BIRZEIT UNIVERSITY

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COMPUTER NETWORKS LABORATORY ENCS4130

EXP.5 Dynamic Routing 3 (Path Vector) BGP

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Section: 1

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Abstract

The main object of this experiment is to learn how to configure and verify IP routing with Cisco routers, and to Introduce the exterior gateway protocol (EGP) and interior gateway protocols (IGP). Also Introducing to Autonomous systems and Dynamic routing BGP.

In this experiment we used four Cisco routers, Six PCs, one Cisco switch, Several CAT5 straight-wired cables and two Serial cable. (male and female).

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Acronyms and Abbreviations

OSPF	Open Shortest Path First
BGP	Border Gateway Protocol
AS	Autonomous systems

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1.Introduction

1.1. Border Gateway Protocol (BGP)

Border Gateway Protocol (BGP) refers to a gateway protocol that enables the internet to exchange routing information between autonomous systems (AS). As networks interact with each other, they need a way to communicate. This is accomplished through peering. BGP makes peering possible. Without it, networks would not be able to send and receive information with each other. [1]

1.2. Using BGP

BGP is typically used in the following scenarios:

Interconnecting Autonomous Systems: BGP is used to connect different networks operated by separate organizations (autonomous systems) to exchange routing information and establish optimal paths for data exchange.

Internet Connectivity: BGP is essential for ISPs and large organizations to connect to the global Internet, enabling them to advertise their IP prefixes and route traffic effectively.

Multi-Homed Networks: When a network is connected to multiple ISPs for redundancy or load balancing, BGP helps in managing traffic distribution across these connections.

Traffic Engineering: BGP allows network administrators to control the flow of traffic by influencing route selection based on policies, optimizing network utilization and performance. [2]

1.3. BGP Peers/Neighbors

BGP neighbors are peer-to-peer nodes that are manually installed between routers. To maintain the BGP connection, the speaker sends keepalive messages every 60 seconds. The main difference between BGP and other routing protocols is that it uses TCP as the transport protocol.

There are two types of BGP: internal or iBGP and external eBGP. It is called internal when it works in one autonomous system (AS), and external when it works in different autonomous systems.

iBGP and eBGP also differ in how routes received from one neighbor propagate to other neighbors. For example, new routes received from eBGP are usually redistributed between all iBGP nodes and all other eBGP neighbors. However, if new routes are advertised on an iBGP peer, they are only re-advertised to all BGP peers. This means that all iBGP neighbors must be connected to the same network. [3]

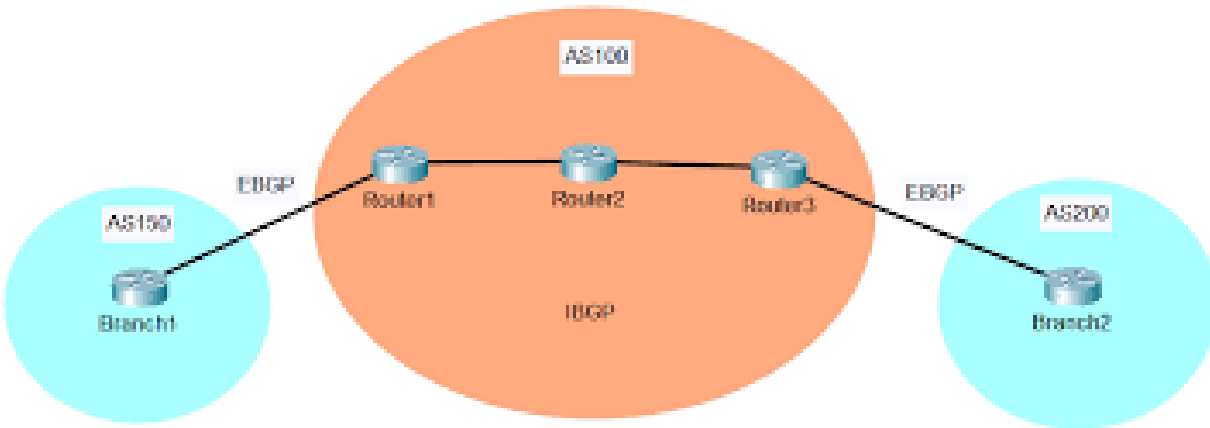


Figure 1 BGP peers (EBGP & IBGP)

1.4. BGP Peers Messages

BGP peers exchange different types of messages to establish and maintain the BGP session and to share routing information. Some of the key BGP message types include:

Open Message: The Open message is the first message exchanged between BGP peers during session establishment.

Keepalive Message: After the Open message is successfully exchanged, BGP peers send Keepalive messages at regular intervals to confirm that the connection is still active. If a peer doesn't receive a Keepalive within a certain time, it considers the connection lost.

Update Message: The Update message is the most important BGP message type. It carries information about routes, attributes, and reachability updates.

Notification Message: If there's an issue with the BGP session, such as a misconfiguration or a problem with route updates, BGP peers send Notification messages to alert the other peer and terminate the session.

Withdrawn Routes: Within the Update message, BGP peers can send withdrawn routes to indicate that certain routes are no longer valid.

These messages collectively facilitate the exchange of routing information and the establishment of a coherent view of the network's topology between BGP peers. By sending and processing these messages, BGP routers collaboratively build and maintain routing tables that determine how data flows across the Internet. [2]

1.5. BGP Finite-State Machine (FSM)

BGP's behavior at routing engine startup and during the establishment of BGP neighbor sessions. The finite-state-machine is a description of what actions should be taken by the BGP routing engine and when. There are six states in the model, and there are specific conditions under which each BGPstate will transition to the next during the process of establishing first a TCP connection, and then a BGP session. Each step indicates a different state in the BGP session. For the purpose of this discussion, a router is any device running BGP. [4]

2.Procedure & Discussion

In this lab, we connected four routers and several PCs on different networks. This required configuring routing protocols between the routers. We configured dynamic routing (OSPF) which was used as a routing protocol inside the same Antonymous System and BGP between the different Antonymous Systems.

2.1. Building the topology

We Built the topology shown in Figure 2-1.

For the routers we used Router-PT, for the switches we used Switch-PT, for the PCs we used PC-PT, for the connections between the PCs, switches and routers we used Automatically use connection type.

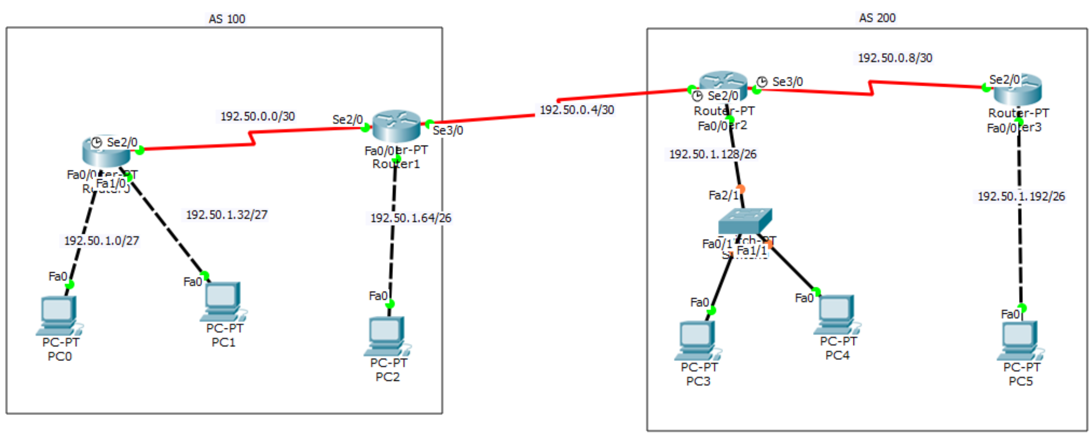


Figure 2 The topology

2.2. Configure the IPs for the PCs and Routers

We used the following IPs shown in Table 2-1 for the configuration. In order to configure the IPs for the PCs and Routers.

