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Using Cisco Packet Tracer to Build Topologies, Perform VLSM Subnetting, and Configure OSPF Routing

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ABSTRACT: This paper highlights the use Cisco Packet tracer Software to build sample network topologies, perform VLSM subnetting and configuration of an OSPF routing operations. Real time Simulation was carried out on the star, bus, mess and ring topologies. The data packet travel across the nodes were observed. This work also cover VSLM subnetting of a class C address (192.168.11.0)/24 and OSPF configuration and data simulation was also covered

1. INTRODUCTION

Network topology is the physical and logical arrangement of nodes and connections in a computer network. It is the layout and structural arrangement of network devices which governs how data flows between devices in a network. Network topology captures both the Physical Topology which is the actual, tangible placement of devices, cables, and hardware within the network and the logical topology which is how the data itself travels across the network devices, irrespective of the physical wiring [1]. The common types of network topologies are the star topology, bus topology, mesh topology, and the hybrid topology. Adopting the right topology is key in-service delivery, reliability and performance base on the network requirement. Each topology adopted offer its pros as well as the cons.

In the Star topology all devices connect directly to a single central hub or switch. If one device fails, the rest of the network remains functional whereas in the bus topology, every device links to a single, centralized cable known as the "bus". It is easy to implement, but the entire network fails if the main cable breaks down.

In the ring topology, all the devices are connected in a continuous circular loop. Data flows in a unidirectional manner. If one device fails, the communication loop is broken while in Mesh topology, all the devices (nodes) are interconnected, meaning data can travel through multiple pathways. This guarantee maximum reliability and data speed but can be very capital intensive and complicated to set up.

Hybrid Topology refers to the combination of two or more distinct topologies (e.g., a Star-bus network) designed primarily to service the specific needs of a complex multinational organization. The exhaustion of IPv4 address was a major challenge for network administrators, research on how to tackle this setback led to the introduction of VSLM [2].

VLSM stands for Variable Length Subnet Mask. VLSM is a subnetting technique that allows network admins to allocate IP addresses more efficiently using different subnet masks for different network segments. It provides greater flexibility in assigning IP addresses by creating subnets of varying sizes based on the specific needs and number of hosts in each subnet [3].

OSPF is a link-state routing protocol that finds the shortest path between two network points and then uses this path to send packets [4]. While OSPF offers numerous advantages such as supports multiple routes for a single destination, low bandwidth utilization, supports Variable Length Subnet Mask (VLSM) and provide updates quickly with network changes. It also has the following limitations; not been suitable for large-scale networks. Complexity in implementing OSPF configuration and non-washes removal and increased memory needed for neighborhood tables, routing, topology [5].

BGP (Border Gateway Protocol) relays routing information across autonomous systems (AS) which are large, distinct networks operated by one or more service providers [6],

BGP is a protocol used to exchange routing information between different networks on the internet. It helps routers determine the best path to send data across the vast and interconnected network of the internet.

Cisco Packet Tracer is a powerful network simulation and visualization software that plays a pivotal role in enhancing the practical knowledge of computer networking principles among students.

In the context of computer networking education, it offers several key advantages and applications such as enhancing Practical knowledge, promoting innovation and creativity, aiding the understanding of networking protocols etc [7].

2. TOPOLOGY

Simulation of the various topologies using Cisco Packet Tracer will be highlighted in the preceding sections.

Star Topology.

Star topology is the commonest network configuration in which each device connects individually to a central hub or switch. This topology takes the shape of a star, with cables radiating from the hub, allowing for effective network communication and management of network traffic.

Steps in Simulating a star topology in Cisco Packet Tracer

Step Simulating a Star topology.

Launch Cisco Packet Network Tracer

Step 1. Adding hardware

- Point to the bottom left corner of the Cisco Packet Tracer interface.
- Click on Switches and select a generic model (e.g., 2960-24TT), then drag and drop on the workspace,
- Click on End Devices and drag four PCs, drop each around the of the switch, forming a star like configuration.

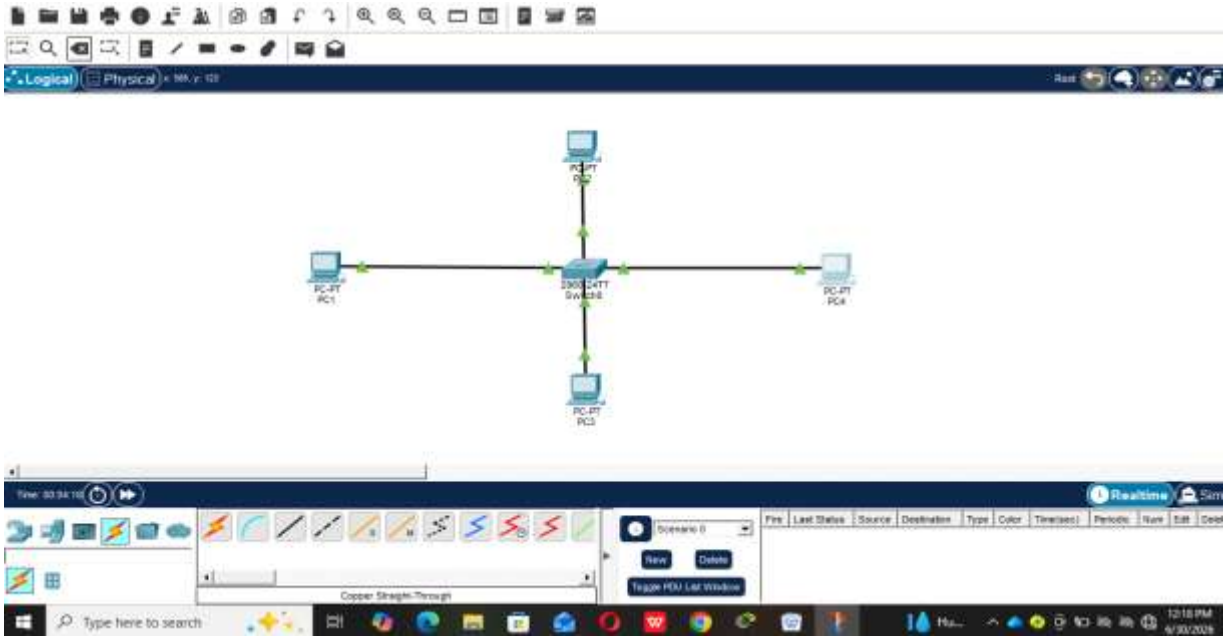

Fig. 1 The Star Topology

Step 2. Connect the Devices

- Click the **Connections** icon (Arch Flash Sign) in the bottom-left corner.
- Select the **Copper Straight-Through** cable (black solid line).
- Click on a PC, select **FastEthernet0** and then click the central Switch and select an available port (e.g., **FastEthernet0/1**).
- Go over step 2 above for all PCs so every device connects directly to the switch. (The link lights usually turn from red to green once active)

Step 3. Configuring PCs

- Click on any PC you intend to configure.
- go to the Desktop tab, and click IP Configuration.
- Fill a static IPv4 address for PC1 (192.168.1.10) in the dialog box and click outside then a Subnet Mask (typically (255.255.255.0) indicating class C will fill automatically).
- Repeat step 3 above for all PCs, ensuring a common network address range but having a unique host numbers PC2 (192.168.1.20), PC3: (192.168.1.30) and PC4 (192.168.1.40)

