Border Gateway Protocol

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**Purpose**

Through this lab, we learned the basics of how to set up a BGP network. Although BGP was a concept we learned about for the first time in this lab, we also learned how the application of BGP works into different external protocols, like OSPF, RIP, and EIGRP. The implementation of IPv4 and IPv6 was also covered as an important aspect of this lab.

**Background Info**

Border Gateway Protocol (BGP) is the routing protocol of the internet. It takes care of the ability that we have to send packets across the world. This protocol determines the bet route for the traveling data on the Internet by analyzing all the available paths and optimizing the quickest and most efficient path.

It is a path vector protocol that includes independently operating systems that are called autonomous system (AS). These are connected by neighbor adjacencies that are established by BGP speakers. An AS is a routing domain, consisting of devices that all use the same set of protocols, and are operated by a single administrator. Similar to OSPF areas, BGP AS has numbers that identify them on the internet, and because of the sheer number of AS on the internet today, these ID numbers are sorted in rangers, like IP addresses. Originally, there were only 2-byte AS numbers, ranging from 0 to 65535—however, because the internet has grown so much, more AS were created than people had numbers for. 4-byte addresses were added, ranging 0 to 4294967295.

This is a table showing the 2-byte AS numbers (as we used 2-byte numbers for this lab):

|  |  |
| --- | --- |
| AS number/range | Utility |
| 0 | Reserved |
| 1-64495 | Public numbers |
| 64496-64511 | Reserved for Documentation usage |
| 64512-65534 | Private numbers |
| 65535 | Reserved |

In BGP, there are two main types. Internal BGP and external BGP. These are two different routing protocols, and are used to exchange routing information between numerous AS.

|  |  |
| --- | --- |
| eBGP | iBGP |
| Does not require a full mesh of routers | Requires a full mesh of routers |
| Used AS\_PATH attribute for loop prevention | Does not use AS\_PATH attribute for loop prevention |
| Sends updates over TCP port 179 | Sends updates over TCP port 179 |
| Uses hop-by-hop approach for path selection | Uses a recursive approach for path selection |

The biggest advantage of eBGP is the scalability—it can handle large amounts of data and route them all quickly, with no interruption in the actual service, making it highly ideal for apps that require high levels of throughput. It’s crucial for growing businesses and organizations to consider scalability. eBGP enables automatic route advertisement between multiple AS, making it so that it and be used to exchange routing information between numerous AS. A disadvantage of using eBGP is the complexity of the configurations the maintenance. Because of its reliance on manual configuration from networks administrators and with how there are multiple IP addresses per router, the misconfiguration risk is high.

**Lab Summary**

1. Design topology with a single switch connected to 3 routers (with loopbacks).
2. Assign each respective router to OSPF, EIGRP, and RIP networks, *in addition to* BGP.
3. Utilize the topology to set up a physical router network (3 routers, 1 switch)
4. Make sure to configure IPv4 and IPv6 addresses on routers.
5. Assign OSPF for router 1, EIGRP for router 2, and RIP or router 3.
6. Configure BGP for all the ABS routers—to redistribute routes and connect traffic from separate networks.
7. Test connectivity through pinging IP addresses

**Lab Commands**

**router bgp [autonomous-system #]:** enables BGP’s configuration mode

**address-family [ipv4/ipv6]:** if IPv4—enables address family configuration mode and creates a BGP IPv2 unicast address. If IPv6—enables address family configuration mode except for IPv6 and creates a BGP IPv6 unicast address.

**neighbor [ipv4 address/ipv6 address] remote-as [autonomous-system #]:** configured in address family mode, BGP routes gets redistributed and received through neighbors.

**neighbor [ipv4 address] weight [weight value]:** sets the weight to the routes learned from one of the neighbors, the higher weight value – the higher the preference for that path is.

**neighbor [ipv4 address] advertisement-interval [interval]:** this sets the minimum time between the BGP routing updates to a neighbor to maintain a routing table that is table.

