in a distance-vector routing protocol such as BGP or RIP.
4. Favoring *eBGP* paths over iBGP paths.

BGP is a *distance-vector* routing protocol. Distance-vector routing protocols work by advertising routing tables to their neighbors. If the routes from the neighbor are better than the ones they currently have, the router will update its routing table to the preferable routes. Like all other routing protocols, BGP must first establish a neighbor adjacency with another BGP router to be able to exchange routing information. Unlike other routing protocols, BGP does not broadcast or multicast to discover other BGP neighbors. Neighbor relationships must be established manually and BGP uses TCP port 179 for the connection. There are a couple of different states BGP routers may encounter when becoming neighbors:

1. Idle. In Idle, BGP waits for a “start event”. This could be when a new BGP neighbor is configured or when a reset occurs between peers that already had a connection. After the start event, BGP will initialize a TCP connection with the remote neighbor and initialize some functions. In success, BGP moves to the *Connect* state, while in failure, BGP remains in the *Idle* state.
2. Connect. In *Connect*, BGP waits for the TCP three-way handshake to complete. Both sides need to *synchronize* (SYN) and *acknowledge* (ACK) each other in a TCP three-way handshake. If the results are successful, BGP advances to the *OpenSent* state. If the results are unsuccessful, BGP begins the *Active* state.



1. Active. BGP will try another TCP three-way handshake to establish a connection with the remote neighbor. On success, BGP will transition to the *OpenSent* state. After a certain amount of time has passed with no success, BGP will revert to the *Connect* state.
2. OpenSent. BGP will wait for an “open message” from the remote neighbor. Open messages contain information about the BGP router, such as version, ASN, BGP router ID, and hold time. If the versions or hold times mismatch, BGP reverts to the *Idle* state. The ASN determines whether the BGP session will be running iBGP or eBGP. If the TCP session ever fails, BGP will revert to the *Active* state. If all passes, BGP will start sending keepalive messages to maintain the TCP session.
3. OpenConfirm. BGP waits for a keepalive message from the remote BGP neighbor. When keepalive messages are consistently received, BGP moves to the *Established* state. In any other case, BGP falls back to the *Idle* state.
4. Established. The neighbor adjacency has been formed. As long as keepalive messages are sent, the neighborship remains up. Otherwise, BGP resets back to Idle state.

Adjacencies are often formed by defining the *directly connected* interface as a neighbor, a common trait in most routing protocols. However, a technique when working with BGP is to use loopback interfaces as neighbors. Using loopbacks is common for iBGP but it also works with eBGP. Loopbacks are preferred because of redundancy: if the physical interface goes down, perhaps due to hardware, loopback interfaces will stay up since they are *virtual*.

Brief History of BGP

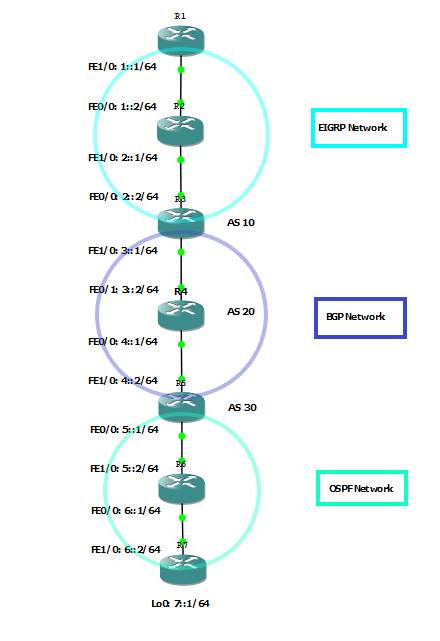
In the beginnings of the internet there was no BGP. Instead, there was *Gateway Gateway Protocol* (GGP), a brilliantly named protocol and a slightly more advanced version of an outdated protocol we have today – *Router Information Protocol* (RIP). Back then, routers were known as gateways, explaining the redundancy in the name.

Gateway Gateway Protocol was replaced by *Exterior Gateway Protocol* (EGP) in 1984, created to support the growing network infrastructure around the world. EGP introduced the concept of *autonomous systems*, which later became a big part of BGP.

However, engineers foresaw a fundamental problem with EGP: the inability to detect routing loops. If a topology was configured incorrectly and a router failed, an error could cause packets could circulate endlessly. Among other problems, it needed an update. In 1989 an early version of BGP emerged, BGP-1, closely followed by BGP-2, then BGP-3 in 1991. However, there was yet another problem that all three BGPs shared: they only supported *classful* addressing. This meant that each network supported one of these three prefix sizes: [/24], [/16], [/8]; or 255, 65535, 16777215 hosts, respectively. If I wanted a network that could support roughly 500 hosts back in BGP-3, I’d have to opt with a prefix of [**/**16] (65,535 hosts). I’d be wasting over 65,000 remaining addresses.

Throughout the 1990s, BGP adopted some innovations, including IPv6, but it wasn’t until 2006 that the current version of BGP (BGP-4) was released with the support of *classless* inter-domain routing (CIDR). Classless addressing gave engineers much more flexibility with prefixes – the major downside of BGP-3 – and engineers gained access to *subnets*. Even today, the internet is still running the very same BGP-4.

Network Diagram



Summary

In this lab, I configured three routing protocols: eBGP, OSPF, and EIGRP. I began by designing a topology composed of seven routers. They were to be placed in a straight line, sectioned off into three networks by the different routing protocols. For those who have read my previous writeup, you may recognize this topology because it is the same. The difference here is the support of IPv6 routing configured in GNS3.

A good place to start on these types of configurations is assigning the IPs to the interfaces of the routers. When the stable green port lights indicated linked ethernet, I moved to OSPF configs. As I’d learnt from my previous encounters with OSPF, network statements are the most reliable way to enable an OSPF interface. OSPF-enabled interfaces peer with neighbor OSPF interfaces and share routing information. However, IPv6 is different. In OSPFv3 (OSPF, but with support for IPv6), network statements do not exist. They are replaced by extra configurations on an interface. For example, if I wanted my *gigabitethernet* interface to run OSPFv3, I’d need *ipv6**ospf [#] area [#]*writtenin that interface, instead of the *router* interface. My topology placed OSPF on the bottom half of the network, met by BGP in the middle, then EIGRP on top. Though I configured it before, I ran into some problems with forming OSPFv3 adjacencies. After finishing up OSPFv3, I moved to EIGRP.