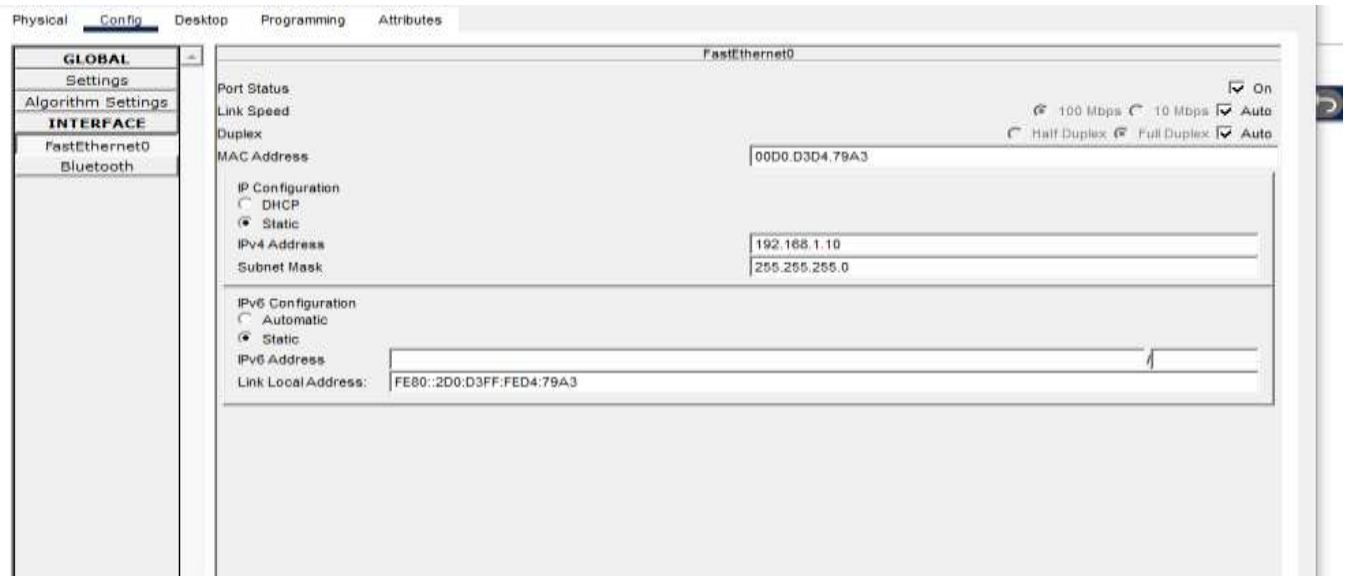

Figure 2: IPv4 Configuration of PC1

Step 4. Testing for Connectivity

- Click PC 2, go to Desktop then Command Prompt.
- Type ping 192.168.1.10 (the IP of PC1) to check if the network is communicating.
- There should be a reply from or feedback from other PCs indicating a connection.

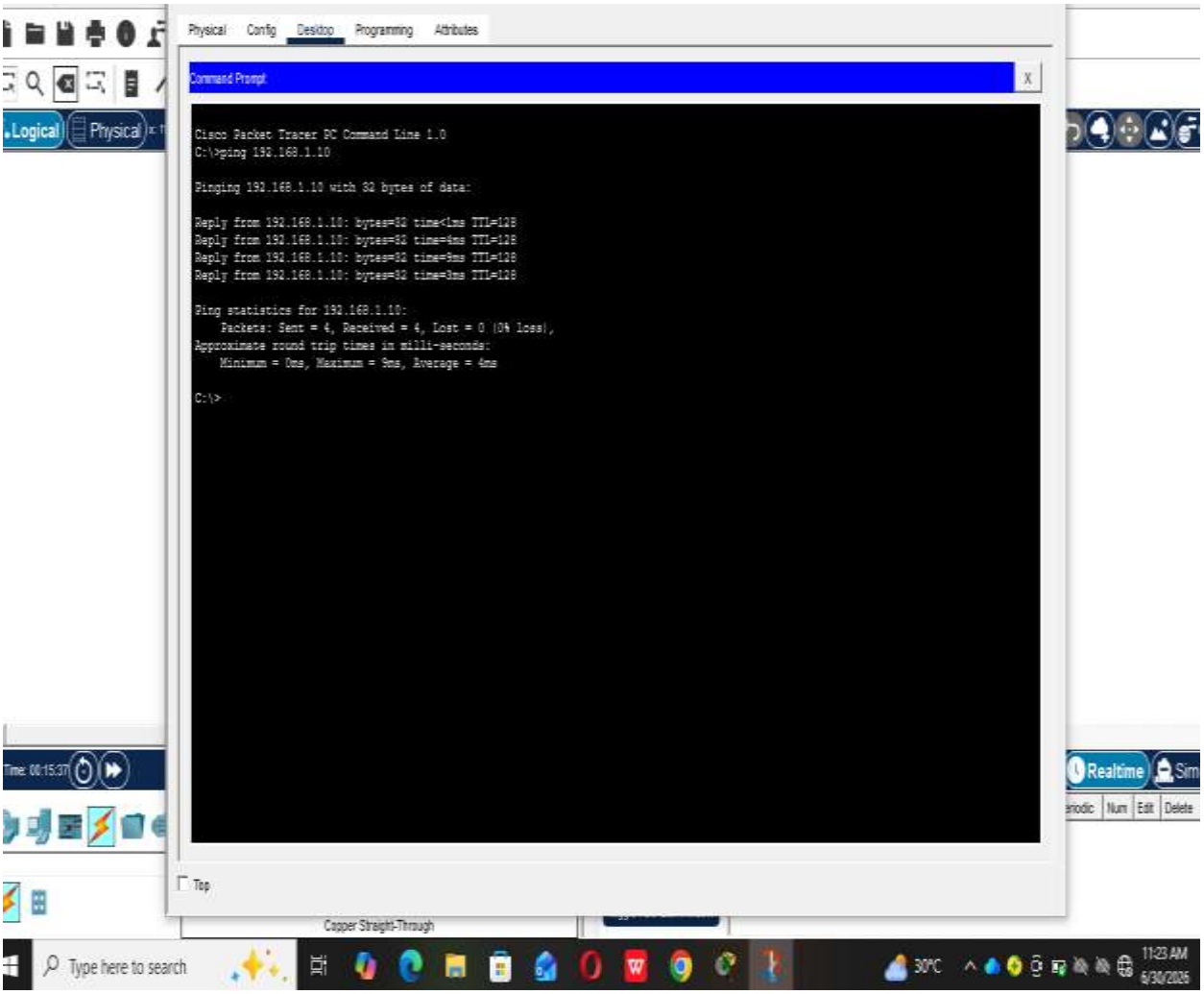

Fig. 3 Ping Command.

Step 5. Operating PDU (Switch to Simulation Mode)

- Click on simulation at the (bottom right)
- Add Simple PDU tool (envelope icon)
- click a source PC, and click a destination PC.
- Click the Play button to visually trace data traveling from the source through switch to the intended destination.