Table 1 IP configuration for PCs and routers

Area/AS & BGP Links	Network	Device	Interface	IP	Subnet Mask	Wildcard Mask
Area 0 / AS 100	192.50.0.0/30	Router 0	Se2/0	192.50.0.1	255.255.255.252	0.0.0.3
		Router 1	Se2/0	192.50.0.2	255.255.255.252	0.0.0.3
	192. 50.1.0/27	Router 0	Fa0/0	192.50.1.1	255.255.255.224	0.0.0.31
		PC0	Fa0	192.50.1.2	255.255.255.224	0.0.0.31
	192. 50.1.32/27	Router 0	Fa1/0	192.50.1.33	255.255.255.224	0.0.0.31
		PC1	Fa0	192.50.1.34	255.255.255.224	0.0.0.31
	192. 50.1.64/26	Router 1	Fa0/0	192.50.1.65	255.255.255.192	0.0.0.63
		PC2	Fa0	192.50.1.66	255.255.255.192	0.0.0.63
Area 0 / AS 200	192.50.0.8/30	Router 2	Se3/0	192.50.0.9	255.255.255.252	0.0.0.3
		Router 3	Se2/0	192.50.0.10	255.255.255.252	0.0.0.3
	192.50.1.128/26	Router 2	Fa0/0	192.50.1.129	255.255.255.192	0.0.0.63
		PC 3	Fa0	192.50.1.130	255.255.255.192	0.0.0.63
		PC 4	Fa0	192.50.1.131	255.255.255.192	0.0.0.63
	192.50.1.192/26	Router 3	Fa0/0	192.50.1.193	255.255.255.192	0.0.0.63
		PC 5	Fa0	192.50.1.194	255.255.255.192	0.0.0.63
BGP Links	192.50.0.4/30	Router 1	Se3/0	192.50.0.5	255.255.255.252	0.0.0.3
		Router 2	Se2/0	192.50.0.6	255.255.255.252	0.0.0.3

Figure 3 shows the ip configuration for pc0, where ip = 192.50.1.2, subnet mask = 255.255.255.224 and default gateway 192.50.1.1.

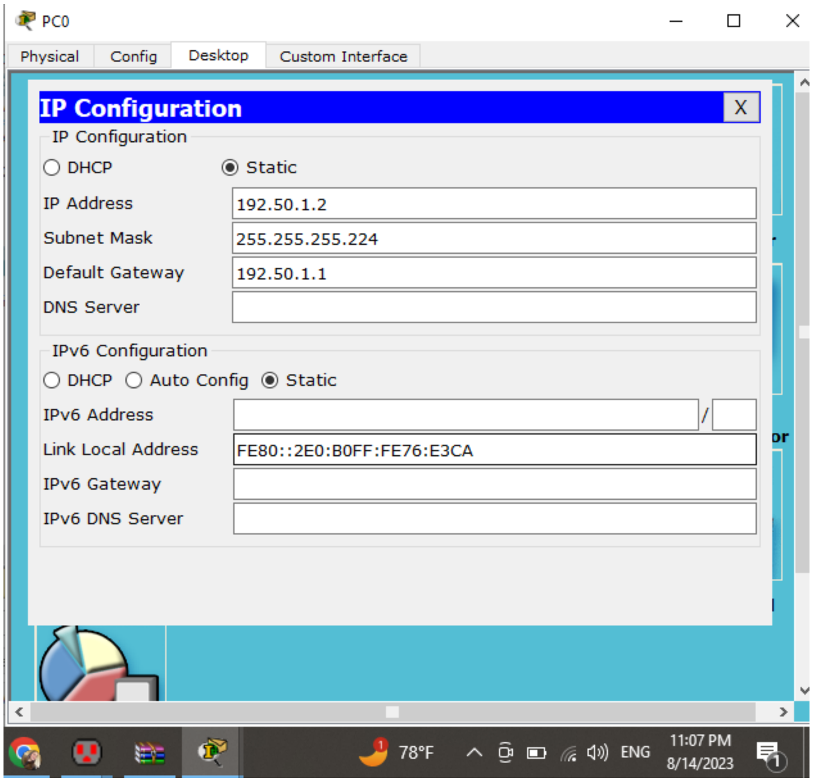


Figure 3 IP configuration for PC0

2.3. Configuring OSPF Routing

We configured OSPF routing protocol for the two antonyms systems (100 and 200) separately.

Figure 4 below shows the configuration of OSPF routing in router 0, where it is connected with network 192.50.1.0, 192.50.1.32 and 192.50.0.0.

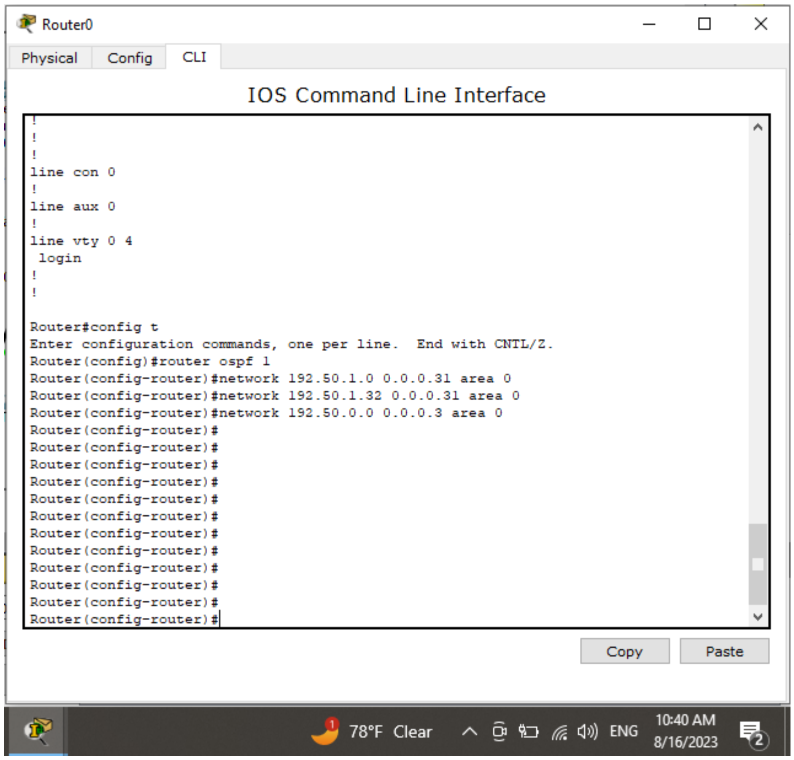


Figure 4 OSPF routing configuration for router0

Commands :
Router(config)#router ospf 1
Router(config-router)#network 192.50.1.0 0.0.0.31 area 0
Router(config-router)#network 192.50.1.32 0.0.0.31 area 0
Router(config-router)#network 192.50.0.0 0.0.0.3 area 0

Figure 5 shows the OSPF configuration for router 1, whit networks 192.50.0.0 and network 192.50.1.64.

