FIRST HOP REDUNDANCY PROTOCOLS (FHRP)

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Purpose

The focus area for this lab was the three main First Hop Redundancy Protocols (FHRP). Through this lab, I learned to configure Hot Standby Routing Protocol (HSRP), Gateway Load Balancing Protocol (GLBP), and Virtual Router Redundancy Protocol (VRRP) for IPv4 and IPv6 on routers and a layer 3 switch. The overall purpose was to build on existing CCNA knowledge of HSRP and GLBP, with added complexity with the addition of a layer 3 switch and VRRP configuration.

Background Information

First Hop Redundancy Protocol (FHRP) is a networking protocol that uses two or more routers to protect the default gateway (main router) from failing. If the active router fails, the backup router will take over virtual address. For example, imagine that an earthquake has just occurred, but children are still at school. The teacher will look at the child's contact information, and start by attempting to contact the mother/guardian. If they are unable to reach the parent, the teacher will look at the emergency contact information and try to call a secondary number. The same is true with all FHRP protocols.

More specifically, Hot Standby Routing Protocol (HSRP), is Cisco proprietary, meaning this protocol is only compatible with Cisco devices. Enabled on the interface of the active and standby routers, a physical IP address and a virtual IP address are configured on the interface. Both IP addresses should be in the same subnet. Because the routers share the same virtual IP address, PCs can be assigned the virtual IP address as their default gateway, ensuring a constant and consistent default gateway for the hosts. In the example of emergency contact information, the secondary emergency contact would most likely be another family member, like the child's father or grandmother. The child's "default gateway" is their home phone number, where both father and mother live, but both parents have individual cell phones as well.

Virtual Router Redundancy Protocol (VRRP) is extremely similar to HSRP. VRRP is not Cisco proprietary, and is the industry standard. There are some slight differences, in that VRRP is designed to have 1 master router and 1 or more backup routers. In addition, VRRP does not support IPv6. Unlike HSRP, which uses a virtual IP address as the gateway, VRRP uses a physical IP address. In the emergency contact example, the main contact is still the child's mother, but the secondary contact may be a close family friend rather than a family member.

Gateway Load Balancing Protocol (GLBP) also seeks to protect the default gateway, but its main goal is load balancing. Multiple routers can be configured in a GLBP group, and the router with the highest priority is assigned to be Active Virtual Gateway (AVG). All other members of the group are Active Virtual Forwarders (AVF) or Standby Virtual Forwarders (SVF). The AVG assigns the AVFs and SVF virtual MAC addresses. GLBP allows for a maximum of four AVFs, and the rest are SVFs. In the emergency contact example, the mother/primary guardian is the Active Virtual Gateway. The next four emergency contacts (close family and friends) are Active Virtual Forwarders, and any additional contacts (possibly out-of-state contacts) are Standby Virtual Forwarders.

Lab Summary

First, I created my topology in Packet Tracer and assigned each router interface an appropriate IP address. Next, I physically connected my topology, making sure to match the physical topology with my virtual image. I originally decided to run HSRP on R5 and S1, VRRP on R1 and R2, and GLBP on R3 and R4. However, due to complications with the layer 3 switch, I decided to use VRRP on R5 and S1 and HSRP on R1 and R2. To configure VRRP, I started by assigning the appropriate IPv4 addresses to each interface on R5 and S3. Next, I assigned interface G0/0 on R5 and F1/0/1 on S3 to the VRRP group 1 with the virtual IP address of 192.168.3.3. I also configured EIGRP on the router and switch for G0/1 and F1/0/2, the side without VRRP. All interfaces on the non-FHRP side of the router/switch are in the same network and same EIGRP autonomous system group. Since VRRP does not support IPv6, I did not configure IPv6 EIGRP on R5 and S3. In addition, I configured corresponding IPv4 and IPv6 addresses on the interfaces of R6 and set up EIGRPv2 and EIGRPv3. To test the protocol, I assigned PC-A with the default gateway address of the virtual router, and PC-B with R6 as the default gateway. I ran a continuous ping from PC-A to PC-B, and pulled the cord out of port F1/0/1 on S3 to test if R5 would become the Master router. To configure GLBP, I assigned appropriate IPv4 and IPv6 addresses to each interface on R3 and R4. For IPv4, the two interfaces are in GLBP group 1, and for IPv6, they are in GLBP group 11. I configured EIGRPv2 and EIGRP v3 on both routers, making sure that the FHRP interface side was made passive. I repeated the same steps, but configured HSRP standby group 1 for IPv4 and standby group 2 for IPv6 on R1 and R2. When testing each protocol, it is important to note that IPv6 automatically configures many features, so it is best to test each protocol individually by removing the cables not required for that protocol.

