BIRZEIT UNIVERSITY

Faculty of Engineering & Technology
Electrical & Computer Engineering Department

ENCS3320

COMPUTER NETWORKS

(Summer Semester – 2023/2024)

Project #2

Network Design

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Abstract

The aim of the project is to understand and build Network Design using Packet Tracer Software, the project is divided into five parts: IP subnetting, Building Topology, Setting-up Servers, Routing, Testing and Troubleshooting. To implement each part, a deep understanding of the IP addresses and how they are divided into subnetting is required and an understanding of the routing and how packets are sent by different devices, routers and switches by the ports and the IP address for each port.

In the experiment, The OSPF protocol is used on the routers. HTTP and DNS servers are used to integrate HTTP requests for some domain that then translated to an IP address to open some HTML page. Ping and tracert commands are used between the PCs to see the details of the packets moving along the network.

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Task0: IP subnetting Part

IP stands for Internet Protocol version v4 stands for Version Four (IPv4), is the most widely used system for identifying devices on a network. It uses a set of four numbers, separated by periods (like 192.168.0.1), to give each device a unique address. This address helps data find its way from one device to another over the internet.

IPv4 was the primary version brought into action for production within the ARPANET in 1983. IP version four addresses are 32-bit integers which will be expressed in decimal notation. Example- 192.0.2.126 could be an IPv4 address [1].

IPv4 addresses consist of three parts:

- **Network Part**: The network part indicates the distinctive variety that's appointed to the network. The network part conjointly identifies the category of the network that's assigned.
- **Host Part**: The host part uniquely identifies the machine on your network. This part of the IPv4 address is assigned to every host.
  For each host on the network, the network part is the same, however, the host half must vary.
- **Subnet Number**: This is the nonobligatory part of IPv4. Local networks that have massive numbers of hosts are divided into subnets and subnet numbers are appointed to that.

The IP address used in the project is obtained by the ID number of Abd Alhameed Maree 1220775 → 175.7.8.0/22

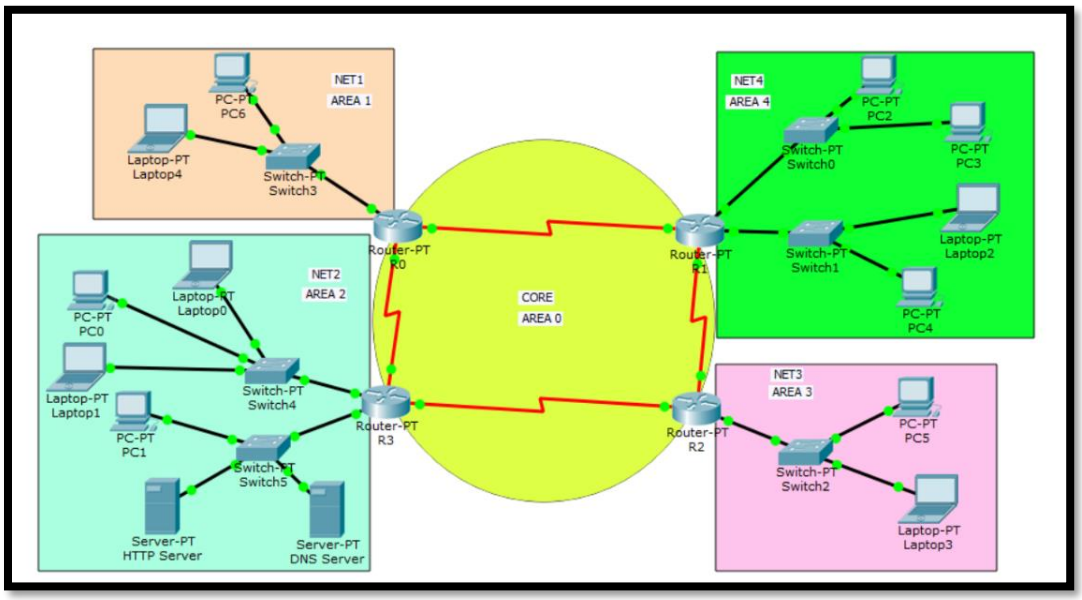

Figure 1: Network Topology

Table 1: Number of hosts (Laptops, PCs, and Servers) per network excluding the router interface.

Network	Number of Hosts
Net1	20
Net2	60
Net3	30
Net4	10

From the Network Topology in Fig (1) and Table (1), there are four networks and a core network, each network has a router that is connected with other routers and switches in the network it is responsible for. It can be noticed from the topology that Net2 and Net4 contain two switches that are connected directly to the routers, while Net1 and Net3 contain only one switch.

As a result of the two switches in Net2 and Net4, Net2 is divided into Net2.1 and Net2.2 each of 30 hosts, and Net4 is divided into Net4.1 and Net4.2 each of 5 hosts.

There are four links in the topology connecting the routers, each link needs 2 hosts (one for each router) to be assigned to the ports.

To assign the IPs properly, the networks have to be sorted:

Table 2: Number of hosts, Number of IPs and the power of 2 needed for each sub network.

Sub Network	Number of Hosts	Number of IPs	Power of 2
Net 3	30	32	5
Net 1	20	32	5
Net 2.1	30	32	5
Net 2.2	30	32	5
Net 4.1	5	7	3
Net 4.2	5	7	3
R0-R1 Link	2	4	2
R1-R2 Link	2	4	2
R2-R3 Link	2	4	2
R3-R0 Link	2	4	2

Starting from the IP address 175.7.8.0/22, the IPs would be divided among the networks starting with the subnet that has the most hosts (or IPs) until the one that has the lowest.

Table 3: Subnetting details.

Subnet	Subnet Mask "/x"	Network IP	Broadcast IP	First IP	Last IP	#hosts
Net 3	255.255.255.224/27	175.7.8.0	175.7.8.31	175.7.8.1	175.7.8.30	30
Net 1	255.255.255.224/27	175.7.8.32	175.7.8.63	175.7.8.33	175.7.8.62	30
Net 2.1	255.255.255.224/27	175.7.8.64	175.7.8.95	175.7.8.65	175.7.8.94	30
Net 2.2	255.255.255.224/27	175.7.8.96	175.7.8.127	175.7.8.97	175.7.8.126	30
Net 4.1	255.255.255.248/29	175.7.8.128	175.7.8.135	175.7.8.129	175.7.8.134	6
Net 4.2	255.255.255.248/29	175.7.8.136	175.7.8.143	175.7.8.137	175.7.8.142	6
R0-R1 Link	255.255.255.252/30	175.7.8.144	175.7.8.147	175.7.8.145	175.7.8.146	2
R1-R2 Link	255.255.255.252/30	175.7.8.148	175.7.8.151	175.7.8.149	175.7.8.150	2
R2-R3 Link	255.255.255.252/30	175.7.8.152	175.7.8.155	175.7.8.153	175.7.8.154	2
R3-R0 Link	255.255.255.252/30	175.7.8.156	175.7.8.159	175.7.8.157	175.7.8.158	2

Task1: Building Topology Part

Building the topology in Fig (1):

- End Devices

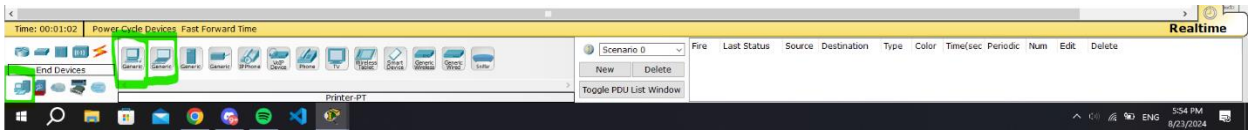

Figure 2: End Devices Icons

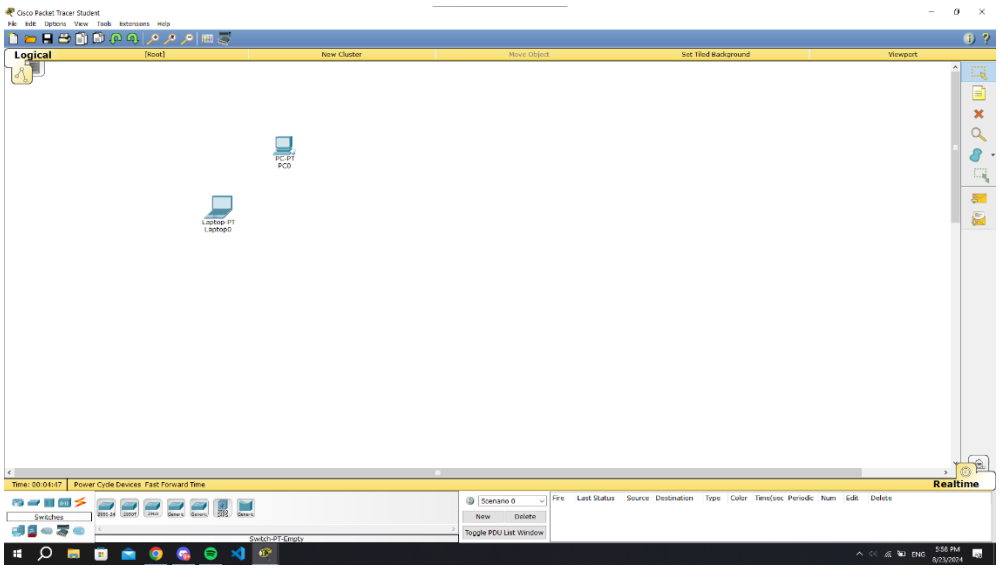

Figure 3: Adding End Devices

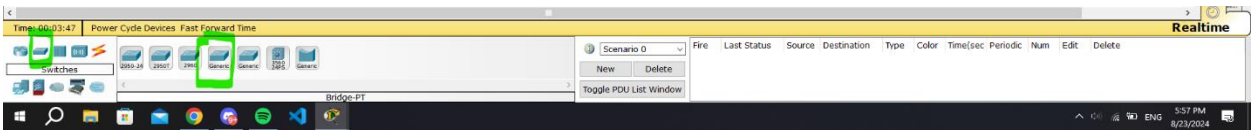

Figure 4: Switch Icon

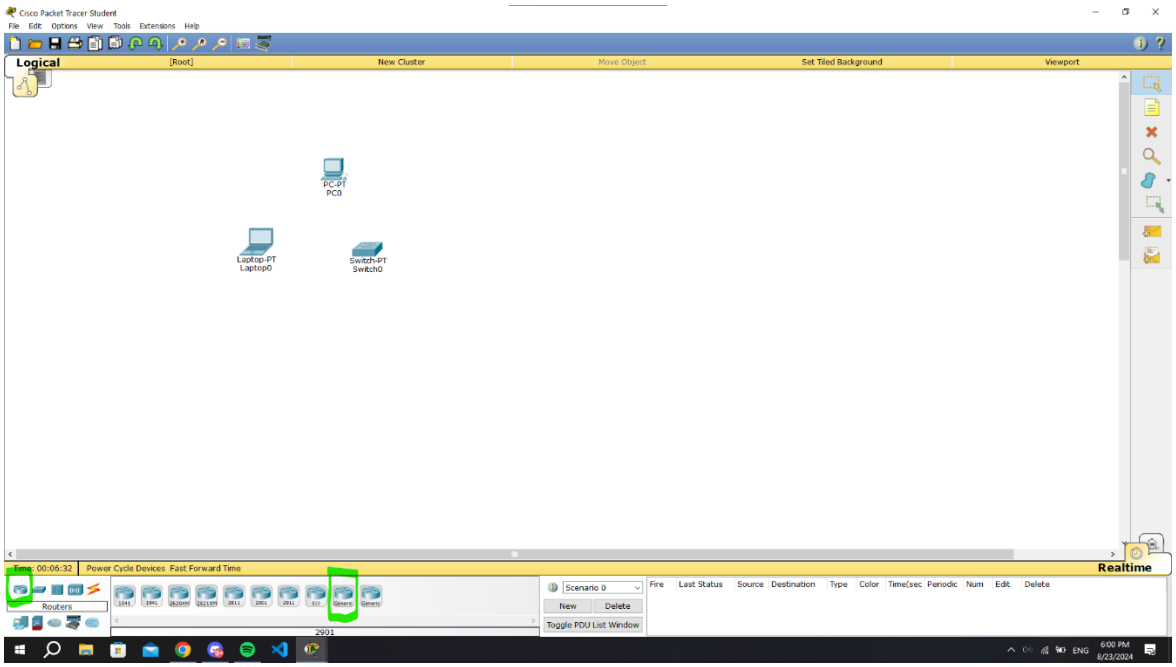

Figure 5: Adding Switch

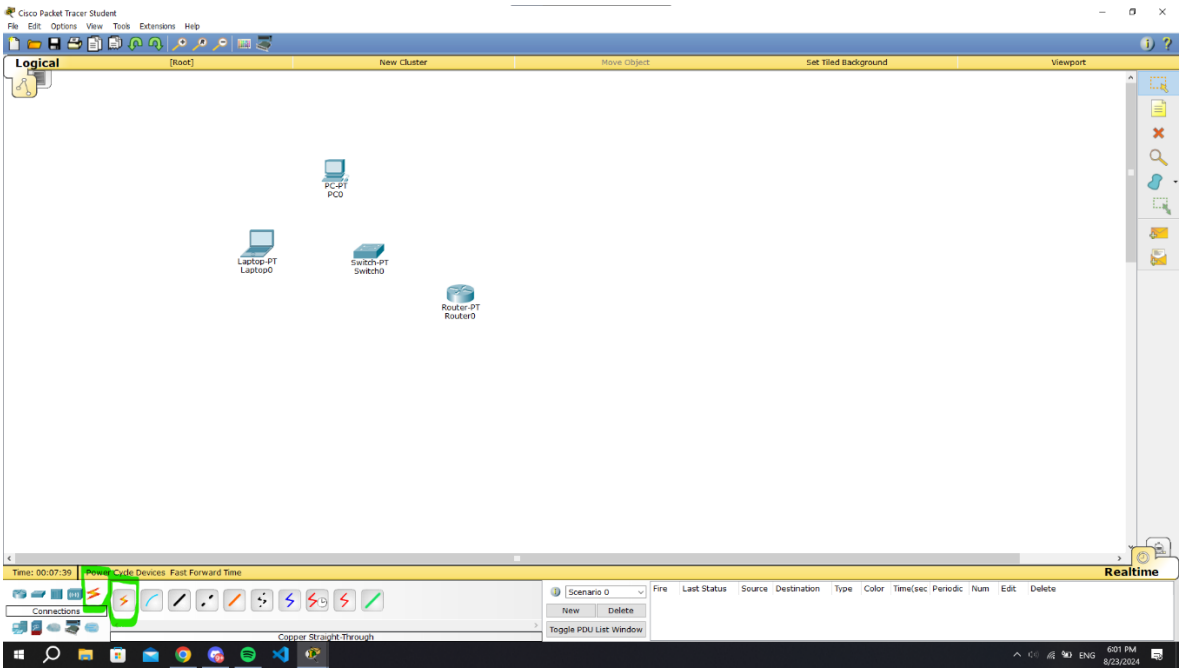

Figure 6: Adding Router

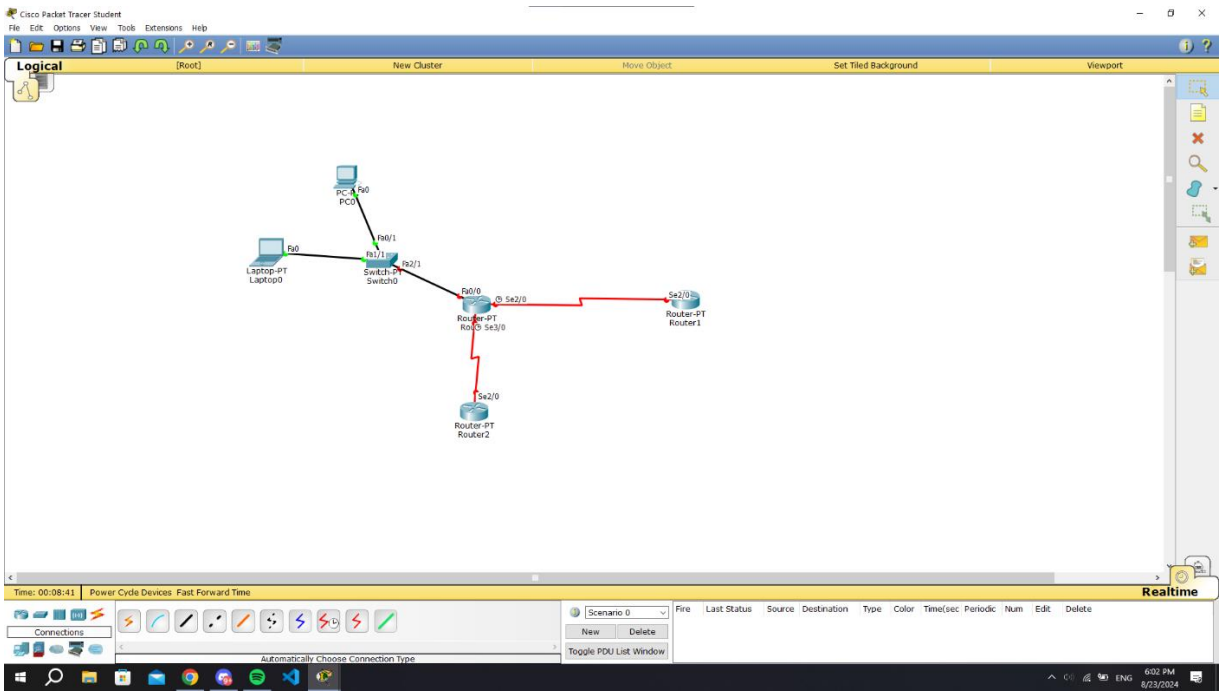

Figure 7: Connect Components

All the devices and the links between them are done for Net1: PC, Laptop, Switch and Router. The Router is connected with other two routers. The same steps must be done to all networks, then the settings of the devices should be edited and the IP addresses must be distributed.