EIGRPv6 is a lot like OSPFv3 regarding the configuration. Both use what I like to call *interface commands,* commands written in interface-configuration mode. While OSPF is entirely a link-state routing protocol, EIGRP is a hybrid of link-state and distance-vector. They are used interchangeably in enterprise networks, though each have their specific benefits.

After the *Interior Gateway Protocols* were routing within their small domains, it was time to set up IPv6 BGP. Navigating around BGP’s the *address-families* was a little confusing, but I grew to appreciate the versatility that BGP brought compared to OSPF or EIGRP at the cost of more complexity. For example, enabling OSPF on an interface, but not broadcasting the network to the routing tables is not possible in OSPF because OSPF uses the same command for both features. However, BGP has separate commands for both adjacencies and network advertisement, giving the admin more control over their network. Eventually, I got IPv6 running in BGP with full redistribution between OSPF and EIGRP networks.

Lab Commands

|  |  |
| --- | --- |
| **Command** | A statement necessary for a configuration to work, denoted in bold |
| **[*Argument*]** | An argument necessary for a command to function, denoted in bold italics. |
| *Optional-Statement*  *<Optional Argument>* | An optional argument or statement, not necessary for a command to function, denoted in italics |

Router(config)# **interface [*interface*] [*id*]**

* Enables configuration on a specific interface

// BGP

Router(config)# **router bgp [*autonomous system number*]**

* Activates a BGP router and enters BGP router configuration mode

*The autonomous system number (ASN) is a number that identifies a large collection of routers on the internet. Typically, there are networks run under an ASN by a technical administration. eBGP connects different autonomous systems while iBGP is run within each ASN.*

Router(config-router)# **address-family [*protocol*]**

* Enters configuration mode for a BGP address family

*I like to think of address-families as workspaces for certain IP protocols. For example, one might enter the “ipv4” or “ipv6” address-families to configure IP routing. This is where redistribution, network statements or activation commands occur.*

Router(config-router)# **neighbor [*ipv6 address*] remote-as [*neighbor’s asn*]**

* Used in forming BGP neighbor adjacencies

*This command takes an IP address of a neighbor’s interface and the ASN of the neighbor. For a BGP neighborship to be established, each router must have* routes to the neighbor’s IP *and the* ASN of their neighbor*.*

Router(config-router-af)# **network [*ipv6* *network address*] mask [*subnet mask*]**

* Advertises a directly connected network to the BGP routing table

*BGP’s network statements are not to be confused with OSPF or EIGRPs; they aren’t used to form adjacencies between BGP routers. A BGP network statement is configured alongside a neighbor statement, the former advertising the network and the latter the neighbor establishment. Example: network 1::/64.*

Router(config-router-af)# **neighbor [*ipv6 address*] activate**

* Enables a BGP neighbor

// OSPFv3

Router(config)# **ipv6** **router ospf [*process id*]**

* Enables the OSPFv3 routing protocol and enters OSPFv3 router configuration mode

*Generally, OSPF process ids should be the same, though OSPF should still form adjacencies with different process ids. Each OSPF process retains a different routing table; depending on the configuration, process ID could determine what routes are redistributed. A router can run multiple OSPF processes but will contain a separate OSPF database per process.*

Router(config-router)# **router-id** **[*router* *id*]**

* Uniquely determines an OSPF router within a domain

*Router ids are automatically determined by the highest loopback interface if they are not manually defined. Router ids can play a part in DR/BDR elections.*

Router(config-if)# **ipv6 ospf [*process id*] area [*area number*]**

* Advertises the specified subnet to neighbor routers

*Configured in interface-configuration mode. The defined subnet should match an interface on the router. Routers in an area share a complete topological database and have route summaries of external areas.*

// EIGRPv6

Router(config)# **ipv6 router eigrp [*instance*]**

* Enables EIGRP of a particular instance and enters router configuration mode.

*There can be multiple instances of EIGRP running on a router, however, adjacent routers will only communicate if they are using the same instance.*

Router(config-if)# **ipv6 eigrp [*instance*]**

* Enables EIGRPv6 on the current interface

*The network on the interface will be broadcast to adjacent EIGRPv6 routers.*

// Redistribution

Router(config-router)# **redistribute [*routing protocol*] [*protocol instance*]** <*metric*<*value*>> *subnets*

* Redistributes routes from a routing protocol into another local routing protocol

*The routing protocol defined will be distributed in the local router that the user is in. There are many different additional options when redistributing routes, but I’ve found the metric and subnets to be the most useful. Each routing protocol has a different metric, so when redistributing be sure to use the right one. Subnets usually refers to redistributing classless networks.*