Lab Commands

VRRP:
```
router(config-if)#vrrp [group number] ip [virtual ip address]
router(config-if)#vrrp [group number] preempt
```

This command facilitates the creation of a VRRP group. An IPv4 address must be configured on the interface before this command is applied. The group number ranges from 1 to 254, and should be the same on both routers. The virtual IP address should be a unique address in the same subnet as the address configured on the interface. The preempt command ensures that the router the command is applied on is chosen as the Master router.

HSRP:

```
router(config-if)#standby [group number] ip [virtual ip address]
```

```
router(config-if)#standby [group number] ipv6 [virtual ipv6 address]
```
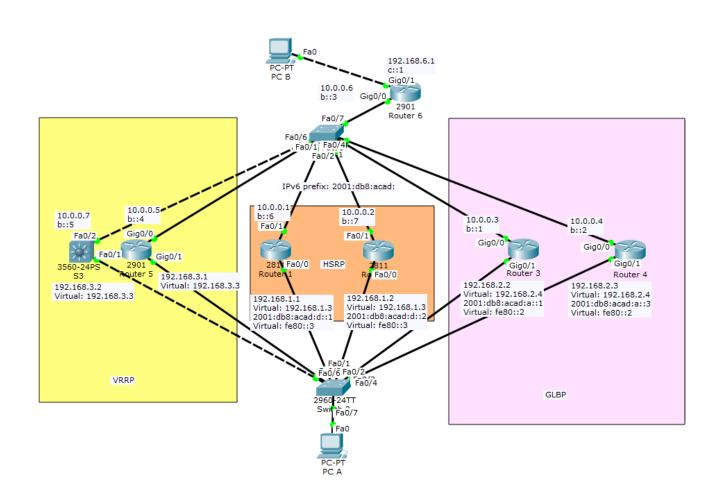
This command is similar to the VRRP command. The group number must be the same on both routers, but the range is from 1 to 255. In HSRP version 2, the group number range is expanded to

be from 0 to 4095. Like VRRP, the virtual ip address should share the same subnet as the address configured on the interface.

GLBP:

```
router(config-if)#glbp [group number] ip [virtual ip address]
router(config-if)#glbp [group number] ipv6 [virtual ipv6 address]
```
This command is used to configure GLBP on an interface. Each router involved must share the same group number, and the number can range from 0 to 1023. The virtual IP address must share the same subnet as the address configured on the interface. The only difference in GLBPv3 is the keyword "ipv6" instead of "ipv4".

Network Diagram

Configurations

Router 1 show run:

```
Current configuration : 1950 bytes
version 12.4
hostname R1
no ip domain lookup
ipv6 unicast-routing
ipv6 cef
interface FastEthernet0/0
 ip address 192.168.1.1 255.255.255.0
 duplex auto
 speed auto
 ipv6 address FE80::5 link-local
 ipv6 address 2001:DB8:ACD:D::1/64
 ipv6 enable
 ipv6 eigrp 1
 standby version 2
 standby 1 ip 192.168.1.3
 standby 1 priority 105
standby 1 preempt
 standby 2 ipv6 FE80::3
interface FastEthernet0/1
```

```
 ip address 10.0.0.1 255.255.0.0
 duplex auto
 speed auto
 ipv6 address 2001:DB8:ACAD:B::6/64
 ipv6 enable
 ipv6 eigrp 1
router eigrp 1
 passive-interface FastEthernet0/0
 network 10.0.0.0 0.0.255.255
 network 192.168.1.0
 auto-summary
ipv6 router eigrp 1
 eigrp router-id 1.1.1.1
 shutdown
 passive-interface FastEthernet0/0
control-plane
banner motd ^C
AUTHORIZED ACCESS ONLY
Configured by Sonya Lao
^C
end
```

Router 2 show run:

```
Current configuration : 1654 bytes
version 12.4
no service password-encryption
hostname R2
no ip domain lookup
ipv6 unicast-routing
ipv6 cef
interface FastEthernet0/0
 ip address 192.168.1.2 255.255.255.0
 duplex auto
 speed auto
 ipv6 address FE80::4 link-local
 ipv6 address 2001:DB8:ACAD:D::2/64
 ipv6 enable
 ipv6 eigrp 1
 standby version 2
 standby 1 ip 192.168.1.3
 standby 2 ipv6 FE80::3
interface FastEthernet0/1
```

```
 ip address 10.0.0.2 255.255.0.0
 duplex auto
 speed auto
 ipv6 address 2001:DB8:ACAD:B::7/64
 ipv6 enable
 ipv6 eigrp 1
router eigrp 1
 passive-interface FastEthernet0/0
 network 10.0.0.0 0.0.255.255
 network 192.168.1.0
 auto-summary
ipv6 router eigrp 1
 eigrp router-id 2.2.2.2
 shutdown
 passive-interface FastEthernet0/0
banner motd ^C
AUTHORIZED ACCESS ONLY
Configured by Sonya Lao
^C
end
```

