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iBGP

with loopbacks

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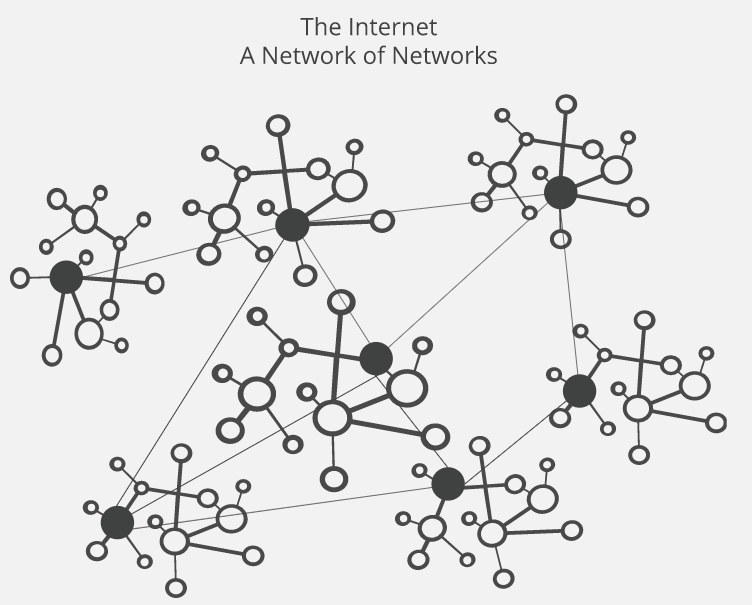
Purpose

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

BGP (border gateway protocol) is a routing protocol that makes the internet work. 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 hopping between autonomous systems.

So, what are autonomous systems? The network of the world consists of many subnets, where are referred to as Autonomous systems (AS). Each AS is a collection of devices that are aware of each other. They could also be thought of as different groups running under different areas. AS’s 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.



**Figure 1**

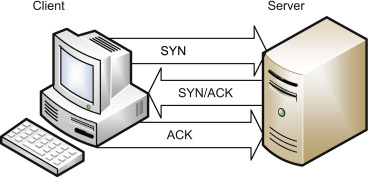
Different autonomous systems have different autonomous system numbers. The autonomous system number (ASN) is a numerical value that uniquely identifies a network on the internet. There are two types of ASNs: public and private. Private ASNs can repeat but public ASNs must be officially registered by an ISP. Public ASNs are required for a system to exchange information over the internet. Back to BGP.

There are two types of BGP: external BGP (eBGP) and internal BGP (iBGP). External BGP is used to connect different autonomous systems together, while internal BGP manages the internals of an AS. So why not just implement an Interior Gateway Protocol (IGP) like OSPF, RIP or EIGRP instead of working with iBGP? iBGP is useful in an AS because BGP can deal with an immense amount more routing data than IGPs. The 500,000 routes formed from the entirety of the internet that BGP might work with would overwhelm a protocol like OSPF. One problem with iBGP is that it doesn’t route packets, meaning an IGP would likely need to run in parallel with iBGP. Routers can run multiple routing protocols at the same time which makes running iBGP and an IGP, for instance, OSPF possible. For example, in a team of OSPF and iBGP, OSPF would handle creating and running the new routes in an internal network whilst iBGP would handle all the routes obtained from the entirety of the internet. Another use of iBGP is as a bridge between AS’s, which is known as a transit AS in the industry. To sum up, the main benefits of BGP are its scalability, control, and flexibility, however, BGP has slower speeds than IGPs. iBGP is usually used in a large internal network to provide more information to the internal routers.

So how does BGP work? The main purpose BGP serves is to forward traffic to an IP in 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 is a variable that determines which path is preferred when exiting the AS to reach a certain network.
3. The path with the **highest AS\_PATH**. The main purpose of AS\_PATH is to avoid loops. If a known router goes down in a network, then this might cause the other routers to falsely change their paths, resulting in a new routing table that forwards the traffic that was intended for the down router in an infinite loop around themselves. This can only happen in a distance-vector routing protocol such as BGP or RIP, so BGP’s AS\_PATH is designed in order to prevent these infinite loops.
4. **Favoring eBGP** paths over iBGP paths.

These are some of the factors in BGP’s best path selection algorithm. BGP is a distance-vector routing protocol. The way distance-vector routing protocols work is by advertising their routing tables to their neighbors. If the routes from the neighbor’s routing table are better than the ones they currently have, the routes are updated to fit with the preferable ones. Like all other routing protocols, BGP must first establish a neighbor adjacency with another BGP router to be able to exchange routing information. However, 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 to the remote neighbor and begin some resources. In success, BGP moves to the Connect state, while in failure, BGP remains in the Idle state.
2. **Connect**. In Connect, BGP waits for the TCP three-way handshake to complete. Both sides need to synchronize (SYN) and acknowledge (ACK) each other in a TCP three-way handshake. If the results are successful, BGP continues to the OpenSent state. If the results are unsuccessful, BGP continues to the Active state.
3. **Active**. BGP will try another TCP three-way handshake to establish a connection with the remote neighbor. On success, BGP will transition to the OpenSent state. After a certain amount of time has passed with no success, BGP will transition back to the Connect state.
4. **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 for whatever reason the TCP session fails, BGP will revert to the Active state. If all the failsafes pass, BGP will start sending keepalive messages to maintain the TCP session.
5. **OpenConfirm**. BGP waits for a keepalive message from the remote BGP neighbor. When the keepalive messages are being consistently received, BGP moves to the Established state in which the neighbor relationship is complete. In any other case, BGP falls back to the Idle state.
6. **Established**. The neighbor adjacency has been formed. As long as keepalive messages are being sent, the neighborship remains up. Otherwise, BGP resets back to Idle state.

