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iBGP

with loopbacks

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*Author*:

Gabriel Rosas



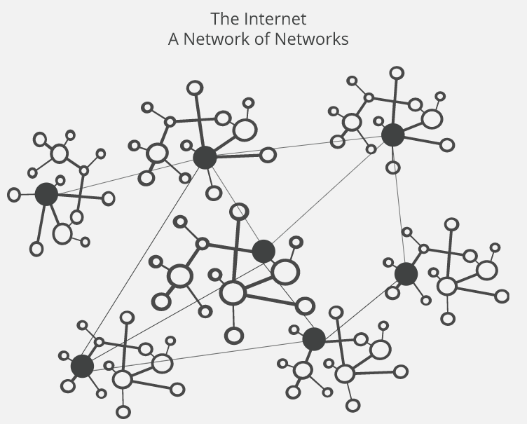
Purpose

The purpose of this lab was to configure internal BGP using the neighbor’s loopback addresses as the interface to form adjacencies. Since BGP is the main contributor in the miracle that is the internet, it was useful to learn each aspect of BGP and how it played a role in contributing to the internet.

Background Information

What is BGP?

*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.

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.

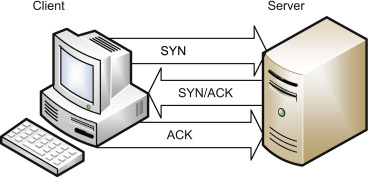
How does BGP function?

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

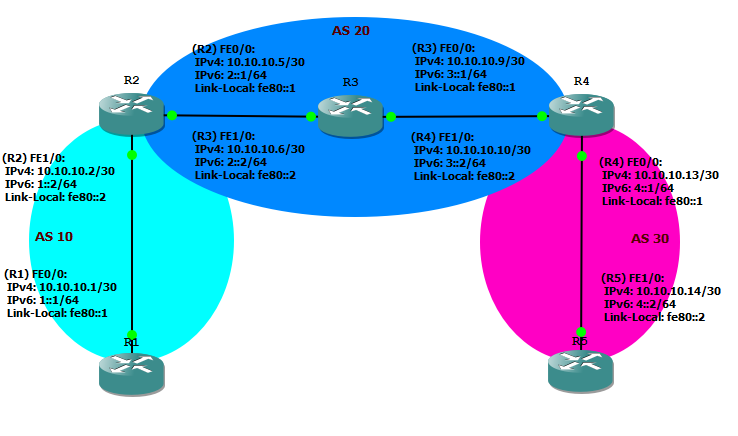
In the beginnings of the internet there was no BGP. Instead, there was *Gateway Gateway Protocol* (GGP), a brilliantly named protocol and a slightly more advanced version of an outdated protocol we have today – *Router Information Protocol* (RIP). Back then, routers were known as gateways, explaining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

I began by creating a topology that would house my five virtual Cisco 7200 series routers. For each serial interface of every router, I devised an appropriate IP scheme mainly consisting of */30* subnets, chaining together the five routers. Since the purpose of this project was to use *loopback* interfaces to establish connections between the BGP peers, I configured one loopback per router. The loopbacks act as neighbor interfaces for adjacent routers. After *IPv4* was complete, I did the same for *IPv6*.

The next step was configuring the routing protocol, BGP. I decided to take a plunge in the deep end and started implementing iBGP first; having configured eBGP in previous projects, I had a fair understanding of the concepts, but had yet to touch iBGP. iBGP needs to be configured in a mesh-like topology, where every router is a neighbor with the others on the network. The problem arises when neighbors are not directly connected, for example, like router 3 and 5 in my topology. These routers are not directly connected, so, ironically, I would need to implement an *underlaying* routing protocol for iBGP to “become aware” of every router. Kind of funny how iBGP, a routing protocol, needs the support of another routing protocol (or just static routes) to operate.

I chose to use OSPF as my “intermediary” routing protocol for iBGP. Luckily, the actual configuration for iBGP was much like eBGP, so I did not have many problems once OSPF was set up. Before I enabled the loopbacks to act as the neighbors, I wanted to test my iBGP network with the physical interfaces. I configured iBGP routing on the internal portion of the network using physical interfaces as my neighbor interfaces. I could ping throughout the iBGP network, inspiring confidence that the loopbacks would work once I made the transition.

After fixing a conflicting addressing problem caused by my loopback addresses and reworking the IP scheme, I began switching the iBGP neighbors to the loopback interfaces. Once iBGP was configured with the loopback interfaces, I moved to enabling the eBGP part of the network. I used static routing so the eBGP loopback interfaces were “aware” of each other instead of a routing protocol like with the iBGP network. With iBGP and eBGP pinging correctly in *IPv4*, I did the same for *IPv6*.

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 [*type*] [*interface number*]**

* Enter interface configuration mode

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

* Enter router configuration mode for BGP

*The ASN specifies the autonomous system of the router. This will determine whether the router is part of an iBGP or eBGP network.*

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

* Enables advertising for IPv6 routes

*By default, BGP only enables the IPv4 address-family.*

Router(config-router)# **address-family [*protocol*]** *vrf <vrf name>*

* Enters configuration mode for a BGP address family

*I like to think of address-families as workspaces for certain IP protocols. For example, IPv6 is configured in the IPv6 address family. This is where redistribution, network statements or activation commands occur.*

Router(config-router-af)# **neighbor [*ip 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* correct IP and ASN of their neighbor*.*

Router(config-router-af)# **network [*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 network statements; 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.*

Router(config-router)# **neighbor [*ip*] update-source [*interface id*]**

* Specifies the interface of the neighbor that will act as the BGP neighbor

Forces the router to use a specific interface when exchanging IPv4 BGP updates with another router rather than using the directly connected interface by default. Unlike network statements, this command takes a host address (not a network address). The second argument is for an interface on the neighboring BGP router which will be used instead of the directly connected interface, such as a loopback interface.

Router(config-router)# **neighbor *IPv6-address* update-source *Interface***

Forces the router to use a specific interface when exchanging IPv6 BGP updates with another router rather than using the directly connected interface by default. Unlike network statements, this command takes a host address (not a network address). The second argument is for an interface on the neighboring BGP router which will be used instead of the directly connected interface, such as a loopback interface.

Router(config-router)# **neighbor *IPv4-address* ebgp-multihop *0-255***

Helps connect IPv4 eBGP peers that aren’t directly connected. By default, this value is 1, which enables code that checks if the peer is directly connected or not. Since the idea is to peer using loopback address, which are not directly connected, a value greater than 1 must be set to disable the code that checks for the peer being a directly connected neighbor.

Router(config-router)# **neighbor *IPv6-address* ebgp-multihop *0-255***

Helps connect IPv6 eBGP peers that aren’t directly connected. By default, this value is 1, which enables code that checks if the peer is directly connected or not. Since the idea is to peer using loopback address, which are not directly connected, a value greater than 1 must be set to disable the code that checks for the peer being a directly connected neighbor.

Router(config-router)# **address-family *IPv4***

Enters configuration mode for specified IPv4 BGP address families. This is where redistribution, network statements or activation commands take place.

Router(config-router)# **address-family *IPv6***

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

Router(config-router-af)# **network *IPv4-network-address* / *subnet-mask***

Specifies a directly connected IPv4 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-af)# **network *IPv6-network-address* / *subnet-mask***

Specifies a directly connected IPv6 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-af)# **neighbor *IPv4-address* activate**

Enables the exchange of an IPv4 address with a BGP neighbor.

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

Enables the exchange of an IPv6 address with a BGP neighbor.