**router eigrp:** enables EIGRP on the router, enters EIGRP configuration mode.

**router rip:** enables RIP on the router, enters RIP configuration mode.

**Network Diagram/Topology**

A diagram of a computer network

Description automatically generated

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | g0/0/0 IPv4 | g0/0/0 IPv6 | Lo0 IPv4 | Lo0 IPv6 |
| R1 | 10.0.0.1 /24 | 10::1 /64 | 192.168.1.1 /32 | 1::1 /64 |
| R2 | 10.0.0.2 /24 | 10::2 /64 | 192.168.2.1 /32 | 2::2 /64 |
| R3 | 10.0.0.3 /24 | 10::3 /64 | 192.168.3.1 /32 | 3::3 /64 |

**Configurations** – show run/show ip route/show ipv6 route

**Router 1**

show run

Current configuration : 2934 bytes

!

! Last configuration change at 18:41:07 UTC Mon Nov 13 2023

!

version 16.7

service timestamps debug datetime msec

service timestamps log datetime msec

platform qfp utilization monitor load 80

no platform punt-keepalive disable-kernel-core

!

hostname R1

!

boot-start-marker

boot-end-marker

!

vrf definition Mgmt-intf

!

address-family ipv4

exit-address-family

!

address-family ipv6

exit-address-family

!

no aaa new-model

!

subscriber templating

!

vtp domain cisco

vtp mode transparent

ipv6 unicast-routing

!

!

multilink bundle-name authenticated

!

license udi pid ISR4321/K9 sn FDO220523GF

license boot level appxk9

no license smart enable

diagnostic bootup level minimal

!

spanning-tree extend system-id

!

redundancy

mode none

!

interface Loopback0

ip address 192.168.1.1 255.255.255.255

ipv6 address 1::1/64

ipv6 ospf 1 area 0

!

interface GigabitEthernet0/0/0

ip address 10.0.0.1 255.255.255.0

negotiation auto

ipv6 address 10::1/64

!

interface GigabitEthernet0/0/1

no ip address

negotiation auto

!

interface Serial0/1/0

no ip address

shutdown

!

interface Serial0/1/1

no ip address

shutdown

!

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

!

router ospfv3 1

router-id 1.1.1.1

!

address-family ipv6 unicast

exit-address-family

!

router ospf 1

router-id 1.1.1.1

network 192.168.1.0 0.0.0.255 area 1

!

router bgp 65001

bgp router-id 1.1.1.1

bgp log-neighbor-changes

timers bgp 5 20

neighbor 10::2 remote-as 65002

neighbor 10::3 remote-as 65003

neighbor 10.0.0.2 remote-as 65002

neighbor 10.0.0.3 remote-as 65003

!

address-family ipv4

bgp scan-time 20

network 10.0.0.0 mask 255.255.255.0

redistribute connected

redistribute ospf 1

no neighbor 10::2 activate

no neighbor 10::3 activate

neighbor 10.0.0.2 activate

neighbor 10.0.0.2 weight 200

neighbor 10.0.0.2 advertisement-interval 0

neighbor 10.0.0.2 route-map ASPREPEND1 out

neighbor 10.0.0.3 activate

neighbor 10.0.0.3 advertisement-interval 0

neighbor 10.0.0.3 route-map ASPREPEND1 out

exit-address-family

!

address-family ipv6

redistribute connected

redistribute ospf 1

network 10::/64

neighbor 10::2 activate

neighbor 10::3 activate

exit-address-family

!

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

!

access-list 1 permit 10.0.0.0 0.0.0.255

!

route-map ASPREPEND1 permit 10

match ip address 1

set as-path prepend 65001 65001

!

control-plane

!

line con 0

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

!

wsma agent exec

!

wsma agent config

!

wsma agent filesys

!

wsma agent notify

!

end

show bgp summary

**A screenshot of a computer program

Description automatically generated**

pings for R1 (IPv4)

A screenshot of a computer program

Description automatically generated

pings for IPv6

A screenshot of a computer program

Description automatically generated

**Router 2**

show run

Current configuration : 5163 bytes

!