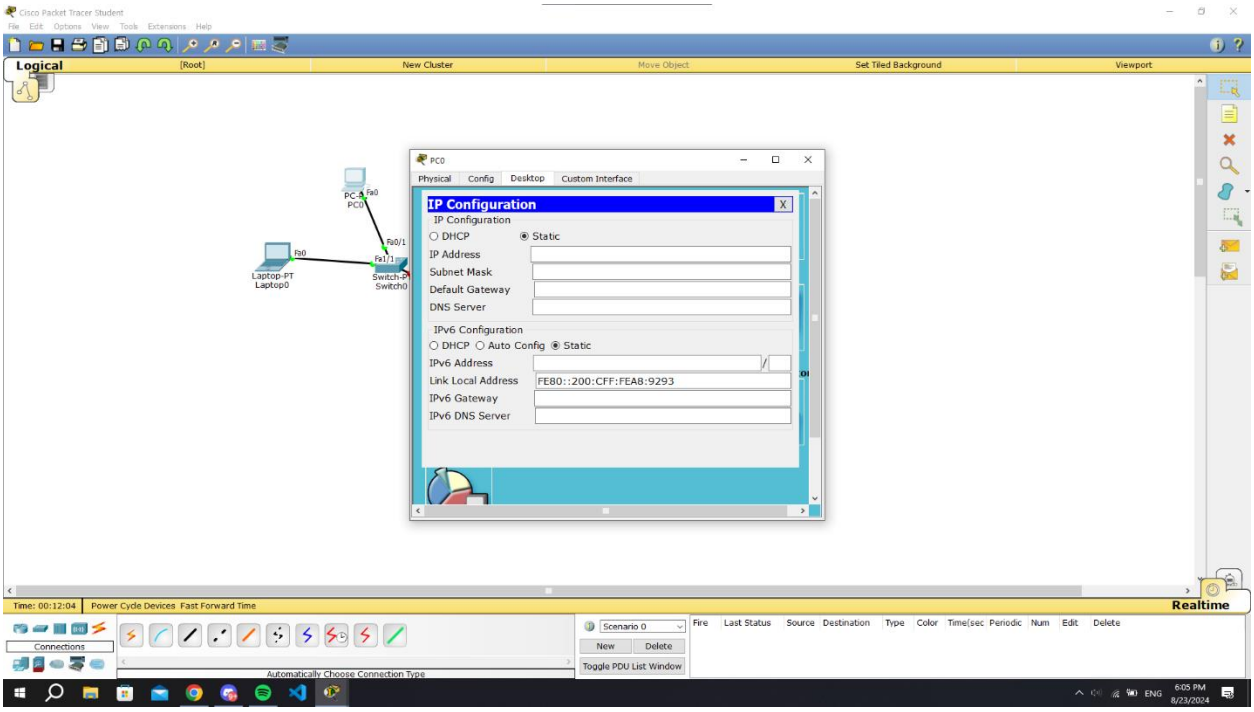

Figure 8: PC Configuration

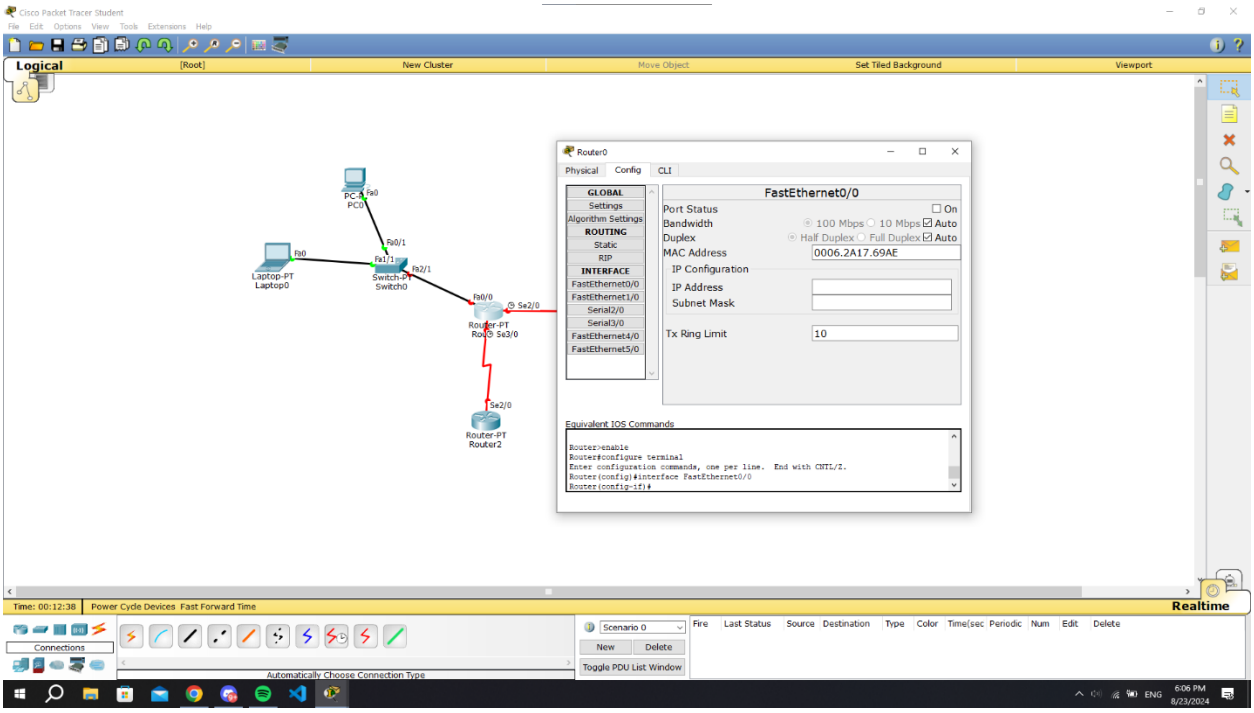

Figure 9: Router Configuration

By the configuration of each device, the IP address must be assigned according to Table (3).

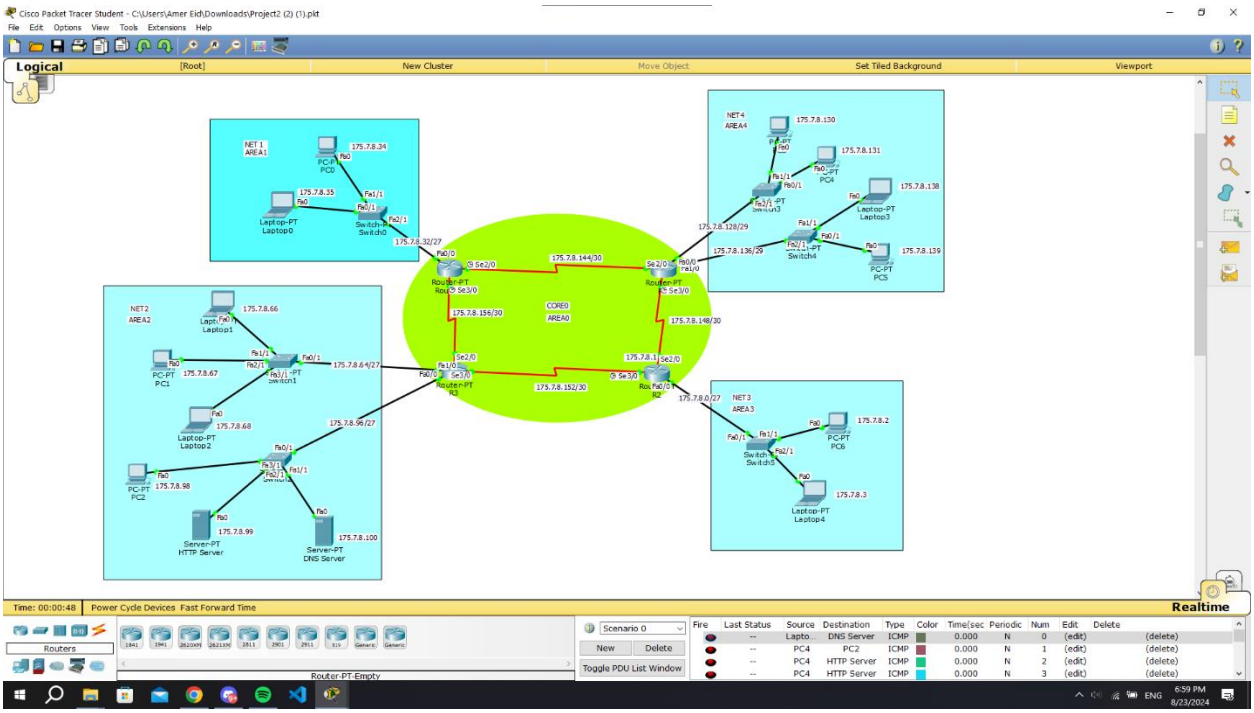

Figure 10: Final Network Design

The Final Network Design is represented in Fig (10), all IP addresses were assigned properly for each device in the network, for example:

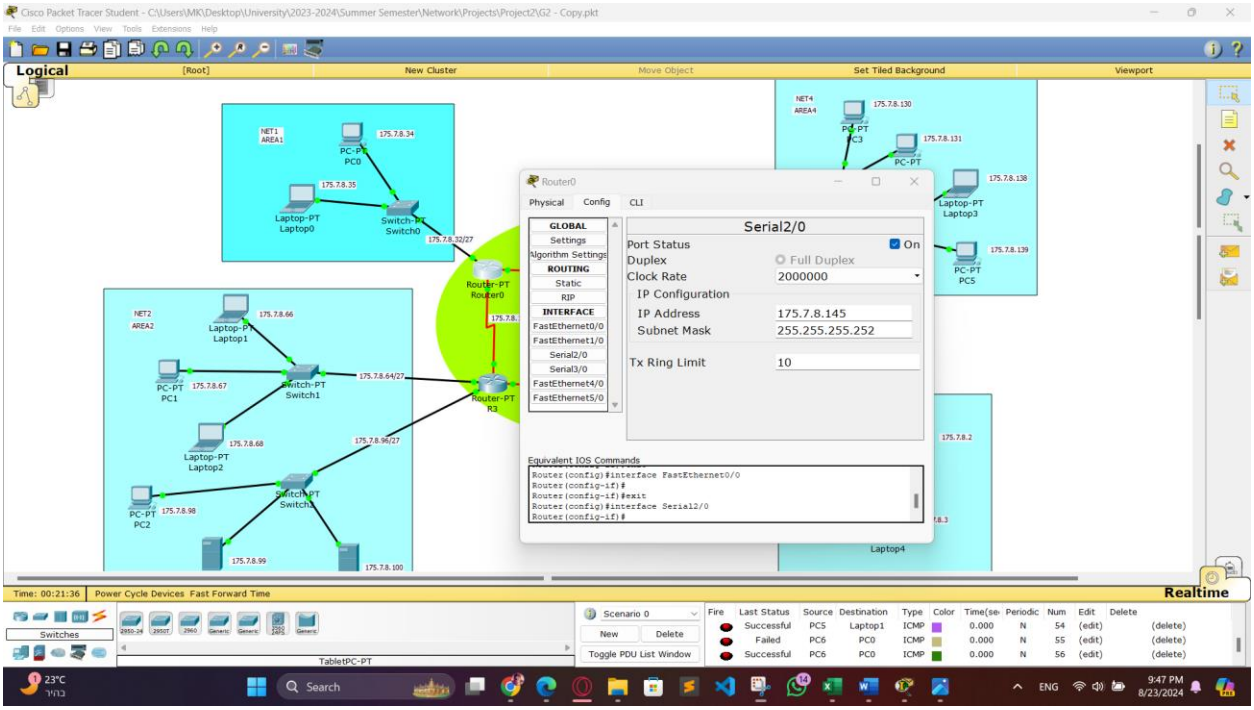

Figure 11: Router0 IP link with Router1

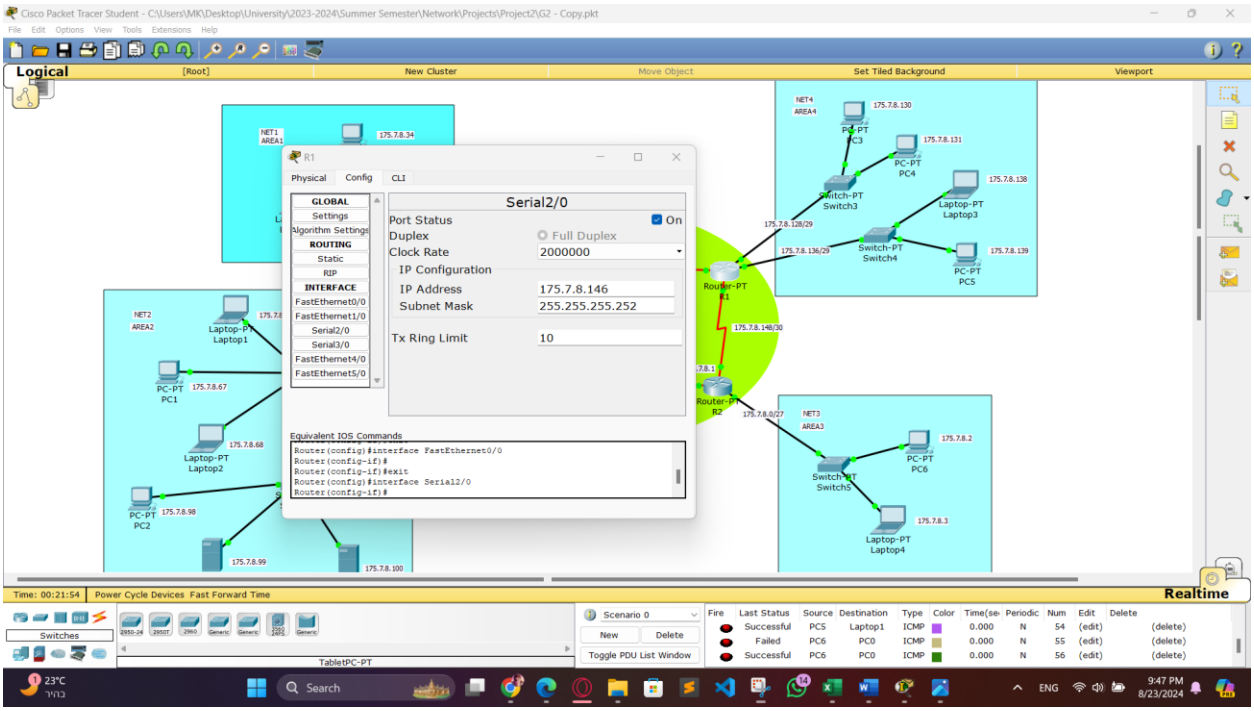

Figure 12: Router1 IP link with Router0

The link between Router0 and Router1 has Network IP 175.7.8.144/30, the IP of Router0 for this link is 175.7.8.145 as shown in Fig (11), while the IP address of Router1 for this link is 175.7.8.146 as shown in Fig (12). These IP addresses are distributed according to the values in Table (3). All the links between any two devices in the network are done in the same as the explained example of the link between Router0 and Router1.

Task2: Setting-up Servers Part

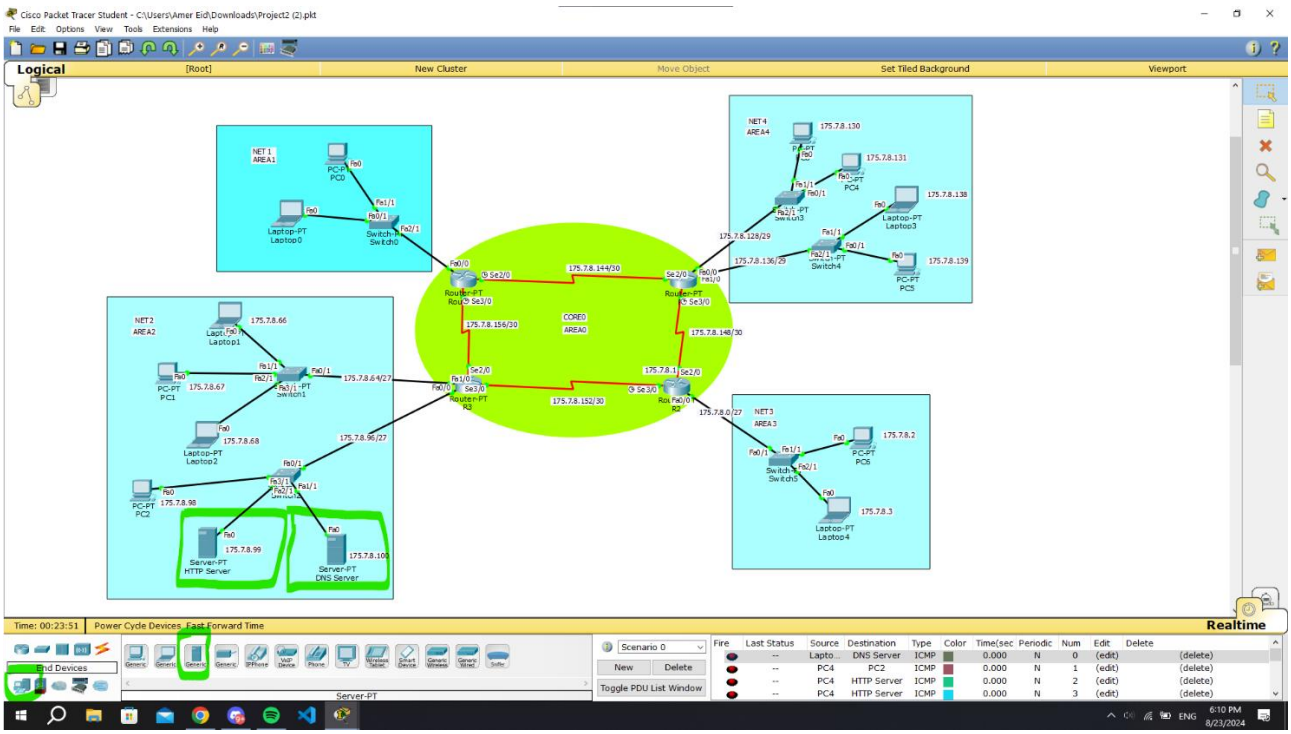

Figure 13: Server Icon and position

Two Servers are connected to the topology in Net2. First one is the HTTP server which contains a page called index.html which have to be edited in this project do display a page with some requirements. Second server is the DNS server which would translate the domain www.ENCS3320Summer.com to the IP address of the HTTP server to open the index.html page.