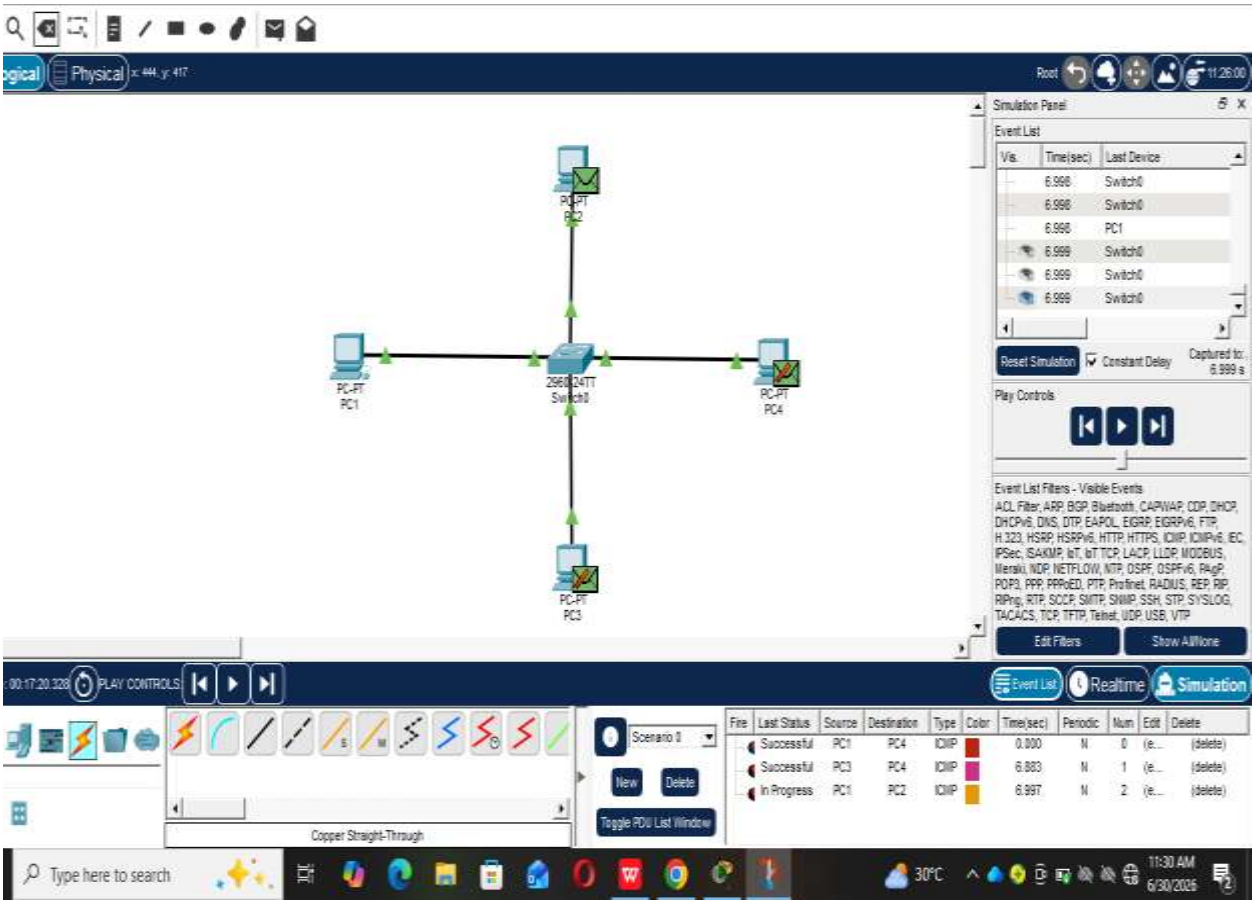

Figure 4: Data Packet Simulation

Bus Topology

Bus topology is one of the simplest and most traditional network configurations, where all devices are connected to a single central cable known as the "bus" or backbone. This main cable acts as a shared communication line, allowing data to travel in both directions to reach connected devices such as computers, printers, or servers [8]

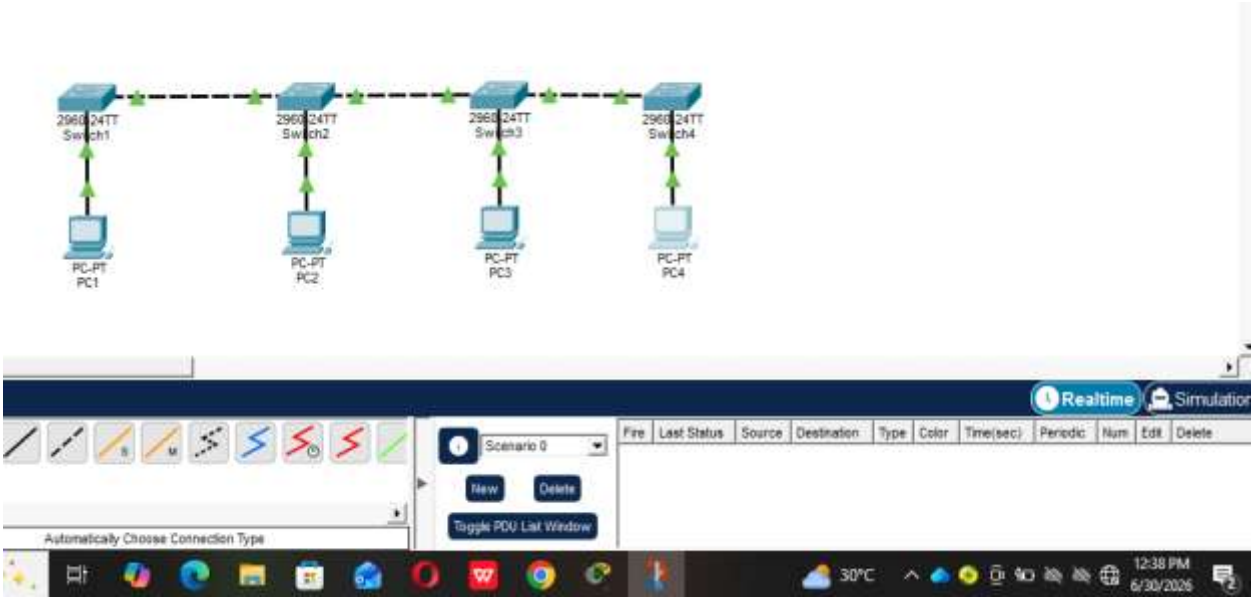

Figure 5: The Bus Topology

Steps in Simulating a Bus topology in Cisco Packet Tracer
Launch Cisco Packet Tracer
Step 1. Adding hardware

- Point to the bottom left corner of the Cisco Packet Tracer interface
- Click on End Devices
- Click on switch and Drag four switches into your workspace placing them in a horizontal line above the PCs to act as your "bus backbone
- Click and drop four PCs onto the workspace,

Step 2. Connect the Devices

- Click the **Connection** icon (Arch Flash Sign) in the bottom-left corner.
- Select the **Copper Straight-Through** cable (black solid line).
- Click on a PC, select **FastEthernet0** and then click the central Switch and select an available port (e.g., **FastEthernet0/1**).
- Go over step 2 above for all PCs so every device connects directly to the switch. (The link lights usually turn from red to green once active)
- For switch to switch connection, click on Copper Cross over cable.