Router 3 show run:

```
Current configuration : 1947 bytes
Last configuration change at 15:22:03
UTC Wed Oct 5 2016
no service password-encryption
hostname R3
no ip domain lookup
ipv6 unicast-routing
ipv6 cef
interface GigabitEthernet0/0
 ip address 192.168.2.2 255.255.255.0
 glbp 1 ip 192.168.2.4
 glbp 11 ipv6 FE80::2
 glbp 11 priority 110
 duplex auto
 speed auto
 ipv6 address FE80::1 link-local
 ipv6 address 2001:DB8:ACAD:A::1/64
 ipv6 enable
 ipv6 eigrp 1
interface GigabitEthernet0/1
 ip address 10.0.0.3 255.255.0.0
 duplex auto
 speed auto
 ipv6 address 2001:DB8:ACAD:B::1/64
 ipv6 enable
 ipv6 eigrp 1
router eigrp 1
 network 10.0.0.0 0.0.255.255
 network 192.168.2.0
 passive-interface GigabitEthernet0/0
ipv6 router eigrp 1
 passive-interface GigabitEthernet0/0
 eigrp router-id 3.3.3.3
banner motd ^C
AUTHORIZED ACCESS ONLY
Configured by Sonya Lao
^C
end
```

Router 4 show run:

```
Current configuration : 1930 bytes
Last configuration change at 15:31:39
UTC Wed Oct 5 2016
no service password-encryption
hostname R4
no ip domain lookup
ipv6 unicast-routing
ipv6 cef
interface GigabitEthernet0/0
 ip address 192.168.2.3 255.255.255.0
 glbp 1 ip 192.168.2.4
 glbp 11 ipv6 FE80::2
 duplex auto
 speed auto
 ipv6 address 2001:DB8:ACAD:A::3/64
 ipv6 enable
 ipv6 eigrp 1
interface GigabitEthernet0/1
 ip address 10.0.0.4 255.255.0.0
 duplex auto
 speed auto
 ipv6 address 2001:DB8:ACAD:B::2/64
 ipv6 enable
 ipv6 eigrp 1
router eigrp 1
 network 10.0.0.0 0.0.255.255
 network 192.168.2.0
 passive-interface GigabitEthernet0/0
ipv6 router eigrp 1
 passive-interface GigabitEthernet0/0
 eigrp router-id 4.4.4.4
banner motd ^C
AUTHORIZED ACCESS ONLY
Configured by Sonya Lao
^C
end
```

Router 5 show run:

```
Current configuration : 2021 bytes
Last configuration change at 15:39:41
UTC Wed Oct 5 2016
no service password-encryption
hostname R5
no ip domain lookup
ipv6 unicast-routing
ipv6 cef
interface GigabitEthernet0/0
 ip address 192.168.3.1 255.255.255.0
 ip broadcast-address 192.168.3.0
 duplex auto
 speed auto
 ipv6 address 2001:DB8:ACAD:D::1/64
```

```
 vrrp 1 ip 192.168.3.3
interface GigabitEthernet0/1
 ip address 10.0.0.5 255.255.0.0
 ip broadcast-address 10.0.0.0
 duplex auto
 speed auto
 ipv6 address 2001:DB8:ACAD:B::4/64
router eigrp 1
 network 10.0.0.0 0.0.255.255
 network 192.168.3.0
 passive-interface GigabitEthernet0/0
ip forward-protocol nd
banner motd ^C
AUTHORIZED ACCESS ONLY!
Configured by Sonya Lao
^C
end
```

Router 6 show run:

```
Current configuration : 2024 bytes
Last configuration change at 16:18:05
UTC Wed Oct 5 2016
no service password-encryption
hostname R6
no ip domain lookup
ipv6 unicast-routing
ipv6 cef
interface GigabitEthernet0/0
 ip address 10.0.0.6 255.255.0.0
 duplex auto
 speed auto
 ipv6 address 2001:DB8:ACAD:B::3/64
 ipv6 enable
 ipv6 eigrp 1
interface GigabitEthernet0/1
```

```
 ip address 192.168.6.1 255.255.255.0
 duplex auto
 speed auto
 ipv6 address 2001:DB8:ACAD:C::1/64
 ipv6 enable
 ipv6 eigrp 1
router eigrp 1
 network 10.0.0.0 0.0.255.255
 network 192.168.6.0
 passive-interface GigabitEthernet0/1
ipv6 router eigrp 1
 passive-interface GigabitEthernet0/1
 eigrp router-id 6.6.6.6
banner motd ^C
AUTHORIZED ACCESS ONLY
Configured by Sonya Lao
^C
end
```