Configurations

Router 1

**R1#show running-config**hostname R1boot-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 ip address 100.10.10.10 255.255.255.255 ipv6 address 10::1/64interface FastEthernet0/0 ip address 10.10.10.1 255.255.255.252 duplex full ipv6 address FE80::1 link-local ipv6 address 1::1/64router bgp 10 bgp log-neighbor-changes no bgp default ipv4-unicast neighbor 20::1 remote-as 20 neighbor 20::1 ebgp-multihop 2 neighbor 20::1 update-source Loopback0 neighbor 20.20.20.20 remote-as 20 neighbor 20.20.20.20 ebgp-multihop 2 neighbor 20.20.20.20 update-source Loopback0 address-family ipv4 network 10.10.10.0 mask 255.255.255.252 network 100.10.10.10 mask 255.255.255.255 neighbor 20.20.20.20 activate exit-address-family address-family ipv6 redistribute static network 1::/64 network 10::1/128 neighbor 20::1 activate exit-address-familyip forward-protocol ndno ip http serverno ip http secure-serverip route 20.20.20.20 255.255.255.255 FastEthernet0/0ipv6 route 20::1/128 FastEthernet0/0 1::2ipv6 route 20::/64 FastEthernet0/0control-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 ip route**Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, \* - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP + - replicated route, % - next hop overrideGateway of last resort is not set 10.0.0.0/8 is variably subnetted, 5 subnets, 2 masksC 10.10.10.0/30 is directly connected, FastEthernet0/0L 10.10.10.1/32 is directly connected, FastEthernet0/0B 10.10.10.4/30 [20/0] via 20.20.20.20, 00:07:16B 10.10.10.8/30 [20/2] via 20.20.20.20, 00:07:16B 10.10.10.12/30 [20/0] via 20.20.20.20, 00:07:16 20.0.0.0/32 is subnetted, 1 subnetsS 20.20.20.20 is directly connected, FastEthernet0/0 30.0.0.0/32 is subnetted, 1 subnetsB 30.30.30.30 [20/2] via 20.20.20.20, 00:07:16 40.0.0.0/32 is subnetted, 1 subnetsB 40.40.40.40 [20/3] via 20.20.20.20, 00:07:16 50.0.0.0/32 is subnetted, 1 subnetsB 50.50.50.50 [20/0] via 20.20.20.20, 00:07:16 100.0.0.0/32 is subnetted, 1 subnetsC 100.10.10.10 is directly connected, Loopback0**R1#show ipv6 route**IPv6 Routing Table - default - 13 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::1/128 [0/0] via FastEthernet0/0, receiveB 2::/64 [20/0] via 20::1B 3::/64 [20/2] via 20::1B 4::/64 [20/0] via 20::1C 10::/64 [0/0] via Loopback0, directly connectedL 10::1/128 [0/0] via Loopback0, receiveS 20::/64 [1/0] via FastEthernet0/0, directly connectedS 20::1/128 [1/0] via 1::2, FastEthernet0/0B 30::1/128 [20/1] via 20::1B 40::1/128 [20/2] via 20::1B 50::1/128 [20/0] via 20::1L FF00::/8 [0/0] via Null0, receive**R1#show ip bgp ipv4 unicast topology \***For address family: IPv4 UnicastBGP table version is 10, local router ID is 100.10.10.10Status 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 \* 10.10.10.0/30 20.20.20.20 0 0 20 i \*> 0.0.0.0 0 32768 i \*> 10.10.10.4/30 20.20.20.20 0 0 20 ? \*> 10.10.10.8/30 20.20.20.20 2 0 20 ? \*> 10.10.10.12/30 20.20.20.20 0 20 i r> 20.20.20.20/32 20.20.20.20 0 0 20 i \*> 30.30.30.30/32 20.20.20.20 2 0 20 ? \*> 40.40.40.40/32 20.20.20.20 3 0 20 ? \*> 50.50.50.50/32 20.20.20.20 0 20 i \* 100.10.10.10/32 20.20.20.20 0 0 20 i \*> 0.0.0.0 0 32768 i**R1#show ip bgp ipv4 unicast neighbors**BGP neighbor is 20.20.20.20, remote AS 20, external link BGP version 4, remote router ID 20.20.20.20 BGP state = Established, up for 00:08:26 Last read 00:00:47, last write 00:00:08, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 2 6 Keepalives: 10 9 Route Refresh: 0 0 Total: 13 16 Default minimum time between advertisement runs is 30 seconds For address family: IPv4 Unicast Session: 20.20.20.20 BGP table version 10, neighbor version 10/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 2 9 (Consumes 720 bytes) Prefixes Total: 2 9 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 7 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 7 n/a Total: 7 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 20.20.20.20 Connections established 1; dropped 0 Last reset never External BGP neighbor may be up to 2 hops away. Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 2Local host: 100.10.10.10, Local port: 179Foreign host: 20.20.20.20, Foreign port: 35632Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x804A8):Timer Starts Wakeups NextRetrans 13 1 0x0TimeWait 0 0 0x0AckHold 11 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 175411824 snduna: 175412155 sndnxt: 175412155 sndwnd: 16054irs: 2521166 rcvnxt: 2521706 rcvwnd: 15845 delrcvwnd: 539SRTT: 231 ms, RTTO: 769 ms, RTV: 538 ms, KRTT: 1538 msminRTT: 48 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 23 (out of order: 0), with data: 11, total data bytes: 539Sent: 22 (retransmit: 1 fastretransmit: 0),with data: 12, total data bytes: 330**R1#show ip bgp ipv6 unicast neighbors**BGP neighbor is 20::1, remote AS 20, external link BGP version 4, remote router ID 20.20.20.20 BGP state = Established, up for 00:08:28 Last read 00:00:35, last write 00:00:23, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 3 7 Keepalives: 10 9 Route Refresh: 0 0 Total: 14 17 Default minimum time between advertisement runs is 30 seconds For address family: IPv6 Unicast Session: 20::1 BGP table version 12, neighbor version 12/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 4 10 (Consumes 1040 bytes) Prefixes Total: 4 10 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 7 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 7 n/a Total: 7 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 20::1 Connections established 1; dropped 0 Last reset never External BGP neighbor may be up to 2 hops away. Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 2Local host: 10::1, Local port: 179Foreign host: 20::1, Foreign port: 19443Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x80980):Timer Starts Wakeups NextRetrans 12 0 0x0TimeWait 0 0 0x0AckHold 12 10 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 306007271 snduna: 306007734 sndnxt: 306007734 sndwnd: 15922irs: 382103485 rcvnxt: 382104261 rcvwnd: 15609 delrcvwnd: 775SRTT: 244 ms, RTTO: 698 ms, RTV: 454 ms, KRTT: 0 msminRTT: 48 ms, maxRTT: 420 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 24 (out of order: 0), with data: 12, total data bytes: 775Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 23, total data bytes: 1390