Step 3. Configuring PCs

- Click on any PC you intend to configure.
- go to the Desktop tab, and click IP Configuration.
- Fill a static IPv4 address for PC1 (192.168.1.10) in the dialog box and click outside then a Subnet Mask (typically (255.255.255.0) indicating class C will fill automatically).
- Repeat step 3 above for all PCs, ensuring a common network address range but having a unique host numbers PC2 (192.168.1.20), PC3: (192.168.1.30) and PC4 (192.168.1.40)

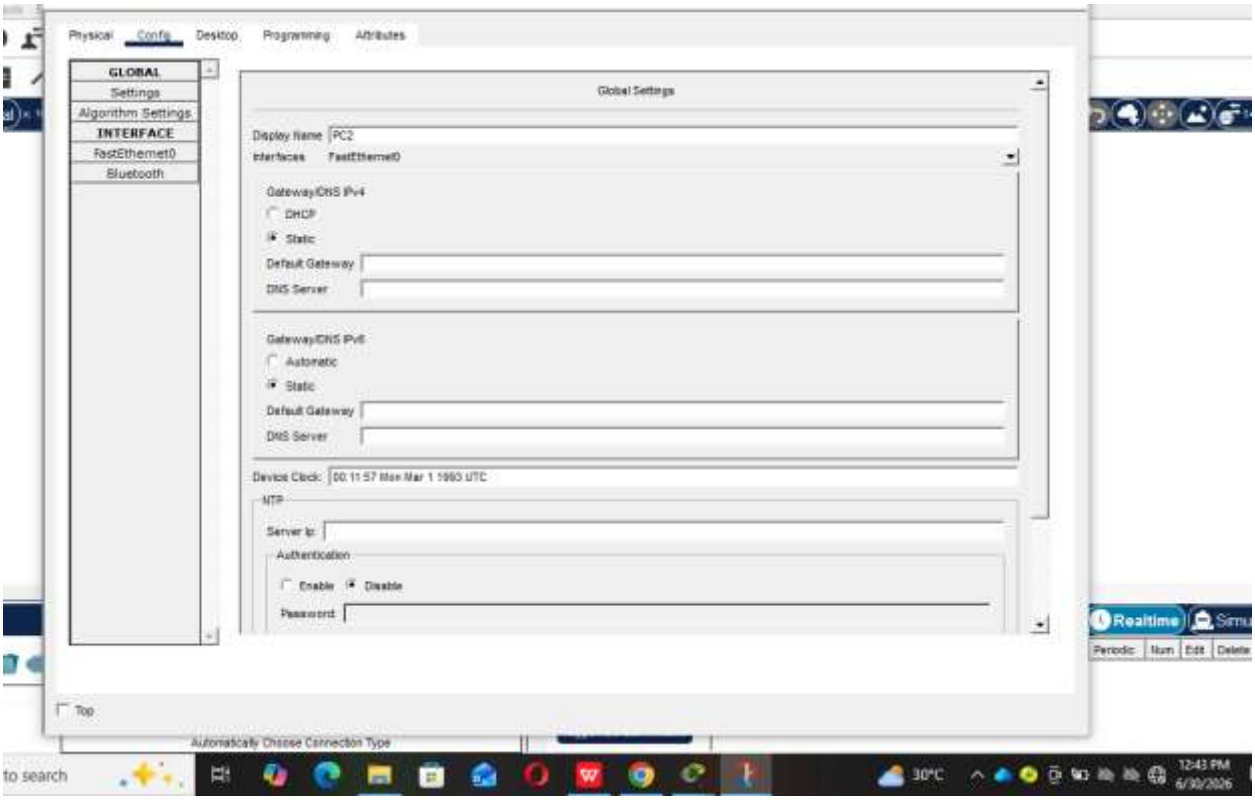

Figure 6: IPv4 Address configuration for PC2

Step 4. Testing for Connectivity

- Click PC1, go to Desktop then Command Prompt.
- Type ping 192.168.1.40 (the IP of PC4) to check if the network is communicating.
- There should be a reply from or feedback from other PCs indicating a connection.

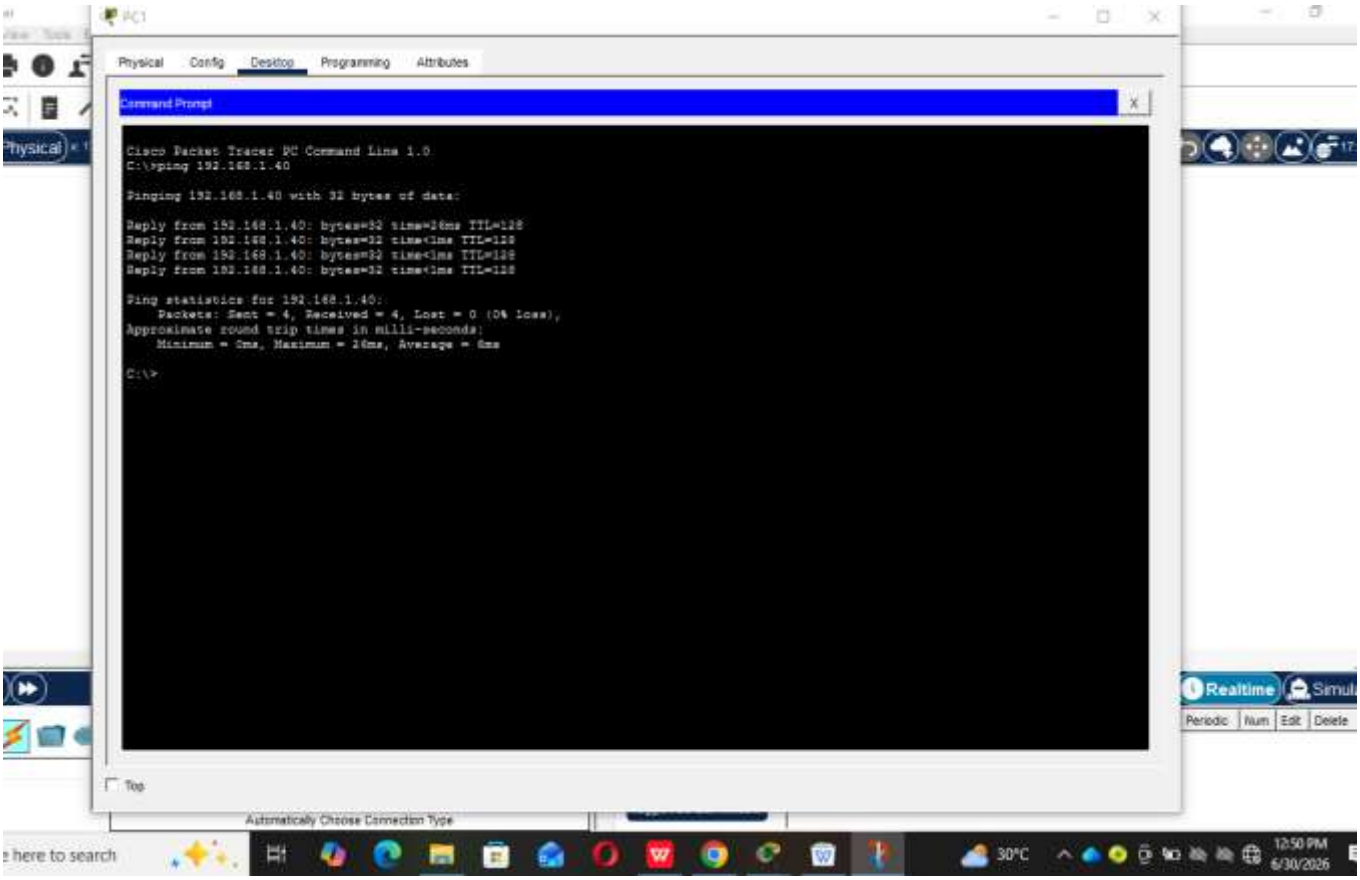

Figure 7: The Ping Command

Step 5. Operating PDU (Switch to Simulation Mode)