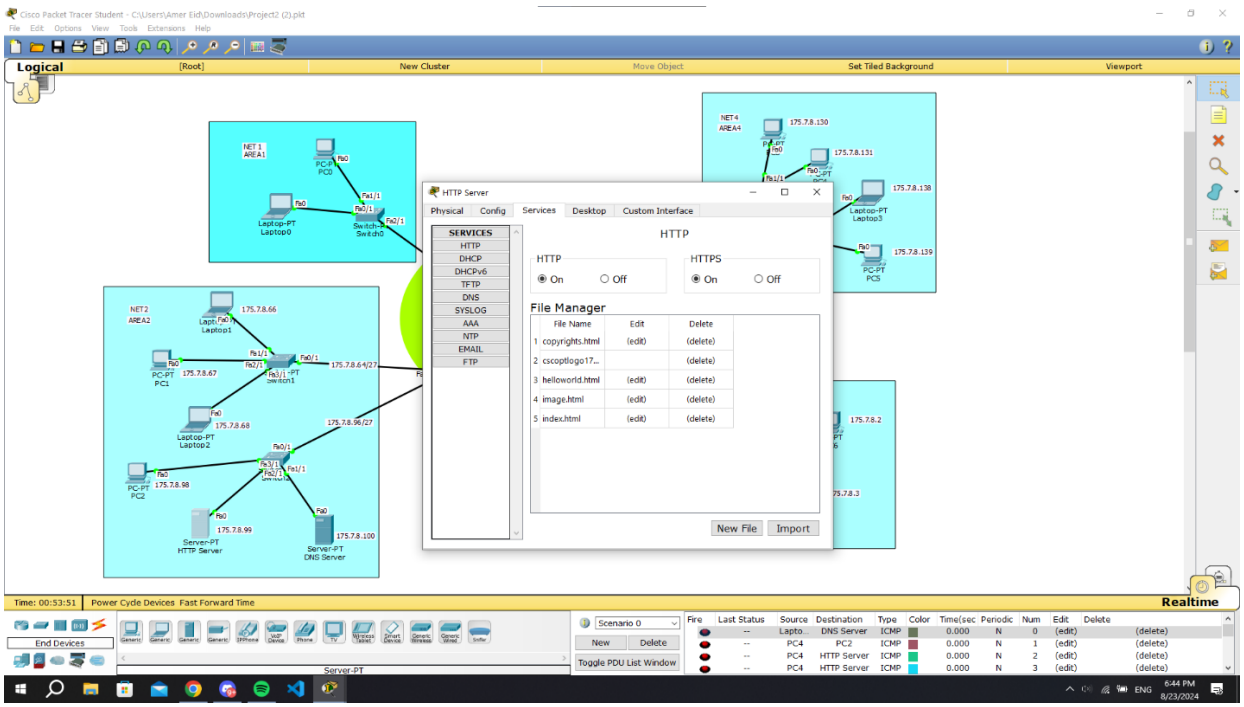

Figure 14: Enable HTTP server

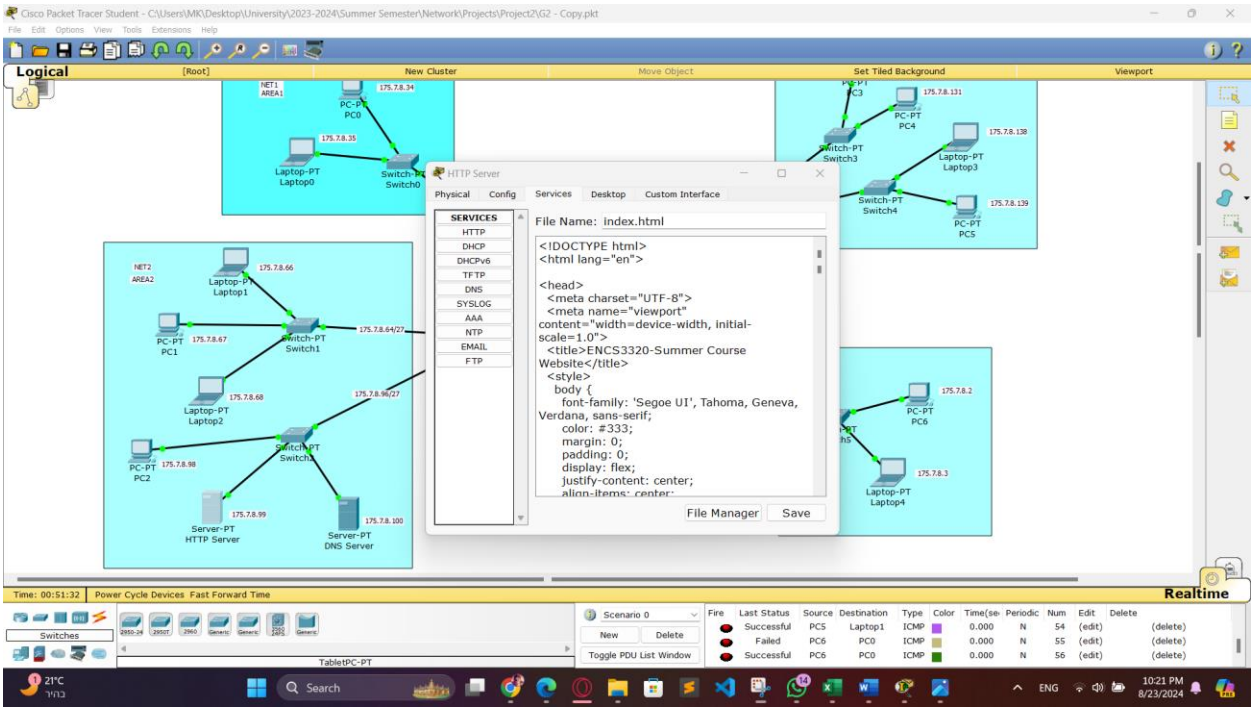

Figure 15: index.html page in the HTTP server

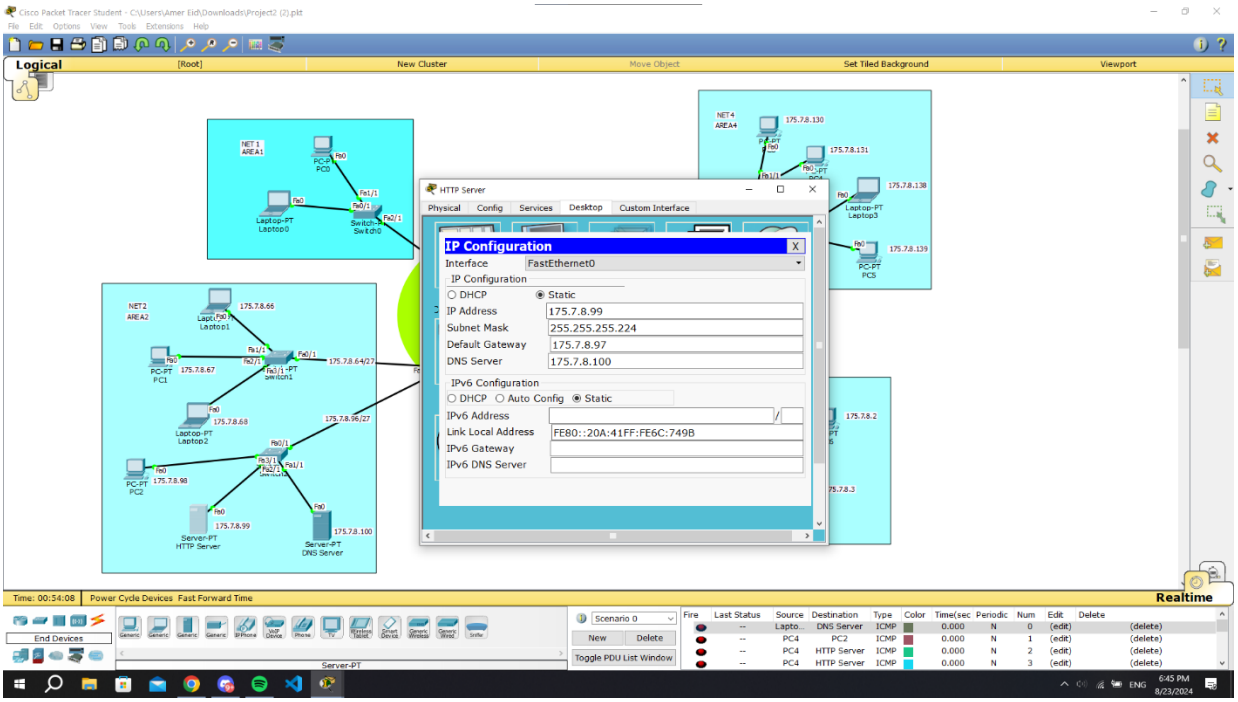

Figure 16: IP configuration of HTTP server

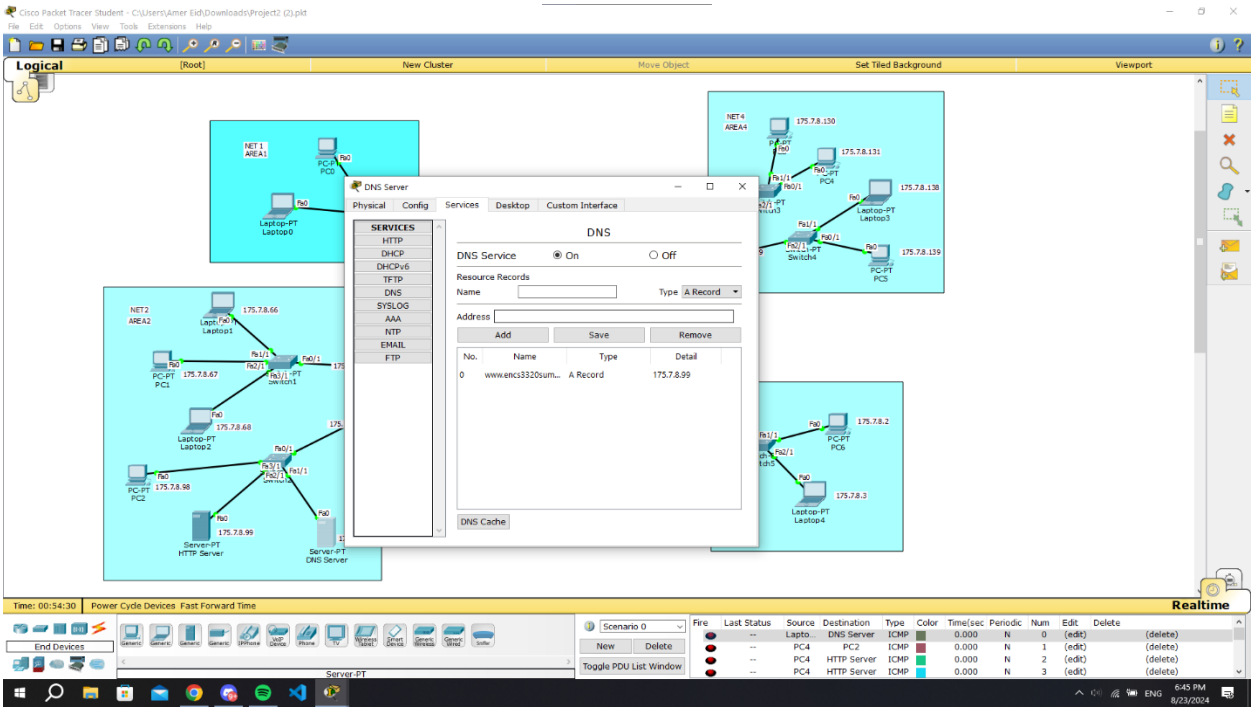

Figure 17: Enable DNS server and set the IP address of the domain

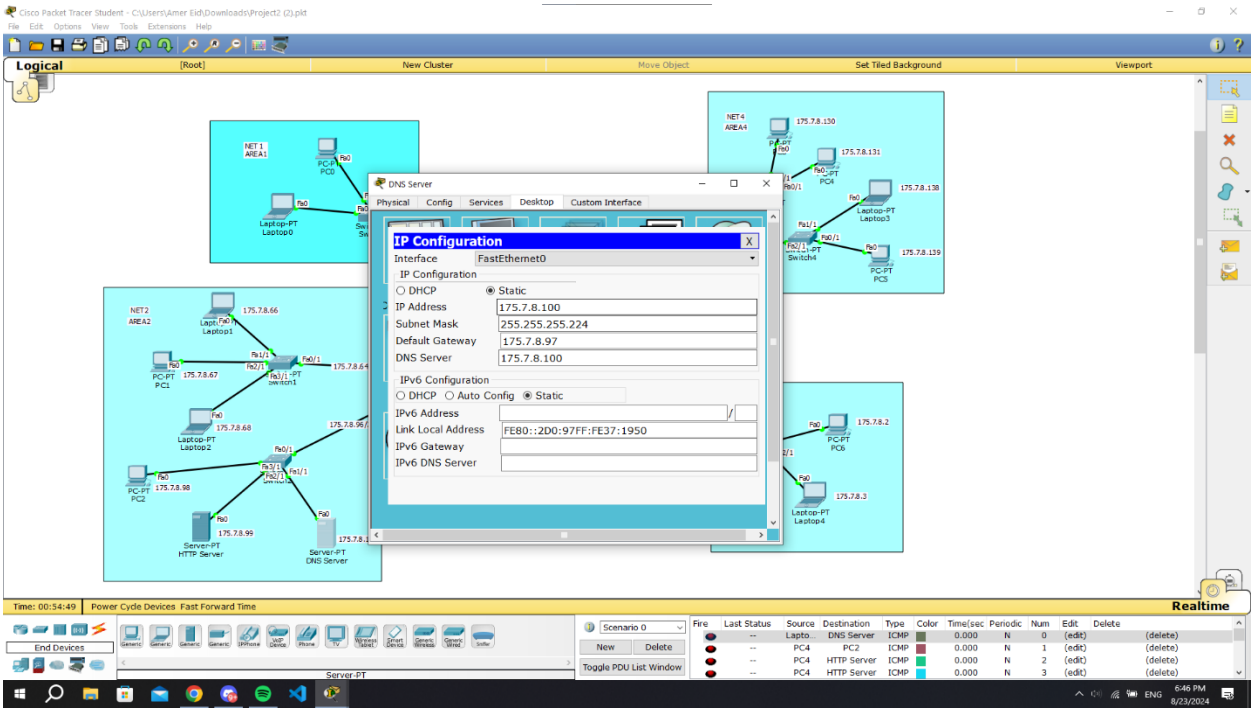

Figure 18: IP configuration of DNS server

The IP addresses for the HTTP server can be seen in Fig (16) which is 175.7.8.99, and the IP address for the DNS server can be seen in Fig (18) which is 175.7.8.100. Both IP addresses lie in the range of IPs given to Net2 as can be seen in Table (3).

It can be seen in Fig (17) that the DNS server contain the IP address of the domain www.ENCS3320Summer.com, which is 175.7.8.99, which is the IP address of the HTTP server. When request the domain www.ENCS3320Summer.com, the DNS server would translate to the IP 175.7.8.99, then an HTTP request is sent to open the index.html page in the HTTP server that holds that IP.

Task3: Routing Part

The Open Shortest Path Protocol (OSPF) with process id 20 is used on all routers.

Open Shortest Path First (OSPF) is a link-state routing protocol that was developed for IP networks and is based on the Shortest Path First (SPF) algorithm. OSPF is an Interior Gateway Protocol (IGP).

In an OSPF network, routers or systems within the same area maintain an identical link-state database that describes the topology of the area. Each router or system in the area generates its link-state database from the link-state advertisements (LSAs) that it receives from all the other routers or systems in the same area and the LSAs that itself generates. An LSA is a packet that contains information about neighbors and path costs. Based on the link-state database, each router or system calculates a shortest-path spanning tree, with itself as the root, using the SPF algorithm [2].

OSPF has the following key advantages:

- Compared with distance-vector routing protocols such as the Routing Information Protocol (RIP), OSPF is more suitable for serving large, heterogeneous internetworks. OSPF can recalculate the routes in a short amount of time when the network topology changes.
- With OSPF, you can divide an Autonomous System (AS) into areas and keep area topologies separate to decrease the OSPF routing traffic and the size of the link-state database of each area.
- OSPF provides equal-cost multipath routing. You can add duplicate routes to the TCP stack using different next hops.

The commands used to define the OSPF:

- show ip route: Displays the networks to which the router is currently directly connected.
- configure terminal: Enters configuration mode to set up the router's interfaces.
- router ospf 20: Initiates the OSPF protocol with process ID 20. It can then configure OSPF by specifying the network, wildcard mask, and area number in the format: "network (interface IP) (wildcard mask) (area number)"
  For example: "network 175.7.8.33 0.0.0.31 area 1"

Task4: Testing and Troubleshooting Part

1) ping and tracert commands between devices in the network.
    - ping: sends request over the network to a specific device, the request is small packets of data to the target IP. It tests the reachability of a host; it also measures the round-trip time (RTT).
    - tracert: sends packets to the destination IP, it tracks the path of the packets; It shows the IP addresses of each router the packet passes through and the time it takes to get to each one.

There are a lot of devices in the network, the commands would be applied from a device in each sub network to another device from other sub networks and the sub network itself.