! Last configuration change at 18:12:02 UTC Mon Nov 13 2023

!

version 16.9

service timestamps debug datetime msec

service timestamps log datetime msec

platform qfp utilization monitor load 80

platform punt-keepalive disable-kernel-core

!

hostname R2

!

boot-start-marker

boot-end-marker

!

vrf definition Mgmt-intf

!

address-family ipv4

exit-address-family

!

address-family ipv6

exit-address-family

!

no aaa new-model

!

login on-success log

!

subscriber templating

!

vtp domain cisco

vtp mode transparent

ipv6 unicast-routing

multilink bundle-name authenticated

!

crypto pki trustpoint TP-self-signed-2189345785

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-2189345785

revocation-check none

rsakeypair TP-self-signed-2189345785

!

crypto pki certificate chain TP-self-signed-2189345785

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274

69666963 6174652D 32313839 33343537 3835301E 170D3233 31313133 31373137

30355A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 31383933

34353738 35308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 0100C469 84A078AD 8768CE16 D35CF51B B3B7D09B 2D0D1B42 FE6C5F8B

E2991709 7732E24A A08E248A 8F58FE50 B629E22C 2C00FC76 AE8B68DE FC58A696

7992BA99 377F89AC 6FA5B39B 56BA15E7 284D7E03 A4163C8F C2CDFB4A CC2AFF85

356E5D61 52D35D26 F2547161 0C7E3F3E E8E8F308 09665783 880D3187 7C35A6DA

0266523F 5A1E4026 15924D36 61B5519F 666B9CE4 021E8CA8 32AA1297 3B2CF342

315DA92C D63E555F 705A120D 74F745DC EC27341B 1BFC1803 38B896E4 C6F10C66

220B21E6 FC76468C 8AAE96DC F729E93B 574A2FD1 18617877 72501FB3 B1E6FFA3

F19F1968 60421A58 4A1D9F6F A46EE8ED 2AB68A95 899EFE1A 0F45A99C FC7B007A

08DC495D 6DF10203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 14F07468 69839C7F 648A0E98 EA351350 69B8D0F1

29301D06 03551D0E 04160414 F0746869 839C7F64 8A0E98EA 35135069 B8D0F129

300D0609 2A864886 F70D0101 05050003 82010100 AF4C7176 A0CA5D6A 80F3582D

F16E69D8 87B4E775 635CB666 6179C448 8F316D84 2568C820 D6E77499 4C219AB0

9050B812 7E1DA7E5 8C824C1B 6C7F11C8 44BC34B0 411AB5AF 98BF3716 CB0B34B9

D6CBE3DB 7E390E83 D90BBC29 A246CBB0 DECA54C3 6C70CC0B C0CE37B7 7C72975C

3F3EE123 097E9054 B381A5C3 8161C1F7 3277D918 A761F4C3 F87A839C A6A880D8

F3805726 8B78FB9C 6DB20340 D34F6DE1 F7F0F154 94D26EF4 2979D346 3432A44F

F09F92D9 B1732E9A 2976169E 866ACF08 F017803B 7C48884E FAB89444 A9D2FE5E

F4AF75A5 7B53E4CF 1147AB1D 2D7FBE91 9DB657CF D606DC72 E477F411 D0222A12

33553DAC A25DDDF3 E8DC116C F7F62CB6 DEA9DD52

quit

!

license udi pid ISR4321/K9 sn FDO21482DXE

license boot level appxk9

no license smart enable

diagnostic bootup level minimal

!

spanning-tree extend system-id

!

redundancy

mode none

!

interface Loopback0

ip address 192.168.2.1 255.255.255.255

ipv6 address 2::2/64

ipv6 eigrp 1

!

interface GigabitEthernet0/0/0

ip address 10.0.0.2 255.255.255.0

negotiation auto

ipv6 address 10::2/64

!

interface GigabitEthernet0/0/1

no ip address

shutdown

negotiation auto

!

interface Serial0/1/0

no ip address

shutdown

!

interface Serial0/1/1

no ip address

shutdown

!