Configurations

Router 1

**R1#show running-config**no service timestamps debug uptimeno service timestamps log uptimehostname R1boot-start-markerboot-end-markerno aaa new-modelno ip icmp rate-limit unreachableno ip cefno ip domain lookupipv6 unicast-routingno ipv6 cefmultilink bundle-name authenticatedip tcp synwait-time 5interface FastEthernet0/0 no ip address shutdown duplex fullinterface FastEthernet1/0 ip address 10.10.10.1 255.255.255.252 speed auto duplex auto ipv6 address FE80::1 link-local ipv6 address 1::1/64 ipv6 eigrp 10interface FastEthernet1/1 no ip address shutdown speed auto duplex autointerface FastEthernet2/0 no ip address shutdown speed auto duplex autointerface FastEthernet2/1 no ip address shutdown speed auto duplex autointerface FastEthernet3/0 no ip address shutdown duplex fullinterface FastEthernet4/0 no ip address shutdown duplex fullrouter eigrp 10 network 10.10.10.0 0.0.0.3 eigrp router-id 1.1.1.1ip forward-protocol ndip flow-export version 9no ip http serverno ip http secure-serveripv6 router eigrp 10 eigrp router-id 1.1.1.0control-planeline con 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line aux 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line vty 0 4 loginend**R1#show ipv6 route**IPv6 Routing Table - default - 9 entriesCodes: C - Connected, L - Local, S - Static, U - Per-user Static route B - BGP, R - RIP, H - NHRP, 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, l - LISPC 1::/64 [0/0] via FastEthernet1/0, directly connectedL 1::1/128 [0/0] via FastEthernet1/0, receiveD 2::/64 [90/30720] via FE80::2, FastEthernet1/0EX 3::/64 [170/33280] via FE80::2, FastEthernet1/0EX 4::/64 [170/2573568] via FE80::2, FastEthernet1/0EX 5::/64 [170/2573568] via FE80::2, FastEthernet1/0EX 6::/64 [170/2573568] via FE80::2, FastEthernet1/0EX 7::1/128 [170/2573568] via FE80::2, FastEthernet1/0L FF00::/8 [0/0] via Null0, receive**R1#show ipv6 eigrp interfaces**EIGRP-IPv6 Interfaces for AS(10) Xmit Queue PeerQ Mean Pacing Time Multicast PendingInterface Peers Un/Reliable Un/Reliable SRTT Un/Reliable Flow Timer RoutesFa1/0 1 0/0 0/0 1018 0/0 5056 0**R1#show ipv6 eigrp neighbors**EIGRP-IPv6 Neighbors for AS(10)H Address Interface Hold Uptime SRTT RTO Q Seq (sec) (ms) Cnt Num0 Link-local address: Fa1/0 5 00:03:35 1018 5000 0 10 FE80::2**R1#show ipv6 eigrp topology**EIGRP-IPv6 Topology Table for AS(10)/ID(1.1.1.0)Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply, r - reply Status, s - sia Status P 6::/64, 1 successors, FD is 2573568 via FE80::2 (2573568/2571008), FastEthernet1/0P 1::/64, 1 successors, FD is 28160 via Connected, FastEthernet1/0P 5::/64, 1 successors, FD is 2573568 via FE80::2 (2573568/2571008), FastEthernet1/0P 7::1/128, 1 successors, FD is 2573568 via FE80::2 (2573568/2571008), FastEthernet1/0P 2::/64, 1 successors, FD is 30720 via FE80::2 (30720/28160), FastEthernet1/0P 3::/64, 1 successors, FD is 33280 via FE80::2 (33280/30720), FastEthernet1/0P 4::/64, 1 successors, FD is 2573568 via FE80::2 (2573568/2571008), FastEthernet1/0

Router 2

**R2#show running-config**no service timestamps debug uptimeno service timestamps log uptimehostname R2boot-start-markerboot-end-markerno aaa new-modelno ip icmp rate-limit unreachableip cefno ip domain lookupipv6 unicast-routingno ipv6 cefmultilink bundle-name authenticatedip tcp synwait-time 5interface FastEthernet0/0 ip address 10.10.10.2 255.255.255.252 duplex full ipv6 address FE80::2 link-local ipv6 address 1::2/64 ipv6 eigrp 10interface FastEthernet1/0 ip address 10.10.10.5 255.255.255.252 speed auto duplex auto ipv6 address FE80::1 link-local ipv6 address 2::1/64 ipv6 eigrp 10interface FastEthernet1/1 no ip address shutdown speed auto duplex autointerface FastEthernet2/0 no ip address shutdown speed auto duplex autointerface FastEthernet2/1 no ip address shutdown speed auto duplex autointerface FastEthernet3/0 no ip address shutdown duplex fullinterface FastEthernet4/0 no ip address shutdown duplex fullrouter eigrp 10 network 10.10.10.0 0.0.0.3 network 10.10.10.4 0.0.0.3 eigrp router-id 2.2.2.2ip forward-protocol ndip flow-export version 9no ip http serverno ip http secure-serveripv6 router eigrp 10 eigrp router-id 2.2.2.0control-planeline con 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line aux 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line vty 0 4 loginend**R2#show ipv6 route**IPv6 Routing Table - default - 10 entriesCodes: C - Connected, L - Local, S - Static, U - Per-user Static route B - BGP, R - RIP, H - NHRP, 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, l - LISPC 1::/64 [0/0] via FastEthernet0/0, directly connectedL 1::2/128 [0/0] via FastEthernet0/0, receiveC 2::/64 [0/0] via FastEthernet1/0, directly connectedL 2::1/128 [0/0] via FastEthernet1/0, receiveEX 3::/64 [170/30720] via FE80::2, FastEthernet1/0EX 4::/64 [170/2571008] via FE80::2, FastEthernet1/0EX 5::/64 [170/2571008] via FE80::2, FastEthernet1/0EX 6::/64 [170/2571008] via FE80::2, FastEthernet1/0EX 7::1/128 [170/2571008] via FE80::2, FastEthernet1/0L FF00::/8 [0/0] via Null0, receive**R2#show ipv6 eigrp interfaces**EIGRP-IPv6 Interfaces for AS(10) Xmit Queue PeerQ Mean Pacing Time Multicast PendingInterface Peers Un/Reliable Un/Reliable SRTT Un/Reliable Flow Timer RoutesFa0/0 1 0/0 0/0 44 0/0 180 0Fa1/0 1 0/0 0/0 57 0/0 248 0**R2#show ipv6 eigrp neighbors**EIGRP-IPv6 Neighbors for AS(10)H Address Interface Hold Uptime SRTT RTO Q Seq (sec) (ms) Cnt Num1 Link-local address: Fa0/0 10 00:03:41 44 264 0 5 FE80::10 Link-local address: Fa1/0 11 00:03:45 57 342 0 6 FE80::2**R2#show ipv6 eigrp topology**EIGRP-IPv6 Topology Table for AS(10)/ID(2.2.2.0)Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply, r - reply Status, s - sia Status P 6::/64, 1 successors, FD is 2571008 via FE80::2 (2571008/2568448), FastEthernet1/0P 1::/64, 1 successors, FD is 28160 via Connected, FastEthernet0/0P 5::/64, 1 successors, FD is 2571008 via FE80::2 (2571008/2568448), FastEthernet1/0P 7::1/128, 1 successors, FD is 2571008 via FE80::2 (2571008/2568448), FastEthernet1/0P 2::/64, 1 successors, FD is 28160 via Connected, FastEthernet1/0P 3::/64, 1 successors, FD is 30720 via FE80::2 (30720/28160), FastEthernet1/0P 4::/64, 1 successors, FD is 2571008 via FE80::2 (2571008/2568448), FastEthernet1/0