Switch 3 show run:

```
Current configuration : 3534 bytes
Last configuration change at 00:51:51 UTC Mon Mar 1 1993
hostname S3
ip routing
no ip domain-lookup
ipv6 unicast-routing
spanning-tree mode pvst
spanning-tree extend system-id
interface FastEthernet1/0/1
 no switchport
 ip address 192.168.3.2 255.255.255.0
 vrrp 1 ip 192.168.3.3
 vrrp 1 preempt
interface FastEthernet1/0/2
 no switchport
 ip address 10.0.0.7 255.255.0.0
 ipv6 address 2001:DB8:ACAD:B::5/64
interface Vlan1
 no ip address
 shutdown
router eigrp 1
 network 10.0.0.0 0.0.255.255
 network 192.168.3.0
 passive-interface FastEthernet1/0/1
banner motd ^C
AUTHORIZED ACCESS ONLY!
Configured by Sonya Lao
^C
end
```

Router 1 show ip route:

```
R1>sh ip route
Codes: 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

Gateway of last resort is not set

     10.0.0.0/16 is subnetted, 1 subnets
C        10.0.0.0 is directly connected, FastEthernet0/1
C     192.168.1.0/24 is directly connected, FastEthernet0/0
D     192.168.2.0/24 [90/30720] via 10.0.0.4, 00:51:44, FastEthernet0/1
                     [90/30720] via 10.0.0.3, 00:51:44, FastEthernet0/1
D     192.168.3.0/24 [90/30720] via 10.0.0.7, 00:24:12, FastEthernet0/1
                     [90/30720] via 10.0.0.5, 00:24:12, FastEthernet0/1
```

Router 1 show ipv6 route:

```
R1>sh ipv6 route
IPv6 Routing Table - Default - 5 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, M - MIPv6, R - RIP, I1 - ISIS L1
       I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP
       EX - EIGRP external
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2001:DB8:ACD:D::/64 [0/0]
     via FastEthernet0/0, directly connected
L   2001:DB8:ACD:D::1/128 [0/0]
     via FastEthernet0/0, receive
C   2001:DB8:ACAD:B::/64 [0/0]
     via FastEthernet0/1, directly connected
L   2001:DB8:ACAD:B::6/128 [0/0]
     via FastEthernet0/1, receive
L   FF00::/8 [0/0]
     via Null0, receive
```

Router 2 show ip route:

```
R2>sh ip route
Codes: 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


Gateway of last resort is not set

     10.0.0.0/16 is subnetted, 1 subnets
C       10.0.0.0 is directly connected, FastEthernet0/1
C    192.168.1.0/24 is directly connected, FastEthernet0/0
D    192.168.2.0/24 [90/30720] via 10.0.0.4, 00:53:13, FastEthernet0/1
                    [90/30720] via 10.0.0.3, 00:53:13, FastEthernet0/1
D    192.168.3.0/24 [90/30720] via 10.0.0.7, 00:25:41, FastEthernet0/1
                    [90/30720] via 10.0.0.5, 00:25:41, FastEthernet0/1
```

Router 2 show ipv6 route:

```
R2>sh ipv6 route
IPv6 Routing Table - Default - 5 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, M - MIPv6, R - RIP, I1 - ISIS L1
       I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary, D - EIGRP
       EX - EIGRP external
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2001:DB8:ACAD:B::/64 [0/0]
     via FastEthernet0/1, directly connected
L   2001:DB8:ACAD:B::7/128 [0/0]
     via FastEthernet0/1, receive
C   2001:DB8:ACAD:D::/64 [0/0]
     via FastEthernet0/0, directly connected
L   2001:DB8:ACAD:D::2/128 [0/0]
     via FastEthernet0/0, receive
L   FF00::/8 [0/0]
     via Null0, receive
```

Router 3 show ip route:

```
R3>sh 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 override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.0.0.0/16 is directly connected, GigabitEthernet0/1
L        10.0.0.3/32 is directly connected, GigabitEthernet0/1
D     192.168.1.0/24 [90/30720] via 10.0.0.2, 00:56:18, GigabitEthernet0/1
                      [90/30720] via 10.0.0.1, 00:56:18, GigabitEthernet0/1
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.2.0/24 is directly connected, GigabitEthernet0/0
L        192.168.2.2/32 is directly connected, GigabitEthernet0/0
D     192.168.3.0/24 [90/30720] via 10.0.0.7, 00:27:41, GigabitEthernet0/1
                      [90/30720] via 10.0.0.5, 00:27:41, GigabitEthernet0/1
```

Router 3 show ipv6 route:

```
R3>sh ipv6 route
IPv6 Routing Table - default - 5 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
       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 - LISP
C   2001:DB8:ACAD:A::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:DB8:ACAD:A::1/128 [0/0]
     via GigabitEthernet0/0, receive
C   2001:DB8:ACAD:B::/64 [0/0]
     via GigabitEthernet0/1, directly connected
L   2001:DB8:ACAD:B::1/128 [0/0]
     via GigabitEthernet0/1, receive
L   FF00::/8 [0/0]
     via Null0, receive
```