Router 2

**R2#show running-config**hostname R2boot-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 ip address 20.20.20.20 255.255.255.255 ipv6 address 20::1/64 ipv6 ospf 20 area 20interface FastEthernet0/0 ip address 10.10.10.5 255.255.255.252 duplex full ipv6 address FE80::1 link-local ipv6 address 2::1/64 ipv6 ospf 20 area 20interface FastEthernet1/0 ip address 10.10.10.2 255.255.255.252 speed auto duplex auto ipv6 address FE80::2 link-local ipv6 address 1::2/64router ospf 10 router-id 2.2.2.2 network 10.10.10.4 0.0.0.3 area 0 network 20.20.20.20 0.0.0.0 area 0router bgp 20 bgp log-neighbor-changes no bgp default ipv4-unicast neighbor 10::1 remote-as 10 neighbor 10::1 ebgp-multihop 2 neighbor 10::1 update-source Loopback0 neighbor 30::1 remote-as 20 neighbor 30::1 update-source Loopback0 neighbor 40::1 remote-as 20 neighbor 40::1 update-source Loopback0 neighbor 30.30.30.30 remote-as 20 neighbor 30.30.30.30 update-source Loopback0 neighbor 40.40.40.40 remote-as 20 neighbor 40.40.40.40 update-source Loopback0 neighbor 100.10.10.10 remote-as 10 neighbor 100.10.10.10 ebgp-multihop 2 neighbor 100.10.10.10 update-source Loopback0 address-family ipv4 network 10.10.10.0 mask 255.255.255.252 network 20.20.20.20 mask 255.255.255.255 network 100.10.10.10 mask 255.255.255.255 redistribute ospf 10 match internal external 1 external 2 neighbor 30.30.30.30 activate neighbor 40.40.40.40 activate neighbor 100.10.10.10 activate exit-address-family address-family ipv6 redistribute ospf 20 match internal external 1 external 2 redistribute static network 1::/64 network 2::/64 network 10::1/128 network 20::1/128 neighbor 10::1 activate neighbor 30::1 activate neighbor 40::1 activate exit-address-familyip forward-protocol ndno ip http serverno ip http secure-serverip route 100.10.10.10 255.255.255.255 FastEthernet1/0ipv6 route 10::1/128 FastEthernet1/0 1::1ipv6 route 10::/64 FastEthernet1/0ipv6 router ospf 20 router-id 20.20.20.20control-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 ip route**Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, \* - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP + - replicated route, % - next hop overrideGateway of last resort is not set 10.0.0.0/8 is variably subnetted, 6 subnets, 2 masksC 10.10.10.0/30 is directly connected, FastEthernet1/0L 10.10.10.2/32 is directly connected, FastEthernet1/0C 10.10.10.4/30 is directly connected, FastEthernet0/0L 10.10.10.5/32 is directly connected, FastEthernet0/0O 10.10.10.8/30 [110/2] via 10.10.10.6, 00:08:00, FastEthernet0/0B 10.10.10.12/30 [200/0] via 40.40.40.40, 00:07:29 20.0.0.0/32 is subnetted, 1 subnetsC 20.20.20.20 is directly connected, Loopback0 30.0.0.0/32 is subnetted, 1 subnetsO 30.30.30.30 [110/2] via 10.10.10.6, 00:08:00, FastEthernet0/0 40.0.0.0/32 is subnetted, 1 subnetsO 40.40.40.40 [110/3] via 10.10.10.6, 00:08:00, FastEthernet0/0 50.0.0.0/32 is subnetted, 1 subnetsB 50.50.50.50 [200/0] via 40.40.40.40, 00:07:29 100.0.0.0/32 is subnetted, 1 subnetsS 100.10.10.10 is directly connected, FastEthernet1/0R2#show ipv6 routeIPv6 Routing Table - default - 14 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::2/128 [0/0] via FastEthernet1/0, receiveC 2::/64 [0/0] via FastEthernet0/0, directly connectedL 2::1/128 [0/0] via FastEthernet0/0, receiveO 3::/64 [110/2] via FE80::2, FastEthernet0/0B 4::/64 [200/0] via 40::1S 10::/64 [1/0] via FastEthernet1/0, directly connectedS 10::1/128 [1/0] via 1::1, FastEthernet1/0C 20::/64 [0/0] via Loopback0, directly connectedL 20::1/128 [0/0] via Loopback0, receiveO 30::1/128 [110/1] via FE80::2, FastEthernet0/0O 40::1/128 [110/2] via FE80::2, FastEthernet0/0B 50::1/128 [200/0] via 4::2L FF00::/8 [0/0] via Null0, receive**R2#show ip bgp ipv4 unicast topology \***For address family: IPv4 UnicastBGP table version is 10, local router ID is 20.20.20.20Status 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 \* 10.10.10.0/30 100.10.10.10 0 0 10 i \*> 0.0.0.0 0 32768 i \* i 10.10.10.4/30 10.10.10.9 2 100 0 ? \*> 0.0.0.0 0 32768 ? \* i 10.10.10.8/30 40.40.40.40 0 100 0 ? \*> 10.10.10.6 2 32768 ? \*>i 10.10.10.12/30 40.40.40.40 0 100 0 i \* i 20.20.20.20/32 10.10.10.9 3 100 0 ? \*> 0.0.0.0 0 32768 i \* i 30.30.30.30/32 10.10.10.9 2 100 0 ? \*> 10.10.10.6 2 32768 ? \* i 40.40.40.40/32 40.40.40.40 0 100 0 ? \*> 10.10.10.6 3 32768 ? \*>i 50.50.50.50/32 40.40.40.40 0 100 0 i \* 100.10.10.10/32 100.10.10.10 0 0 10 i \*> 0.0.0.0 0 32768 i**R2#show ip bgp ipv4 unicast neighbors**BGP neighbor is 30.30.30.30, remote AS 20, internal link BGP version 4, remote router ID 30.30.30.30 BGP state = Established, up for 00:07:55 Last read 00:00:05, last write 00:00:07, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 5 1 Keepalives: 10 10 Route Refresh: 0 0 Total: 16 12 Default minimum time between advertisement runs is 0 seconds For address family: IPv4 Unicast Session: 30.30.30.30 BGP table version 10, neighbor version 10/0 Output queue size : 0 Index 2, Advertise bit 1 2 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 7 0 Prefixes Total: 7 0 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 0 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from iBGP peer: 2 n/a Total: 2 0 Number of NLRIs in the update sent: max 3, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 30.30.30.30 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 20.20.20.20, Local port: 31609Foreign host: 30.30.30.30, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x84080):Timer Starts Wakeups NextRetrans 13 1 0x0TimeWait 0 0 0x0AckHold 10 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0xA265CDeadWait 0 0 0x0Linger 0 0 0x0iss: 407237472 snduna: 407237982 sndnxt: 407237982 sndwnd: 15875irs: 1299635048 rcvnxt: 1299635319 rcvwnd: 16114 delrcvwnd: 270SRTT: 232 ms, RTTO: 772 ms, RTV: 540 ms, KRTT: 0 msminRTT: 40 ms, maxRTT: 312 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 270Sent: 23 (retransmit: 1 fastretransmit: 0),with data: 12, total data bytes: 509BGP neighbor is 40.40.40.40, remote AS 20, internal link BGP version 4, remote router ID 40.40.40.40 BGP state = Established, up for 00:07:54 Last read 00:00:12, last write 00:00:19, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 5 5 Keepalives: 10 10 Route Refresh: 0 0 Total: 16 16 Default minimum time between advertisement runs is 0 seconds For address family: IPv4 Unicast Session: 40.40.40.40 BGP table version 10, neighbor version 10/0 Output queue size : 0 Index 2, Advertise bit 1 2 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 7 7 (Consumes 560 bytes) Prefixes Total: 7 7 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 2 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from iBGP peer: 2 n/a Total: 2 0 Number of NLRIs in the update sent: max 3, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 40.40.40.40 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 20.20.20.20, Local port: 57069Foreign host: 40.40.40.40, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x840B4):Timer