Router 3

**R3#show running-config**no service timestamps debug uptimeno service timestamps log uptimehostname R3boot-start-markerboot-end-markerno aaa new-modelno ip icmp rate-limit unreachableip cefno ip domain lookupipv6 unicast-routingno ipv6 cefmultilink bundle-name authenticatedip tcp synwait-time 5interface FastEthernet0/0 ip address 10.10.10.6 255.255.255.252 duplex full ipv6 address FE80::2 link-local ipv6 address 2::2/64 ipv6 enable ipv6 eigrp 10interface FastEthernet1/0 ip address 10.10.10.9 255.255.255.252 speed auto duplex auto ipv6 address FE80::1 link-local ipv6 address 3::1/64 ipv6 enableinterface FastEthernet1/1 no ip address shutdown speed auto duplex autointerface FastEthernet2/0 no ip address shutdown speed auto duplex autointerface FastEthernet2/1 no ip address shutdown speed auto duplex autointerface FastEthernet3/0 no ip address shutdown duplex fullinterface FastEthernet4/0 no ip address shutdown duplex fullrouter eigrp 10 network 10.10.10.4 0.0.0.3 redistribute bgp 10 metric 1000 33 255 1 1500 eigrp router-id 3.3.3.3router bgp 10 bgp router-id 10.10.10.10 bgp log-neighbor-changes no bgp default ipv4-unicast neighbor 3::2 remote-as 20 neighbor 3::2 ebgp-multihop 255 neighbor 10.10.10.10 remote-as 20 address-family ipv4 network 10.10.10.4 mask 255.255.255.252 network 10.10.10.8 mask 255.255.255.252 redistribute eigrp 10 neighbor 10.10.10.10 activate exit-address-family address-family ipv6 redistribute connected redistribute eigrp 10 network 2::/64 network 3::/64 neighbor 3::2 activate exit-address-familyip forward-protocol ndip flow-export version 9no ip http serverno ip http secure-serveripv6 router eigrp 10 eigrp router-id 3.3.3.0 redistribute bgp 10 metric 1000 33 255 1 1500 redistribute connectedcontrol-planeno parser cacheline con 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line aux 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line vty 0 4 loginend**R3#show ipv6 route**IPv6 Routing Table - default - 10 entriesCodes: C - Connected, L - Local, S - Static, U - Per-user Static route B - BGP, R - RIP, H - NHRP, 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, l - LISPD 1::/64 [90/30720] via FE80::1, FastEthernet0/0C 2::/64 [0/0] via FastEthernet0/0, directly connectedL 2::2/128 [0/0] via FastEthernet0/0, receiveC 3::/64 [0/0] via FastEthernet1/0, directly connectedL 3::1/128 [0/0] via FastEthernet1/0, receiveB 4::/64 [20/0] via 3::2B 5::/64 [20/0] via 3::2B 6::/64 [20/0] via 3::2B 7::1/128 [20/0] via 3::2L FF00::/8 [0/0] via Null0, receive**R3#show ipv6 eigrp interfaces**EIGRP-IPv6 Interfaces for AS(10) Xmit Queue PeerQ Mean Pacing Time Multicast PendingInterface Peers Un/Reliable Un/Reliable SRTT Un/Reliable Flow Timer RoutesFa0/0 1 0/0 0/0 43 0/0 184 0**R3#show ipv6 eigrp neighbors**EIGRP-IPv6 Neighbors for AS(10)H Address Interface Hold Uptime SRTT RTO Q Seq (sec) (ms) Cnt Num0 Link-local address: Fa0/0 13 00:04:00 43 258 0 9 FE80::1**R3#show ipv6 eigrp topology**EIGRP-IPv6 Topology Table for AS(10)/ID(3.3.3.0)Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply, r - reply Status, s - sia Status P 6::/64, 1 successors, FD is 2568448 via Redistributed (2568448/0)P 1::/64, 1 successors, FD is 30720 via FE80::1 (30720/28160), FastEthernet0/0P 5::/64, 1 successors, FD is 2568448 via Redistributed (2568448/0)P 7::1/128, 1 successors, FD is 2568448 via Redistributed (2568448/0)P 2::/64, 1 successors, FD is 28160 via Connected, FastEthernet0/0P 3::/64, 1 successors, FD is 28160 via Rconnected (28160/0)P 4::/64, 1 successors, FD is 2568448 via Redistributed (2568448/0)**R3#show bgp ipv6 unicast**BGP table version is 8, local router ID is 10.10.10.10Status codes: s suppressed, d damped, h history, \* valid, > best, i - internal, r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-compressed, Origin codes: i - IGP, e - EGP, ? - incompleteRPKI validation codes: V valid, I invalid, N Not found Network Next Hop Metric LocPrf Weight Path \*> 1::/64 FE80::1 30720 32768 ? \*> 2::/64 :: 0 32768 i \* 3::/64 3::2 0 0 20 i \*> :: 0 32768 i \*> 4::/64 3::2 0 0 20 i \*> 5::/64 3::2 0 20 30 i \*> 6::/64 3::2 0 20 30 ? \*> 7::1/128 3::2 0 20 30 ?