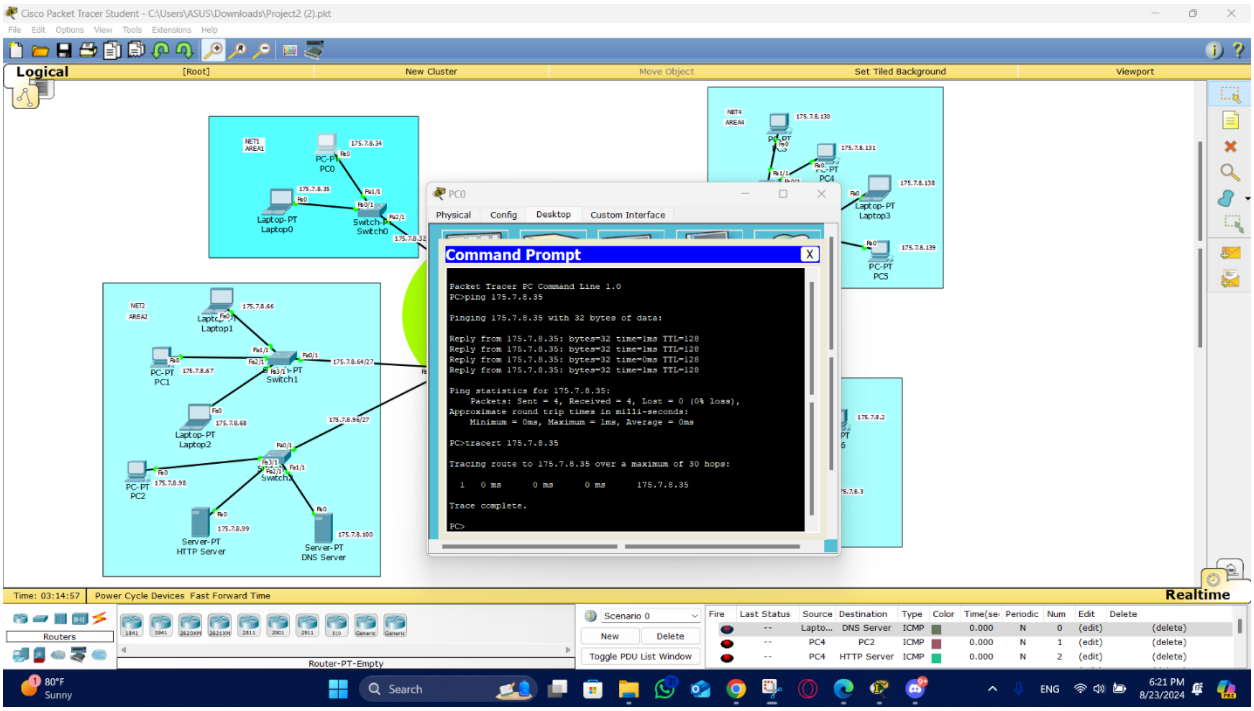

Figure 19: ping and tracert from Net1 to Net1

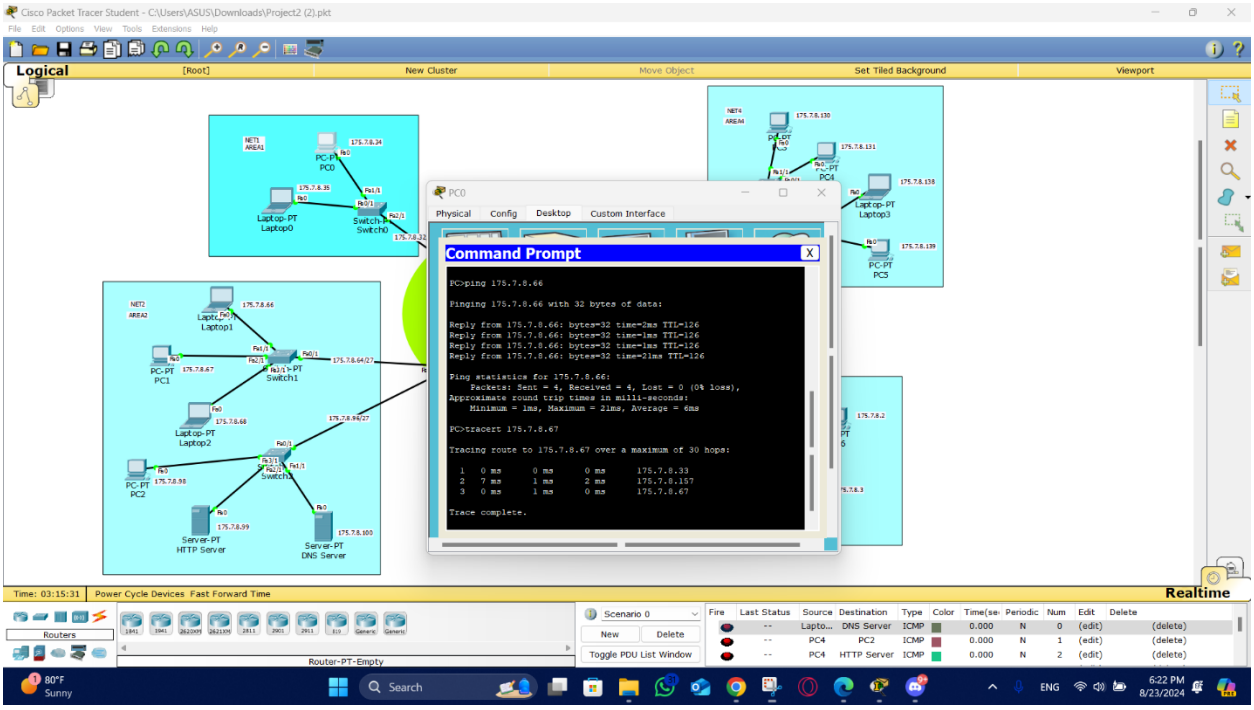

Figure 20: Figure 19: ping and tracert from Net1 to Net2

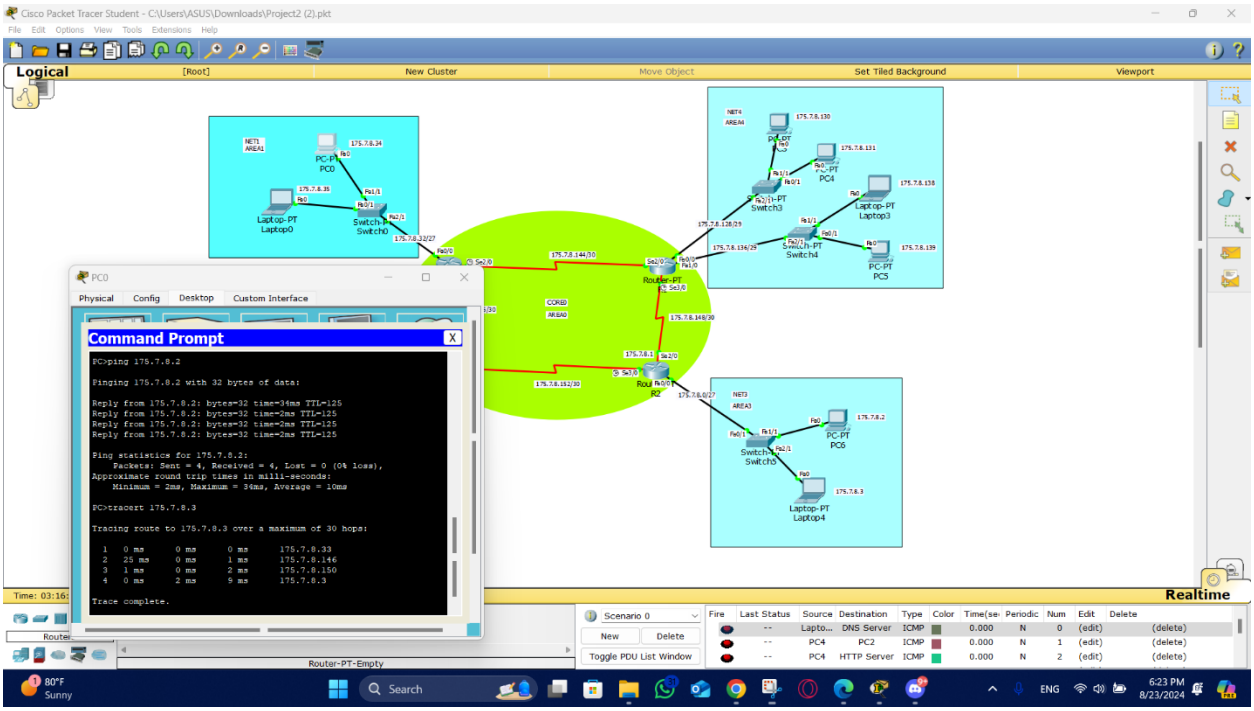

Figure 21: Figure 19: ping and tracert from Net1 to Net3

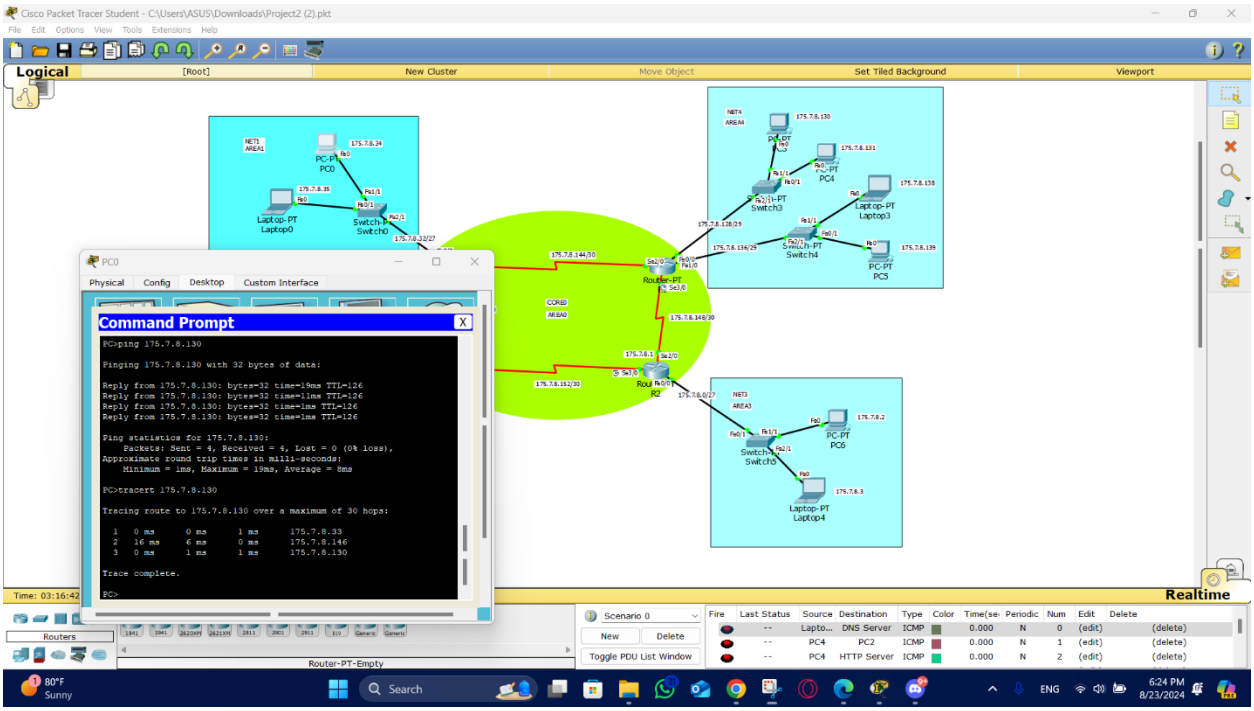

Figure 22: Figure 19: ping and tracert from Net1 to Net4

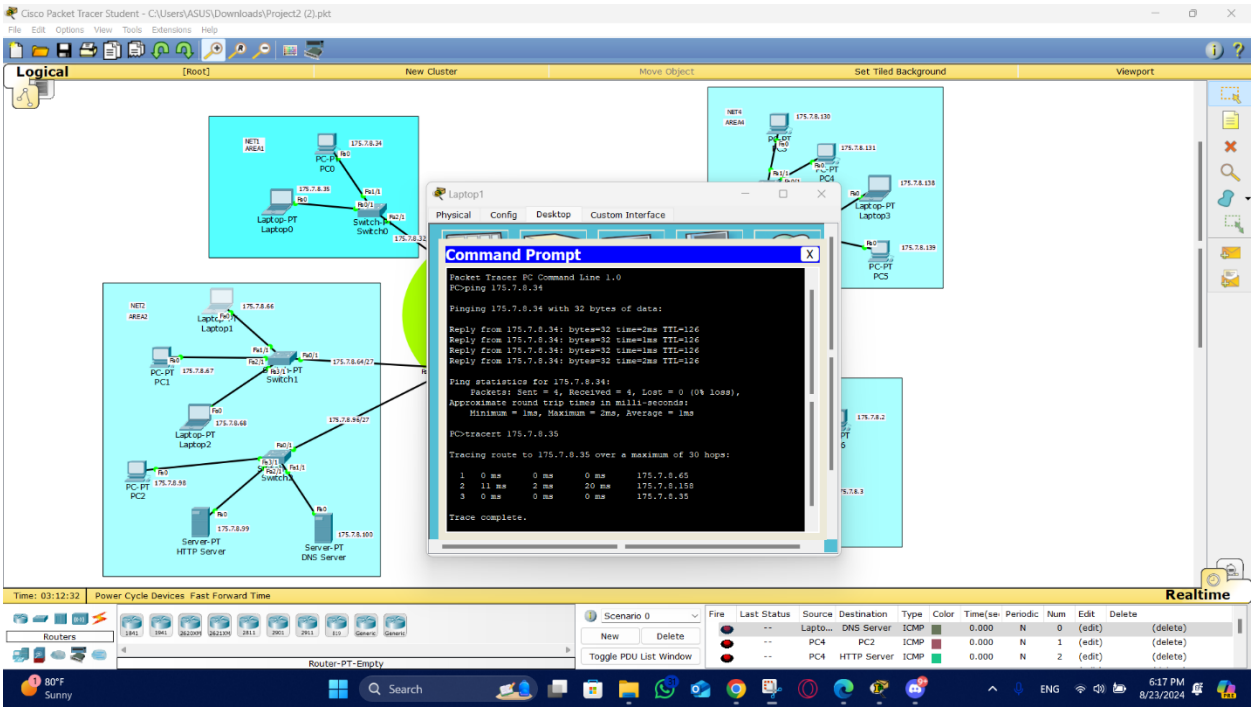

Figure 23: Figure 19: ping and tracert from Net2 to Net1

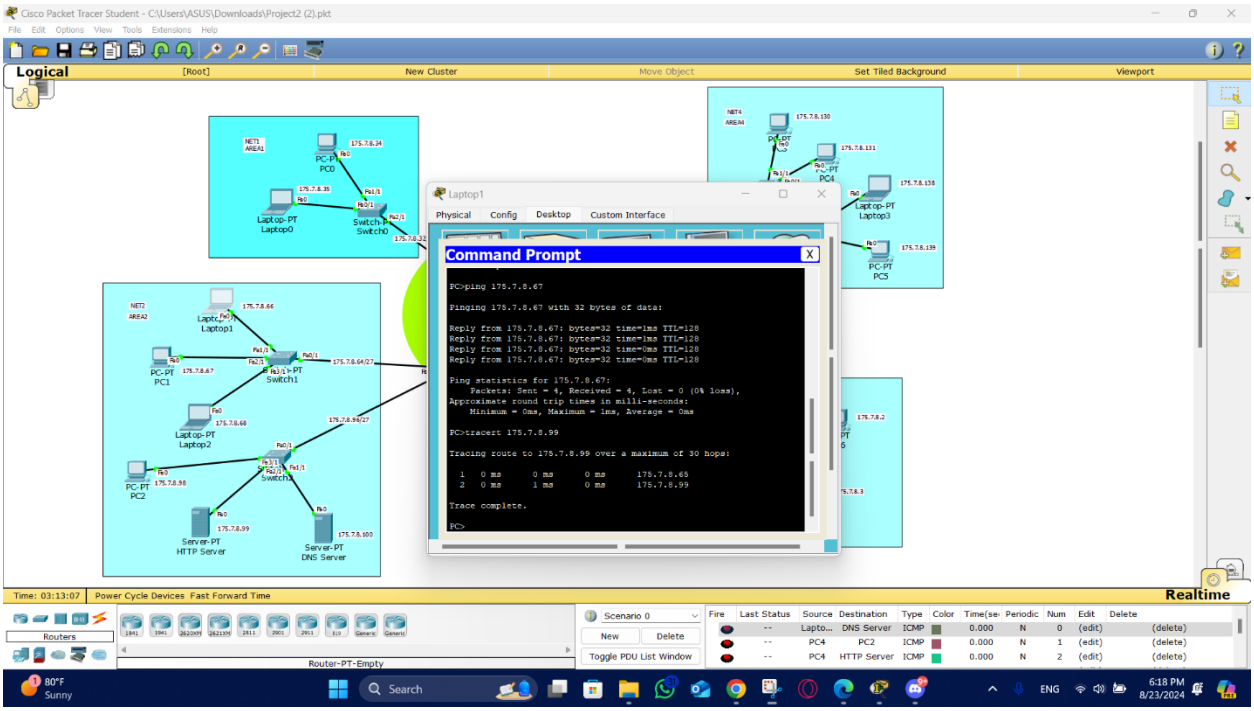

Figure 24: ping and tracert from Net2 to Net2

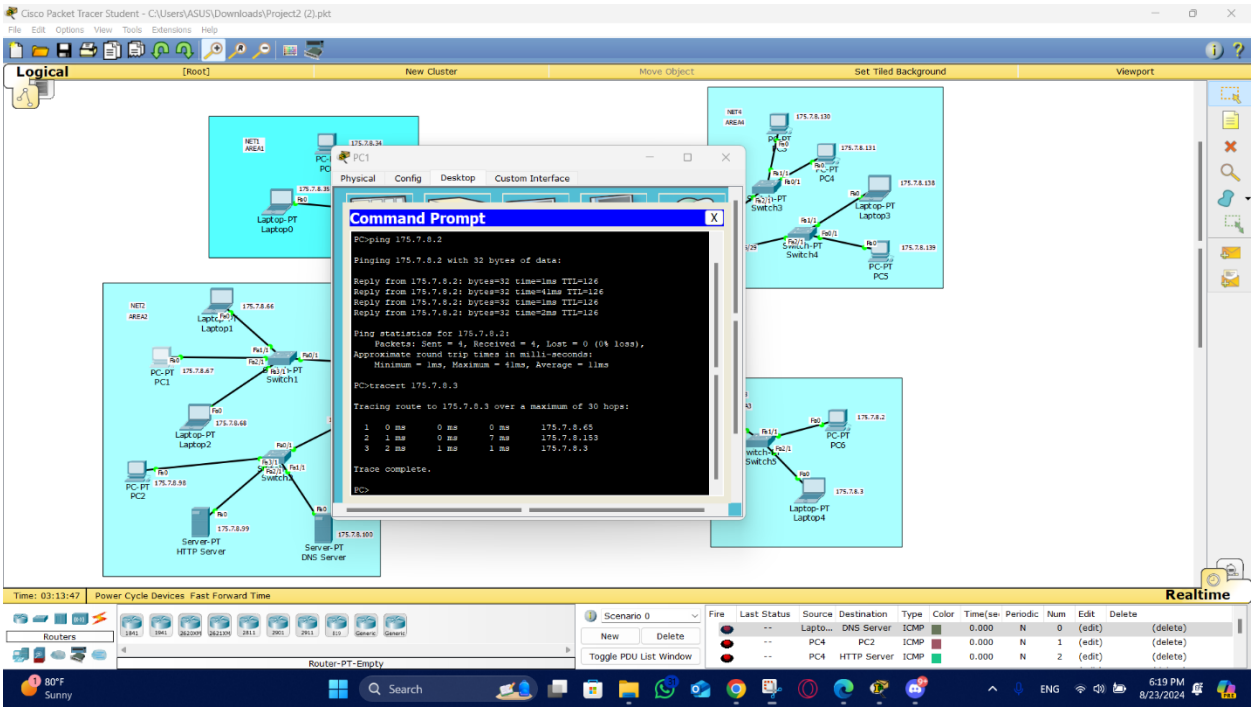