Router 4 show ip route:
```
R4>sh 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 override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.0.0.0/16 is directly connected, GigabitEthernet0/1
L        10.0.0.4/32 is directly connected, GigabitEthernet0/1
D      192.168.1.0/24 [90/30720] via 10.0.0.2, 00:56:24, GigabitEthernet0/1
                      [90/30720] via 10.0.0.1, 00:56:24, GigabitEthernet0/1
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.2.0/24 is directly connected, GigabitEthernet0/0
L        192.168.2.3/32 is directly connected, GigabitEthernet0/0
D      192.168.3.0/24 [90/30720] via 10.0.0.7, 00:28:52, GigabitEthernet0/1
                      [90/30720] via 10.0.0.5, 00:28:52, GigabitEthernet0/1
```
Router 4 show ipv6 route:
```
R4>sh ipv6 route
IPv6 Routing Table - default - 5 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
       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 - LISP
C   2001:DB8:ACAD:A::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:DB8:ACAD:A::3/128 [0/0]
     via GigabitEthernet0/0, receive
C   2001:DB8:ACAD:B::/64 [0/0]
     via GigabitEthernet0/1, directly connected
L   2001:DB8:ACAD:B::2/128 [0/0]
     via GigabitEthernet0/1, receive
L   FF00::/8 [0/0]
     via Null0, receive
```

Router 5 show ip route:
```
R5>sh 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 override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.0.0.0/16 is directly connected, GigabitEthernet0/1
L        10.0.0.5/32 is directly connected, GigabitEthernet0/1
D     192.168.1.0/24 [90/30720] via 10.0.0.2, 00:30:55, GigabitEthernet0/1
                      [90/30720] via 10.0.0.1, 00:30:55, GigabitEthernet0/1
D     192.168.2.0/24 [90/30720] via 10.0.0.4, 00:30:55, GigabitEthernet0/1
                      [90/30720] via 10.0.0.3, 00:30:55, GigabitEthernet0/1
      192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.3.0/24 is directly connected, GigabitEthernet0/0
L        192.168.3.1/32 is directly connected, GigabitEthernet0/0
```
Router 5 show ipv6 route:
```
R5>sh ipv6 route
IPv6 Routing Table - default - 3 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, D - EIGRP, EX - EIGRP external
       ND - Neighbor Discovery
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2001:DB8:ACAD:B::/64 [0/0]
     via FastEthernet1/0/2, directly connected
L   2001:DB8:ACAD:B::5/128 [0/0]
     via FastEthernet1/0/2, receive
L   FF00::/8 [0/0]
     via Null0, receive
```

Switch 3 show ip route:

```
S3#sh 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 override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.0.0.0/16 is directly connected, FastEthernet1/0/2
L        10.0.0.7/32 is directly connected, FastEthernet1/0/2
D     192.168.1.0/24 [90/30720] via 10.0.0.2, 00:31:51, FastEthernet1/0/2
                     [90/30720] via 10.0.0.1, 00:31:51, FastEthernet1/0/2
D     192.168.2.0/24 [90/30720] via 10.0.0.4, 00:31:51, FastEthernet1/0/2
                     [90/30720] via 10.0.0.3, 00:31:51, FastEthernet1/0/2
      192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.3.0/24 is directly connected, FastEthernet1/0/1
L        192.168.3.2/32 is directly connected, FastEthernet1/0/1
```

Switch 3 show ipv6 route:

```
S3#sh ipv6 route
IPv6 Routing Table - default - 3 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, D - EIGRP, EX - EIGRP external
       ND - Neighbor Discovery
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
C   2001:DB8:ACAD:B::/64 [0/0]
     via FastEthernet1/0/2, directly connected
L   2001:DB8:ACAD:B::5/128 [0/0]
     via FastEthernet1/0/2, receive
L   FF00::/8 [0/0]
     via Null0, receive
```

Router 6 show ip route:

```
R6>sh 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 override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.0.0.0/16 is directly connected, GigabitEthernet0/0
L        10.0.0.6/32 is directly connected, GigabitEthernet0/0
D     192.168.1.0/24 [90/30720] via 10.0.0.2, 00:50:28, GigabitEthernet0/0
                     [90/30720] via 10.0.0.1, 00:50:28, GigabitEthernet0/0
D     192.168.2.0/24 [90/30720] via 10.0.0.4, 00:50:28, GigabitEthernet0/0
                     [90/30720] via 10.0.0.3, 00:50:28, GigabitEthernet0/0
D     192.168.3.0/24 [90/30720] via 10.0.0.7, 00:32:59, GigabitEthernet0/0
                     [90/30720] via 10.0.0.5, 00:32:59, GigabitEthernet0/0
```
Router 6 show ipv6 route:

```
R6>sh ipv6 route
IPv6 Routing Table - default - 4 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, HA - Home Agent, MR - Mobile Router, R - RIP
       H - NHRP, I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
       IS - ISIS summary, D - EIGRP, EX - EIGRP external, NM - NEMO
       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 - LISP
D   2001:DB8:ACAD:A::/64 [90/30720]
     via FE80::26E9:B3FF:FE3C:1C61, GigabitEthernet0/0
     via FE80::7ADA:6EFF:FE99:AB21, GigabitEthernet0/0
C   2001:DB8:ACAD:B::/64 [0/0]
     via GigabitEthernet0/0, directly connected
L   2001:DB8:ACAD:B::3/128 [0/0]
     via GigabitEthernet0/0, receive
L   FF00::/8 [0/0]
     via Null0, receive
```