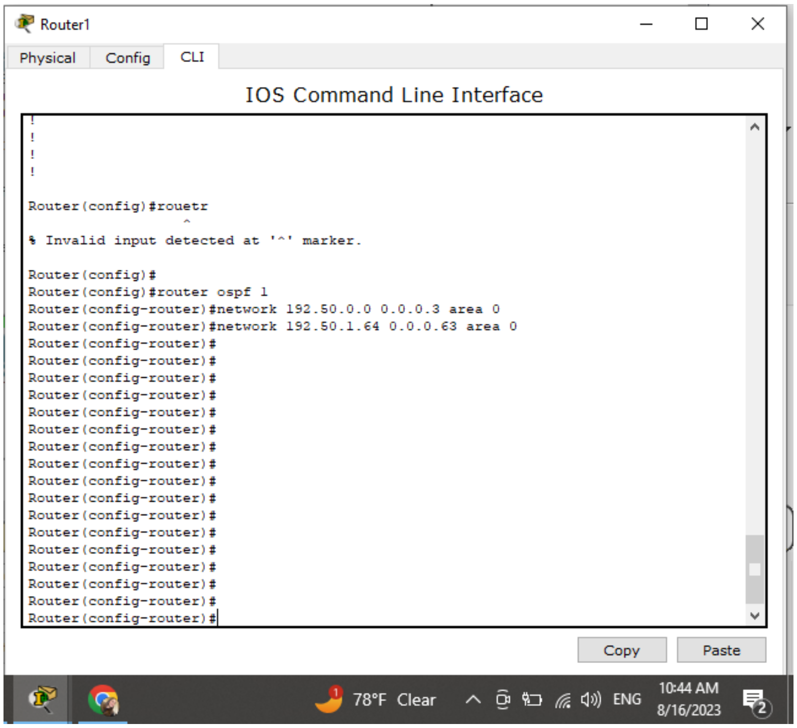


Figure 5 OSPF routing configuration for router1

Commands :
Router(config)#router ospf 1
Router(config-router)#network 192.50.0.0 0.0.0.3 area 0
Router(config-router)#network 192.50.1.64 0.0.0.63 area 0

Note: routers 0 & 1 are in AS 100.

Figure 6 below shows the configuration of OSPF routing in router 2.

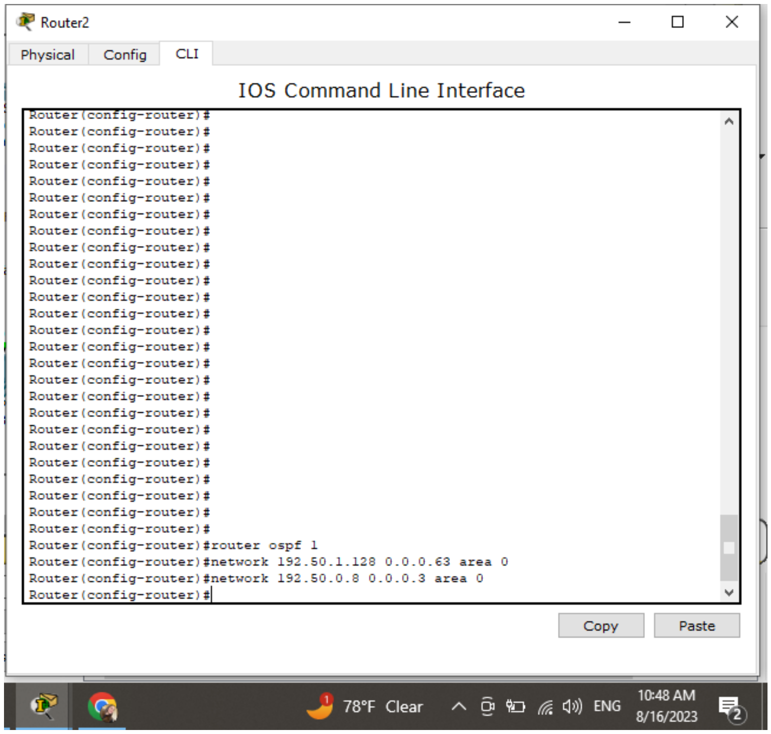


Figure 6 OSPF routing configuration for router2

Commands :
Router(config)#router ospf 1
Router(config-router)#network 192.50.0.8 0.0.0.3 area 0
Router(config-router)#network 192.50.1.128 0.0.0.63 area 0

Figure 7 below shows the configuration of OSPF routing in router 3.

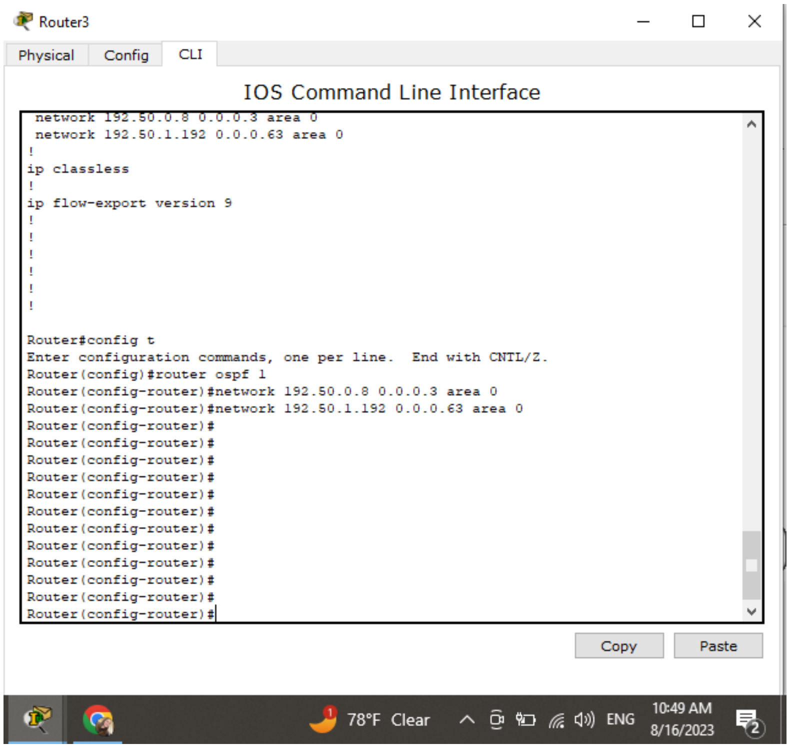


Figure 7 OSPF routing configuration for router3

Commands :
Router(config)#router ospf 1
Router(config-router)#network 192.50.0.8 0.0.0.3 area 0
Router(config-router)#network 192.50.1.192 0.0.0.63 area 0

Note: routers 2 & 3 are in AS 200.

2.4. Configuring BGP Routing

We only did BGP configuration on Router 1 and Router 2. The first step in configuring BGP is to enable the BGP process, and specify the router's Autonomous System (AS), where the AS-NUMBER is the autonomous system number where the router is. Here BGP is now enabled on router 1. The next step is to configure a neighbor relationship with a router in separate AS (eBGP Peer). These steps are done with the following commands:

Router(config)# router bgp <AS-NUMBER>

Router(config-router)# neighbor <IP-ADDRESS-NEXT-INTERFACE> remote-as <AS-OF-REMOTE-NEIGHBOR>

Where IP-ADDRESS-NEXT-INTERFACE is the address of the interface on other peer. And the AS_OF_REMOTE_NEIGHBOR is the autonomous system number of the next AS.

To configure BGP on router 1 I did the following command as shown in figure 8 below.