Figure 25: ping and tracert from Net2 to Net3

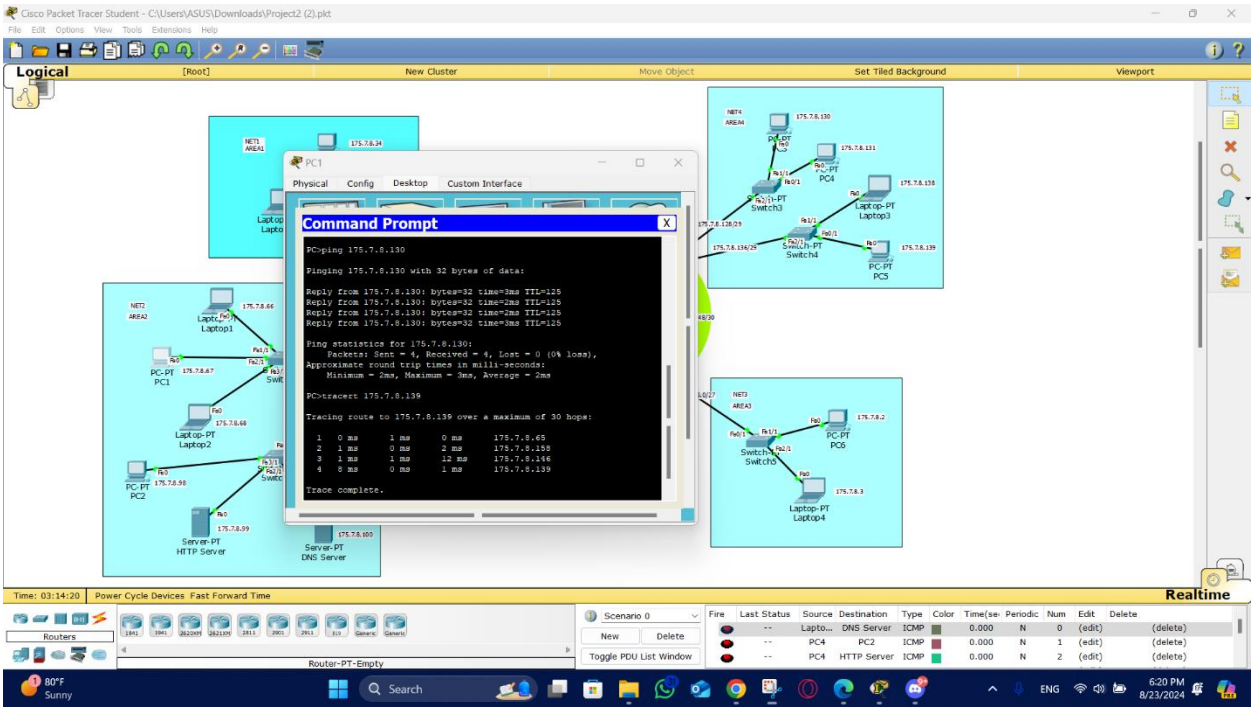

Figure 26: ping and tracert from Net2 to Net4

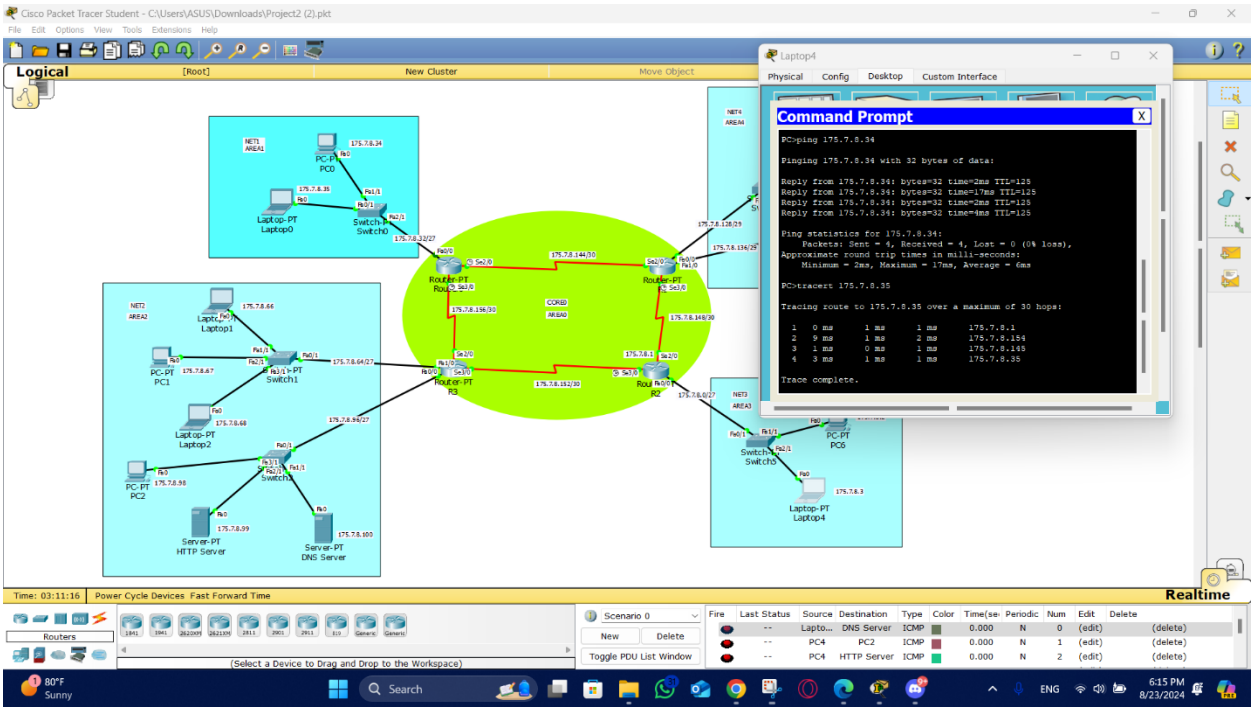

Figure 27: ping and tracert from Net3 to Net1

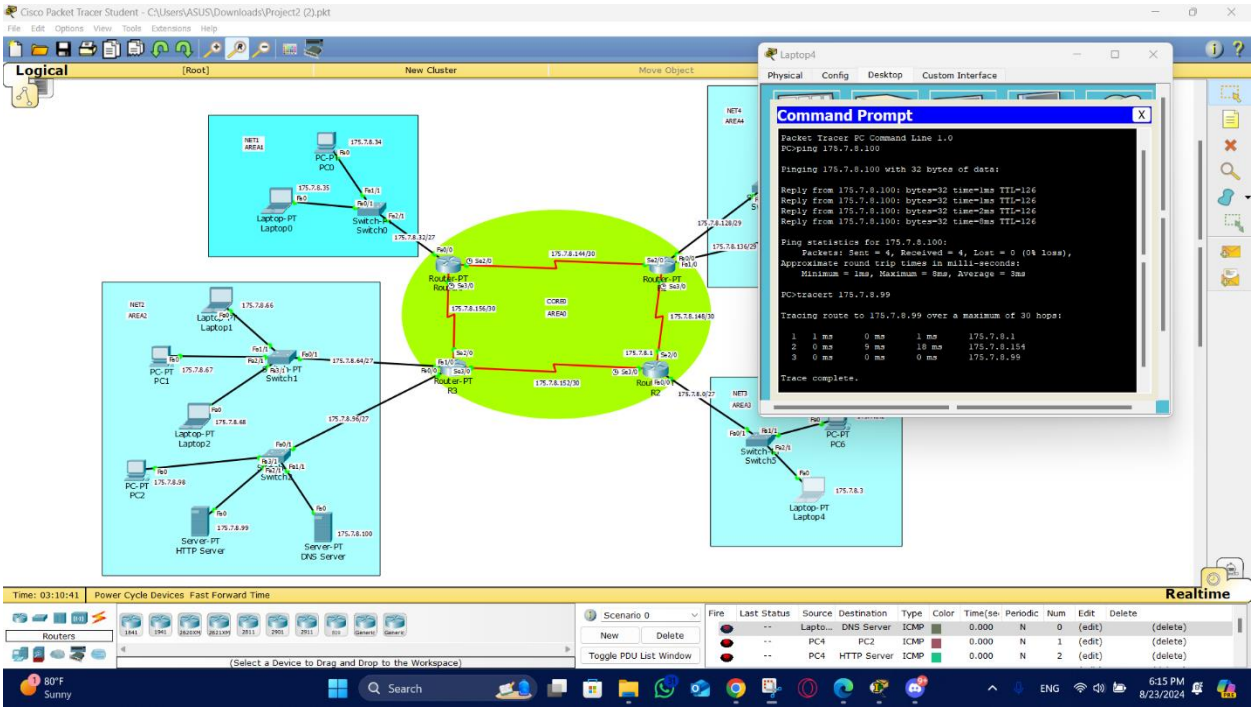

Figure 28: ping and tracert from Net3 to Net2

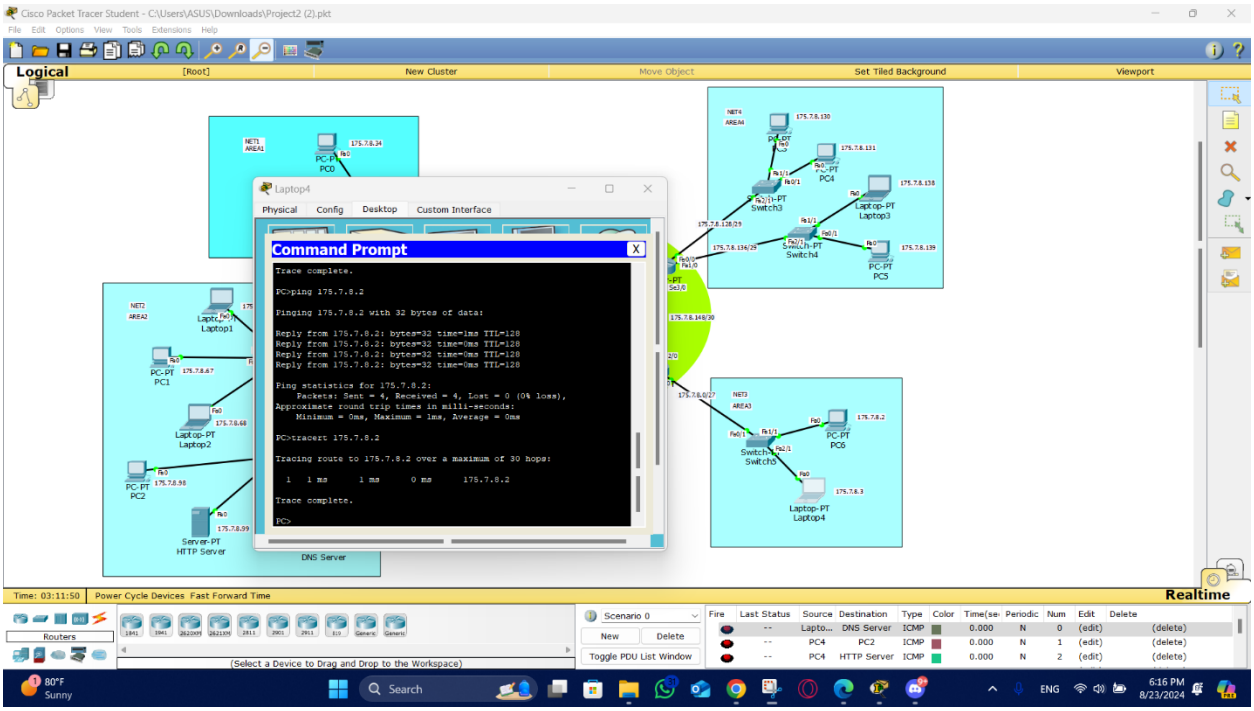

Figure 29: ping and tracert from Net3 to Net3

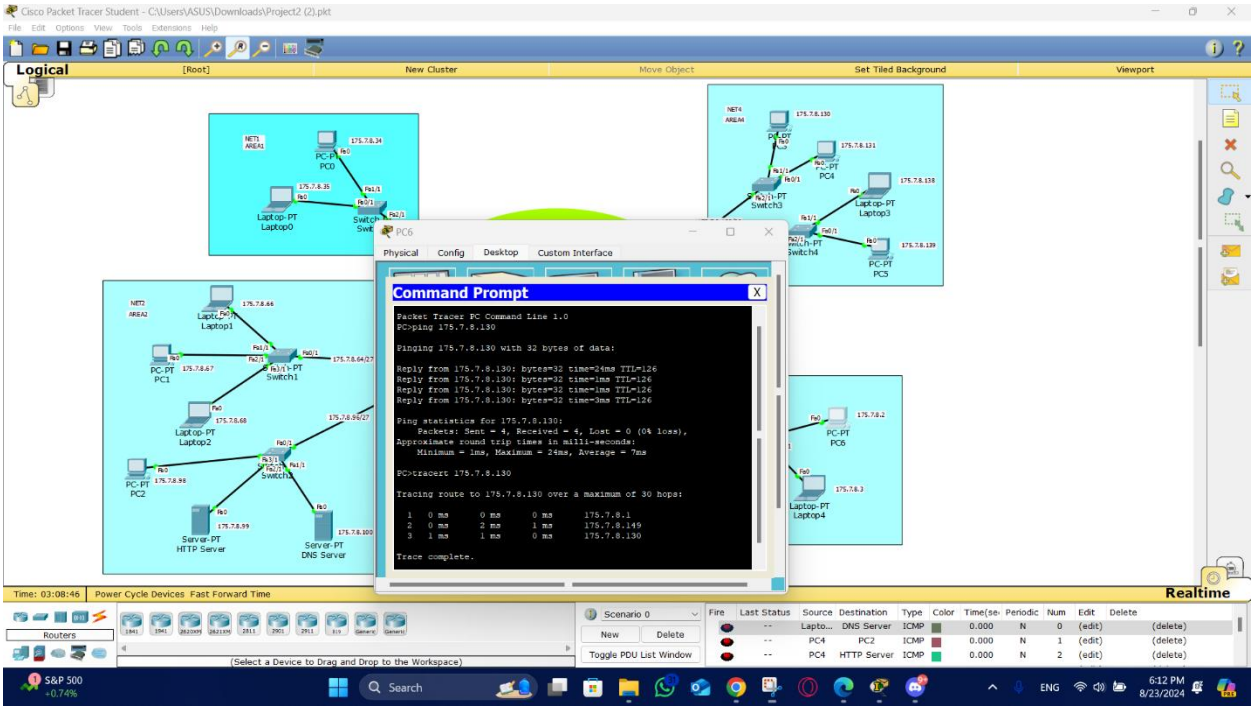

Figure 30: ping and tracert from Net3 to Net4

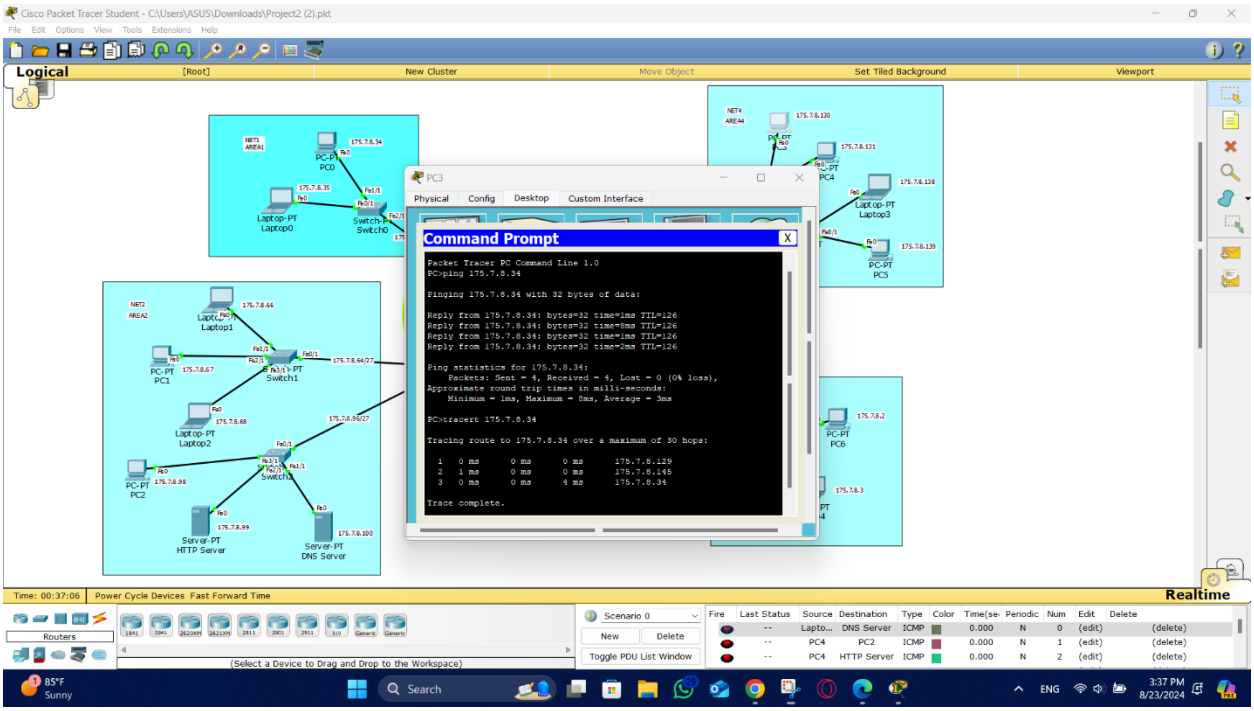

Figure 31: ping and tracert from Net4 to Net1

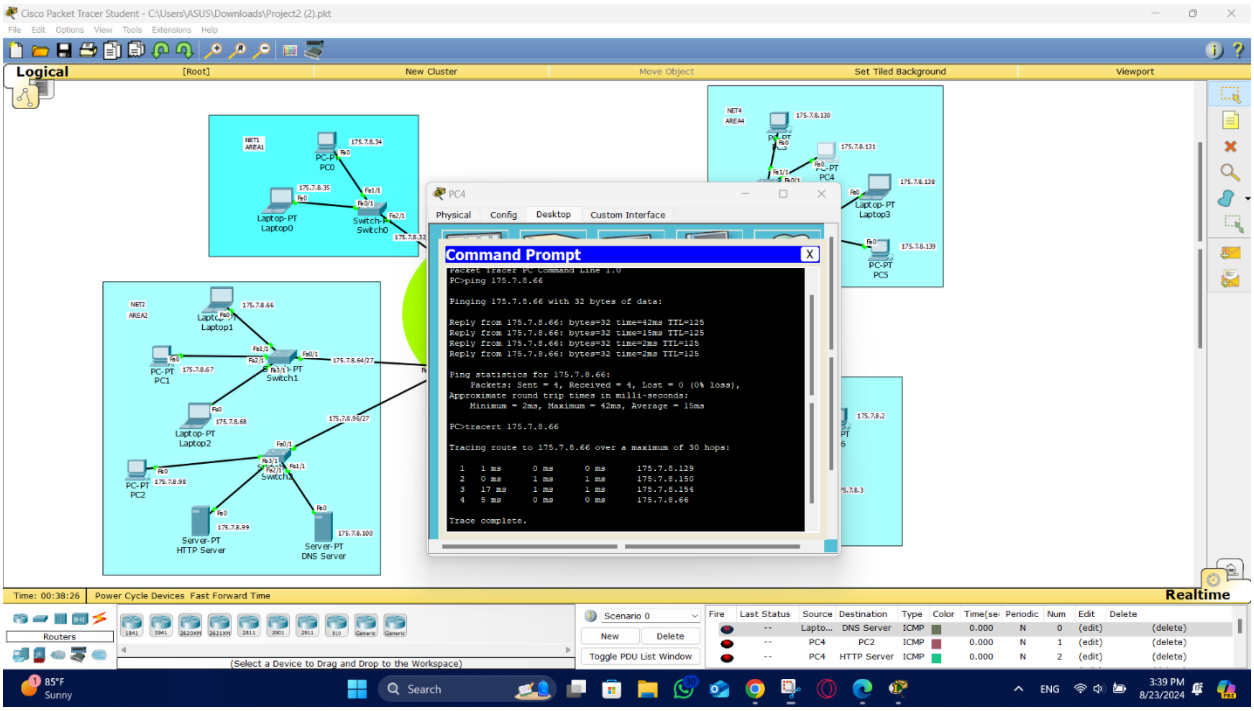