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

!

router eigrp 1

network 192.168.2.1 0.0.0.0

redistribute bgp 65002 metric 100 1 255 1 15

eigrp router-id 2.2.2.2

!

router bgp 65002

bgp router-id 2.2.2.2

bgp log-neighbor-changes

timers bgp 5 20

neighbor 10::1 remote-as 65001

neighbor 10::3 remote-as 65003

neighbor 10.0.0.1 remote-as 65001

neighbor 10.0.0.3 remote-as 65003

!

address-family ipv4

bgp scan-time 20

network 10.0.0.0 mask 255.255.255.0

redistribute connected

redistribute eigrp 1

no neighbor 10::1 activate

no neighbor 10::3 activate

neighbor 10.0.0.1 activate

neighbor 10.0.0.1 weight 100

neighbor 10.0.0.1 advertisement-interval 0

neighbor 10.0.0.1 route-map ASPREPEND2 out

neighbor 10.0.0.3 activate

neighbor 10.0.0.3 advertisement-interval 0

neighbor 10.0.0.3 route-map ASPREPEND2 out

exit-address-family

!

address-family ipv6

redistribute connected

redistribute eigrp 1

network 10::/64

neighbor 10::1 activate

neighbor 10::3 activate

exit-address-family

!

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

!

access-list 5 permit 10.0.0.0 0.0.0.255

ipv6 router eigrp 1

eigrp router-id 2.2.2.2

redistribute bgp 65002 metric 100 1 255 1 1500

!

route-map ASPREPEND2 permit 10

match ip address 5

set as-path prepend 65002

!

route-map ASPREPEND2 permit 20

!

control-plane

!

line con 0

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

!

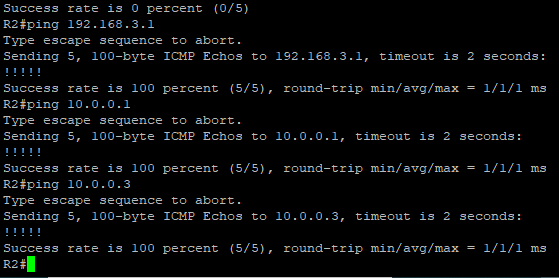
end

show bgp summary

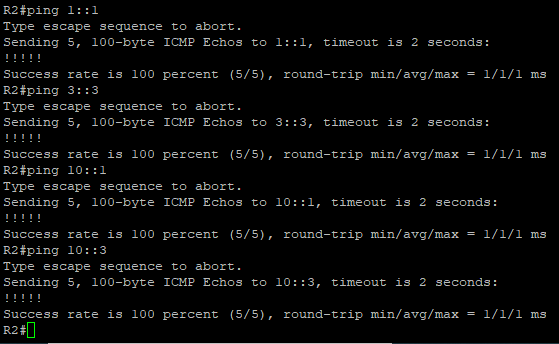
**A computer screen shot of a black screen

Description automatically generated**

pings from R2 (IPv4)



pings from R2 (IPv6)



**Router 3**

show run

Current configuration : 5068 bytes

!

! Last configuration change at 17:51:39 UTC Mon Nov 13 2023

!

version 16.9

service timestamps debug datetime msec

service timestamps log datetime msec

platform qfp utilization monitor load 80

platform punt-keepalive disable-kernel-core

!

hostname R3

!

boot-start-marker

boot-end-marker

!

vrf definition Mgmt-intf

!

address-family ipv4

exit-address-family

!

address-family ipv6

exit-address-family

!

no aaa new-model

!

login on-success log

!

subscriber templating

!

vtp domain cisco

vtp mode transparent

ipv6 unicast-routing

multilink bundle-name authenticated

!

crypto pki trustpoint TP-self-signed-2557841031

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-2557841031

revocation-check none

rsakeypair TP-self-signed-2557841031

!