Router (config)# router bgp 100

Router(config-router)# neighbor 192.50.0.6 remote-as 200

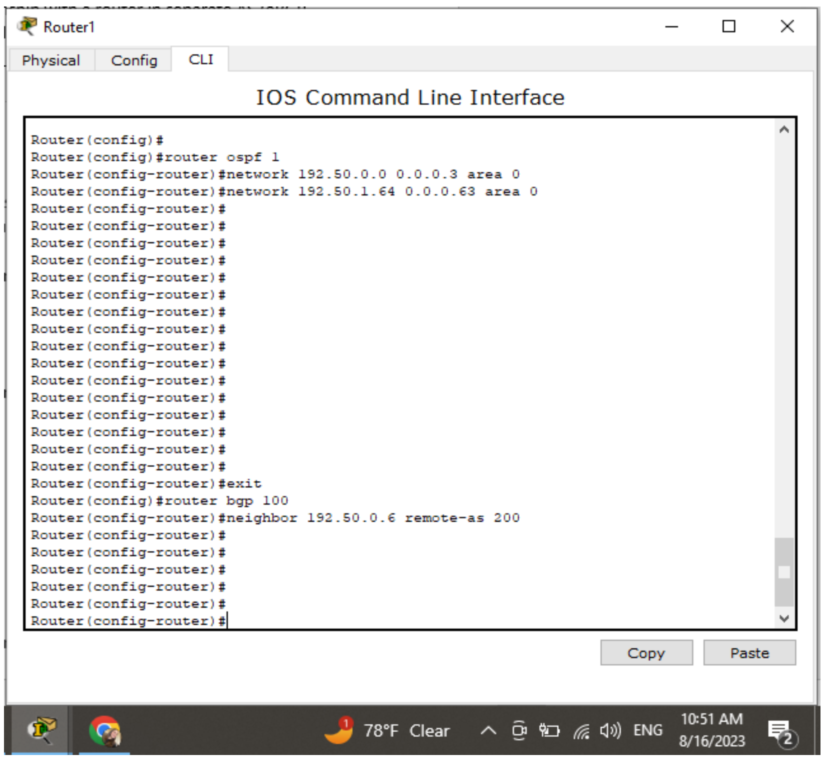


Figure 8 BGP routing configuration for router1

To configure BGP on router 2 I did the following command as shown in figure 9 below.

Router (config)# router bgp 200

Router(config-router)# neighbor 192.50.0.5 remote-as 100

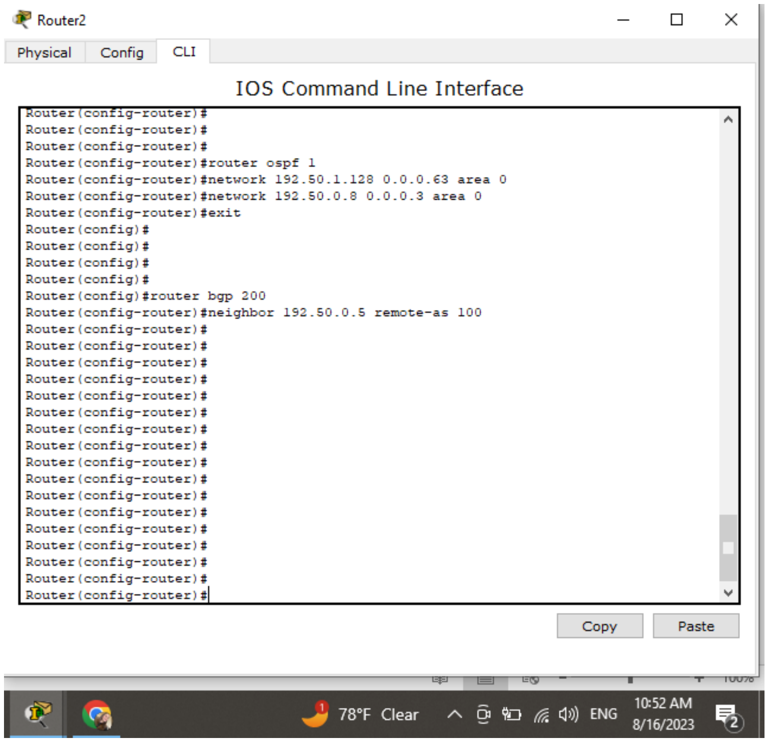


Figure 9 BGP routing configuration for router2

2.5. Define the BGP Over the OSPF

To allow the OSPF to communicate with the BGP a redistribute command is used to define the BGP protocol over the OSPF protocol:

Router(config)# router ospf <PROCESS-ID>
Router(config-router)# redistribute bgp <AS-NUMBER> subnets

Where the PROCESS-ID is the OSPF ID we configured earlier and the ASNUMBER is the autonomous number for the BGP of configured on the same router.

To redistribute the BGP over the OSPF on router 1 we used the following commands with process id for the OSPF to be 1. As shown in figure 10.

Router(config)# router ospf 1
Router(config-router)# redistribute bgp 100 subnets

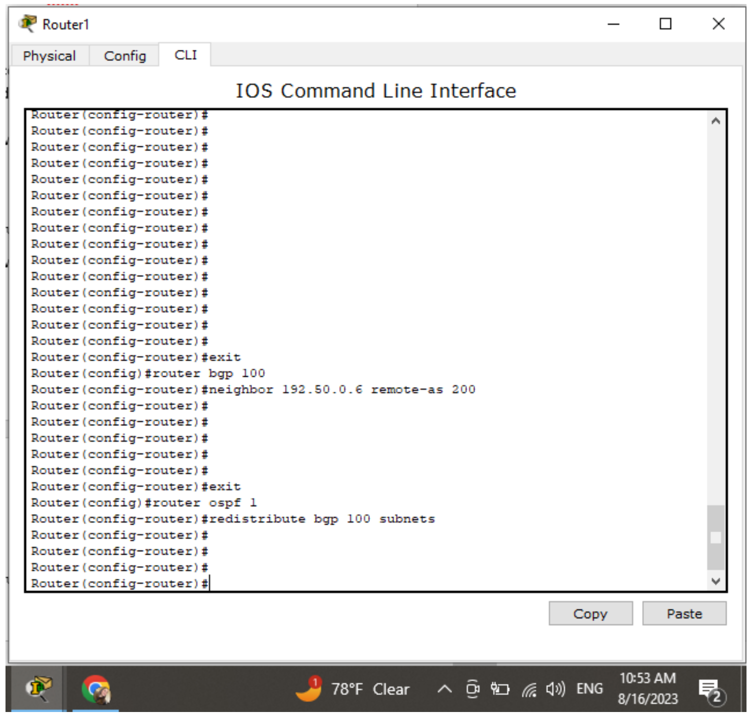


Figure 10 BGP over OSPF routing for router1

To redistribute the BGP over the OSPF on router 2 we used the following commands with the same process id for the OSPF. As shown in figure 11.