Figure 32: ping and tracert from Net4 to Net2

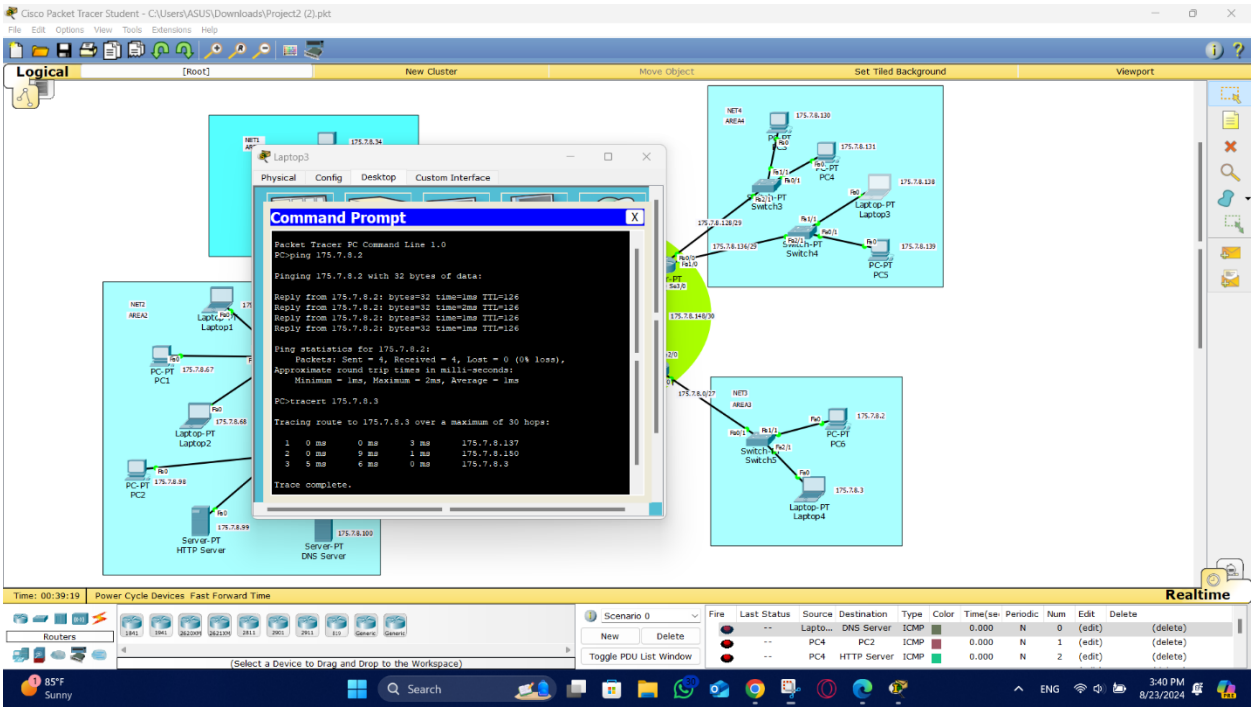

Figure 33: ping and tracert from Net4 to Net3

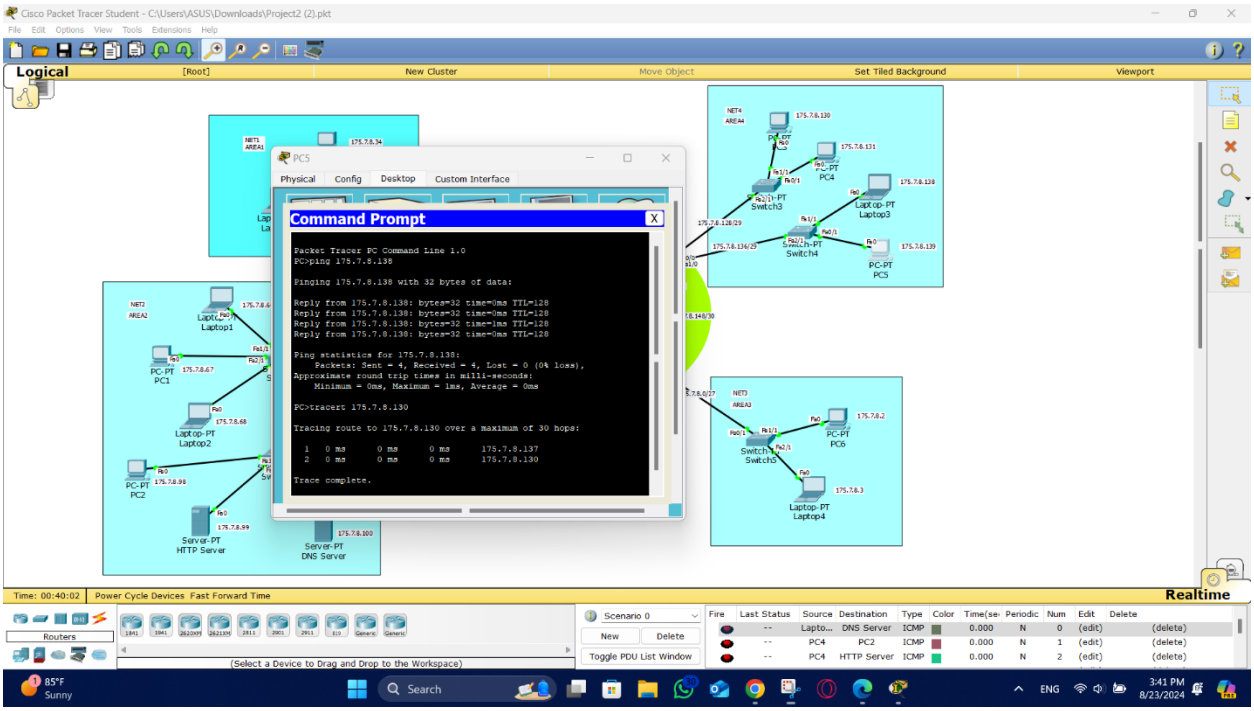

Figure 34: ping and tracert from Net4 to Net4

In Figures (19 – 34), the ping and tracert commands are used from each sub network to the other sub networks and the sub net work itself. Each command is done from a different device in the network to guarantee that each device is working properly.

2) Access www.ENCS3320Summer.com from all devices.

To access a domain from a device, open the device and select “Desktop” then Web browser and enter the domain.