Router 4

**R4#show running-config**no service timestamps debug uptimeno service timestamps log uptimeno service password-encryptionhostname R4boot-start-markerboot-end-markerno aaa new-modelmemory-size iomem 5no ip icmp rate-limit unreachableip cefno ip domain lookupip auth-proxy max-nodata-conns 3ip admission max-nodata-conns 3ipv6 unicast-routingip tcp synwait-time 5interface FastEthernet0/0 ip address 10.10.10.13 255.255.255.252 duplex auto speed auto ipv6 address 4::1/64 ipv6 address FE80::1 link-local ipv6 enableinterface FastEthernet0/1 ip address 10.10.10.10 255.255.255.252 duplex auto speed auto ipv6 address 3::2/64 ipv6 address FE80::2 link-localinterface FastEthernet1/0 no ip address shutdown duplex auto speed auto ipv6 enableinterface FastEthernet2/0 no ip address shutdown duplex auto speed autointerface FastEthernet3/0 no ip address shutdown duplex auto speed autointerface FastEthernet4/0 no ip address shutdown duplex auto speed autorouter bgp 20 bgp router-id 20.20.20.20 no bgp default ipv4-unicast bgp log-neighbor-changes neighbor 3::1 remote-as 10 neighbor 3::1 ebgp-multihop 255 neighbor 4::2 remote-as 30 neighbor 4::2 ebgp-multihop 255 neighbor 10.10.10.9 remote-as 10 neighbor 10.10.10.14 remote-as 30 address-family ipv4 neighbor 3::1 activate neighbor 4::2 activate neighbor 10.10.10.9 activate neighbor 10.10.10.14 activate no auto-summary no synchronization network 10.10.10.8 mask 255.255.255.252 network 10.10.10.12 mask 255.255.255.252 exit-address-family address-family ipv6 neighbor 3::1 activate neighbor 4::2 activate network 3::/64 network 4::/64 redistribute connected no synchronization exit-address-familyno ip http serverno ip http secure-serverip forward-protocol ndip flow-export version 9no cdp log mismatch duplexcontrol-planeline con 0 exec-timeout 0 0 privilege level 15 logging synchronousline aux 0 exec-timeout 0 0 privilege level 15 logging synchronousline vty 0 4 loginend**R4#show ipv6 route**IPv6 Routing Table - 11 entriesCodes: C - Connected, L - Local, S - Static, R - RIP, B - BGP U - Per-user Static route I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2 ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2B 1::/64 [20/30720] via 3::1B 2::/64 [20/0] via 3::1C 3::/64 [0/0] via ::, FastEthernet0/1L 3::2/128 [0/0] via ::, FastEthernet0/1C 4::/64 [0/0] via ::, FastEthernet0/0L 4::1/128 [0/0] via ::, FastEthernet0/0B 5::/64 [20/0] via 4::2B 6::/64 [20/2] via 4::2B 7::1/128 [20/2] via 4::2L FE80::/10 [0/0] via ::, Null0L FF00::/8 [0/0] via ::, Null0**R4#show bgp ipv6 unicast**BGP table version is 8, local router ID is 20.20.20.20Status codes: s suppressed, d damped, h history, \* valid, > best, i - internal, r RIB-failure, S StaleOrigin codes: i - IGP, e - EGP, ? - incomplete Network Next Hop Metric LocPrf Weight Path\*> 1::/64 3::1 30720 0 10 ?\*> 2::/64 3::1 0 0 10 i\* 3::/64 3::1 0 0 10 i\*> :: 0 32768 i\* 4::/64 4::2 0 0 30 i\*> :: 0 32768 i\*> 5::/64 4::2 0 0 30 i\*> 6::/64 4::2 2 0 30 ?\*> 7::1/128 4::2 2 0 30 ?