- Point at the (bottom right)
- Add Simple PDU tool (envelope icon)
- click a source PC, and click a destination PC.
- Click the Play button to visually trace data traveling from the source to switch to destination

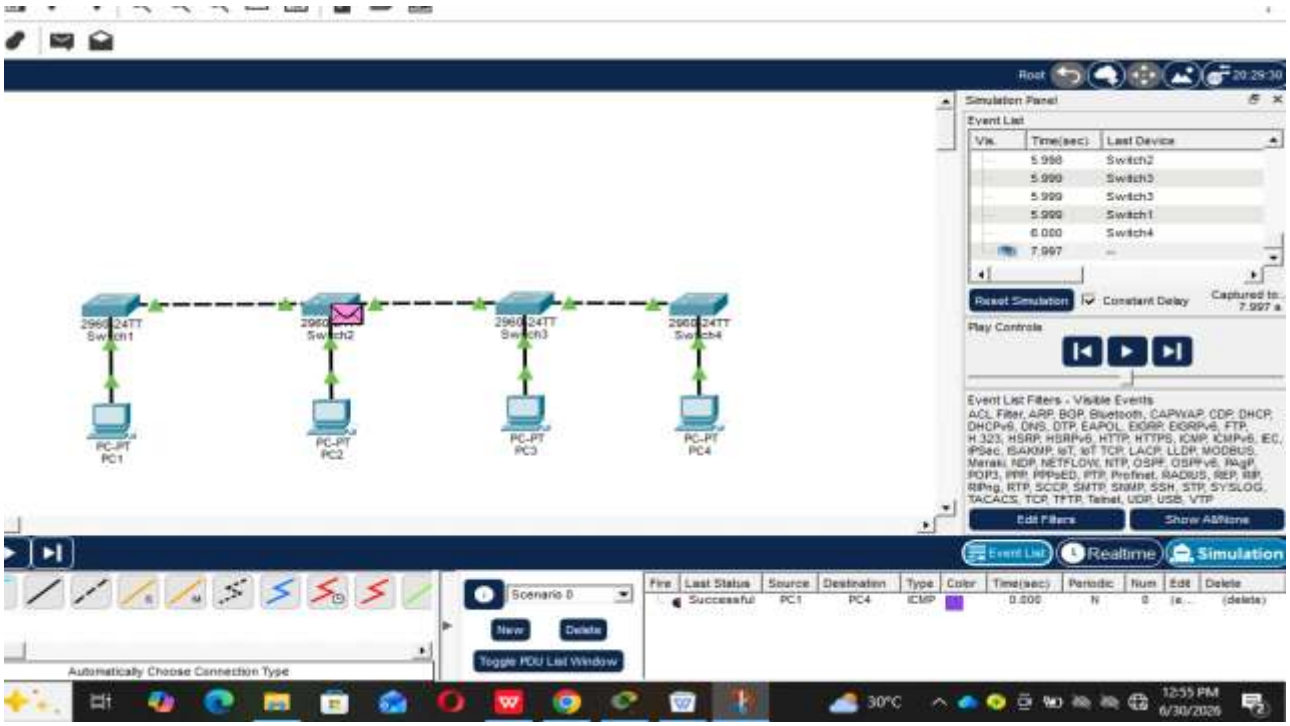

Figure 7: Data Simulation in the Bus Topology

Ring Topology

Ring topology refers to a network set up where each device is connected to exactly two other devices, forming a circular path. Data flows in a single direction (unidirectional)

In the ring topology there are no data collisions because a single token (or similar mechanism) control who can send data at any given time. It offers predictable performance, even with heavy network traffic.

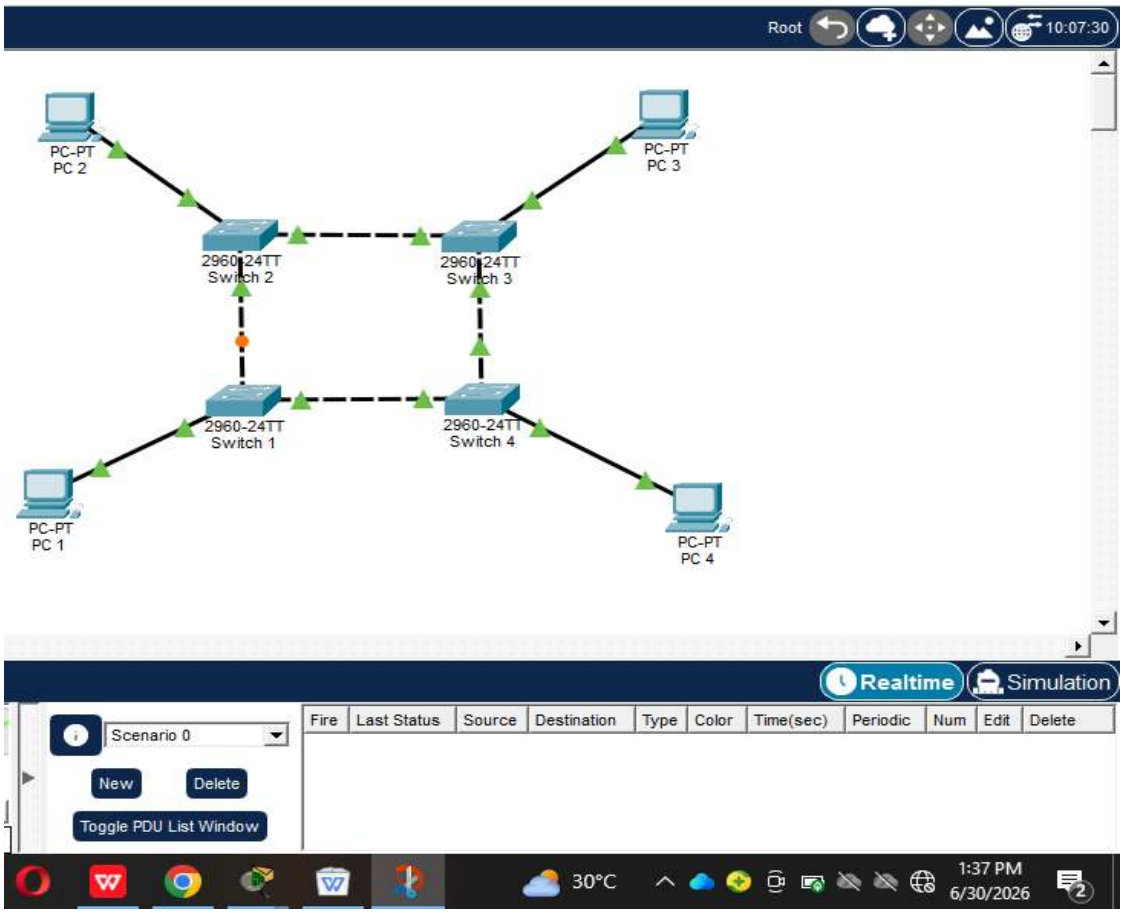

Figure 8: Ring Topology

Steps in Simulating a Ring topology in Cisco Packet Tracer

Launch Cisco Packet Tracer

Step 1. Adding hardware

- Point to the bottom left corner of the Cisco Packet Tracer interface
- Open Cisco Packet Tracer and select End Devices
- Click on PCs and drop four PCs into your workspace
- Click and drag four Switches (e.g., 2960) onto the workspace, placing them in a ring form.