Router 1 show standby:

```
R1>sh standby
FastEthernet0/0 - Group 1 (version 2)
  State is Active
    2 state changes, last state change 00:47:33
  Virtual IP address is 192.168.1.3
  Active virtual MAC address is 0000.0c9f.f001
    Local virtual MAC address is 0000.0c9f.f001 (v2 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 1.808 secs
  Preemption enabled
  Active router is local
  Standby router is 192.168.1.2, priority 100 (expires in 8.656 sec)
  Priority 105 (configured 105)
  Group name is "hsrp-Fa0/0-1" (default)
FastEthernet0/0 - Group 2 (version 2)
  State is Active
    2 state changes, last state change 00:47:32
  Virtual IP address is FE80::3
  Active virtual MAC address is 0005.73a0.0002
    Local virtual MAC address is 0005.73a0.0002 (v2 IPv6 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 0.400 secs
  Preemption disabled
  Active router is local
  Standby router is FE80::4, priority 100 (expires in 9.936 sec)
  Priority 100 (default 100)
  Group name is "hsrp-Fa0/0-2" (default)
```

Router 2 show standby:

```
R2>sh standby
FastEthernet0/0 - Group 1 (version 2)
  State is Standby
    4 state changes, last state change 00:47:57
  Virtual IP address is 192.168.1.3
  Active virtual MAC address is 0000.0c9f.f001
    Local virtual MAC address is 0000.0c9f.f001 (v2 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 1.920 secs
  Preemption disabled
  Active router is 192.168.1.1, priority 105 (expires in 9.024 sec)
    MAC address is 001b.d495.de20
  Standby router is local
  Priority 100 (default 100)
  Group name is "hsrp-Fa0/0-1" (default)
FastEthernet0/0 - Group 2 (version 2)
  State is Standby
    4 state changes, last state change 00:47:57
  Virtual IP address is FE80::3
  Active virtual MAC address is 0005.73a0.0002
    Local virtual MAC address is 0005.73a0.0002 (v2 IPv6 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 2.432 secs
  Preemption disabled
  Active router is FE80::5, priority 100 (expires in 10.736 sec)
    MAC address is 001b.d495.de20
  Standby router is local
  Priority 100 (default 100)
  Group name is "hsrp-Fa0/0-2" (default)
```

Router 3 show glbp:

```
R3>sh glbp
GigabitEthernet0/0 - Group 1
  State is Standby
    3 state changes, last state change
00:45:29
  Virtual IP address is 192.168.2.4
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 1.344 secs
  Redirect time 600 sec, forwarder timeout
14400 sec
  Preemption disabled
  Active is 192.168.2.3, priority 100
(expires in 11.648 sec)
  Standby is local
  Priority 100 (default)
  Weighting 100 (default 100), thresholds:
lower 1, upper 100
  Load balancing: round-robin
  Group members:
    24e9.b33c.1c60 (192.168.2.2) local
    78da.6e99.ab20 (192.168.2.3)
  There are 2 forwarders (1 active)
  Forwarder 1
    State is Active
      3 state changes, last state change
00:44:56
    MAC address is 0007.b400.0101 (default)
    Owner ID is 24e9.b33c.1c60
    Preemption enabled, min delay 30 sec
    Active is local, weighting 100
    Client selection count: 2
  Forwarder 2
    State is Listen
      2 state changes, last state change
00:44:53
    MAC address is 0007.b400.0102 (learnt)
    Owner ID is 78da.6e99.ab20
    Time to live: 14400.032 sec (maximum
14400 sec)
    Preemption enabled, min delay 30 sec
    Active is 192.168.2.3 (primary),
weighting 100 (expires in 10.816 sec)
GigabitEthernet0/0 - Group 11
  State is Active
      1 state change, last state change
00:47:02
  Virtual IP address is FE80::2
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 1.856 secs
  Redirect time 600 sec, forwarder timeout
14400 sec
  Preemption disabled
  Active is local
  Standby is FE80::7ADA:6EFF:FE99:AB20,
priority 100 (expires in 7.808 sec)
  Priority 110 (configured)
  Weighting 100 (default 100), thresholds:
lower 1, upper 100
  Load balancing: round-robin
  Group members:
    24e9.b33c.1c60 (FE80::1) local
    78da.6e99.ab20
(FE80::7ADA:6EFF:FE99:AB20)
  There are 2 forwarders (1 active)
  Forwarder 1
    State is Listen
      4 state changes, last state change
00:44:59
    MAC address is 0007.b400.0b01 (learnt)
    Owner ID is 78da.6e99.ab20
    Redirection enabled, 597.824 sec
remaining (maximum 600 sec)
    Time to live: 14397.824 sec (maximum
14400 sec)
    Preemption enabled, min delay 30 sec
    Active is FE80::7ADA:6EFF:FE99:AB20
(primary), weighting 100 (expires in 9.408
sec)
    Client selection count: 3
  Forwarder 2
    State is Active
      1 state change, last state change
00:44:54
    MAC address is 0007.b400.0b02 (default)
    Owner ID is 24e9.b33c.1c60
    Redirection enabled
    Preemption enabled, min delay 30 sec
    Active is local, weighting 100
```