Starts Wakeups NextRetrans 13 1 0x0TimeWait 0 0 0x0AckHold 10 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0xA2A50DeadWait 0 0 0x0Linger 0 0 0x0iss: 3006581127 snduna: 3006581637 sndnxt: 3006581637 sndwnd: 15875irs: 28662226 rcvnxt: 28662736 rcvwnd: 15875 delrcvwnd: 509SRTT: 243 ms, RTTO: 776 ms, RTV: 533 ms, KRTT: 0 msminRTT: 68 ms, maxRTT: 452 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 509Sent: 23 (retransmit: 1 fastretransmit: 0),with data: 12, total data bytes: 509BGP neighbor is 100.10.10.10, remote AS 10, external link BGP version 4, remote router ID 100.10.10.10 BGP state = Established, up for 00:08:41 Last read 00:00:15, last write 00:00:02, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 6 2 Keepalives: 10 10 Route Refresh: 0 0 Total: 17 13 Default minimum time between advertisement runs is 30 seconds For address family: IPv4 Unicast Session: 100.10.10.10 BGP table version 10, neighbor version 10/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 9 2 (Consumes 160 bytes) Prefixes Total: 9 2 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 0 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Total: 0 0 Number of NLRIs in the update sent: max 3, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 100.10.10.10 Connections established 1; dropped 0 Last reset never External BGP neighbor may be up to 2 hops away. Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 2Local host: 20.20.20.20, Local port: 35632Foreign host: 100.10.10.10, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x84230):Timer Starts Wakeups NextRetrans 13 0 0x0TimeWait 0 0 0x0AckHold 11 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0x97220DeadWait 0 0 0x0Linger 0 0 0x0iss: 2521166 snduna: 2521725 sndnxt: 2521725 sndwnd: 15826irs: 175411824 rcvnxt: 175412155 rcvwnd: 16054 delrcvwnd: 330SRTT: 247 ms, RTTO: 663 ms, RTV: 416 ms, KRTT: 0 msminRTT: 40 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 24 (out of order: 0), with data: 12, total data bytes: 330Sent: 24 (retransmit: 0 fastretransmit: 0),with data: 12, total data bytes: 558R2#show ip bgp ipv6 unicast neighborsBGP neighbor is 10::1, remote AS 10, external link BGP version 4, remote router ID 100.10.10.10 BGP state = Established, up for 00:08:43 Last read 00:00:29, last write 00:00:41, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 7 3 Keepalives: 9 10 Route Refresh: 0 0 Total: 17 14 Default minimum time between advertisement runs is 30 seconds For address family: IPv6 Unicast Session: 10::1 BGP table version 12, neighbor version 12/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 10 4 (Consumes 416 bytes) Prefixes Total: 10 4 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 1 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 1 n/a Total: 1 0 Number of NLRIs in the update sent: max 4, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 10::1 Connections established 1; dropped 0 Last reset never External BGP neighbor may be up to 2 hops away. Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 2Local host: 20::1, Local port: 19443Foreign host: 10::1, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x844CC):Timer Starts Wakeups NextRetrans 13 0 0x0TimeWait 0 0 0x0AckHold 11 10 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0x96E50DeadWait 0 0 0x0Linger 0 0 0x0iss: 382103485 snduna: 382104261 sndnxt: 382104261 sndwnd: 15609irs: 306007271 rcvnxt: 306007734 rcvwnd: 15922 delrcvwnd: 462SRTT: 247 ms, RTTO: 663 ms, RTV: 416 ms, KRTT: 0 msminRTT: 56 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 462Sent: 24 (retransmit: 0 fastretransmit: 0),with data: 24, total data bytes: 1743BGP neighbor is 30::1, remote AS 20, internal link BGP version 4, remote router ID 30.30.30.30 BGP state = Established, up for 00:08:01 Last read 00:00:56, last write 00:00:31, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 7 3 Keepalives: 10 9 Route Refresh: 0 0 Total: 18 13 Default minimum time between advertisement runs is 0 seconds For address family: IPv6 Unicast Session: 30::1 BGP table version 12, neighbor version 12/0 Output queue size : 0 Index 2, Advertise bit 1 2 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 9 4 (Consumes 416 bytes) Prefixes Total: 9 4 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 0 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from iBGP peer: 2 n/a Total: 2 0 Number of NLRIs in the update sent: max 3, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 30::1 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 20::1, Local port: 179Foreign host: 30::1, Foreign port: 18015Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x84570):Timer Starts Wakeups NextRetrans 11 0 0x0TimeWait 0 0 0x0AckHold 10 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 2504308026 snduna: 2504308830 sndnxt: 2504308830 sndwnd: 15581irs: 2965554686 rcvnxt: 2965555132 rcvwnd: 15939 delrcvwnd: 445SRTT: 231 ms, RTTO: 769 ms, RTV: 538 ms, KRTT: 0 msminRTT: 44 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 22 (out of order: 0), with data: 11, total data bytes: 445Sent: 22 (retransmit: 0 fastretransmit: 0),with data: 22, total data bytes: 1691BGP neighbor is 40::1, remote AS 20, internal link BGP version 4, remote router ID 40.40.40.40 BGP state = Established, up for 00:07:51 Last read 00:00:00, last write 00:00:17, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 7 5 Keepalives: 10 10 Route Refresh: 0 0 Total: 18 16 Default minimum time between advertisement runs is 0 seconds For address family: IPv6 Unicast Session: 40::1 BGP table version 12, neighbor version 12/0 Output queue size : 0 Index 2, Advertise bit 1 2 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 9 6 (Consumes 624 bytes) Prefixes Total: 9 6 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 2 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from iBGP peer: 2 n/a Total: 2 0 Number of NLRIs in the update sent: max 3, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 40::1 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 20::1, Local port: 50210Foreign host: 40::1, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x84614):Timer Starts Wakeups NextRetrans 12 0 0x0TimeWait 0 0 0x0AckHold 10 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0xA3B44DeadWait 0 0 0x0Linger 0 0 0x0iss: 809750997 snduna: 809751801 sndnxt: 809751801 sndwnd: 15581irs: 3817979458 rcvnxt: 3817980085 rcvwnd: 15758 delrcvwnd: 626SRTT: 273 ms, RTTO: 815 ms, RTV: 542 ms, KRTT: 0 msminRTT: 52 ms, maxRTT: 696 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 626Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 23, total data bytes: 1731**R2#show ip ospf neighbor**Neighbor ID Pri State Dead Time Address Interface3.3.3.3 1 FULL/DR 00:00:35 10.10.10.6 FastEthernet0/0**R2#show ipv6 ospf neighbor** OSPFv3 Router with ID (20.20.20.20) (Process ID 20)Neighbor ID Pri State Dead Time Interface ID Interface30.30.30.30 1 FULL/DR 00:00:36 3 FastEthernet0/0