Router 5

**R5#show running-config**no service timestamps debug uptimeno service timestamps log uptimehostname R5boot-start-markerboot-end-markerno aaa new-modelno ip icmp rate-limit unreachableip cefno ip domain lookupipv6 unicast-routingipv6 cefmultilink bundle-name authenticatedip tcp synwait-time 5interface FastEthernet0/0 ip address 10.10.10.17 255.255.255.252 duplex full ipv6 address FE80::1 link-local ipv6 address 5::1/64 ipv6 ospf 10 area 0interface FastEthernet1/0 ip address 10.10.10.14 255.255.255.252 speed auto duplex auto ipv6 address FE80::2 link-local ipv6 address 4::2/64interface FastEthernet1/1 no ip address shutdown speed auto duplex autointerface FastEthernet2/0 no ip address shutdown speed auto duplex autointerface FastEthernet2/1 no ip address shutdown speed auto duplex autointerface FastEthernet3/0 no ip address shutdown duplex fullinterface FastEthernet4/0 no ip address shutdown duplex fullrouter ospf 10 router-id 5.5.5.5 redistribute bgp 30 subnets network 10.10.10.16 0.0.0.3 area 0router bgp 30 bgp router-id 30.30.30.30 bgp log-neighbor-changes no bgp default ipv4-unicast neighbor 4::1 remote-as 20 neighbor 4::1 ebgp-multihop 255 neighbor 10.10.10.13 remote-as 20 address-family ipv4 network 10.10.10.16 mask 255.255.255.252 redistribute ospf 10 neighbor 10.10.10.13 activate exit-address-family address-family ipv6 redistribute connected redistribute ospf 10 include-connected network 4::/64 network 5::/64 neighbor 4::1 activate exit-address-familyip forward-protocol ndip flow-export version 9no ip http serverno ip http secure-serveripv6 router ospf 10 router-id 5.5.5.0 redistribute connected redistribute bgp 30control-planeline con 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line aux 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line vty 0 4 loginend**R5#show ipv6 route**IPv6 Routing Table - default - 10 entriesCodes: C - Connected, L - Local, S - Static, U - Per-user Static route B - BGP, R - RIP, H - NHRP, 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, l - LISPB 1::/64 [20/0] via 4::1B 2::/64 [20/0] via 4::1B 3::/64 [20/0] via 4::1C 4::/64 [0/0] via FastEthernet1/0, directly connectedL 4::2/128 [0/0] via FastEthernet1/0, receiveC 5::/64 [0/0] via FastEthernet0/0, directly connectedL 5::1/128 [0/0] via FastEthernet0/0, receiveO 6::/64 [110/2] via FE80::2, FastEthernet0/0O 7::1/128 [110/2] via FE80::2, FastEthernet0/0L FF00::/8 [0/0] via Null0, receive**R5#show ipv6 ospf database** OSPFv3 Router with ID (5.5.5.0) (Process ID 10) Router Link States (Area 0)ADV Router Age Seq# Fragment ID Link count Bits 5.5.5.0 751 0x80000002 0 1 E 6.6.6.0 744 0x80000003 0 2 None 7.7.7.0 755 0x80000002 0 1 None Net Link States (Area 0)ADV Router Age Seq# Link ID Rtr count 6.6.6.0 752 0x80000001 3 2 7.7.7.0 755 0x80000001 3 2 Link (Type-8) Link States (Area 0)ADV Router Age Seq# Link ID Interface 5.5.5.0 804 0x80000002 2 Fa0/0 6.6.6.0 788 0x80000002 3 Fa0/0 Intra Area Prefix Link States (Area 0)ADV Router Age Seq# Link ID Ref-lstype Ref-LSID 6.6.6.0 752 0x80000001 3072 0x2002 3 7.7.7.0 755 0x80000003 0 0x2001 0 7.7.7.0 755 0x80000001 3072 0x2002 3 Type-5 AS External Link StatesADV Router Age Seq# Prefix 5.5.5.0 767 0x80000001 1::/64 5.5.5.0 767 0x80000001 2::/64 5.5.5.0 767 0x80000001 3::/64 5.5.5.0 613 0x80000001 4::/64**R5#show ipv6 ospf interface**FastEthernet0/0 is up, line protocol is up Link Local Address FE80::1, Interface ID 2 Area 0, Process ID 10, Instance ID 0, Router ID 5.5.5.0 Network Type BROADCAST, Cost: 1 Transmit Delay is 1 sec, State BDR, Priority 1 Designated Router (ID) 6.6.6.0, local address FE80::2 Backup Designated router (ID) 5.5.5.0, local address FE80::1 Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5 Hello due in 00:00:06 Graceful restart helper support enabled Index 1/1/1, flood queue length 0 Next 0x0(0)/0x0(0)/0x0(0) Last flood scan length is 1, maximum is 2 Last flood scan time is 0 msec, maximum is 0 msec Neighbor Count is 1, Adjacent neighbor count is 1 Adjacent with neighbor 6.6.6.0 (Designated Router) Suppress hello for 0 neighbor(s)**R5#show ipv6 ospf neighbor** OSPFv3 Router with ID (5.5.5.0) (Process ID 10)Neighbor ID Pri State Dead Time Interface ID Interface6.6.6.0 1 FULL/DR 00:00:22 3 FastEthernet0/0**R5#show bgp ipv6 unicast**BGP table version is 8, local router ID is 30.30.30.30Status codes: s suppressed, d damped, h history, \* valid, > best, i - internal, r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter, x best-external, a additional-path, c RIB-compressed, Origin codes: i - IGP, e - EGP, ? - incompleteRPKI validation codes: V valid, I invalid, N Not found Network Next Hop Metric LocPrf Weight Path \*> 1::/64 4::1 0 20 10 ? \*> 2::/64 4::1 0 20 10 i \*> 3::/64 4::1 0 0 20 i \* 4::/64 4::1 0 0 20 i \*> :: 0 32768 i \*> 5::/64 :: 0 32768 i \*> 6::/64 FE80::2 2 32768 ? \*> 7::1/128 FE80::2 2 32768 ?