Step 2. Connect the Devices

- Click the **Connections** icon (Arch Flash Sign) in the bottom-left corner.
- Select the **copper cross over** cable (black broken line) to connect the switches in a ring form
- Select Copper Straight through cable to connect each PC to its corresponding switch
- Click on a PC, select **FastEthernet0** and then click its corresponding switch

Step 3. Configuring PCs

- Click on any PC you intend to configure.
- go to the Desktop tab, and click IP Configuration.
- Fill a static IPv4 address for PC0 (192.168.1.10) in the dialog box and click outside then a Subnet Mask (typically (255.255.255.0) indicating class C will fill automatically will).
- Repeat step 3 above for all PCs, ensuring a common network address range but having a unique host numbers PC2 (192.168.1.20), PC3: (192.168.1.30) and PC4 (192.168.1.40)

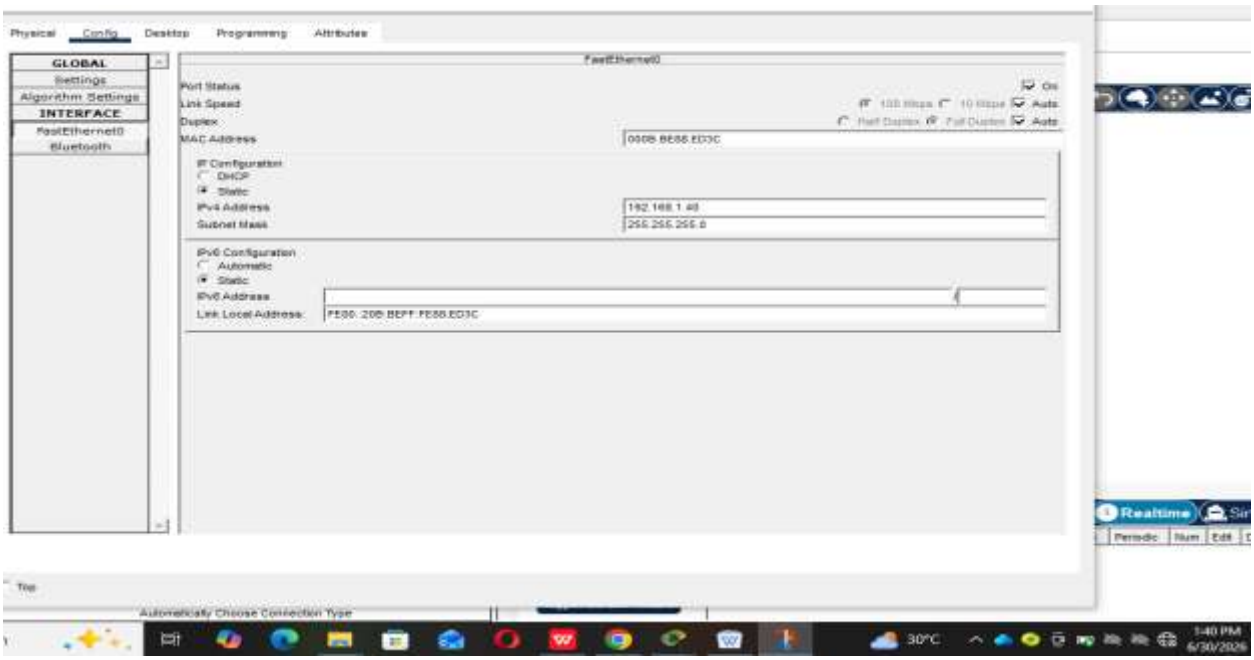

Figure 9: IPv4 Configuration for PC 4

Step 4. Testing for Connectivity

- Click PC1, go to Desktop then Command Prompt.
- Type ping 192.168.1.30 to check if the network is communicating.
- There should be a reply from or feedback from other PCs indicating a connection.