crypto pki certificate chain TP-self-signed-2557841031

certificate self-signed 01

30820330 30820218 A0030201 02020101 300D0609 2A864886 F70D0101 05050030

31312F30 2D060355 04031326 494F532D 53656C66 2D536967 6E65642D 43657274

69666963 6174652D 32353537 38343130 3331301E 170D3233 31313133 31363439

32335A17 0D333030 31303130 30303030 305A3031 312F302D 06035504 03132649

4F532D53 656C662D 5369676E 65642D43 65727469 66696361 74652D32 35353738

34313033 31308201 22300D06 092A8648 86F70D01 01010500 0382010F 00308201

0A028201 0100B255 9B514A9C 60A24365 592DC9A5 907955AF 6DF6CA70 E0FEDBCA

DB500CE5 D2B52E89 272F09FD EEF290B9 8CD3B57B E3F5A5E5 AA4C6261 ABE7B7AF

70E47FB0 FCCB3336 FB30979D 7F61F40C ADAB1DEC 48A35286 384549E0 7DA2E5B9

9A325C6C 424A62AB 0D84C8C9 BE26B3BA A357CB89 AE67B9A8 711F0253 FD581178

29A525C0 A6B200EA FD2DD511 D3FFBA7F 44BFB9C0 2687549D A9DDDA59 5F076B8D

6C3E2B4A 4E707F73 48F4B98E 8A887D8C 0DBDEB2F 0FD878D3 B2D017EC 5458F609

68B8127E 1E617CE2 92795E84 7F1D9905 A01BE684 264B4865 DF70FD47 296D9F82

539D693A 279E033E 18744F7A D59F0C0D A9EF81E3 91E97601 E2D374E3 F05BFB20

6EF4619B 8CF70203 010001A3 53305130 0F060355 1D130101 FF040530 030101FF

301F0603 551D2304 18301680 1436FA18 E5661BD0 BCBEE39C DDA0F049 31BBCE3B

76301D06 03551D0E 04160414 36FA18E5 661BD0BC BEE39CDD A0F04931 BBCE3B76

300D0609 2A864886 F70D0101 05050003 82010100 31DA03B8 972ACD60 6CCDCB39

C5B2B696 CB7B8835 6D09BBC4 FA71C656 7E9C93D3 A33A5DD9 D3ADF6D6 B25F9B96

CEC42C4F CEB0F465 5C70D97E A1E2921D E2276671 CB90BFDC CA1C4416 0CFA5D82

811CD2C8 BC2AE58F 224F4BE6 7B1C34B2 E4602BBF FE700D67 6581A994 99DF251A

10396C51 F5DDB3E6 67302A29 04A10606 8458A94D E08841F1 BC83A68D 4D255C4F

DD8E75CF 00A88729 2B6DA3DF 48471CBC CD5B0B48 D8B57B21 166D86FF B3D16144

A864CD92 693CC74D 171ABB72 82C39247 1CC060B6 D64D41D1 198F1FC3 761A1F96

456ECAE9 4B677FD7 9F039F0B 7E25A0F6 A77BCB8F C556084C D9E0F514 08BDBDB2

24FB97A0 92298A6E F799AE54 BF23F315 7CF6C016

quit

!

license udi pid ISR4321/K9 sn FDO21500G1N

license boot level appxk9

no license smart enable

diagnostic bootup level minimal

!

spanning-tree extend system-id

!

redundancy

mode none

!

interface Loopback0

ip address 192.168.3.1 255.255.255.255

ipv6 address 3::3/64

!

interface GigabitEthernet0/0/0

ip address 10.0.0.3 255.255.255.0

negotiation auto

ipv6 address 10::3/64

!

interface GigabitEthernet0/0/1

no ip address

negotiation auto

!

interface Serial0/1/0

no ip address

shutdown

!

interface Serial0/1/1

no ip address

shutdown

!