Router 4 show glbp:

```
R4>sh glbp
GigabitEthernet0/0 - Group 1
  State is Active
    1 state change, last state change
00:47:27
  Virtual IP address is 192.168.2.4
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 1.856 secs
  Redirect time 600 sec, forwarder
timeout 14400 sec
  Preemption disabled
  Active is local
  Standby is 192.168.2.2, priority 100
(expires in 7.904 sec)
  Priority 100 (default)
  Weighting 100 (default 100),
thresholds: lower 1, upper 100
  Load balancing: round-robin
  Group members:
    24e9.b33c.1c60 (192.168.2.2)
    78da.6e99.ab20 (192.168.2.3) local
  There are 2 forwarders (1 active)
  Forwarder 1
    State is Listen
      4 state changes, last state
change 00:46:27
    MAC address is 0007.b400.0101
(learnt)
    Owner ID is 24e9.b33c.1c60
    Redirection enabled, 597.920 sec
remaining (maximum 600 sec)
    Time to live: 14397.920 sec
(maximum 14400 sec)
    Preemption enabled, min delay 30
sec
    Active is 192.168.2.2 (primary),
weighting 100 (expires in 9.120 sec)
    Client selection count: 5
  Forwarder 2
    State is Active
      1 state change, last state change
00:46:24
    MAC address is 0007.b400.0102
(default)
    Owner ID is 78da.6e99.ab20
    Redirection enabled
    Preemption enabled, min delay 30
sec
```

```
    Active is local, weighting 100
    Client selection count: 4
GigabitEthernet0/0 - Group 11
  State is Standby
    3 state changes, last state change
00:47:01
  Virtual IP address is FE80::2
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 1.504 secs
  Redirect time 600 sec, forwarder
timeout 14400 sec
  Preemption disabled
  Active is FE80::1, priority 110
(expires in 11.296 sec)
  Standby is local
  Priority 100 (default)
  Weighting 100 (default 100),
thresholds: lower 1, upper 100
  Load balancing: round-robin
  Group members:
    24e9.b33c.1c60 (FE80::1)
    78da.6e99.ab20
(FE80::7ADA:6EFF:FE99:AB20) local
  There are 2 forwarders (1 active)
  Forwarder 1
    State is Active
      3 state changes, last state
change 00:46:30
    MAC address is 0007.b400.0b01
(default)
    Owner ID is 78da.6e99.ab20
    Preemption enabled, min delay 30
sec
    Active is local, weighting 100
  Forwarder 2
    State is Listen
      2 state changes, last state
change 00:46:25
    MAC address is 0007.b400.0b02
(learnt)
    Owner ID is 24e9.b33c.1c60
    Time to live: 14399.520 sec
(maximum 14400 sec)
    Preemption enabled, min delay 30
sec
    Active is FE80::1 (primary),
weighting 100 (expires in 10.848 sec)
```

Router 5 show vrrp:

```
R5>sh vrrp
GigabitEthernet0/0 - Group 1
  State is Backup
  Virtual IP address is 192.168.3.3
  Virtual MAC address is 0000.5e00.0101
  Advertisement interval is 1.000 sec
  Preemption enabled
  Priority is 100
  Master Router is 192.168.3.2, priority is 100
  Master Advertisement interval is 1.000 sec
  Master Down interval is 3.609 sec (expires in 3.489 sec)
```

Switch 3 show vrrp:

```
S3#sh vrrp
FastEthernet1/0/1 - Group 1
  State is Master
  Virtual IP address is 192.168.3.3
  Virtual MAC address is 0000.5e00.0101
  Advertisement interval is 1.000 sec
  Preemption enabled
  Priority is 100
  Master Router is 192.168.3.2 (local), priority is 100
  Master Advertisement interval is 1.000 sec
  Master Down interval is 3.609 sec
```