Router 6

**R6#show running-config** no service timestamps debug uptimeno service timestamps log uptimehostname R6boot-start-markerboot-end-markerno aaa new-modelno ip icmp rate-limit unreachableip cefno ip domain lookupipv6 unicast-routingipv6 cefmultilink bundle-name authenticatedip tcp synwait-time 5interface FastEthernet0/0 ip address 10.10.10.21 255.255.255.252 duplex full ipv6 address FE80::1 link-local ipv6 address 6::1/64 ipv6 enable ipv6 ospf 10 area 0interface FastEthernet1/0 ip address 10.10.10.18 255.255.255.252 speed auto duplex auto ipv6 address FE80::2 link-local ipv6 address 5::2/64 ipv6 enable ipv6 ospf 10 area 0interface FastEthernet1/1 no ip address shutdown speed auto duplex autointerface FastEthernet2/0 no ip address shutdown speed auto duplex autointerface FastEthernet2/1 no ip address shutdown speed auto duplex autointerface FastEthernet3/0 no ip address shutdown duplex fullinterface FastEthernet4/0 no ip address shutdown duplex fullrouter ospf 10 router-id 6.6.6.6 network 10.10.10.16 0.0.0.3 area 0 network 10.10.10.20 0.0.0.3 area 0ip forward-protocol ndip flow-export version 9no ip http serverno ip http secure-serveripv6 router ospf 10 router-id 6.6.6.0control-planeline con 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line aux 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line vty 0 4 loginend**R6#show ipv6 route**IPv6 Routing Table - default - 10 entriesCodes: C - Connected, L - Local, S - Static, U - Per-user Static route B - BGP, R - RIP, H - NHRP, 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, l - LISPOE2 1::/64 [110/1] via FE80::1, FastEthernet1/0OE2 2::/64 [110/1] via FE80::1, FastEthernet1/0OE2 3::/64 [110/1] via FE80::1, FastEthernet1/0OE2 4::/64 [110/20] via FE80::1, FastEthernet1/0C 5::/64 [0/0] via FastEthernet1/0, directly connectedL 5::2/128 [0/0] via FastEthernet1/0, receiveC 6::/64 [0/0] via FastEthernet0/0, directly connectedL 6::1/128 [0/0] via FastEthernet0/0, receiveO 7::1/128 [110/1] via FE80::2, FastEthernet0/0L FF00::/8 [0/0] via Null0, receive**R6#show ipv6 ospf database** OSPFv3 Router with ID (6.6.6.0) (Process ID 10) Router Link States (Area 0)ADV Router Age Seq# Fragment ID Link count Bits 5.5.5.0 591 0x80000002 0 1 E 6.6.6.0 587 0x80000003 0 2 None 7.7.7.0 593 0x80000002 0 1 None Net Link States (Area 0)ADV Router Age Seq# Link ID Rtr count 6.6.6.0 590 0x80000001 3 2 7.7.7.0 593 0x80000001 3 2 Link (Type-8) Link States (Area 0)ADV Router Age Seq# Link ID Interface 5.5.5.0 644 0x80000002 2 Fa1/0 6.6.6.0 626 0x80000002 3 Fa1/0 6.6.6.0 629 0x80000002 2 Fa0/0 7.7.7.0 629 0x80000002 3 Fa0/0 Intra Area Prefix Link States (Area 0)ADV Router Age Seq# Link ID Ref-lstype Ref-LSID 6.6.6.0 590 0x80000001 3072 0x2002 3 7.7.7.0 593 0x80000003 0 0x2001 0 7.7.7.0 593 0x80000001 3072 0x2002 3 Type-5 AS External Link StatesADV Router Age Seq# Prefix 5.5.5.0 607 0x80000001 1::/64 5.5.5.0 607 0x80000001 2::/64 5.5.5.0 607 0x80000001 3::/64 5.5.5.0 495 0x80000001 4::/64**R6#show ipv6 ospf interface**FastEthernet1/0 is up, line protocol is up Link Local Address FE80::2, Interface ID 3 Area 0, Process ID 10, Instance ID 0, Router ID 6.6.6.0 Network Type BROADCAST, Cost: 1 Transmit Delay is 1 sec, State DR, Priority 1 Designated Router (ID) 6.6.6.0, local address FE80::2 Backup Designated router (ID) 5.5.5.0, local address FE80::1 Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5 Hello due in 00:00:06 Graceful restart helper support enabled Index 1/2/2, flood queue length 0 Next 0x0(0)/0x0(0)/0x0(0) Last flood scan length is 0, maximum is 2 Last flood scan time is 0 msec, maximum is 0 msec Neighbor Count is 1, Adjacent neighbor count is 1 Adjacent with neighbor 5.5.5.0 (Backup Designated Router) Suppress hello for 0 neighbor(s)FastEthernet0/0 is up, line protocol is up Link Local Address FE80::1, Interface ID 2 Area 0, Process ID 10, Instance ID 0, Router ID 6.6.6.0 Network Type BROADCAST, Cost: 1 Transmit Delay is 1 sec, State BDR, Priority 1 Designated Router (ID) 7.7.7.0, local address FE80::2 Backup Designated router (ID) 6.6.6.0, local address FE80::1 Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5 Hello due in 00:00:09 Graceful restart helper support enabled Index 1/1/1, flood queue length 0 Next 0x0(0)/0x0(0)/0x0(0) Last flood scan length is 1, maximum is 5 Last flood scan time is 0 msec, maximum is 0 msec Neighbor Count is 1, Adjacent neighbor count is 1 Adjacent with neighbor 7.7.7.0 (Designated Router) Suppress hello for 0 neighbor(s)**R6#show ipv6 ospf neighbor** OSPFv3 Router with ID (6.6.6.0) (Process ID 10)Neighbor ID Pri State Dead Time Interface ID Interface5.5.5.0 1 FULL/BDR 00:00:31 2 FastEthernet1/07.7.7.0 1 FULL/DR 00:00:26 3 FastEthernet0/0