Router 3

**R3#show running-config**hostname R3boot-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 ip address 30.30.30.30 255.255.255.255 ipv6 address 30::1/64 ipv6 ospf 20 area 20interface FastEthernet0/0 ip address 10.10.10.9 255.255.255.252 duplex full ipv6 address FE80::1 link-local ipv6 address 3::1/64 ipv6 ospf 20 area 20interface FastEthernet1/0 ip address 10.10.10.6 255.255.255.252 speed auto duplex auto ipv6 address FE80::2 link-local ipv6 address 2::2/64 ipv6 ospf 20 area 20router ospf 10 router-id 3.3.3.3 network 10.10.10.4 0.0.0.3 area 0 network 10.10.10.8 0.0.0.3 area 0 network 30.30.30.30 0.0.0.0 area 0router bgp 20 bgp log-neighbor-changes no bgp default ipv4-unicast neighbor 20::1 remote-as 20 neighbor 20::1 update-source Loopback0 neighbor 40::1 remote-as 20 neighbor 40::1 update-source Loopback0 neighbor 20.20.20.20 remote-as 20 neighbor 20.20.20.20 update-source Loopback0 neighbor 40.40.40.40 remote-as 20 neighbor 40.40.40.40 update-source Loopback0 address-family ipv4 neighbor 20.20.20.20 activate neighbor 40.40.40.40 activate exit-address-family address-family ipv6 redistribute ospf 20 match internal external 1 external 2 network 2::/64 network 3::/64 neighbor 20::1 activate neighbor 40::1 activate exit-address-familyip forward-protocol ndno ip http serverno ip http secure-serveripv6 router ospf 20 router-id 30.30.30.30control-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**R3#show ip route**Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, \* - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP + - replicated route, % - next hop overrideGateway of last resort is not set 10.0.0.0/8 is variably subnetted, 6 subnets, 2 masksB 10.10.10.0/30 [200/0] via 20.20.20.20, 00:07:31C 10.10.10.4/30 is directly connected, FastEthernet1/0L 10.10.10.6/32 is directly connected, FastEthernet1/0C 10.10.10.8/30 is directly connected, FastEthernet0/0L 10.10.10.9/32 is directly connected, FastEthernet0/0B 10.10.10.12/30 [200/0] via 40.40.40.40, 00:07:31 20.0.0.0/32 is subnetted, 1 subnetsO 20.20.20.20 [110/2] via 10.10.10.5, 00:07:57, FastEthernet1/0 30.0.0.0/32 is subnetted, 1 subnetsC 30.30.30.30 is directly connected, Loopback0 40.0.0.0/32 is subnetted, 1 subnetsO 40.40.40.40 [110/2] via 10.10.10.10, 00:08:07, FastEthernet0/0 50.0.0.0/32 is subnetted, 1 subnetsB 50.50.50.50 [200/0] via 40.40.40.40, 00:07:31 100.0.0.0/32 is subnetted, 1 subnetsB 100.10.10.10 [200/0] via 20.20.20.20, 00:07:31**R3#show ipv6 route**IPv6 Routing Table - default - 15 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 [200/0] via 20::1C 2::/64 [0/0] via FastEthernet1/0, directly connectedL 2::2/128 [0/0] via FastEthernet1/0, receiveC 3::/64 [0/0] via FastEthernet0/0, directly connectedL 3::1/128 [0/0] via FastEthernet0/0, receiveB 4::/64 [200/0] via 40::1B 10::/64 [200/0] via 20::1B 10::1/128 [200/0] via 1::1B 20::/64 [200/0] via 10::1O 20::1/128 [110/1] via FE80::1, FastEthernet1/0C 30::/64 [0/0] via Loopback0, directly connectedL 30::1/128 [0/0] via Loopback0, receiveO 40::1/128 [110/1] via FE80::2, FastEthernet0/0B 50::1/128 [200/0] via 4::2L FF00::/8 [0/0] via Null0, receive**R3#show ip bgp ipv4 unicast topology \***For address family: IPv4 UnicastBGP table version is 9, 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 \*>i 10.10.10.0/30 20.20.20.20 0 100 0 i r>i 10.10.10.4/30 20.20.20.20 0 100 0 ? r>i 10.10.10.8/30 40.40.40.40 0 100 0 ? \*>i 10.10.10.12/30 40.40.40.40 0 100 0 i r>i 20.20.20.20/32 20.20.20.20 0 100 0 i r>i 40.40.40.40/32 40.40.40.40 0 100 0 ? \*>i 50.50.50.50/32 40.40.40.40 0 100 0 i \*>i 100.10.10.10/32 20.20.20.20 0 100 0 i**R3#show ip bgp ipv4 unicast neighbors**BGP neighbor is 20.20.20.20, remote AS 20, internal link BGP version 4, remote router ID 20.20.20.20 BGP state = Established, up for 00:07:58 Last read 00:00:17, last write 00:00:15, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 1 5 Keepalives: 10 10 Route Refresh: 0 0 Total: 12 16 Default minimum time between advertisement runs is 0 seconds For address family: IPv4 Unicast Session: 20.20.20.20 BGP table version 9, neighbor version 9/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 0 4 (Consumes 320 bytes) Prefixes Total: 0 4 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 4 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- NEXT\_HOP is us: n/a 3 Bestpath from this peer: 4 n/a Bestpath from iBGP peer: 4 n/a Total: 8 3 Number of NLRIs in the update sent: max 0, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 20.20.20.20 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 30.30.30.30, Local port: 179Foreign host: 20.20.20.20, Foreign port: 31609Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x85028):Timer Starts Wakeups NextRetrans 11 0 0x0TimeWait 0 0 0x0AckHold 11 10 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 1299635048 snduna: 1299635319 sndnxt: 1299635319 sndwnd: 16114irs: 407237472 rcvnxt: 407237982 rcvwnd: 15875 delrcvwnd: 509SRTT: 231 ms, RTTO: 769 ms, RTV: 538 ms, KRTT: 0 msminRTT: 44 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 509Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 12, total data bytes: 270BGP neighbor is 40.40.40.40, remote AS 20, internal link BGP version 4, remote router ID 40.40.40.40 BGP state = Established, up for 00:08:03 Last read 00:00:14, last write 00:00:09, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 1 5 Keepalives: 10 10 Route Refresh: 0 0 Total: 12 16 Default minimum time between advertisement runs is 0 seconds For address family: IPv4 Unicast Session: 40.40.40.40 BGP table version 9, neighbor version 9/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 0 4 (Consumes 320 bytes) Prefixes Total: 0 4 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 4 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- NEXT\_HOP is us: n/a 3 Bestpath from this peer: 4 n/a Bestpath from iBGP peer: 4 n/a Total: 8 3 Number of NLRIs in the update sent: max 0, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 40.40.40.40 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 30.30.30.30, Local port: 179Foreign host: 40.40.40.40, Foreign port: 34529Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x85060):Timer Starts Wakeups NextRetrans 11 0 0x0TimeWait 0 0 0x0AckHold 11 8 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 1866645413 snduna: 1866645684 sndnxt: 1866645684 sndwnd: 16114irs: 79667497 rcvnxt: 79668007 rcvwnd: 15875 delrcvwnd: 509SRTT: 231 ms, RTTO: 769 ms, RTV: 538 ms, KRTT: 0 msminRTT: 40 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 509Sent: 21 (retransmit: 0 fastretransmit: 0),with data: 12, total data bytes: 270R3#show ip bgp ipv6 unicast neighborsBGP neighbor is 20::1, remote AS 20, internal link BGP version 4, remote router ID 20.20.20.20 BGP state = Established, up for 00:08:04 Last read 00:00:41, last write 00:00:07, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 3 7 Keepalives: 10 10 Route Refresh: 0 0 Total: 14 18 Default minimum time between advertisement runs is 0 seconds For address family: IPv6 Unicast Session: 20::1 BGP table version 12, neighbor version 12/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 4 9 (Consumes 936 bytes) Prefixes Total: 4 9 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 5 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 5 n/a Bestpath from iBGP peer: 2 n/a Total: 7 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 20::1 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 30::1, Local port: 18015Foreign host: 20::1, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x85444):Timer Starts Wakeups NextRetrans 12 0 0x0TimeWait 0 0 0x0AckHold 10 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0xA17B4DeadWait 0 0 0x0Linger 0 0 0x0iss: 2965554686 snduna: 2965555151 sndnxt: 2965555151 sndwnd: 15920irs: 2504308026 rcvnxt: 2504308830 rcvwnd: 15581 delrcvwnd: 803SRTT: 241 ms, RTTO: 716 ms, RTV: 475 ms, KRTT: 0 msminRTT: 36 ms, maxRTT: 316 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 803Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 23, total data bytes: 1392BGP neighbor is 40::1, remote AS 20, internal link BGP version 4, remote router ID 40.40.40.40 BGP state = Established, up for 00:08:01 Last read 00:00:04, last write 00:00:13, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 3 5 Keepalives: 10 10 Route Refresh: 0 0 Total: 14 16 Default minimum time between advertisement runs is 0 seconds For address family: IPv6 Unicast Session: 40::1 BGP table version 12, neighbor version 12/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 4 6 (Consumes 624 bytes) Prefixes Total: 4 6 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 2 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 5 n/a Bestpath from iBGP peer: 2 n/a Total: 7 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 40::1 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 30::1, Local port: 17281Foreign host: 40::1, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x85444):Timer Starts Wakeups NextRetrans 12 0 0x0TimeWait 0 0 0x0AckHold 10 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0xA23B4DeadWait 0 0 0x0Linger 0 0 0x0iss: 1795976968 snduna: 1795977433 sndnxt: 1795977433 sndwnd: 15920irs: 1301445482 rcvnxt: 1301446109 rcvwnd: 15758 delrcvwnd: 626SRTT: 239 ms, RTTO: 712 ms, RTV: 473 ms, KRTT: 0 msminRTT: 36 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 626Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 23, total data bytes: 1392**R3#show ip ospf neighbor**Neighbor ID Pri State Dead Time Address Interface4.4.4.4 1 FULL/DR 00:00:36 10.10.10.10 FastEthernet0/02.2.2.2 1 FULL/BDR 00:00:33 10.10.10.5 FastEthernet1/0**R3#show ipv6 ospf neighbor** OSPFv3 Router with ID (30.30.30.30) (Process ID 20)Neighbor ID Pri State Dead Time Interface ID Interface20.20.20.20 1 FULL/BDR 00:00:31 2 FastEthernet1/040.40.40.40 1 FULL/DR 00:00:38 3 FastEthernet0/0