Router 6 show ip eigrp neighbors:

```
R6>sh ip eigrp neigh
EIGRP-IPv4 Neighbors for AS(1)
H   Address                Interface        Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
5   10.0.0.7               Gi0/0             14 00:34:06    1   100  0  14
2   10.0.0.5               Gi0/0             13 00:35:09    1   100  0  19
4   10.0.0.1               Gi0/0             11 00:51:34    5   100  0  30
3   10.0.0.2               Gi0/0             10 00:51:34  335  2010  0  30
1   10.0.0.4               Gi0/0             14 00:51:34  335  2010  0  29
0   10.0.0.3               Gi0/0             12 00:51:34  418  2508  0  29
```

Router 6 show ipv6 eigrp neighbors:

```
R6>sh ipv6 neigh
IPv6 Address                            Age Link-layer Addr State Interface
2001:DB8:ACAD:B:9459:4AB3:85B5:AC47      40 4ccc.6a38.8ee4  STALE Gi0/0
2001:DB8:ACAD:C::2                       52 4ccc.6a38.8ef9  STALE Gi0/1
FE80::7ADA:6EFF:FE99:AB21                34 78da.6e99.ab21  STALE Gi0/0
2001:DB8:ACAD:C:D940:1D52:9ECE:7387      34 4ccc.6a38.8ef9  STALE Gi0/1
2001:DB8:ACAD:B:10F4:7B32:4F41:18C6      52 4ccc.6a38.8ee4  STALE Gi0/0
FE80::9459:4AB3:85B5:AC47                35 4ccc.6a38.8ee4  STALE Gi0/0
FE80::26E9:B3FF:FE3C:1C61                34 24e9.b33c.1c61  STALE Gi0/0
FE80::A175:A21F:7D0C:F80D                34 4ccc.6a38.8ef9  STALE Gi0/1
```

Ping 192.168.6.2 from PC-A:
```
C:\>ping –t 192.168.6.2

Pinging 192.168.6.2 with 32 bytes of data:

Reply from 192.168.6.2: bytes=32 time=1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Request timed out.
Request timed out.
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
Reply from 192.168.6.2: bytes=32 time<1ms TTL=255
```

Ping 2001:db8:acad:c::2 from PC-A:
```
C:\>ping –t 2001:db8:acad:c::2

Pinging 2001:db8:acad:c::2 with 32 bytes of data:

Reply from 2001:DB8:ACAD:C::2: bytes=32 time=11ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time<1ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time<1ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time=1ms TTL=255
Request timed out.
Request timed out.
Request timed out.
Reply from 2001:DB8:ACAD:C::2: bytes=32 time=11ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time<1ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time<1ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time=1ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time<1ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time<1ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time=1ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time<1ms TTL=255
Reply from 2001:DB8:ACAD:C::2: bytes=32 time=1ms TTL=255
```

Problems

One problem that I encountered was an unknown password on a Layer 3 switch (S2). Because of the password, all connected ports on the switch were flashing amber. This meant that the switch was preventing the network from fully converging and it impacted EIGRP adjacencies. As a result, I hacked the switch to remove the password. To do so, I started by unplugging the power to the switch. While the switch was off, I held the MODE button and re-inserted the power cord, waiting until the SYST LED light turned solid green. Next, I consoled into the switch and entered commands to rename the flash config.text file. Upon completion, the startup configuration was replaced and all connected ports turned green. This problem solidified my knowledge of hacking switches and routers. If the issue ever arises again, I will have no trouble identifying the problem and hacking the switch.

In addition, several problems occurred while I was configuring EIGRP. When I initially configured the routing protocol on every router, I kept seeing the error message "X.X.X.X not on common subnet". Because of this error, no adjacencies were formed and I was unable to test for connectivity across the network. To fix the error, I looked online for solutions to the problem. I realized that not all IPv4 and IPv6 addresses on the non-FHRP side of the topology were in the same network. Thus, I changed the addressing of the G0/1 interfaces on R3, R4, and R5 to match the subnet that the other devices shared. From this experience, I realized that my original addressing scheme was flawed because I did not have a complete understanding of the lab. For future labs, I will spend more time understanding the lab and its requirements before I create my topology and addressing scheme, to avoid encountering this type of error again.

Another error was in regards to EIGRPv3. R1 and R2 were not receiving any adjacencies, even after all the correct commands for IPv6 EIGRP were entered. Even after searching online and verifying that I had the right commands, there were still no neighbors. The error message that occurred was that EIGRP 1 was in shutdown. After specifically searching about the shutdown error message, I remembered that EIGRP for IPv6 had a shutdown feature. The solution to the problem was to issue the "no shutdown" command in router config mode. From this problem, I learned the value of more specific searches. The Internet will return answers based on the question, so a more efficient method is to ask more specified questions.

Conclusion

Through this lab, I gained a thorough understanding of the three major First Hop Redundancy Protocols. In general, I see the value of using FHRP, as it protects the default gateway and ensures that there is always connectivity. I encountered some errors that could havei been prevented through better planning, but I can avoid those mistakes in future labs.