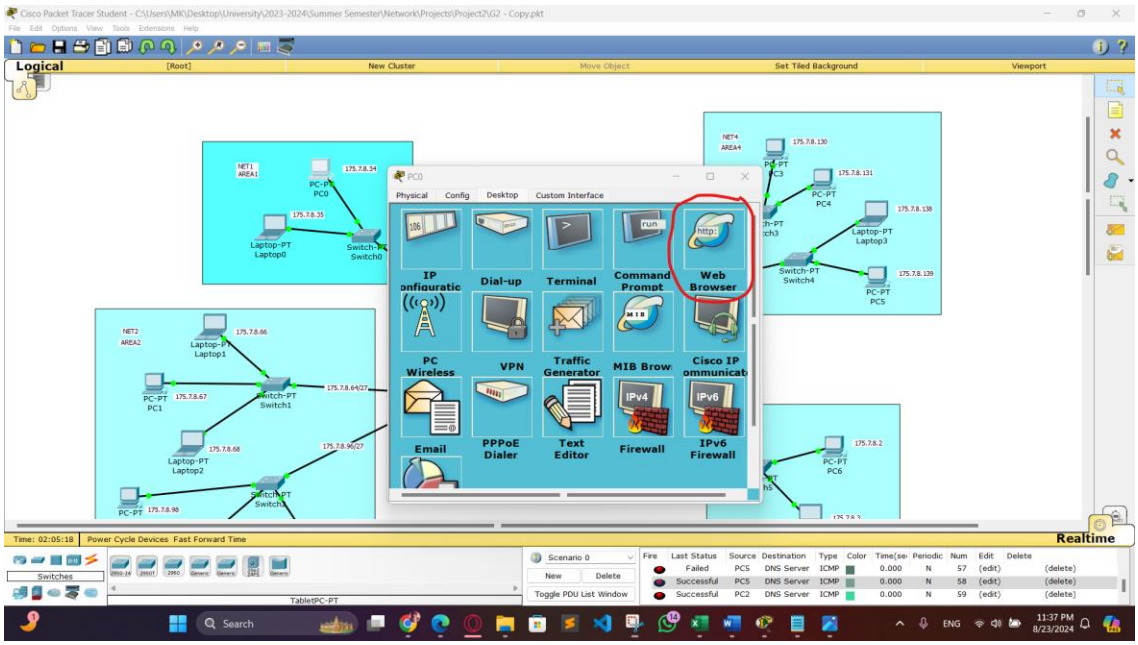

Figure 35: open Web Browser from device

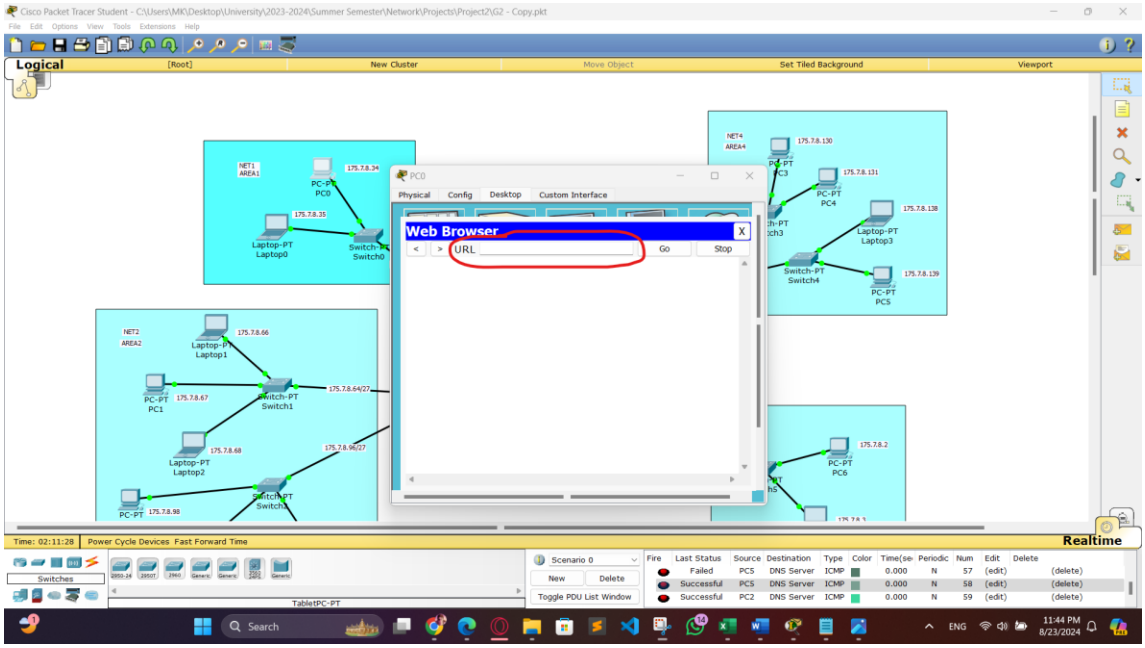

Figure 36: Enter URL from a device

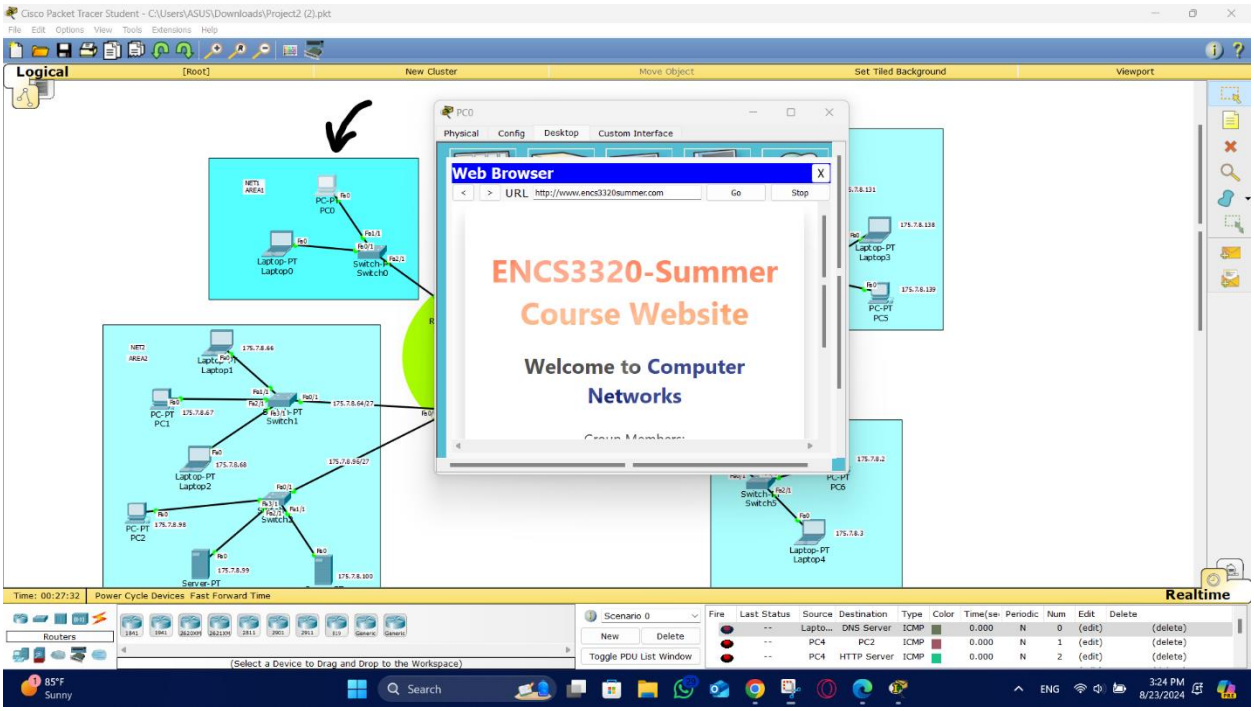

Figure 37: Open www.ENCS3320Summer.com from PC0

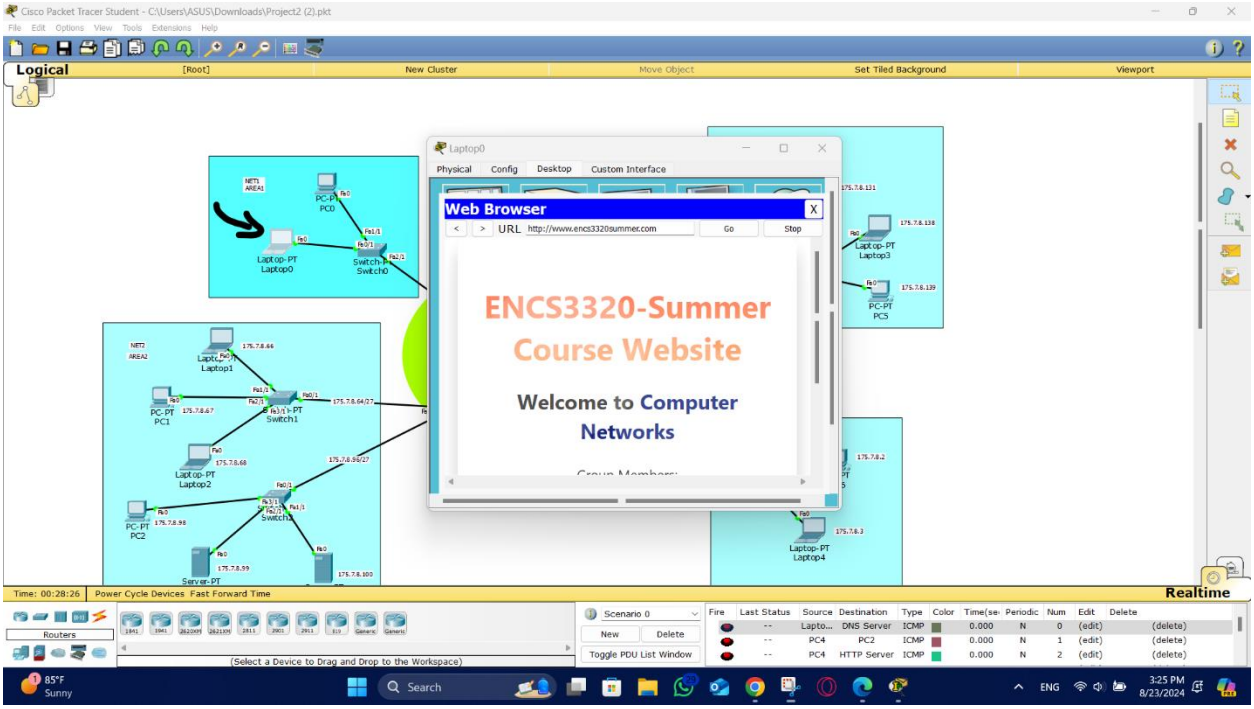

Figure 38: Open www.ENCS3320Summer.com from Laptop0

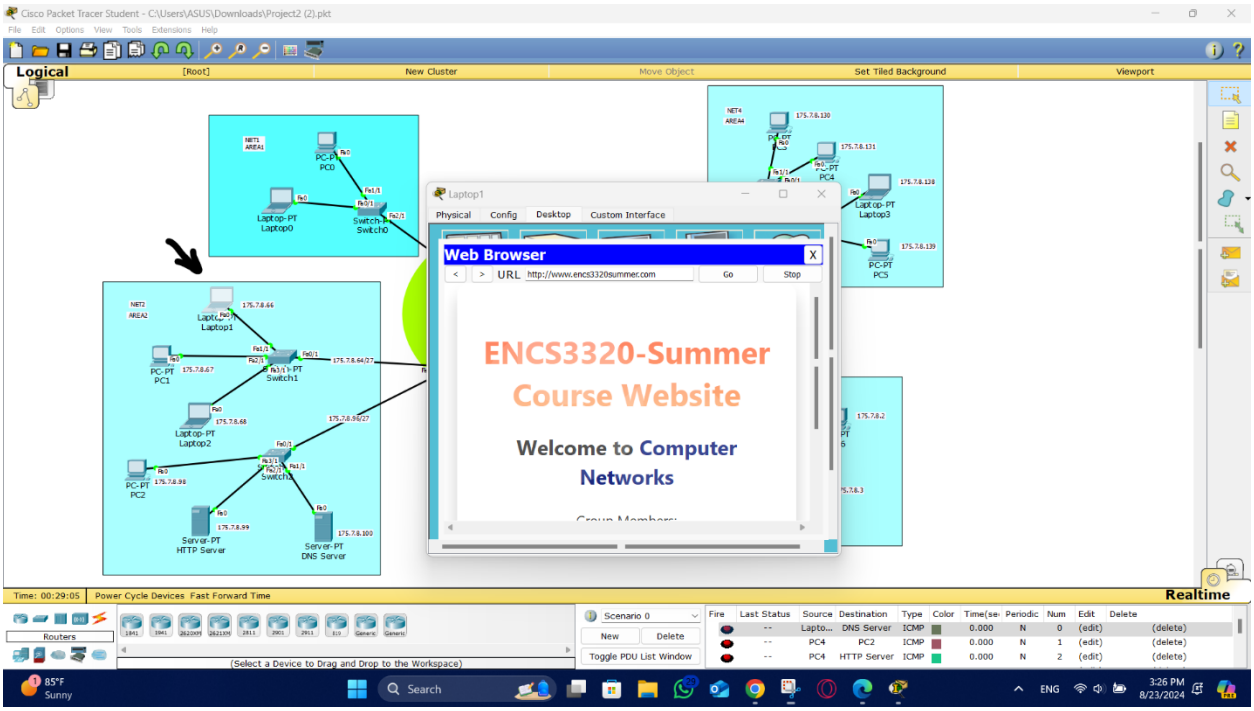

Figure 39: Open www.ENCS3320Summer.com from Laptop1

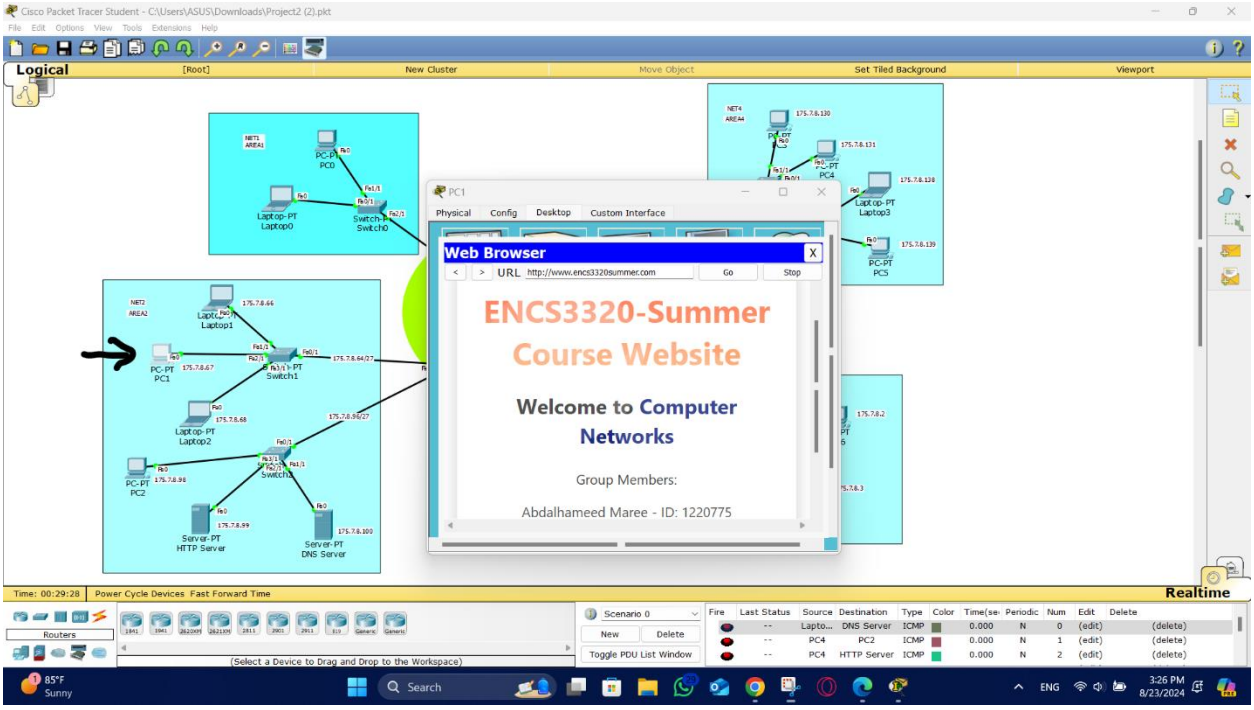

Figure 40: Open www.ENCS3320Summer.com from PC1

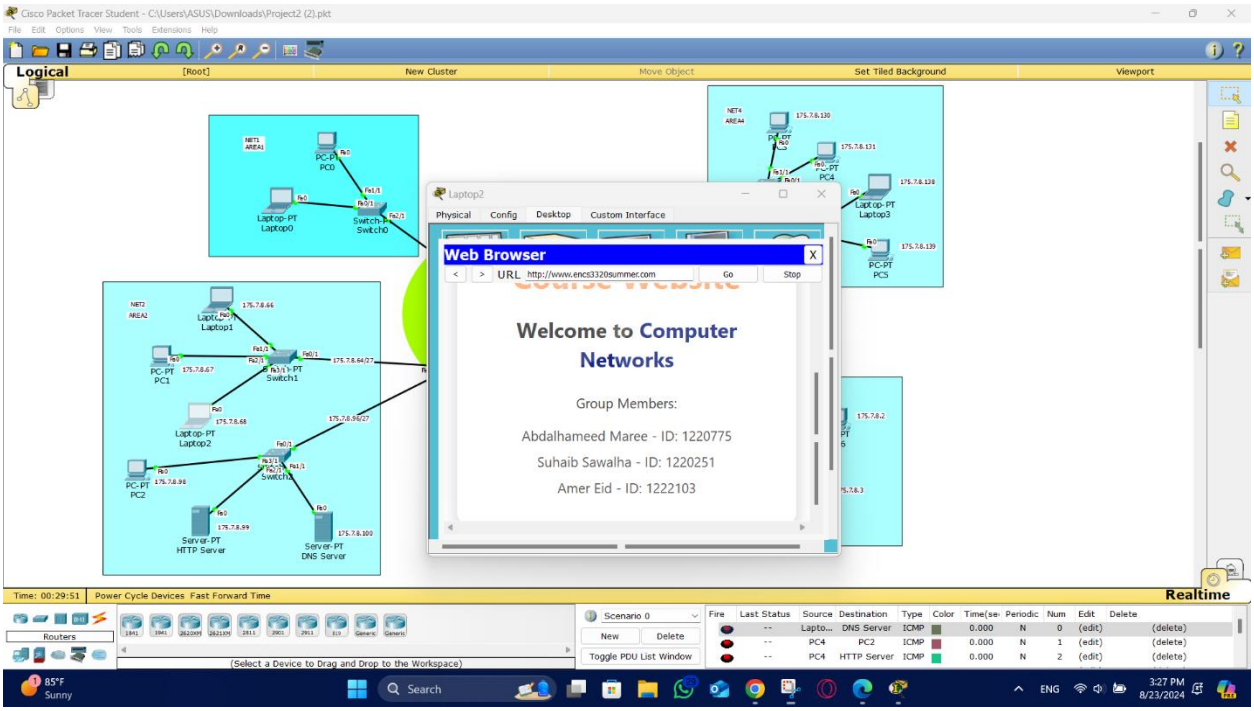

Figure 41: Open www.ENCS3320Summer.com from Laptop2

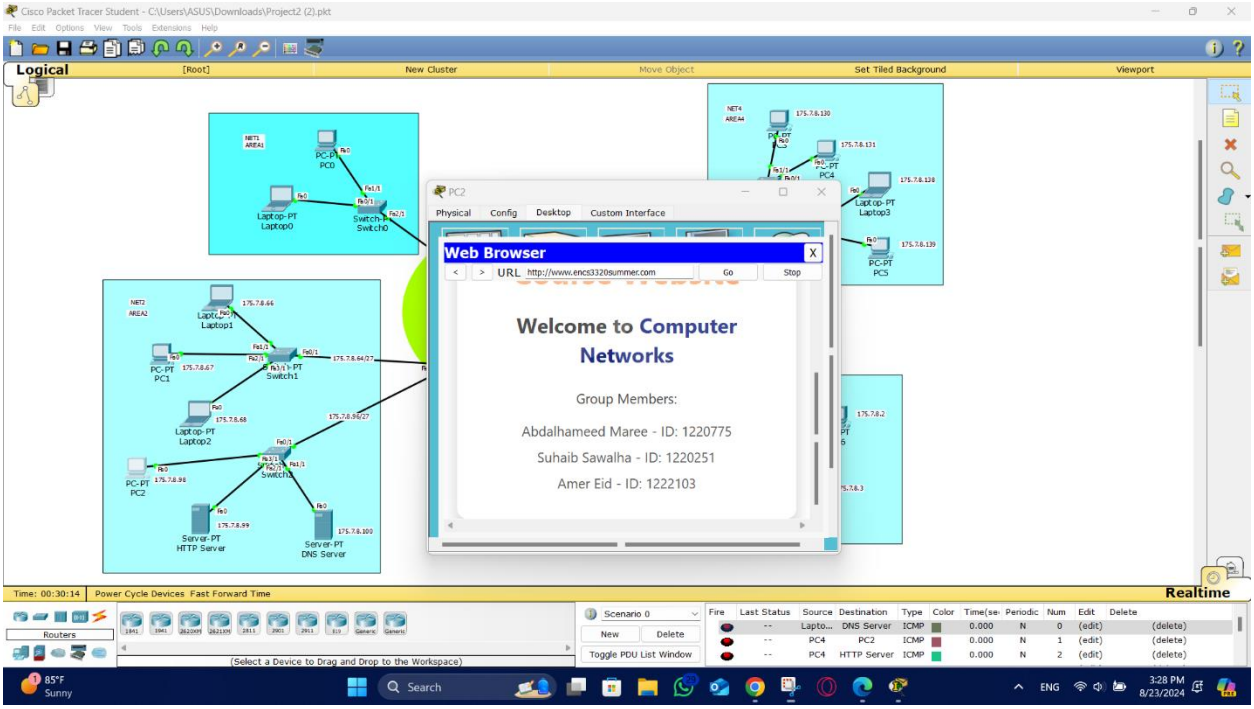

Figure 42: Open www.ENCS3320Summer.com from PC2

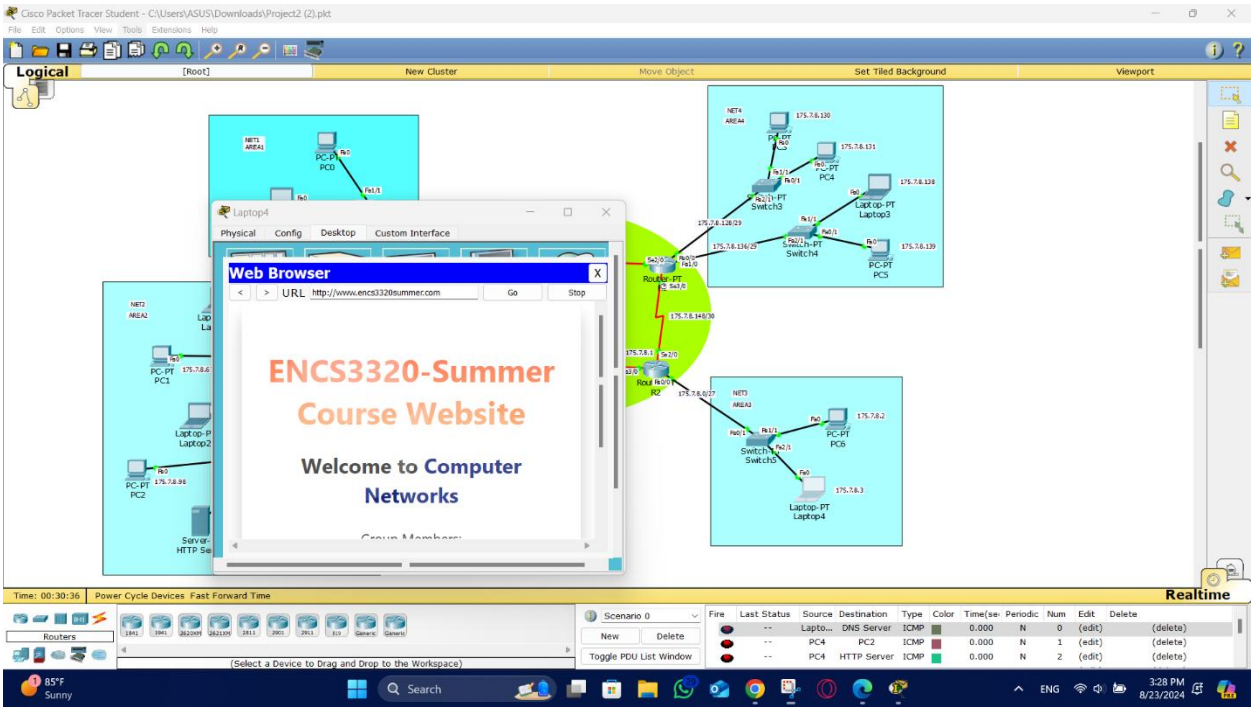

Figure 43: Open www.ENCS3320Summer.com from Laptop4

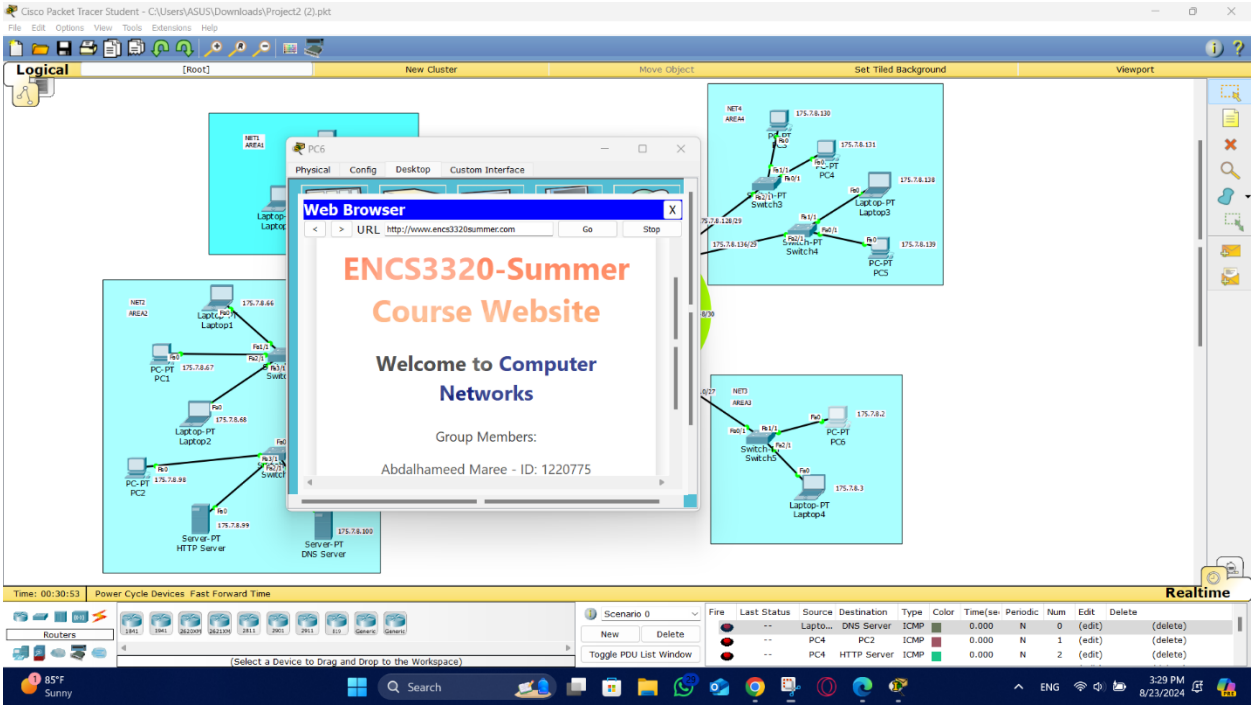

Figure 44: Open www.ENCS3320Summer.com from PC6

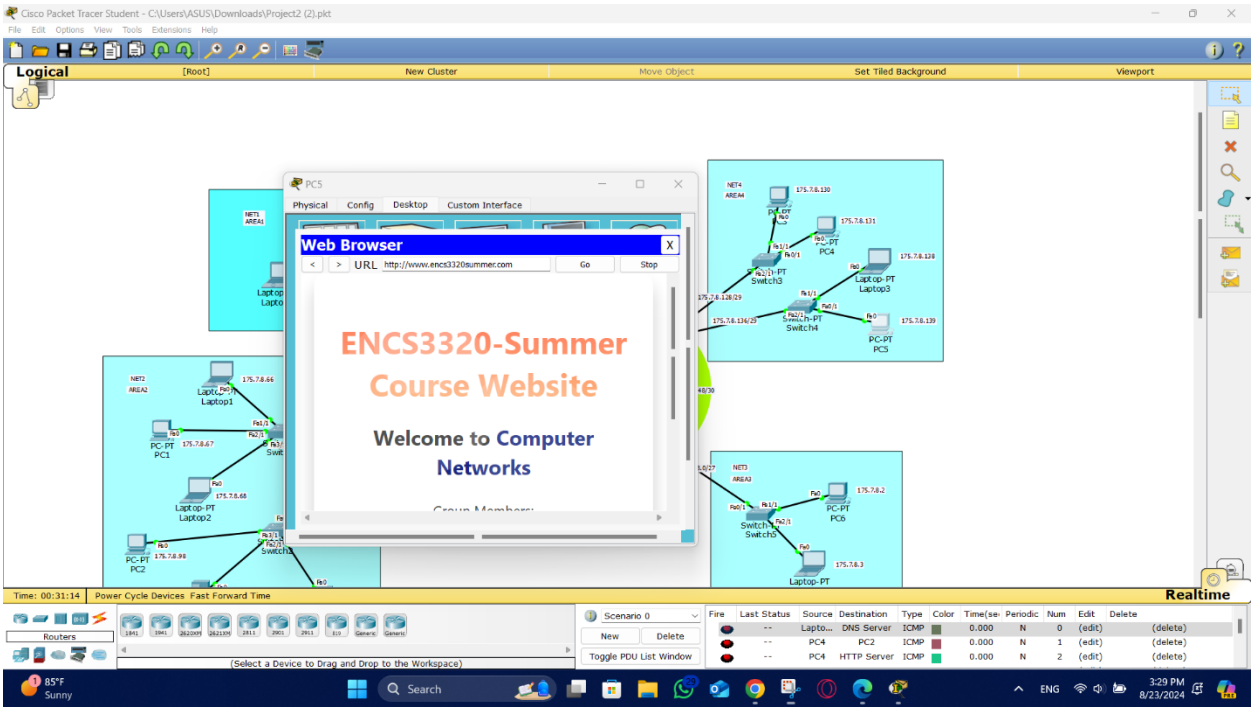

Figure 45: Open www.ENCS3320Summer.com from PC5

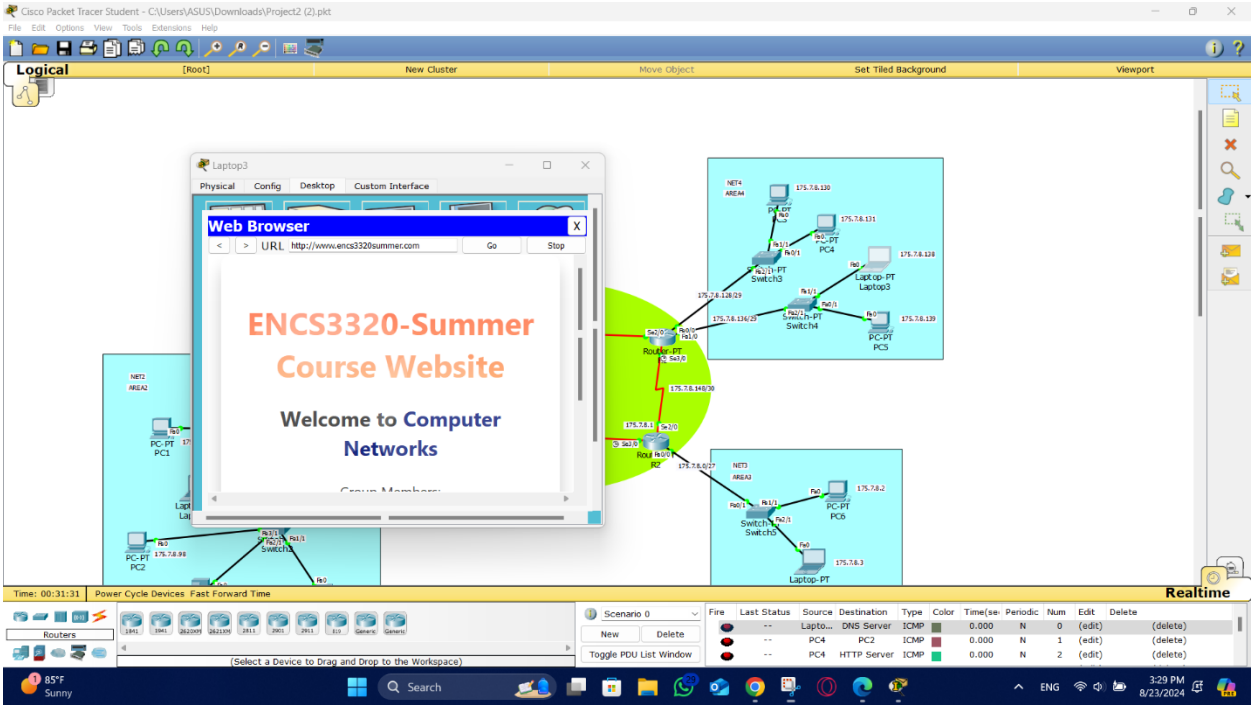