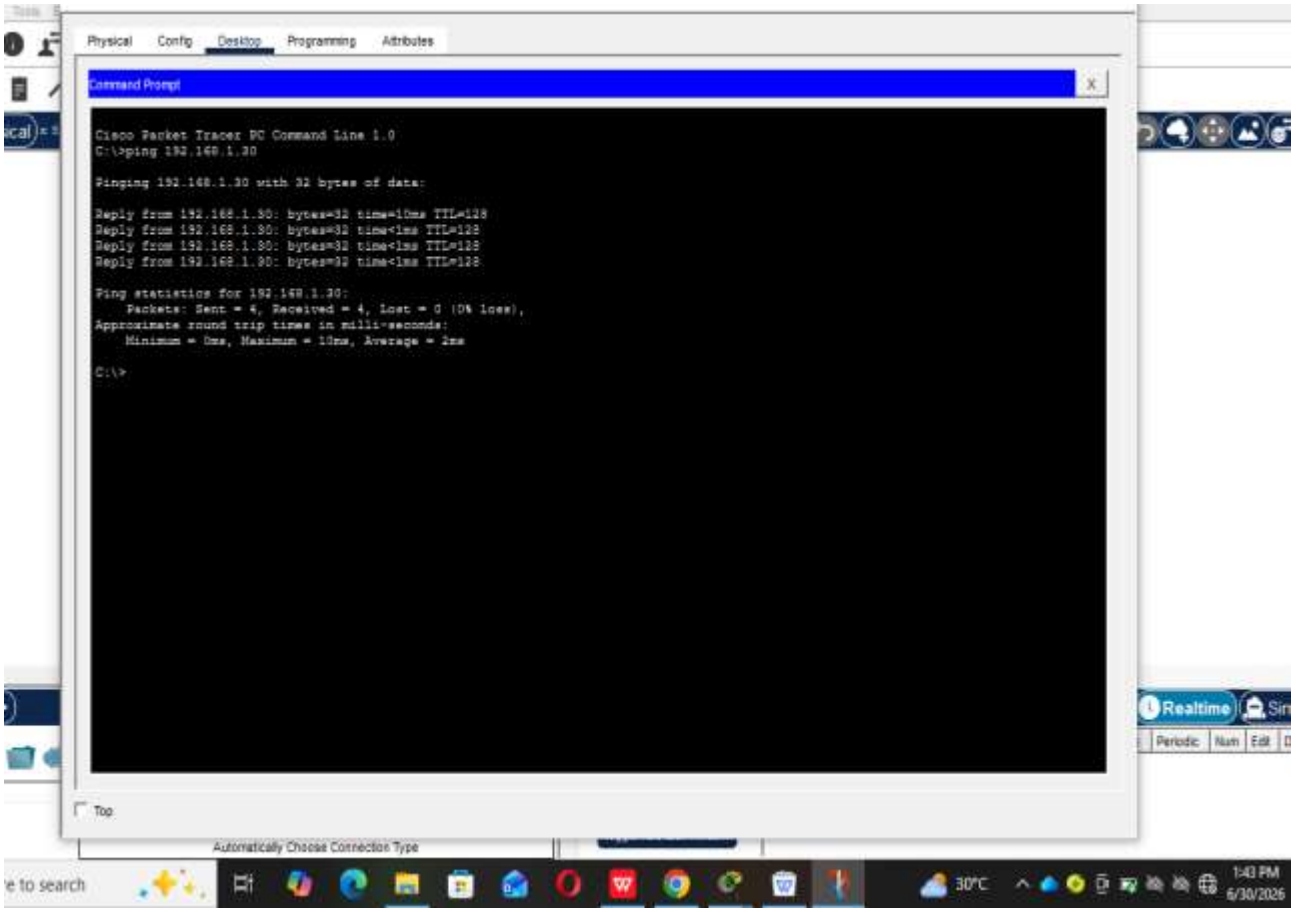

Figure 10: Ping Command on PC 3

Step 5. Operating PDU (Switch to Simulation Mode)

- Point at the (bottom right)
- Add Simple PDU tool (envelope icon)
- click a source PC, and click a destination PC.
- Click the Play button to visually trace data traveling from the source through switch to Destination

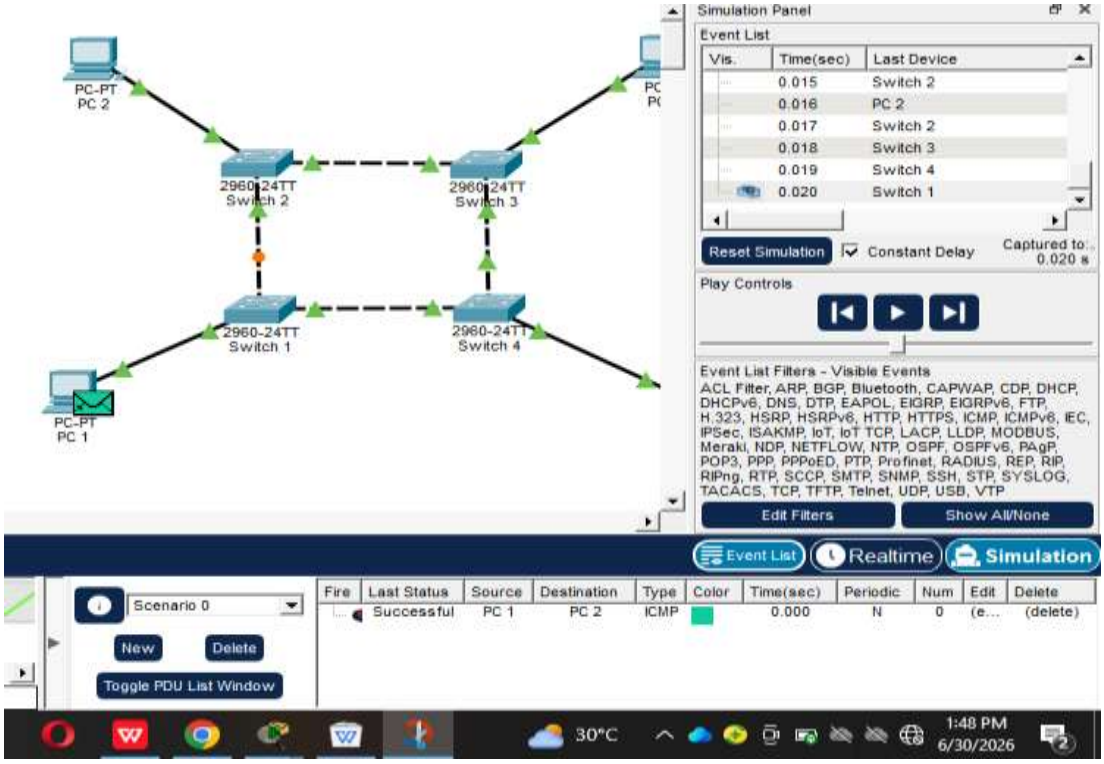

Figure 11: Data Transmission between PC1 and PC 2 showing successful

2.0 VLSM (Variable Length Subnet Masking (VLSM)

Variable Length Subnet Masking (VLSM) is a networking technique that allows administrators to use different subnet masks for different subnets within a single IP class. VLSM breaks down subnets into the smaller subnets, according to the need of individual networks [9] VLSM improves scalability, optimizes IP usage, and is widely used in real-world routing environments (like OSPF, EIGRP, BGP).

Steps to Simulating VLSM Cisco Packet Network Tracer

Step 1.

Calculate Host Bit Required. 2^N where N is the Host bit required

Step 2.

Find the network bit

32 – Host bit => 32 – N

Step 3

Calculate the updated Subnet Marks = 255.255.255.255.summation of on bits (for a class c Configuration)

Step 4

Calculate the range.

Maximum Subnet Marks – Updated Subnet Marks.

Step 5.

Populate your table and then Proceed to simulate on Cisco Packet Tracer

Sample Network

A network consist of three local area networks: LAN1 (60 Hosts), LAN2 (30 Hosts) and LAN 3(3 Hosts). Theses three LANS are connected with serial links A, B and C. Given an IP Address -192.168.11.0/24. Design an IP plan for the network using VLSM.

Considering 60 Hosts.

Step 1. Calculate Host Bit Required.

2^N

$2^N = 2^6 = 64$ is sufficient to cover the host

Step 2. Find the network bit

32 – N = 32 – 6 = 26 Network Bits

Step 3 Calculate the updated Subnet Marks

255.255.255. 255.summation of on bits for 64 Host ($2^7 + 2^6$)

255.255.255. $2^7 + 2^6 = 255.255.255.192$

Step 4 Calculate the range = Maximum Subnet Marks – Updated Subnet Marks.

255.255.255.255

255.255.255.192

…….

0.0.0.0.63

Considering 30 Hosts.

Step 1. Calculate Host Bit Required.

2^N

$2^N = 2^5 = 32$ is sufficient to cover the host

Step 2. Find the network bit

32 – N = 32 – 5 = 27 Network Bits

Step 3 Calculate the updated Subnet Marks

255.255.255.255.summation of on bits for 30 Host ($2^7 + 2^6 + 2^5$)

255.255.255. $2^7 + 2^6 + 2^5 = 255.255.255.224$

Step 4 Calculate the range = Maximum Subnet Marks – Updated Subnet Marks.

255.255.255.255

255.255.255.224

…….

0.0.0.0.31.

Considering 2 Hosts.

Step 1. Calculate Host Bit Required.

2^N

$2^N = 2^2 = 4$ is sufficient to cover the host

Step 2. Find the network bit

32 – N = 32 – 2 = 30 Network Bits

Step 3 Calculate the updated Subnet Marks

255.255.255.255.summation of on bits for 30 Host ($2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^3$)

255.255.255.255.$2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 +$ 255.255.255.252

Step 4 Calculate the range = Maximum Subnet Marks – Updated Subnet Marks.

255.255.255.255

255.255.255.252

…….

Range = 0.0.0.0.3 This result obtain here is application for the two serial link buses.