Router(config)# router ospf 1
Router(config-router)# redistribute bgp 200 subnets

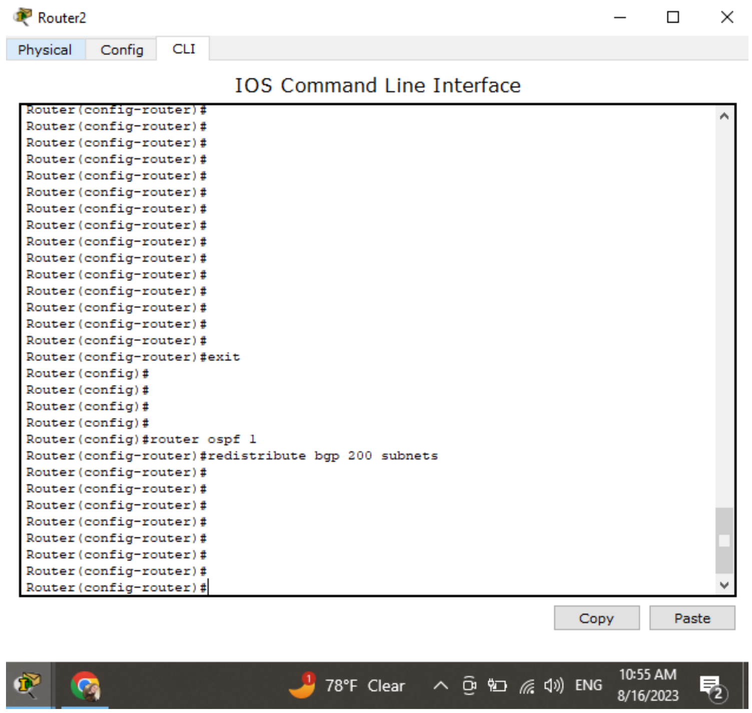


Figure 11 BGP over OSPF routing for router2

2.6. Define the OSPF Over the BGP

To allow the BGP to communicate with the OSPF a redistribute command is used to define the OSPF protocol over the BGP protocol:

Router(config)# router bgp <AS-NUMBER>

Router(config-router)# redistribute ospf <PROCESS-ID>

Where the PROCESS-ID is the OSPF ID we configured earlier and the ASNUMBER is the autonomous number for the BGP of configured on the same router.

To redistribute the OSPF over the BGP on router 1 we used the following with process id for the OSPF to be 1. As shown in figure 12.

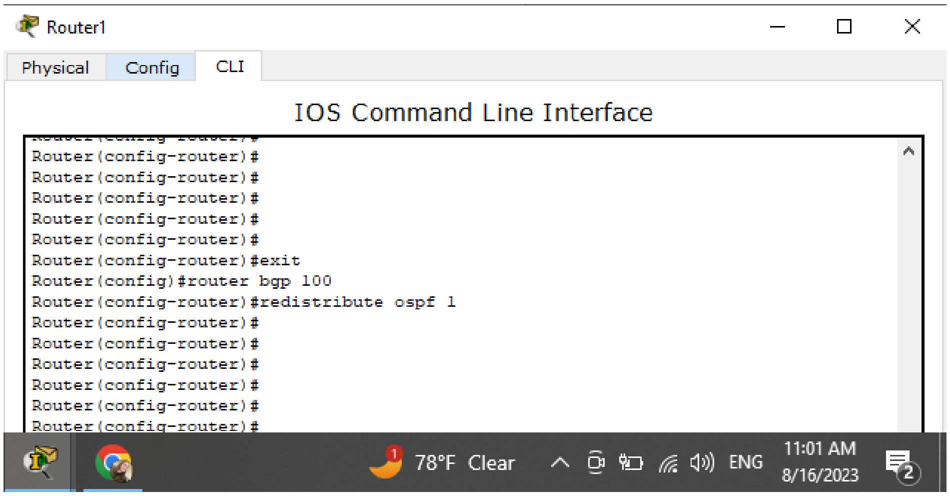


Figure 12 OSPF over BGP routing for router1

Commands:

Router(config)# router bgp 100

Router(config-router)# redistribute ospf 1

To redistribute the OSPF over the BGP on router 2 we used the following with process id for the OSPF to be 1. As shown in figure 13.

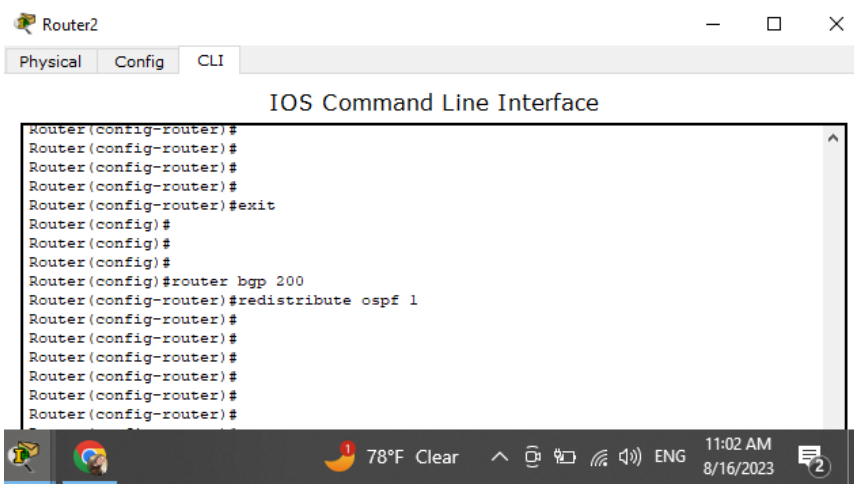


Figure 13 OSPF over BGP routing for router2

Commands:

Router(config)# router bgp 200

Router(config-router)# redistribute ospf 1

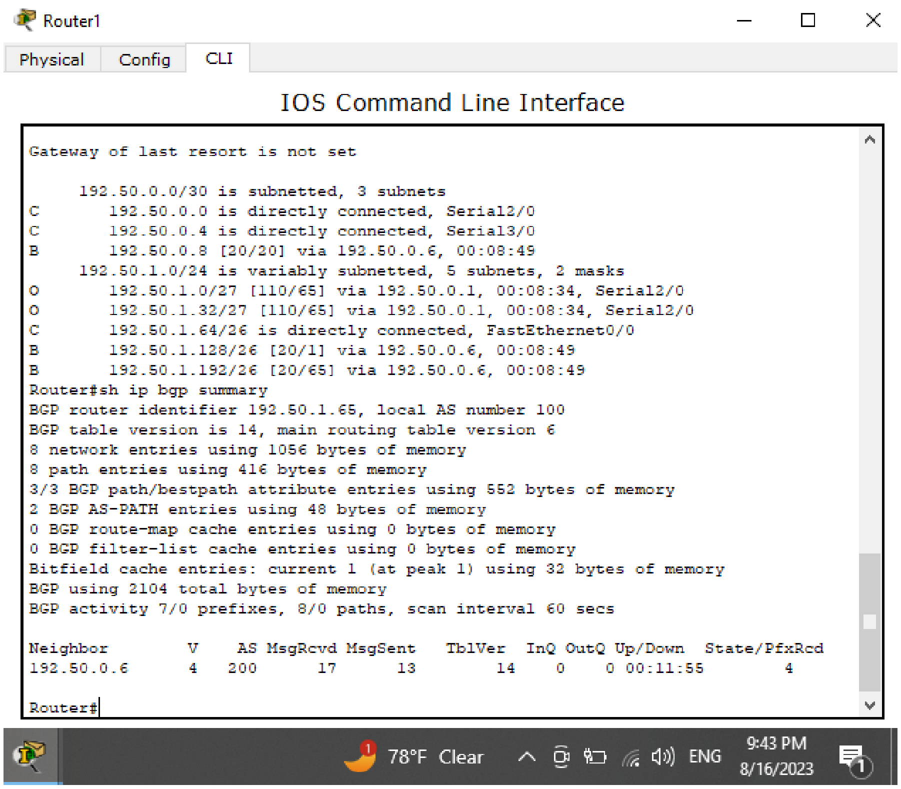
2.7. Viewing BGP Neighbors

To view the status of all BGP neighbors we used the following commands:

Router# show ip bgp summary

Router# show ip route

Figure 14 shows the bgp summary for router 1.




```
Gateway of last resort is not set

     192.50.0.0/30 is subnetted, 3 subnets
C       192.50.0.0 is directly connected, Serial2/0
C       192.50.0.4 is directly connected, Serial3/0
B       192.50.0.8 [20/20] via 192.50.0.6, 00:08:49
     192.50.1.0/24 is variably subnetted, 5 subnets, 2 masks
O       192.50.1.0/27 [110/65] via 192.50.0.1, 00:08:34, Serial2/0
O       192.50.1.32/27 [110/65] via 192.50.0.1, 00:08:34, Serial2/0
C       192.50.1.64/26 is directly connected, FastEthernet0/0
B       192.50.1.128/26 [20/1] via 192.50.0.6, 00:08:49
B       192.50.1.192/26 [20/65] via 192.50.0.6, 00:08:49
Router#sh ip bgp summary
BGP router identifier 192.50.1.65, local AS number 100
BGP table version is 14, main routing table version 6
8 network entries using 1056 bytes of memory
8 path entries using 416 bytes of memory
3/3 BGP path/bestpath attribute entries using 552 bytes of memory
2 BGP AS-PATH entries using 48 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 2104 total bytes of memory
BGP activity 7/0 prefixes, 8/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
192.50.0.6      4   200      17      13       14    0    0 00:11:55        4

Router#
```

Figure 14 router1 bgp summary configuration

Figure 15 shows the bgp summary for router 2.