Figure 46: Open www.ENCS3320Summer.com from Laptop3

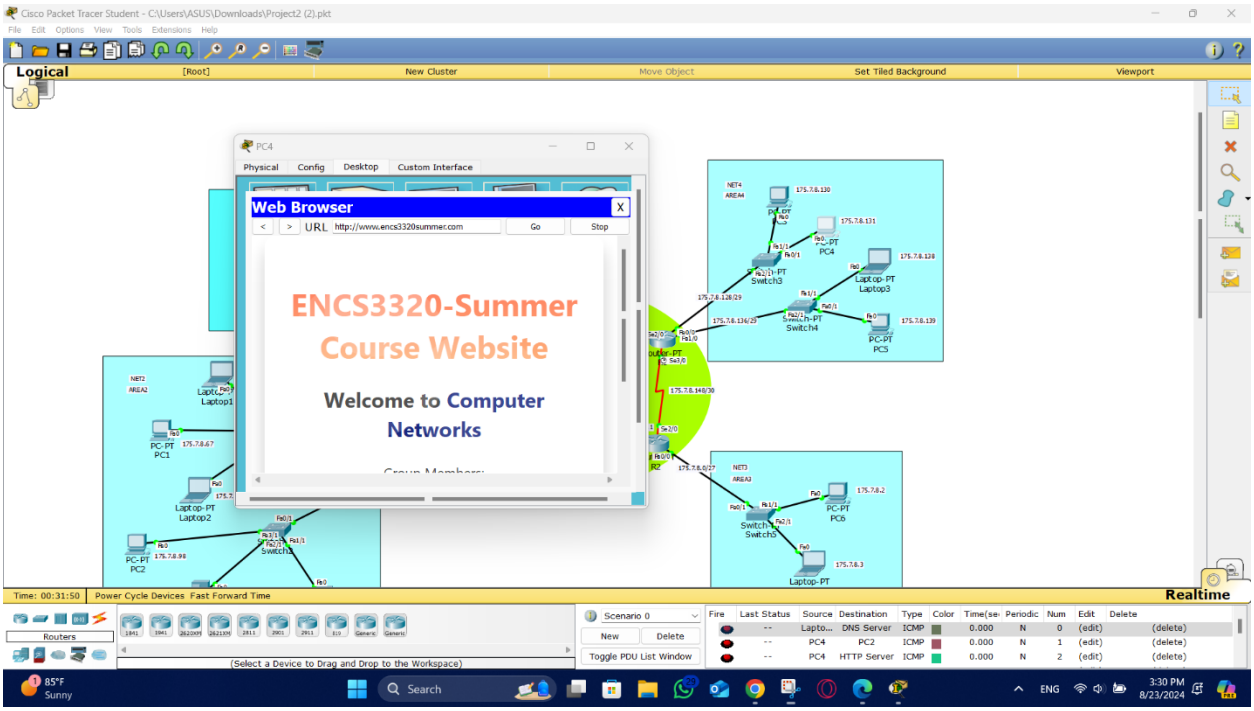

Figure 47: Open www.ENCS3320Summer.com from PC4

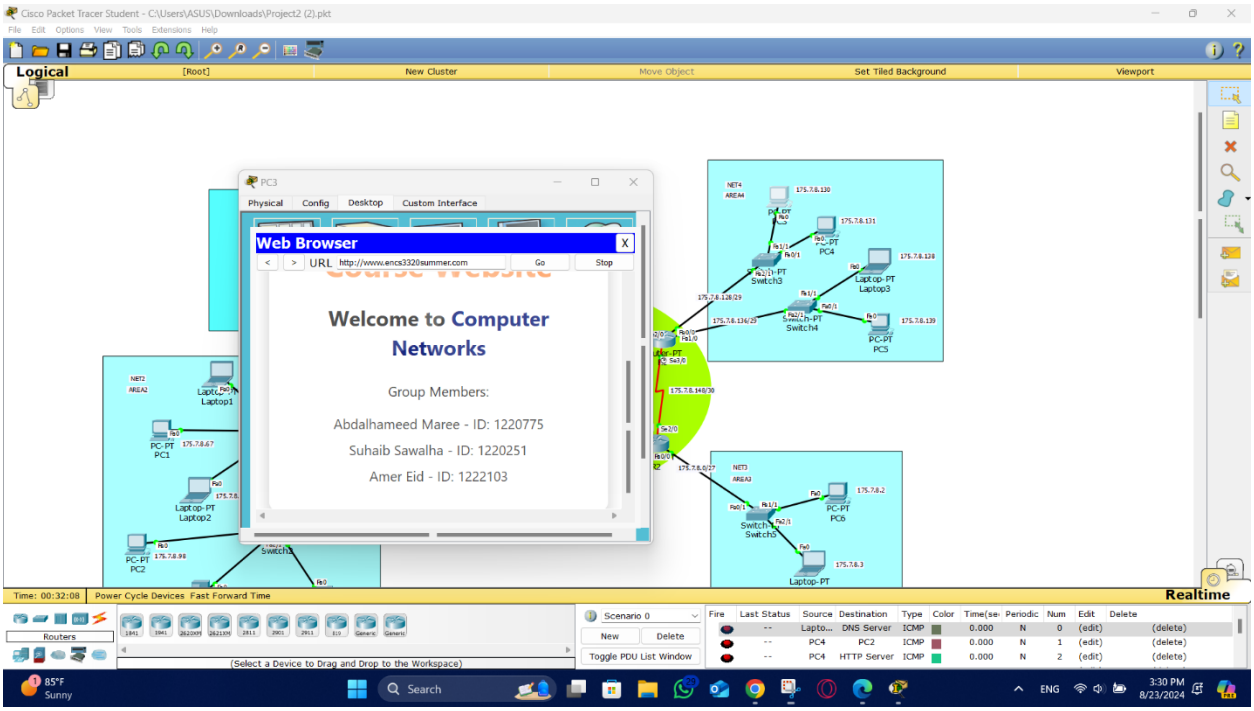

Figure 48: Open www.ENCS3320Summer.com from PC3

Teamwork

The project was done by three students: Suhaib Sawalha, Abd Alhameed Maree and Amer Eid. Each part of the project was distributed between them and each one of them helped the others in their parts, but mainly the distribution was as follows:

- Task0: IP subnetting & Assignment Part: Suhaib Sawalha.
- Task1: Building Topology Part: Abd Alhameed Maree and Amer Eid.
- Task2: Setting-up Servers Part: Abd Alhameed Maree.
- Task3: Routing Part: Amer Eid.
- Task4: Testing and Troubleshooting Part: Abd Alhameed Maree.
- Report: Suhaib Sawalha.

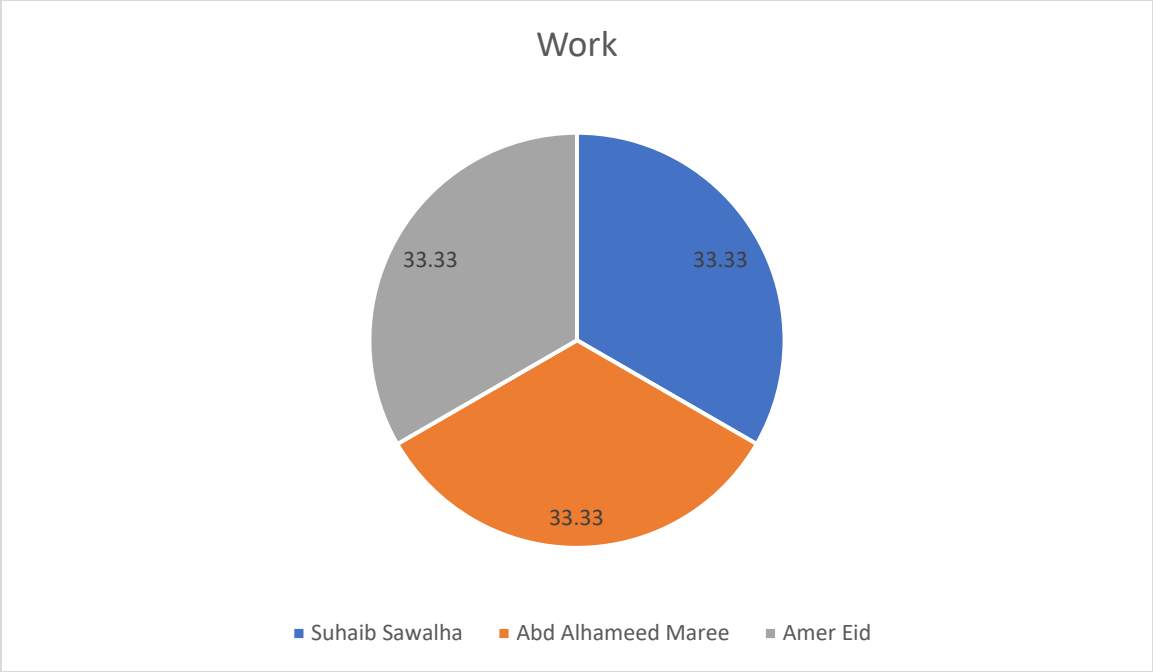

Figure 49: Teamwork

References

[1]: https://www.geeksforgeeks.org/what-is-ipv4/ [Accessed on 23 Aug 2024].

[2]: https://www.ibm.com/docs/en/i/7.4?topic=routing-open-shortest-path-first [Accessed on 23 Aug 2024].