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Configuring IPv6 BGP

in GNS3

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*Author*:

Gabriel Rosas



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

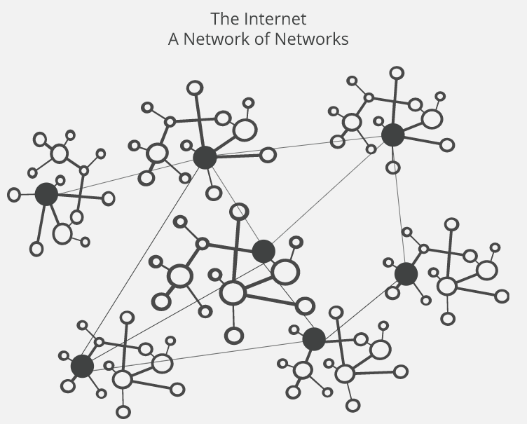
Routing is a significant process in networking, as it allows hosts on different IP networks to connect to each other. **BGP** is a routing protocol simplifying the process of creating routes by using algorithms to figure out the directions automatically. In networking, **routes** are ultimately just **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, perhaps going through a forest. The directions are set in stone; the directions can’t be altered unless they are manually redrawn. Let’s suppose you are following those directions by carriage through a forest but get stuck because there is a fallen tree or a broken bridge across a river. You are now lost and there is nowhere else to go.

However, this time you’ve got a compass that changes direction based on updates it gets from the current situation, allowing you to navigate more flexibly. It might take a bit longer on this path than as the crow flies, but you avoid rivers and rough terrain. Thus, is the magic of routing protocols— automatic updates and directions, not unlike google maps, but for packets.

Border Gateway Protocol

*BGP* (Border Gateway Protocol) is the most popular 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. To qualify for an ASN, one needs proof of a unique routing policy, knowledge on how to link autonomous systems, and a plentiful quantity of hosts. There is no point in creating a kingdom with only a handful of hosts. If you satisfy these rules, then the closest *regional internet registry* (RIR), may delegate you an ASN.

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. This is often why we see iBGP 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.

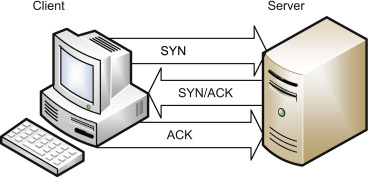
How does BGP function?

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 their 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 continues to the *OpenSent* state. If the results are unsuccessful, BGP continues to 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 transition back 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 the keepalive messages become 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 being 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. However, we did have Gateway Gateway Protocol (GGP), a protocol that was not only fabulously named, but a slightly more advanced version of an outdated IGP we have today (RIP). Back then, routers were known as gateways, explaining the redundancy in the name.

GGP 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.

Even so, engineers foresaw a fundamental problem with EGP: the inability to detect routing loops. If a topology was configured incorrectly and a router drops, 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 a big problem that these three BGPs all shared. They only supported *classful* addressing. This meant that each network could only have one of three prefix sizes: 255, 65535, or 16777215 (the number of hosts). If I wanted one network that could support 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 of the 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. Even today, the internet is still running the very same BGP-4.

Lab 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 virtually be placed in a straight line, sectioned off into three networks by the different routing protocols. If you’re wondering why this sounds so familiar, it’s because this was the topology of my previous lab. The difference here is the support of IPv6 routing.

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 and running interfaces, 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, the OSPF protocol supporting 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. 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 statement commands,* just statements written in an interface. 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 own more specific benefits.

After the IGPs were routing within their small domains, it was time to set up BGP. Initially learning BGP was a little confusing, navigating around the *address-families* and such, but I’ve grown to like it more than OSPF or EIGRP. If I wanted to configure OSPF on an interface, but not automatically add that network to the routing tables, I wouldn’t know where to begin. I don’t think that’s possible in OSPF. However, BGP has separate commands for both adjacencies and network advertisement, giving the admin more control over their network. Eventually, I got eBGPv6 running with full redistribution between OSPF and EIGRP.

Lab commands

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

* Enables configuration on a specific interface.

// OSPFv3

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

* Enables configuration for OSPFv3.

It is good practice for the process ID to be the same, however isn’t necessary for OSPF to form adjacencies; process ID is only locally significant. Each OSPF process retains a different routing table, so depending on the configuration, process ID could determine what routes are redistributed. A router can have 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(config-if)# **ipv6 ospf [*process id*] area [*number*]**

* Activates OSPFv3 under a specific interface.