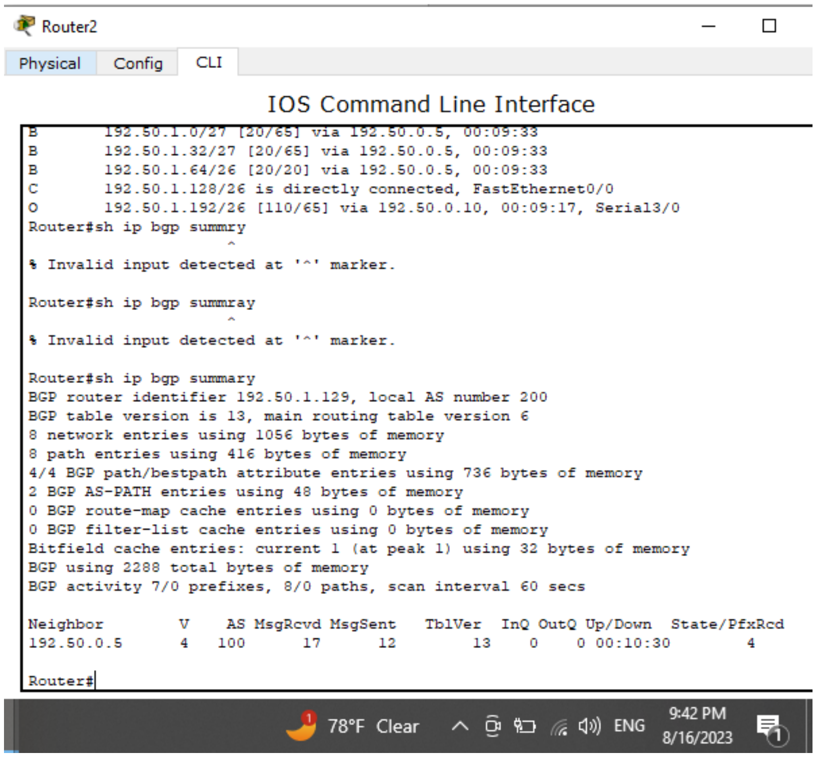


Figure 15 router2 bgp summary configuration

Figure 16 shows the ip route configuration for router1.

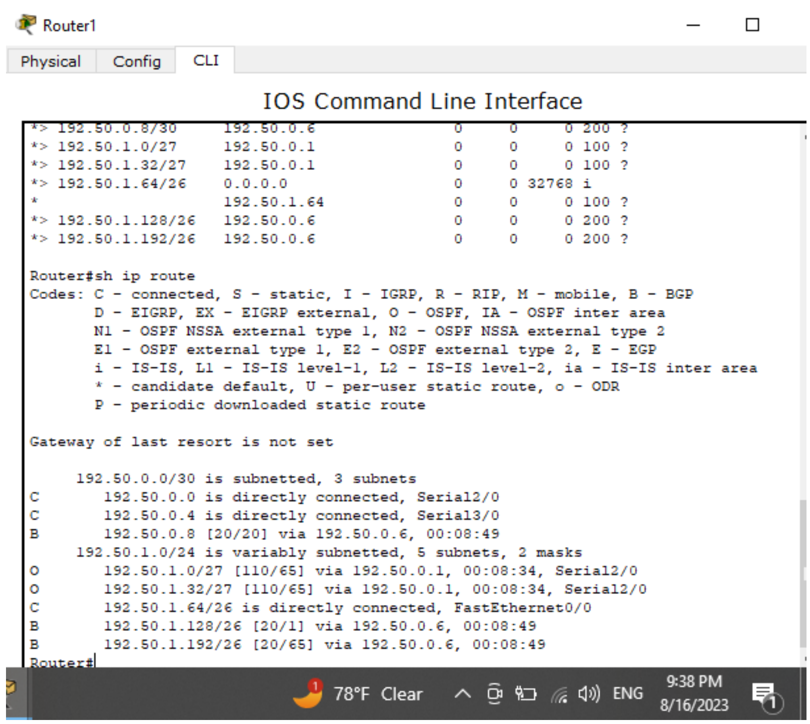


Figure 16 router1 ip route configuration

Figure 17 shows the ip route configuration for router2.

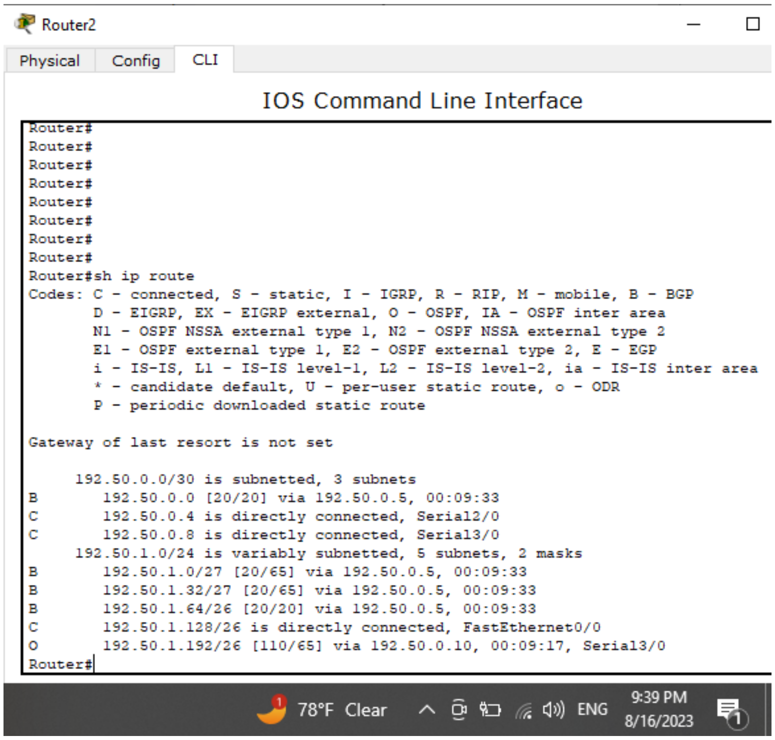


Figure 17 router2 ip route configuration

3.Results

In figures (18 &19 & 20 & 21) the routing table for all the routers in the experiment, showing the connected neighbors, the OSPF and the BGP routing.