The neighbor’s directly connected interface is usually what is used in most routing protocols to form an adjacency. However, a technique when working with BGP is to use loopback addresses when establishing BGP neighbors. Using loopbacks is common for iBGP but it also works with eBGP. The main reason loopbacks are preferred is because of redundancy; if, for whatever reason, the physical interface goes down, perhaps due to hardware, loopback interfaces are virtual and will stay up regardless.

With all the basic technicalities of BGP out of the way, here is a bit of history. In the beginnings of the internet, there was no BGP. BGP evolved from a protocol called Exterior Gateway Protocol (EGP) that evolved from a protocol called Gateway Gateway Protocol (GGP). (Back then, routers were known as gateways which explains the redundancy in the name GGP). A very early version of the internet ran on GGP. GGP was, at its best, a more advanced version of Router Information Protocol (RIP). In 1984, EGP was created to support the growing infrastructure around the world, as the internet became exponentially more popular. EGP introduced the concept of autonomous systems, which became a big part of BGP. In 1989, an early version of BGP emerged, BGP-1, which was updated each year for 2 years birthing BGP-3 in 1991. However, there was a big problem that BGP-1, BGP-2, and BGP-3 all shared: they all only supported classful addressing. Classful addressing excludes the ability to define more specified subnets. In other words, the problem with classful addressing was the number of IP addresses that were being wasted. If you had a network that needed 400 IP addresses, you couldn’t use a class C address, as class C’s only support up to 256 IPs, so you’d just have to opt with a class B address that gave you 65, 536 addresses. It was inefficient and a waste, so the introduction of BGP-4 and CIDR in 1994 fixed these problems. Classless routing was finally supported. A couple of years later, support for IPv6 came along. BGP is even older than IPv6! Even today, the internet is still running on BGP-4. All newer BGP innovations since 1994 are optional extensions.

Lab Summary

Like all my previous labs, I started off by creating the topology for this lab using 5 CISCO 7200 series routers. With the topology in mind, I set up an IP scheme in both IPv4 and IPv6; the former subnetted with /30 addresses for the fast ethernet interfaces and /32 addresses for the loopbacks, and the latter with /64 addresses for the fast ethernet interfaces and /128 addresses for the loopbacks. My next step would be setting up iBGP across the top three routers: routers 2, 3 and 4. Since iBGP needs a crutch (an IGP) to function, I chose to use OSPF. Though the intent for the lab was to configure BGP with loopbacks, I first wanted to see if I could get the whole topology pinging without loopbacks because it was my first time configuring iBGP. Configuring iBGP was actually very similar to configuring eBGP; the main difference being the use of the same autonomous system when defining the neighbors. Connectivity was established, and I could ping throughout the network. The next step was incorporating the loopbacks. I configured the loopback addresses, realized I had some conflicting IP’s, then adjusted accordingly. My IP scheme in the end was a bit different to accommodate in the new loopbacks, but it worked, nevertheless. After I got IBGP and eBGP running with loopbacks, I configured the same for IPv6 which was very similar to IPv4.

Lab commands

|  |  |
| --- | --- |
| **CLI 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 Argument>* | An optional argument, not necessary for a command to function, denoted in italics |

Router(config)# **interface *type* *interface*-*number***

Enables configuration on a specific interface.

Router(config)# **router bgp *ASN***

Enables configuration for BGP. The autonomous system number is a numerical value that identifies a network on the internet. iBGP uses the same ASN but eBGP must use different ASNs.

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

This command is very important for BGPv6, as it enables advertising for IPv6 routes alongside IPv4 routes. By default, BGP only runs the IPv4 address-family, so by enabling multiprotocol, we can run other address-families such as IPv6 or VPNv4.

Router(config-router)# **neighbor *IPv4-address* remote-as *neighbor’s-ASN***

Used in forming IPv4 BGP neighbor adjacencies. Unlike network statements, this command takes a host address (not a network address). The second argument is for the neighbors ASN.

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

Used in forming IPv6 BGP neighbor adjacencies. Unlike network statements, this command takes a host address (not a network address). The second argument is for the neighbors ASN.

Router(config-router)# **neighbor *IPv4-address* update-source *Interface***

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.

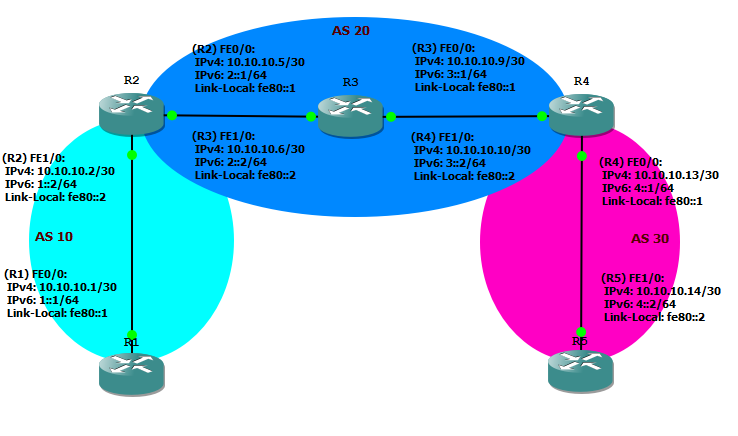
Router(config-router-af)# **neighbor *IPv4-address* activate**

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.

Network Diagram



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.