Router 4

**R4#show running-config**hostname R4boot-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 ip address 40.40.40.40 255.255.255.255 ipv6 address 40::1/64 ipv6 ospf 20 area 20interface FastEthernet0/0 ip address 10.10.10.13 255.255.255.252 duplex full ipv6 address FE80::1 link-local ipv6 address 4::1/64interface FastEthernet1/0 ip address 10.10.10.10 255.255.255.252 speed auto duplex auto ipv6 address FE80::2 link-local ipv6 address 3::2/64 ipv6 ospf 20 area 20router ospf 10 router-id 4.4.4.4 network 10.10.10.8 0.0.0.3 area 0 network 40.40.40.40 0.0.0.0 area 0router bgp 20 bgp log-neighbor-changes no bgp default ipv4-unicast neighbor 20::1 remote-as 20 neighbor 20::1 update-source Loopback0 neighbor 30::1 remote-as 20 neighbor 30::1 update-source Loopback0 neighbor 50::1 remote-as 30 neighbor 50::1 ebgp-multihop 2 neighbor 50::1 update-source Loopback0 neighbor 20.20.20.20 remote-as 20 neighbor 20.20.20.20 update-source Loopback0 neighbor 30.30.30.30 remote-as 20 neighbor 30.30.30.30 update-source Loopback0 neighbor 50.50.50.50 remote-as 30 neighbor 50.50.50.50 ebgp-multihop 2 neighbor 50.50.50.50 update-source Loopback0 address-family ipv4 network 10.10.10.12 mask 255.255.255.252 network 50.50.50.50 mask 255.255.255.255 redistribute ospf 10 match internal external 1 external 2 neighbor 20.20.20.20 activate neighbor 30.30.30.30 activate neighbor 50.50.50.50 activate exit-address-family address-family ipv6 redistribute ospf 20 match internal external 1 external 2 network 3::/64 network 4::/64 network 50::1/128 neighbor 20::1 activate neighbor 30::1 activate neighbor 50::1 activate exit-address-familyip forward-protocol ndno ip http serverno ip http secure-serverip route 50.50.50.50 255.255.255.255 FastEthernet0/0ipv6 route 50::1/128 FastEthernet0/0 4::2ipv6 router ospf 20 router-id 40.40.40.40control-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**R4#show ip route**Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, \* - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP + - replicated route, % - next hop overrideGateway of last resort is not set 10.0.0.0/8 is variably subnetted, 6 subnets, 2 masksB 10.10.10.0/30 [200/0] via 20.20.20.20, 00:07:46O 10.10.10.4/30 [110/2] via 10.10.10.9, 00:08:22, FastEthernet1/0C 10.10.10.8/30 is directly connected, FastEthernet1/0L 10.10.10.10/32 is directly connected, FastEthernet1/0C 10.10.10.12/30 is directly connected, FastEthernet0/0L 10.10.10.13/32 is directly connected, FastEthernet0/0 20.0.0.0/32 is subnetted, 1 subnetsO 20.20.20.20 [110/3] via 10.10.10.9, 00:08:13, FastEthernet1/0 30.0.0.0/32 is subnetted, 1 subnetsO 30.30.30.30 [110/2] via 10.10.10.9, 00:08:23, FastEthernet1/0 40.0.0.0/32 is subnetted, 1 subnetsC 40.40.40.40 is directly connected, Loopback0 50.0.0.0/32 is subnetted, 1 subnetsS 50.50.50.50 is directly connected, FastEthernet0/0 100.0.0.0/32 is subnetted, 1 subnetsB 100.10.10.10 [200/0] via 20.20.20.20, 00:07:47**R4#show ipv6 route**IPv6 Routing Table - default - 15 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 [200/0] via 20::1O 2::/64 [110/2] via FE80::1, FastEthernet1/0C 3::/64 [0/0] via FastEthernet1/0, directly connectedL 3::2/128 [0/0] via FastEthernet1/0, receiveC 4::/64 [0/0] via FastEthernet0/0, directly connectedL 4::1/128 [0/0] via FastEthernet0/0, receiveB 10::/64 [200/0] via 20::1B 10::1/128 [200/0] via 1::1B 20::/64 [200/0] via 10::1O 20::1/128 [110/2] via FE80::1, FastEthernet1/0O 30::1/128 [110/1] via FE80::1, FastEthernet1/0C 40::/64 [0/0] via Loopback0, directly connectedL 40::1/128 [0/0] via Loopback0, receiveS 50::1/128 [1/0] via 4::2, FastEthernet0/0L FF00::/8 [0/0] via Null0, receive**R4#show ip bgp ipv4 unicast topology \***For address family: IPv4 UnicastBGP table version is 10, local router ID is 40.40.40.40Status 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 \*>i 10.10.10.0/30 20.20.20.20 0 100 0 i \* i 10.10.10.4/30 20.20.20.20 0 100 0 ? \*> 10.10.10.9 2 32768 ? \* i 10.10.10.8/30 10.10.10.6 2 100 0 ? \*> 0.0.0.0 0 32768 ? \* 10.10.10.12/30 50.50.50.50 0 0 30 i \*> 0.0.0.0 0 32768 i \* i 20.20.20.20/32 20.20.20.20 0 100 0 i \*> 10.10.10.9 3 32768 ? \* i 30.30.30.30/32 10.10.10.6 2 100 0 ? \*> 10.10.10.9 2 32768 ? \* i 40.40.40.40/32 10.10.10.6 3 100 0 ? \*> 0.0.0.0 0 32768 ? \* 50.50.50.50/32 50.50.50.50 0 0 30 i \*> 0.0.0.0 0 32768 i \*>i 100.10.10.10/32 20.20.20.20 0 100 0 i**R4#show ip bgp ipv4 unicast neighbors**BGP neighbor is 20.20.20.20, remote AS 20, internal link BGP version 4, remote router ID 20.20.20.20 BGP state = Established, up for 00:08:11 Last read 00:00:43, last write 00:00:36, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 5 5 Keepalives: 10 10 Route Refresh: 0 0 Total: 16 16 Default minimum time between advertisement runs is 0 seconds For address family: IPv4 Unicast Session: 20.20.20.20 BGP table version 10, neighbor version 10/0 Output queue size : 0 Index 2, Advertise bit 1 2 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 7 7 (Consumes 560 bytes) Prefixes Total: 7 7 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 2 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 2 n/a Total: 2 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 20.20.20.20 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 40.40.40.40, Local port: 179Foreign host: 20.20.20.20, Foreign port: 57069Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x885A4):Timer Starts Wakeups NextRetrans 11 0 0x0TimeWait 0 0 0x0AckHold 11 10 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 28662226 snduna: 28662736 sndnxt: 28662736 sndwnd: 15875irs: 3006581127 rcvnxt: 3006581637 rcvwnd: 15875 delrcvwnd: 509SRTT: 233 ms, RTTO: 772 ms, RTV: 539 ms, KRTT: 0 msminRTT: 56 ms, maxRTT: 332 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 509Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 12, total data bytes: 509BGP neighbor is 30.30.30.30, remote AS 20, internal link BGP version 4, remote router ID 30.30.30.30 BGP state = Established, up for 00:08:18 Last read 00:00:23, last write 00:00:28, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 5 1 Keepalives: 10 10 Route Refresh: 0 0 Total: 16 12 Default minimum time between advertisement runs is 0 seconds For address family: IPv4 Unicast Session: 30.30.30.30 BGP table version 10, neighbor version 10/0 Output queue size : 0 Index 2, Advertise bit 1 2 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 7 0 Prefixes Total: 7 0 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 0 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 2 n/a Total: 2 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 30.30.30.30 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 40.40.40.40, Local port: 34529Foreign host: 30.30.30.30, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x885D4):Timer Starts Wakeups NextRetrans 12 0 0x0TimeWait 0 0 0x0AckHold 10 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0xA12D4DeadWait 