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

!

router rip

redistribute connected

redistribute static

network 192.168.3.0

neighbor 10.0.0.2

neighbor 10.0.0.1

!

router bgp 65003

bgp log-neighbor-changes

timers bgp 5 20

neighbor 10::1 remote-as 65001

neighbor 10::2 remote-as 65002

neighbor 10.0.0.1 remote-as 65001

neighbor 10.0.0.2 remote-as 65002

!

address-family ipv4

bgp scan-time 20

network 10.0.0.0 mask 255.255.255.0

redistribute connected

redistribute rip

no neighbor 10::1 activate

no neighbor 10::2 activate

neighbor 10.0.0.1 activate

neighbor 10.0.0.1 weight 100

neighbor 10.0.0.1 advertisement-interval 0

neighbor 10.0.0.1 route-map ASPREPEND3 out

neighbor 10.0.0.2 activate

neighbor 10.0.0.2 weight 200

neighbor 10.0.0.2 advertisement-interval 0

neighbor 10.0.0.2 route-map ASPREPEND3 out

exit-address-family

!

address-family ipv6

redistribute connected

network 10::/64

neighbor 10::1 activate

neighbor 10::2 activate

exit-address-family

!

ip forward-protocol nd

ip http server

ip http authentication local

ip http secure-server

ip tftp source-interface GigabitEthernet0

!

access-list 5 permit 10.0.0.0 0.0.0.255

!

!

route-map ASPREPEND permit 20

!

route-map ASPREPEND3 permit 10

match ip address 5

set as-path prepend 65003 65003 65003

!

route-map ASPREPEND3 permit 20

!

control-plane

!

line con 0

transport input none

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

!

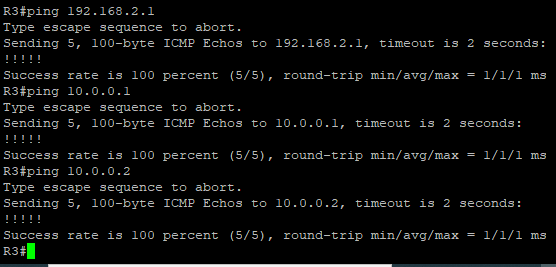
end

show bgp summary

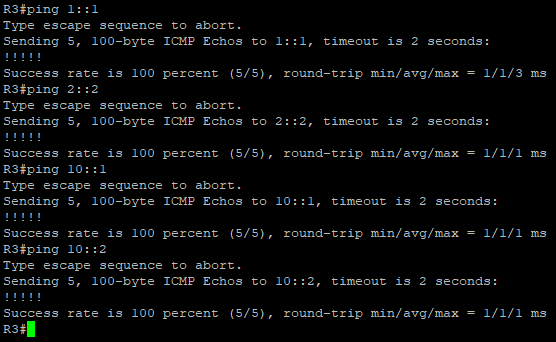
**A computer screen shot of a black screen

Description automatically generated**

pings from R3 (IPv4)



Pings from R3 (IPv6)



**Problems**

The first time we tried our lab, the BGP neighbors showed up, but we were not able to ping from one router to another, showing that our network connection was not properly configured. To determine what was wrong, we did a bit of research and soon found that we missed numerous steps on the BGP setup. We decided to restart the BGP configuration, but keep the OSPF, EIGRP, and RIP configurations the same as last time.

The next time, we learned that we are not able to get routes from any other routing protocols to propagate on the BGP setup. With a bit of scavenger-hunting, we learned that it was because the other routing protocols were not connected to BGP- we used metrics to control the route exchange better.

When we were in our configuration process, we got flooding notifications from router 2 all the sudden. We compared our configuration on the other routers to router 2 and noticed that this was because the IPv6 address was configured in the wrong address family – in the IPv4 address family. We fixed this by simply moving the IP address over to IPv6 address family, and the flooding notifications stopped.

**Conclusion**

In conclusion, this lab taught us how to set up BGP and its basics. In addition to its basics, we learned how the interaction between BGP and other routing protocols (OSPF, RIP, and EIGRP) works. Although we ran into many issues, were used our problem-solving skills and learned which ones are effective. Though this lab, we finally learned to copy over out configurations because we had so many time-consuming configurations that we never saved, making us have to redo all the commands each day, leading to small simple mistakes with the basic router configuration. All in all, this lab helped us develop our basic skill of BGP routing.

A close-up of a letter

Description automatically generated