Routing Table for Router0

Type	Network	Port	Next Hop IP	Metric
C	192.50.0.0/30	Serial2/0	---	0/0
O	192.50.0.8/30	Serial2/0	192.50.0.2	110/20
C	192.50.1.0/27	FastEthernet0/0	---	0/0
C	192.50.1.32/27	FastEthernet1/0	---	0/0
O	192.50.1.64/26	Serial2/0	192.50.0.2	110/65
O	192.50.1.128/26	Serial2/0	192.50.0.2	110/20
O	192.50.1.192/26	Serial2/0	192.50.0.2	110/20

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Figure 18 routing table for router 0

Routing Table for Router1

Type	Network	Port	Next Hop IP	Metric
C	192.50.0.0/30	Serial2/0	---	0/0
C	192.50.0.4/30	Serial3/0	---	0/0
B	192.50.0.8/30	Serial3/0	192.50.0.6	20/20
O	192.50.1.0/27	Serial2/0	192.50.0.1	110/65
O	192.50.1.32/27	Serial2/0	192.50.0.1	110/65
C	192.50.1.64/26	FastEthernet0/0	---	0/0
B	192.50.1.128/26	Serial3/0	192.50.0.6	20/1
B	192.50.1.192/26	Serial3/0	192.50.0.6	20/65

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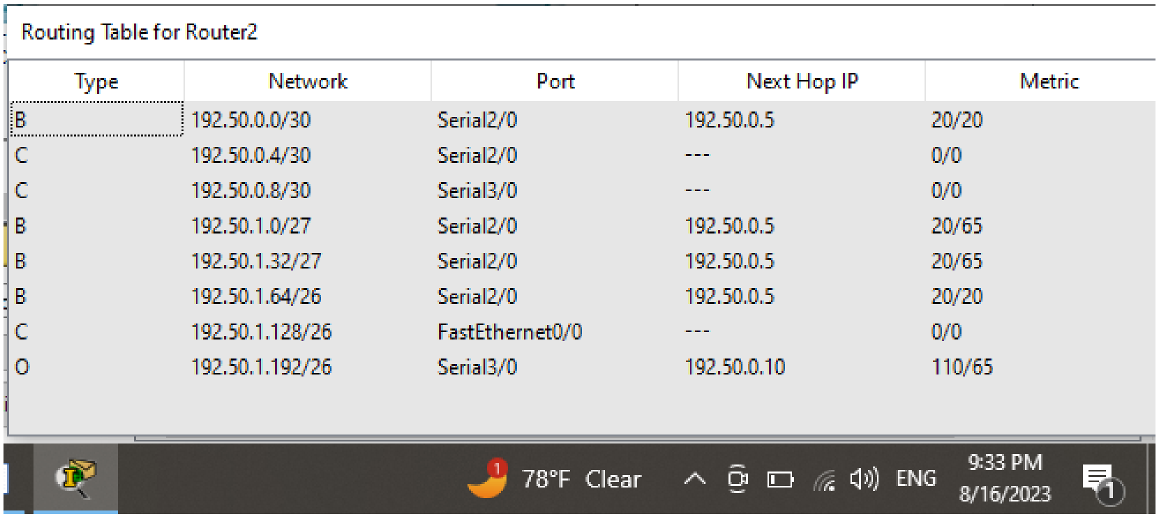
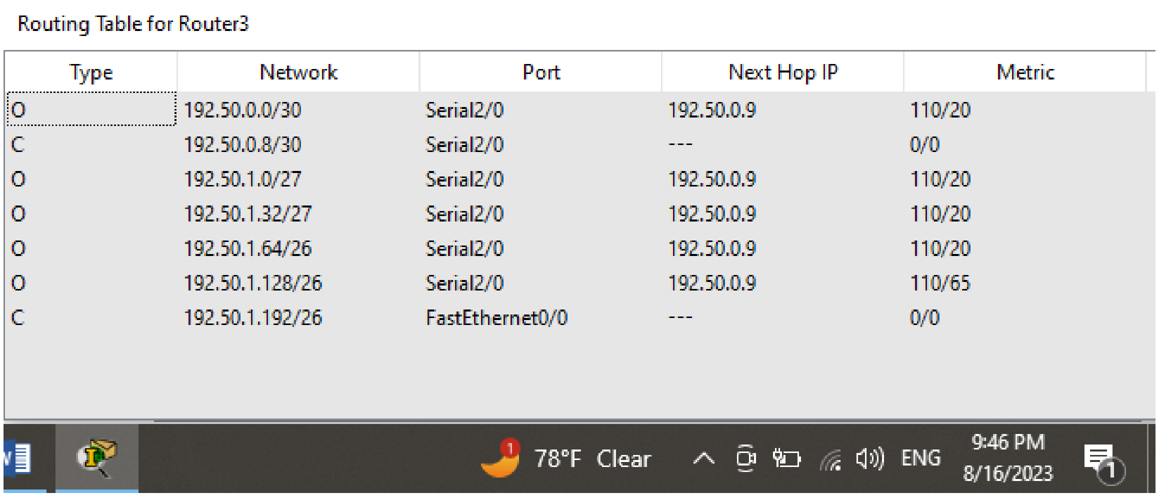
Figure 19 routing table for router 1



Routing Table for Router2

Type	Network	Port	Next Hop IP	Metric
B	192.50.0.0/30	Serial2/0	192.50.0.5	20/20
C	192.50.0.4/30	Serial2/0	---	0/0
C	192.50.0.8/30	Serial3/0	---	0/0
B	192.50.1.0/27	Serial2/0	192.50.0.5	20/65
B	192.50.1.32/27	Serial2/0	192.50.0.5	20/65
B	192.50.1.64/26	Serial2/0	192.50.0.5	20/20
C	192.50.1.128/26	FastEthernet0/0	---	0/0
O	192.50.1.192/26	Serial3/0	192.50.0.10	110/65

Figure 20 routing table for router 2



Routing Table for Router3

Type	Network	Port	Next Hop IP	Metric
O	192.50.0.0/30	Serial2/0	192.50.0.9	110/20
C	192.50.0.8/30	Serial2/0	---	0/0
O	192.50.1.0/27	Serial2/0	192.50.0.9	110/20
O	192.50.1.32/27	Serial2/0	192.50.0.9	110/20
O	192.50.1.64/26	Serial2/0	192.50.0.9	110/20
O	192.50.1.128/26	Serial2/0	192.50.0.9	110/65
C	192.50.1.192/26	FastEthernet0/0	---	0/0

Figure 21 routing table for router 3

Figure 22 shows the output of pinging from PC0 to PC2 with ip 192.50.1.66 in the same AS 100. All massages where sent correctly with no loss or time out which means the OSPF works well in the area of AS 100.