0 0 0x0Linger 0 0 0x0iss: 79667497 snduna: 79668007 sndnxt: 79668007 sndwnd: 15875irs: 1866645413 rcvnxt: 1866645684 rcvwnd: 16114 delrcvwnd: 270SRTT: 239 ms, RTTO: 712 ms, RTV: 473 ms, KRTT: 0 msminRTT: 48 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 21 (out of order: 0), with data: 12, total data bytes: 270Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 12, total data bytes: 509BGP neighbor is 50.50.50.50, remote AS 30, external link BGP version 4, remote router ID 50.50.50.50 BGP state = Established, up for 00:08:59 Last read 00:00:26, last write 00:00:56, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 6 3 Keepalives: 9 10 Route Refresh: 0 0 Total: 16 14 Default minimum time between advertisement runs is 30 seconds For address family: IPv4 Unicast Session: 50.50.50.50 BGP table version 10, neighbor version 10/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 9 2 (Consumes 160 bytes) Prefixes Total: 9 2 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 0 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Total: 0 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 50.50.50.50 Connections established 1; dropped 0 Last reset never External BGP neighbor may be up to 2 hops away. Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 2Local host: 40.40.40.40, Local port: 179Foreign host: 50.50.50.50, Foreign port: 64381Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x8875C):Timer Starts Wakeups NextRetrans 12 0 0x0TimeWait 0 0 0x0AckHold 12 11 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 3389785062 snduna: 3389785602 sndnxt: 3389785602 sndwnd: 15845irs: 2583117260 rcvnxt: 2583117641 rcvwnd: 16004 delrcvwnd: 380SRTT: 245 ms, RTTO: 695 ms, RTV: 450 ms, KRTT: 0 msminRTT: 48 ms, maxRTT: 448 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 25 (out of order: 0), with data: 13, total data bytes: 380Sent: 24 (retransmit: 0 fastretransmit: 0),with data: 12, total data bytes: 539R4#show ip bgp ipv6 unicast neighborsBGP neighbor is 20::1, remote AS 20, internal link BGP version 4, remote router ID 20.20.20.20 BGP state = Established, up for 00:08:08 Last read 00:00:40, last write 00:00:26, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 5 7 Keepalives: 10 10 Route Refresh: 0 0 Total: 16 18 Default minimum time between advertisement runs is 0 seconds For address family: IPv6 Unicast Session: 20::1 BGP table version 13, neighbor version 13/0 Output queue size : 0 Index 2, Advertise bit 1 2 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 6 9 (Consumes 936 bytes) Prefixes Total: 6 9 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 4 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 5 n/a Bestpath from iBGP peer: 1 n/a Total: 6 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 20::1 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 40::1, Local port: 179Foreign host: 20::1, Foreign port: 50210Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x88A08):Timer Starts Wakeups NextRetrans 11 0 0x0TimeWait 0 0 0x0AckHold 11 10 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 3817979458 snduna: 3817980085 sndnxt: 3817980085 sndwnd: 15758irs: 809750997 rcvnxt: 809751801 rcvwnd: 15581 delrcvwnd: 803SRTT: 231 ms, RTTO: 769 ms, RTV: 538 ms, KRTT: 0 msminRTT: 60 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 803Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 23, total data bytes: 1554BGP neighbor is 30::1, remote AS 20, internal link BGP version 4, remote router ID 30.30.30.30 BGP state = Established, up for 00:08:15 Last read 00:00:27, last write 00:00:19, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 5 3 Keepalives: 10 10 Route Refresh: 0 0 Total: 16 14 Default minimum time between advertisement runs is 0 seconds For address family: IPv6 Unicast Session: 30::1 BGP table version 13, neighbor version 13/0 Output queue size : 0 Index 2, Advertise bit 1 2 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 6 4 (Consumes 416 bytes) Prefixes Total: 6 4 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 1 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 5 n/a Bestpath from iBGP peer: 1 n/a Total: 6 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 30::1 Connections established 1; dropped 0 Last reset never Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 255Local host: 40::1, Local port: 179Foreign host: 30::1, Foreign port: 17281Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x88AA4):Timer Starts Wakeups NextRetrans 11 0 0x0TimeWait 0 0 0x0AckHold 11 10 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 1301445482 snduna: 1301446109 sndnxt: 1301446109 sndwnd: 15758irs: 1795976968 rcvnxt: 1795977433 rcvwnd: 15920 delrcvwnd: 464SRTT: 231 ms, RTTO: 769 ms, RTV: 538 ms, KRTT: 0 msminRTT: 56 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 23 (out of order: 0), with data: 12, total data bytes: 464Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 23, total data bytes: 1554BGP neighbor is 50::1, remote AS 30, external link BGP version 4, remote router ID 50.50.50.50 BGP state = Established, up for 00:08:58 Last read 00:00:43, last write 00:00:51, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 9 2 Keepalives: 9 10 Route Refresh: 0 0 Total: 19 13 Default minimum time between advertisement runs is 30 seconds For address family: IPv6 Unicast Session: 50::1 BGP table version 13, neighbor version 13/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 11 2 (Consumes 208 bytes) Prefixes Total: 12 2 Implicit Withdraw: 1 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 0 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Total: 0 0 Number of NLRIs in the update sent: max 3, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 50::1 Connections established 1; dropped 0 Last reset never External BGP neighbor may be up to 2 hops away. Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 2Local host: 40::1, Local port: 21166Foreign host: 50::1, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x88B40):Timer Starts Wakeups NextRetrans 13 0 0x0TimeWait 0 0 0x0AckHold 10 9 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0x9795CDeadWait 0 0 0x0Linger 0 0 0x0iss: 1318632122 snduna: 1318633041 sndnxt: 1318633041 sndwnd: 15466irs: 4180944844 rcvnxt: 4180945214 rcvwnd: 16015 delrcvwnd: 369SRTT: 262 ms, RTTO: 708 ms, RTV: 446 ms, KRTT: 0 msminRTT: 40 ms, maxRTT: 476 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 24 (out of order: 0), with data: 12, total data bytes: 369Sent: 23 (retransmit: 0 fastretransmit: 0),with data: 23, total data bytes: 1846**R4#show ip ospf neighbor**Neighbor ID Pri State Dead Time Address Interface3.3.3.3 1 FULL/BDR 00:00:27 10.10.10.9 FastEthernet1/0**R4#show ipv6 ospf neighbor** OSPFv3 Router with ID (40.40.40.40) (Process ID 20)Neighbor ID Pri State Dead Time Interface ID Interface30.30.30.30 1 FULL/BDR 00:00:27 2 FastEthernet1/0