This command is typed when in interface configuration mode. It is good practice for the process ID to be the same, however isn’t necessary for OSPF to form adjacencies; process ID is only locally significant. Each OSPF process retains a different routing table, so depending on the configuration, process ID could determine what routes are redistributed. A router can have multiple OSPF processes but will contain a separate OSPF database per process. Routers in a particular area share a complete topological database and have route summaries of external areas.

// EIGRPv6

Router(config)# **router bgp <autonomous system number>**

Enables configuration for bgp. The autonomous system number is a numerical value that identifies a network on the internet. iBGP uses the same ASN but eBGP must use different ASNs. In this lab I use eBGP, so all my ASNs are different.

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

This command is very important for BGPv6, as it enables advertising for IPv6 routes along with IPv4 routes. By default, only IPv4 routes are broadcasted.

Router(config-router)# **address-family ipv6**

Enters configuration mode for IPv6 BGP address families. This is where redistribution, network statements or activation commands take place.

Router(config-router-af)# **network <IPv6 network address> \*(Ex. 1::/64)**

Specifies a directly connected network on the router that will be broadcasted to other BGP routers similarly to OSPF network statements. However, to form an adjacency with another BGP router, you also need a neighbor statement.

Router(config-router)# **neighbor <IPv6 address> remote-as <neighbor’s ASN>**

Used in forming BGP neighbor adjacencies. Unlike network statements, this command takes a host address (not a network address) of the neighbor’s connected interface. The second argument is for the neighbors ASN.

Router(config-router-af)# **neighbor <IPv6 address> activate**

Enables the exchange of an address with a BGP neighbor.

Router(config)# **ipv6 router ospf <process id>**

Enables configuration for OSPFv3. The process ID is a numerical value that determines what information you want your router to share with other routers on its area. If the process ID is the same on two routers, then both routers will share the same database. If they are different, then the routers will contain multiple OSPF databases.

Router(config-if)# **ipv6 ospf <process id> area <number>**

Activates OSPFv3 for a specific network. This command is typed after you enter router OSPF configuration mode. The area number limits the scope of route information distribution. This means routers on the same area share a complete topological database, whereas routers on different areas share a route summarization.

Router(config)# **ipv6 router eigrp <instance>**

Enables EIGRPv6 of a particular instance on the router. The process ID is a numerical value that determines the instance of EIGRP that will run on a router. There can be multiple instances of EIGRP running on a router, however, adjacent routers will only communicate if they are using the same process ID.

Router(config-if)# **ipv6 eigrp <instance>**

Activates EIGRPv6 on the interface being currently configured. This command is typed after you enter interface configuration mode.

Router(config-router)# **redistribute ospf <process id>**

Redistributes OSPF routes into an BGP network. The process ID must be set to the process ID of the OSPF network for routes in the process to be distributed. This command is necessary for exchanging information when the router is running both OSPF and BGP.

Router(config-router)# **redistribute eigrp <instance>**

Redistributes EIGRP routes into an BGP network. The instance number must be set to the instance of the EIGRP network for routes in the instance to be distributed. This command is necessary for exchanging information when the router is running both EIGRP and BGP.

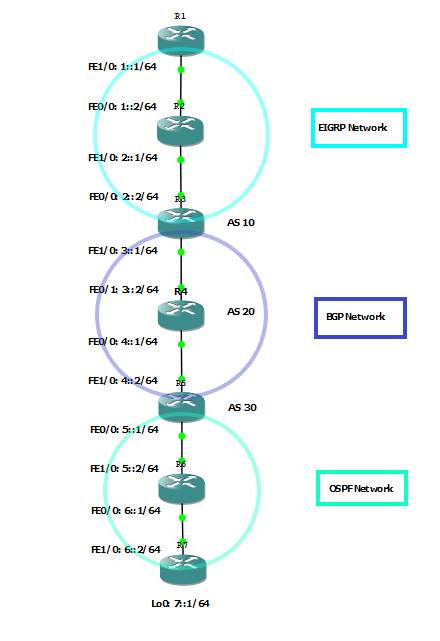
Router(config-router)# **redistribute bgp <ASN> metric <eigrp metric>**

If typed in the EIGRP router interface, this command redistributes BGP routes into an EIGRP network. To distribute the EIGRP routes correctly, the ASN must match the ASN BGP is running under. The metric argument specifies the metrics that the newly distributed routes will have.

Router(config-router)# **redistribute bgp <ASN>**

If typed in the OSPF router interface, this command redistributes BGP routes into an OSFP network. To distribute the OSPF routes correctly, the ASN must match the ASN BGP is running under.