Router 7

**R7#show running-config**no service timestamps debug uptimeno service timestamps log uptimehostname R7boot-start-markerboot-end-markerno aaa new-modelno ip icmp rate-limit unreachableip cefno ip domain lookupipv6 unicast-routingipv6 cefmultilink bundle-name authenticatedip tcp synwait-time 5interface Loopback0 no ip address ipv6 address 7::1/64 ipv6 ospf 10 area 0interface FastEthernet0/0 no ip address shutdown duplex fullinterface FastEthernet1/0 ip address 10.10.10.22 255.255.255.252 speed auto duplex auto ipv6 address FE80::2 link-local ipv6 address 6::2/64 ipv6 ospf 10 area 0interface FastEthernet1/1 no ip address shutdown speed auto duplex autointerface FastEthernet2/0 no ip address shutdown speed auto duplex autointerface FastEthernet2/1 no ip address shutdown speed auto duplex autointerface FastEthernet3/0 no ip address shutdown duplex fullinterface FastEthernet4/0 no ip address shutdown duplex fullrouter ospf 10 router-id 7.7.7.7 network 10.10.10.20 0.0.0.3 area 0ip forward-protocol ndip flow-export version 9no ip http serverno ip http secure-serveripv6 router ospf 10 router-id 7.7.7.0control-planeline con 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line aux 0 exec-timeout 0 0 privilege level 15 logging synchronous stopbits 1line vty 0 4 loginend**R7#show ipv6 route**IPv6 Routing Table - default - 10 entriesCodes: C - Connected, L - Local, S - Static, U - Per-user Static route B - BGP, R - RIP, H - NHRP, 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, l - LISPOE2 1::/64 [110/1] via FE80::1, FastEthernet1/0OE2 2::/64 [110/1] via FE80::1, FastEthernet1/0OE2 3::/64 [110/1] via FE80::1, FastEthernet1/0OE2 4::/64 [110/20] via FE80::1, FastEthernet1/0O 5::/64 [110/2] via FE80::1, FastEthernet1/0C 6::/64 [0/0] via FastEthernet1/0, directly connectedL 6::2/128 [0/0] via FastEthernet1/0, receiveC 7::/64 [0/0] via Loopback0, directly connectedL 7::1/128 [0/0] via Loopback0, receiveL FF00::/8 [0/0] via Null0, receive**R7#show ipv6 ospf database** OSPFv3 Router with ID (7.7.7.0) (Process ID 10) Router Link States (Area 0)ADV Router Age Seq# Fragment ID Link count Bits 5.5.5.0 740 0x80000002 0 1 E 6.6.6.0 737 0x80000003 0 2 None 7.7.7.0 743 0x80000002 0 1 None Net Link States (Area 0)ADV Router Age Seq# Link ID Rtr count 6.6.6.0 741 0x80000001 3 2 7.7.7.0 743 0x80000001 3 2 Link (Type-8) Link States (Area 0)ADV Router Age Seq# Link ID Interface 6.6.6.0 780 0x80000002 2 Fa1/0 7.7.7.0 778 0x80000002 3 Fa1/0 Intra Area Prefix Link States (Area 0)ADV Router Age Seq# Link ID Ref-lstype Ref-LSID 6.6.6.0 741 0x80000001 3072 0x2002 3 7.7.7.0 743 0x80000003 0 0x2001 0 7.7.7.0 743 0x80000001 3072 0x2002 3 Type-5 AS External Link StatesADV Router Age Seq# Prefix 5.5.5.0 758 0x80000001 1::/64 5.5.5.0 758 0x80000001 2::/64 5.5.5.0 758 0x80000001 3::/64 5.5.5.0 613 0x80000001 4::/64**R7#show ipv6 ospf interface**Loopback0 is up, line protocol is up Link Local Address FE80::C803:46FF:FED4:0, Interface ID 10 Area 0, Process ID 10, Instance ID 0, Router ID 7.7.7.0 Network Type LOOPBACK, Cost: 1 Loopback interface is treated as a stub HostFastEthernet1/0 is up, line protocol is up Link Local Address FE80::2, Interface ID 3 Area 0, Process ID 10, Instance ID 0, Router ID 7.7.7.0 Network Type BROADCAST, Cost: 1 Transmit Delay is 1 sec, State DR, Priority 1 Designated Router (ID) 7.7.7.0, local address FE80::2 Backup Designated router (ID) 6.6.6.0, local address FE80::1 Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5 Hello due in 00:00:05 Graceful restart helper support enabled Index 1/2/2, flood queue length 0 Next 0x0(0)/0x0(0)/0x0(0) Last flood scan length is 0, maximum is 5 Last flood scan time is 0 msec, maximum is 0 msec Neighbor Count is 1, Adjacent neighbor count is 1 Adjacent with neighbor 6.6.6.0 (Backup Designated Router) Suppress hello for 0 neighbor(s)**R7#show ipv6 ospf neighbor** OSPFv3 Router with ID (7.7.7.0) (Process ID 10)Neighbor ID Pri State Dead Time Interface ID Interface6.6.6.0 1 FULL/BDR 00:00:38 2 FastEthernet1/0

Problems

The first problem I encountered was setting up EIGRPv6. I assigned all the IPs on the correct interfaces and did a basic setup on every router. I assumed EIGRPv6 would be configured like OSPFv3 (something I’ve done in the past) by means of advertising a network in *interface-configuration mode*. Sure enough, there was a command strikingly just like in OSPFv3: *ipv6 eigrp [instance]*. After confirming with some cisco documentation, I enabled EIGRPv6 in interface-configuration mode and defined the respective EIGRP routers in IPv6. My EIGRPv6 network was active.

Next came OSPFv3 – which I configured incorrectly but did not realize it at the time – and finally BGPv6. BGPv6 was something new to me, so I had to find some resources that explained the basics. I learnt about *address-families*, which are spaces to write protocol-related configurations. For example, BGP requires the admin to enter *the IPv4 address-family* to configure IPv4 content.

There were two issues I had while configuring BGPv6: establishing neighbors and advertising IPv6 networks. I wanted to use *link-local* addresses as my neighbor interfaces. The documentation claimed it was possible by adding a “%” sign at the end of an address, for example, *neighbor fe80::2% remote-as 20*, but I got the error *“create a peer-group first”* instead. I couldn’t find anything regarding peer groups, so I settled on using the global address of the interface.

Even with the proper network and neighbor statements, the routes would still not advertise. No neighbor adjacencies would form, and so no packets could travel across my BGPv6 network. Finally, I stumbled on a command that could solve my issue: *no BGP default ipv4-unicast*. By default, only IPv4 is advertised, regardless of other BGP configuration. I implemented the command on my BGP routers.

Now everything should work. BGP was working, and I was sure I had configured OSPF and EIGRP correctly. But part of my network was down; something was wrong with OSPFv3. I narrowed down the problem to reveal that OSPFv3 neighbor adjacencies were not forming. The link state databases weren’t updating and my debug logs displayed *“area BACKBONE(0) (Inactive)”*. I troubleshooted the *“area BACKBONE(0) (Inactive)”* error and found others with similar issues, except these articles dated back a decade and were in IPv4. There was no solution in any on the old forums.

I double checked the interfaces and addresses of my routers; all were configured correctly according to the topology. I added IPv6 router ids to no avail and power cycled all the routers. There was one more trick up my sleeve: I had another cisco router IOS, the 7200 series. I was currently using the 3600s. My final attempt to fix the adjacencies would be to switch to the 7200s. I disliked this solution, as it seemed unrealistic in reality: you would have to upgrade the hardware which meant spending a lot of money. Luckily, I’m using an emulator, so I did not have to worry about the cost. I configured OSPFv3 on the 7200 series routers the same as it was on the 3600 series IOS, and it worked.

Conclusion

In this lab, I configured BGP, OSPF and EIGRP with IPv6. While it was not the main focus, I also got to learn GNS3 and virtual networking. This lab produced far more problems than I expected, but that was only natural due to the transition from packet tracer to GNS3. Many of these problems are ones I would have faced in the real world since GNS3 is an emulation program. If there is one piece of advice for anyone routing IPv6 in BGP, it would be remembering to add the *no bgp default ipv4-unicast* statement, which is basically BGP’s equivalent of *ipv6 unicast-routing*.