Router 5

**R5#show running-config**hostname 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 Loopback0 ip address 50.50.50.50 255.255.255.255 ipv6 address 50::1/64interface 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::2/64router bgp 30 bgp log-neighbor-changes no bgp default ipv4-unicast neighbor 40::1 remote-as 20 neighbor 40::1 ebgp-multihop 2 neighbor 40::1 update-source Loopback0 neighbor 40.40.40.40 remote-as 20 neighbor 40.40.40.40 ebgp-multihop 2 neighbor 40.40.40.40 update-source Loopback0 address-family ipv4 network 10.10.10.12 mask 255.255.255.252 network 50.50.50.50 mask 255.255.255.255 neighbor 40.40.40.40 activate exit-address-family address-family ipv6 network 4::/64 network 50::1/128 neighbor 40::1 activate exit-address-familyip forward-protocol ndno ip http serverno ip http secure-serverip route 40.40.40.40 255.255.255.255 FastEthernet1/0ipv6 route 40::1/128 FastEthernet1/0 4::1control-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 ip route**Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2 i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, \* - candidate default, U - per-user static route o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP + - replicated route, % - next hop overrideGateway of last resort is not set 10.0.0.0/8 is variably subnetted, 5 subnets, 2 masksB 10.10.10.0/30 [20/0] via 40.40.40.40, 00:07:11B 10.10.10.4/30 [20/2] via 40.40.40.40, 00:07:45B 10.10.10.8/30 [20/0] via 40.40.40.40, 00:07:45C 10.10.10.12/30 is directly connected, FastEthernet1/0L 10.10.10.14/32 is directly connected, FastEthernet1/0 20.0.0.0/32 is subnetted, 1 subnetsB 20.20.20.20 [20/3] via 40.40.40.40, 00:07:45 30.0.0.0/32 is subnetted, 1 subnetsB 30.30.30.30 [20/2] via 40.40.40.40, 00:07:45 40.0.0.0/32 is subnetted, 1 subnetsS 40.40.40.40 is directly connected, FastEthernet1/0 50.0.0.0/32 is subnetted, 1 subnetsC 50.50.50.50 is directly connected, Loopback0 100.0.0.0/32 is subnetted, 1 subnetsB 100.10.10.10 [20/0] via 40.40.40.40, 00:07:11**R5#show ipv6 route**IPv6 Routing Table - default - 14 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 40::1B 2::/64 [20/2] via 40::1B 3::/64 [20/0] via 40::1C 4::/64 [0/0] via FastEthernet1/0, directly connectedL 4::2/128 [0/0] via FastEthernet1/0, receiveB 10::/64 [20/0] via 40::1B 10::1/128 [20/0] via 40::1B 20::/64 [20/0] via 40::1B 20::1/128 [20/2] via 40::1B 30::1/128 [20/1] via 40::1S 40::1/128 [1/0] via 4::1, FastEthernet1/0C 50::/64 [0/0] via Loopback0, directly connectedL 50::1/128 [0/0] via Loopback0, receiveL FF00::/8 [0/0] via Null0, receive**R5#show ip bgp ipv4 unicast topology \***For address family: IPv4 UnicastBGP table version is 10, local router ID is 50.50.50.50Status 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 \*> 10.10.10.0/30 40.40.40.40 0 20 i \*> 10.10.10.4/30 40.40.40.40 2 0 20 ? \*> 10.10.10.8/30 40.40.40.40 0 0 20 ? \* 10.10.10.12/30 40.40.40.40 0 0 20 i \*> 0.0.0.0 0 32768 i \*> 20.20.20.20/32 40.40.40.40 3 0 20 ? \*> 30.30.30.30/32 40.40.40.40 2 0 20 ? r> 40.40.40.40/32 40.40.40.40 0 0 20 ? \* 50.50.50.50/32 40.40.40.40 0 0 20 i \*> 0.0.0.0 0 32768 i \*> 100.10.10.10/32 40.40.40.40 0 20 i**R5#show ip bgp ipv4 unicast neighbors**BGP neighbor is 40.40.40.40, remote AS 20, external link BGP version 4, remote router ID 40.40.40.40 BGP state = Established, up for 00:08:54 Last read 00:00:10, last write 00:00:33, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv4 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 3 6 Keepalives: 10 10 Route Refresh: 0 0 Total: 14 17 Default minimum time between advertisement runs is 30 seconds For address family: IPv4 Unicast Session: 40.40.40.40 BGP table version 10, neighbor version 10/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 2 9 (Consumes 720 bytes) Prefixes Total: 2 9 Implicit Withdraw: 0 0 Explicit Withdraw: 0 0 Used as bestpath: n/a 7 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 7 n/a Total: 7 0 Number of NLRIs in the update sent: max 1, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 40.40.40.40 Connections established 1; dropped 0 Last reset never External BGP neighbor may be up to 2 hops away. Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 2Local host: 50.50.50.50, Local port: 64381Foreign host: 40.40.40.40, Foreign port: 179Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x86E44):Timer Starts Wakeups NextRetrans 13 0 0x0TimeWait 0 0 0x0AckHold 12 11 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 1 0 0x96F30DeadWait 0 0 0x0Linger 0 0 0x0iss: 2583117260 snduna: 2583117641 sndnxt: 2583117641 sndwnd: 16004irs: 3389785062 rcvnxt: 3389785621 rcvwnd: 15826 delrcvwnd: 558SRTT: 247 ms, RTTO: 663 ms, RTV: 416 ms, KRTT: 0 msminRTT: 36 ms, maxRTT: 300 ms, ACK hold: 200 msStatus Flags: noneOption Flags: higher precendence, nagle, path mtu capableDatagrams (max data segment is 1460 bytes):Rcvd: 25 (out of order: 0), with data: 13, total data bytes: 558Sent: 26 (retransmit: 0 fastretransmit: 0),with data: 13, total data bytes: 380R5#show ip bgp ipv6 unicast neighborsBGP neighbor is 40::1, remote AS 20, external link BGP version 4, remote router ID 40.40.40.40 BGP state = Established, up for 00:08:53 Last read 00:00:09, last write 00:00:50, hold time is 180, keepalive interval is 60 seconds Neighbor sessions: 1 active, is not multisession capable (disabled) Neighbor capabilities: Route refresh: advertised and received(new) Four-octets ASN Capability: advertised and received Address family IPv6 Unicast: advertised and received Enhanced Refresh Capability: advertised and received Multisession Capability: Stateful switchover support enabled: NO for session 1 Message statistics: InQ depth is 0 OutQ depth is 0 Sent Rcvd Opens: 1 1 Notifications: 0 0 Updates: 2 9 Keepalives: 10 10 Route Refresh: 0 0 Total: 13 20 Default minimum time between advertisement runs is 30 seconds For address family: IPv6 Unicast Session: 40::1 BGP table version 12, neighbor version 12/0 Output queue size : 0 Index 1, Advertise bit 0 1 update-group member Slow-peer detection is disabled Slow-peer split-update-group dynamic is disabled Sent Rcvd Prefix activity: ---- ---- Prefixes Current: 2 11 (Consumes 1144 bytes) Prefixes Total: 2 12 Implicit Withdraw: 0 1 Explicit Withdraw: 0 0 Used as bestpath: n/a 9 Used as multipath: n/a 0 Outbound Inbound Local Policy Denied Prefixes: -------- ------- Bestpath from this peer: 9 n/a Total: 9 0 Number of NLRIs in the update sent: max 2, min 0 Last detected as dynamic slow peer: never Dynamic slow peer recovered: never Refresh Epoch: 1 Last Sent Refresh Start-of-rib: never Last Sent Refresh End-of-rib: never Last Received Refresh Start-of-rib: never Last Received Refresh End-of-rib: never Sent Rcvd Refresh activity: ---- ---- Refresh Start-of-RIB 0 0 Refresh End-of-RIB 0 0 Address tracking is enabled, the RIB does have a route to 40::1 Connections established 1; dropped 0 Last reset never External BGP neighbor may be up to 2 hops away. Transport(tcp) path-mtu-discovery is enabled Graceful-Restart is disabledConnection state is ESTAB, I/O status: 1, unread input bytes: 0 Connection is ECN DisabledMininum incoming TTL 0, Outgoing TTL 2Local host: 50::1, Local port: 179Foreign host: 40::1, Foreign port: 21166Connection tableid (VRF): 0Enqueued packets for retransmit: 0, input: 0 mis-ordered: 0 (0 bytes)Event Timers (current time is 0x872B0):Timer Starts Wakeups NextRetrans 11 0 0x0TimeWait 0 0 0x0AckHold 13 12 0x0SendWnd 0 0 0x0KeepAlive 0 0 0x0GiveUp 0 0 0x0PmtuAger 0 0 0x0DeadWait 0 0 0x0Linger 0 0 0x0iss: 4180944844 snduna: 4180945214 sndnxt: 4180945214 sndwnd: 16015irs: 1318632122 rcvnxt: 1318633060 rcvwnd: 15447 delrcvwnd: 937SRTT: 245 ms, RTTO: 736 ms, RTV: 491 ms, KRTT: 0 msminRTT: 40 ms, maxRTT: 636 ms, ACK hold: 200 msStatus Flags: passive open, gen tcbsOption Flags: nagle, path mtu capableDatagrams (max data segment is 1440 bytes):Rcvd: 24 (out of order: 0), with data: 13, total data bytes: 937Sent: 25 (retransmit: 0 fastretransmit: 0),with data: 25, total data bytes: 1377

Problems

My first problem occurred when I was assigning IPv4 loopback addresses. The pattern for the loopbacks that I originally thought of was in the form: 10.10.10.10 for router one, 20.20.20.20 for router two, 30.30.30.30 for router three, ext. The IP scheme I used was 10.10.10.X/30 for the directly connected interfaces. So eventually I had a loopback address on router one of 10.10.10.10/32 that conflicted with the same IP address on one of the physical interfaces. I fixed this mistake by changing the loopback on router one to 100.10.10.10, but overall, this was just a mistake made by poor insight in the beginning.

Another problem occurred during the configuration of iBGP, when I was trying to get the neighbors to use their loopback interfaces for adjacencies. After configuring the statements “**neighbor *IPv4-address* remote-as *neighbor’s-ASN***” and “**neighbor *IPv4-address* update-source *loopback0***”, which are meant to establish a BGP neighbor relationship using loopback addresses, the neighbor relationship still didn’t form. After some debugging, I learnt that the neighbors weren’t establishing because they couldn’t see all the way to the loopback interfaces, since the loopback interfaces weren’t directly connected. In this case, I could use static routes directed to each loopback interface, but I opted to simply broadcast the loopback interfaces using OSPF because I already had OSPF running in conjunction with iBGP. I configured network statements for the loopback interfaces in OSPF instead of using static routes for to each loopback interface.

My last major problem was establishing the eBGP neighbor relationships with loopbacks in IPv6. I blew past many commands, including changing the default the eBGP multihop value: “**neighbor *IPv6-address* ebgp-multihop *0-255***”, to little avail. However, this problem was very similar to my last, and I knew it had something to do with the accessibility of the loopback interfaces. Instead of using an IGP like I had before, since this was just a connection between two routers, I opted for static routes. I configured a static route, but my problem remained the same. For a while, I endlessly scoured google for a means to solve this problem, but I found no useful responses. Before I continue with the solution, there is something important to know about static routes; There are three types of static routes. One type uses the “exit interface” of the router as directions for the route. Another type uses the “next hop IP address”, or in other words, the IP on the neighboring router’s interface as directions for the route. The third type uses both the next hop IP address and the exit interface. My first configuration of the static routes only used the next hop IP, but not the exit interface. For whatever reason, this connection needed to have a static route with both a next hop IP and an exit interface to be successful. After reconfiguring the static routes, the loopbacks interfaces could find each other, and connectivity was established.

Conclusion

Overall, I managed to get iBGP and eBGP up and running using loopbacks in both IPv4 and IPv6. Most of my problems stemmed from the actual routing; creating routes using means of IGPs and static routing, but not from the actual BGP commands, which is something to keep in mind of. If connectivity is not being established, perhaps it isn’t the BGP configurations that are wrong, but the routes to the loopbacks. It is also advisable to complete the entire IP scheme, INCLUDING the loopbacks, before attempting a project like this.