Network Diagram



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 full**interface 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 10**interface 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-server**ipv6 router eigrp 10 eigrp router-id 1.1.1.0**control-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 5**interface 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 10**interface 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-server**ipv6 router eigrp 10 eigrp router-id 2.2.2.0**control-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 5**interface 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 enable**interface 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 3.3.3.3**router 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-family**ip forward-protocol ndip flow-export version 9no ip http serverno ip http secure-server**ipv6 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 5**interface 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-local**interface 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 auto**router 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-family**no 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 5**interface 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::2/64**interface 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 0**router 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-family**ip forward-protocol ndip flow-export version 9no ip http serverno ip http secure-server**ipv6 router ospf 10 router-id 5.5.5.0 redistribute connected redistribute bgp 30**control-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 5**interface 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 0**interface 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-server**ipv6 router ospf 10 router-id 6.6.6.0**control-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 full**interface 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 0**interface 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-server**ipv6 router ospf 10 router-id 7.7.7.0**control-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’d assigned all of the IPs on the correct interfaces and had done a very basic setup on every router. I assumed EIGRPv6 would be configured in a way like OSPFv3 (something I’ve done in the past), which means activating it under an interface. Sure enough, there was a command strikingly similar to OSPFv3: ipv6 eigrp *instance*. After confirming with some cisco documentation I found online, I enabled EIGRPv6 and set up the IPv6 EIGRP routers with some router IDs. My EIGRPv6 network was online. Then came OSPFv3 – which I thought I configured correctly – and finally BGPv6. BGPv6 was something new to me, so I had to find some good articles and sources explaining how to configure it. I learnt about address-families, a feature in BGP used to group different types of traffic that BGP can broadcast. For example, IPv4 or IPv6 advertisement traffic. There were two issues I had whilst configuring BGPv6: determining the neighbors and advertising the IPv6 routes. I wanted to use link local addresses as the addresses to establish neighbors. The documentation claimed it was possible by adding a % sign at the end of my address such that *neighbor fe80::2% remote-as 20* would be a valid statement, but I kept getting the error message to “create a peer-group first”. I couldn’t find anything immediately useful on finding what a peer group was, so I settled on just using the global address of the interface. There was not really a good reason to figure out the whole peer group when the global address worked just fine. After all the network and neighbor statements were made, the routes would just not advertise. No neighbors were made, and no packets could travel across my BGPv6 network. I flew from source to source and tried a variety of different configurations. Finally, I stumbled on what I was looking for: “no BGP default ipv4-unicast”. Apparently by default only IPv4 is advertised, so even though I had gotten everything else right, nothing would be broadcasted. On paper it seems quite silly, but I spent a couple head-mashing hours figuring out what was wrong. Now everything should work. But it didn’t. Something was wrong with OSPFv3- the routes weren’t distributing. I narrowed down the cause to being OSPFv3 neighbor adjacencies that weren’t forming. The databases weren’t updating, and kept displaying *Area BACKBONE(0) (Inactive)*. After intensive research on the problem *Area BACKBONE(0) (Inactive)*, I found nothing useful because most of the problems other people had were in IPv4 and were a decade old. I had to manually find the problem. I checked my interfaces and addresses- all were configured correctly according to the topology, I added IPv6 router IDs- to no avail, and power cycled all the routers. I had two cisco router IOS’s in my arsenal: the 3600 and the 7200. I was currently using the 3600. My final attempt to fix the adjacencies would be to switch to the 7200s. I disliked this solution, as it seemed unhelpful in real life: you’d have to upgrade the hardware which means spending a lot of money. Luckily, I’m using an emulator, so I didn’t have to pay a dime. I configured OSPFv3 exactly the same way it was on the other IOS, and it worked.

Conclusion

In this lab I configured IPv6 BGP, OSPF and EIGRP. A bonus was learning how to navigate GNS3. I obviously thought there were things that would go wrong, but problems in this lab were definitely more tedious than usual to fix. Overall, I’m proud of how smoothly EIGRP went and that I troubleshooted most problems of my own accord. If there’s one piece of advice I’d give for anyone configuring BGPv6, it would be to remember to configure a *no bgp default ipv4-unicast* statement. It’s basically the BGP equivalent of an ipv6 unicast-routing.

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| **Useful sources:**  <https://www.cisco.com/c/en/us/support/docs/ip/enhanced-interior-gateway-routing-protocol-eigrp/113267-eigrp-ipv6-00.html>  <https://www.mustbegeek.com/configure-ebgp-in-cisco-ios-router/#.X8WEpmhKiUk>  <https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/iproute_bgp/configuration/xe-16/irg-xe-16-book/ipv-routing-multiprotocol-bgp-link-local-address-peering.html>  <https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/iproute_bgp/configuration/15-mt/irg-15-mt-book/ip6-mbgp-ext.html> |