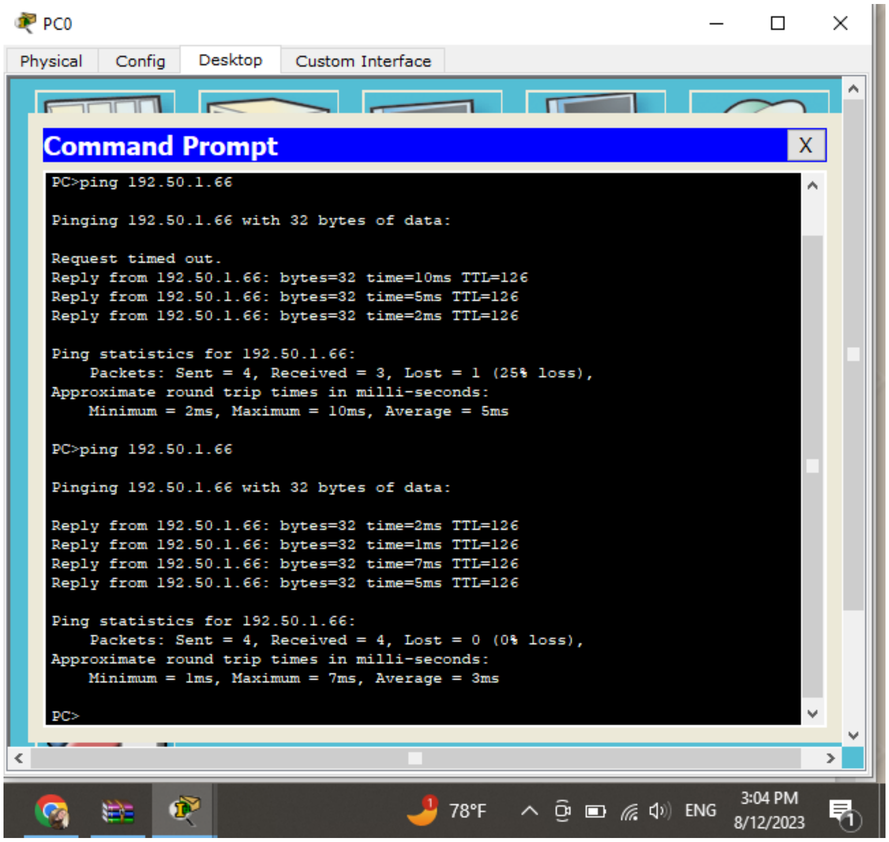


Figure 22 PC0 terminal window

Figure 23 shows the output of pinging from PC3to PC5 with ip 192.50.1.195 in the same AS 200. All massages where sent correctly with no loss or time out which means the OSPF works well in the area of AS 200.

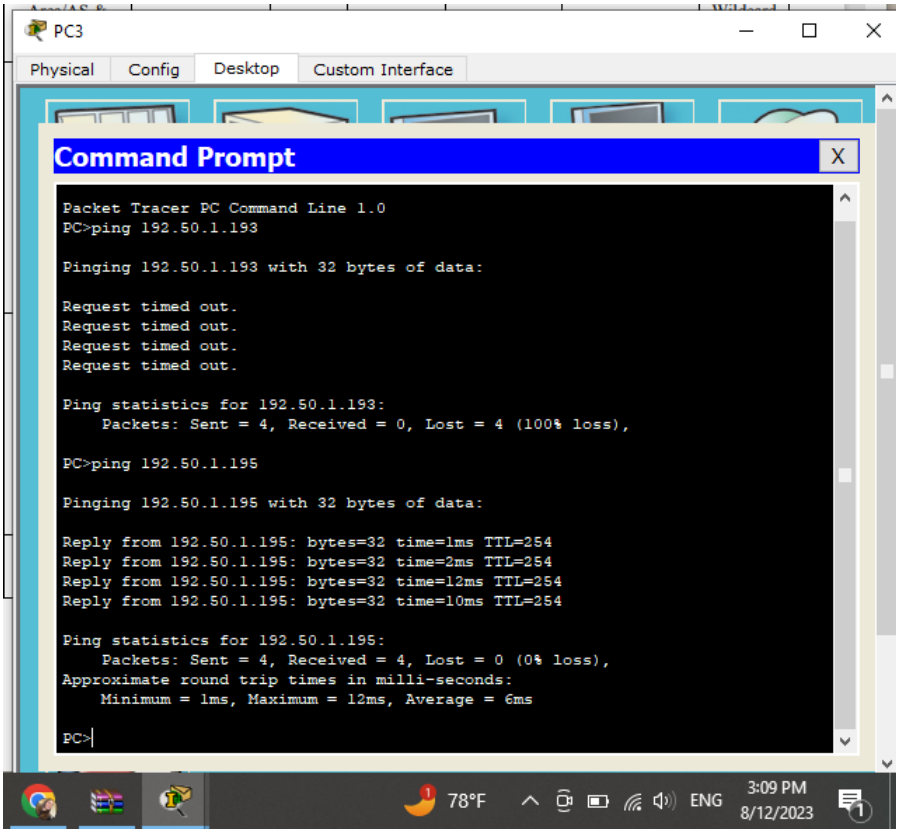


Figure 23 PC3 terminal window

Figure 24 shows the pinging from PC1 to PC5 with ip 192.50.1.195 in different AS along the BGP, as shown the sending was successful with no loss or time out massages which means that the BGP works just well as should.

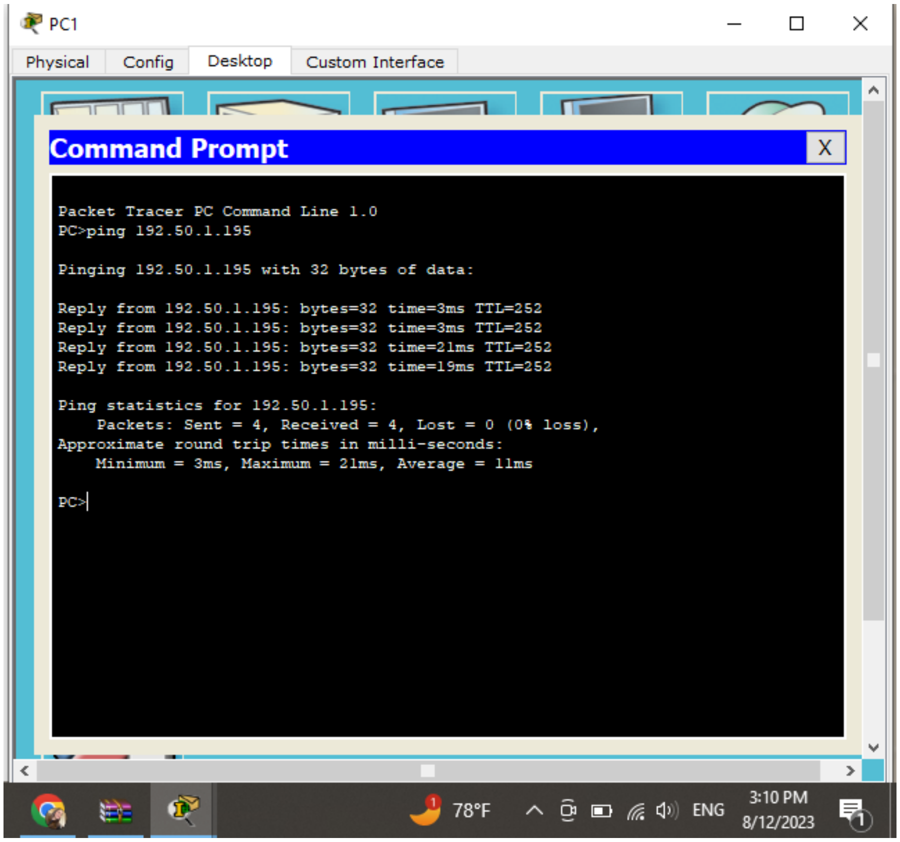


Figure 24 PC1 terminal window

4.Conclusion

The experiment provides an overview of BGP's architecture, route selection, and attributes, emphasizing its role in maintaining stable and scalable global internet connectivity. It also highlights challenges like security issues and the need for effective route filtering. Understanding BGP is essential for managing modern network infrastructures and addressing the evolving demands of internet connectivity.

5.References

[1] https://www.fortinet.com/resources/cyberglossary/bgp-border-gateway-protocol#:~:text=Border%20Gateway%20Protocol%20(BGP)%20refers,BGP%20makes%20peering%20possible.

[2] https://chat.openai.com/

[3] https://stormwall.network/knowledge-base/protocol/bgp

[4]https://www.inetdaemon.com/tutorials/internet/ip/routing/bgp/operation/finite_state_model.shtml#:~:text=The%20finite%2Dstate%2Dmachine%20is,and%20then%20a%20BGP%20session.