Table 1

HOST	NETWORK ADDRESS	FIRST USABLE	LAST USABLE	BROADSCAST
60 HOST	192.168.11.0	192.168.11.1	192.168.11.62	192.168.11.63
30 HOST	192.168.11.64	192.168.11.65	192.168.11.94	192.168.11.95
2 HOSTS	192.168.11.96	192.168.11.97	192.168.11.98	192.168.11.99
2 HOST FOR WAN LINK 1	192.168.11.100	192.168.11.101	192.168.11.102	192.168.11.103
2 HOST WAN LINK 2	192.168.11.104	192.168.11.105	192.168.11.106	192.168.11.107

Summary of Subnet Marks/Network bits

For 60 Hosts = 255.255.255. $2^7 + 2^6 = 255.255.255.192$ /26

For 30 Hosts = 255.255.255. $2^7 + 2^6 + 2^5 = 255.255.255.224$ /27

For 2 Hosts = 255.255.255.255.$2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 =$ 255.255.255.252 /30

The same subnet Marks/Network bits is true and the same for the two Links

SIMULATION FOR VLSM

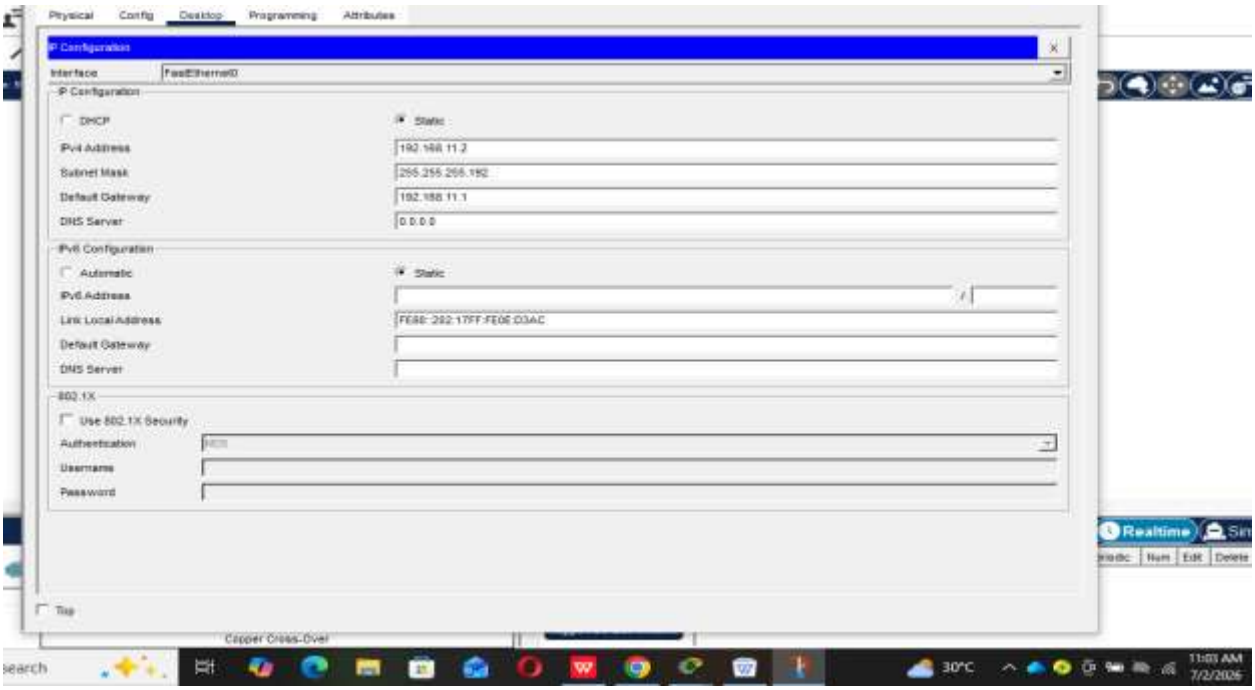

Figure 12: Configuring 60 + 2 Hosts

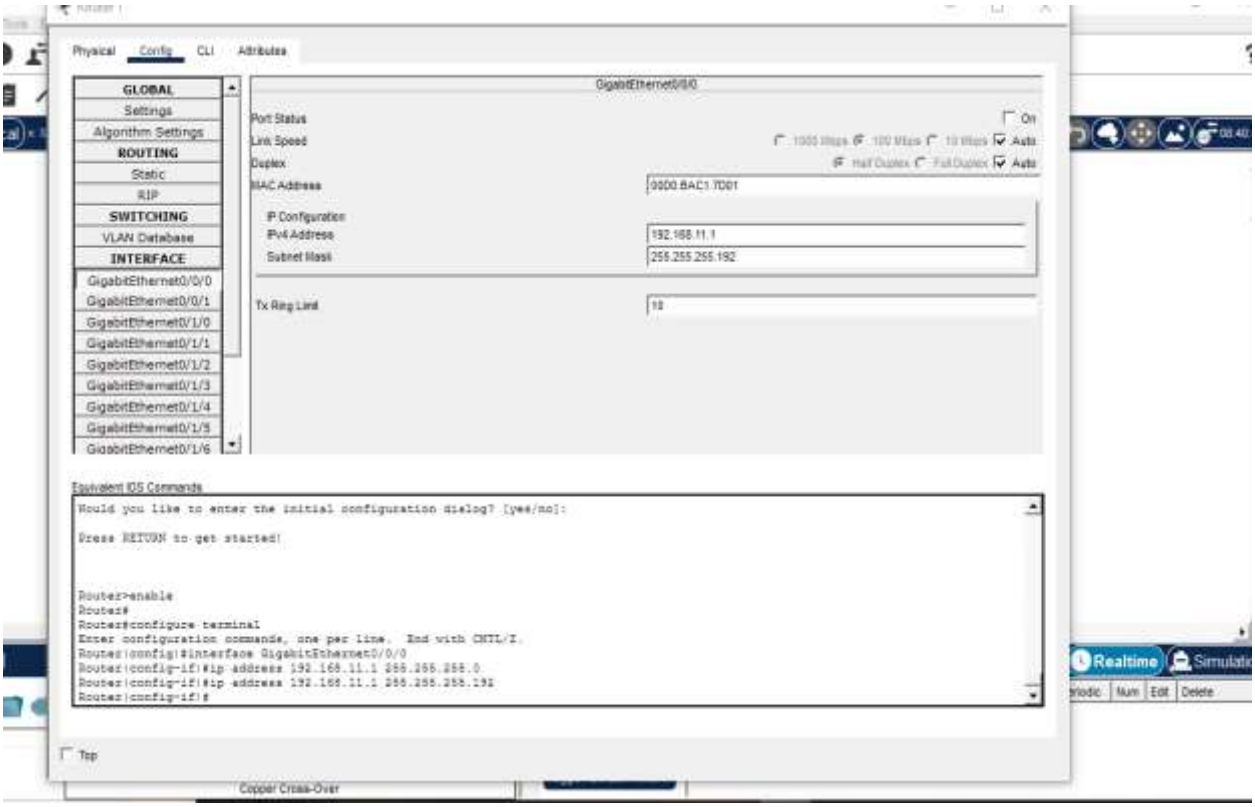

Figure 13: Configuring Router 2

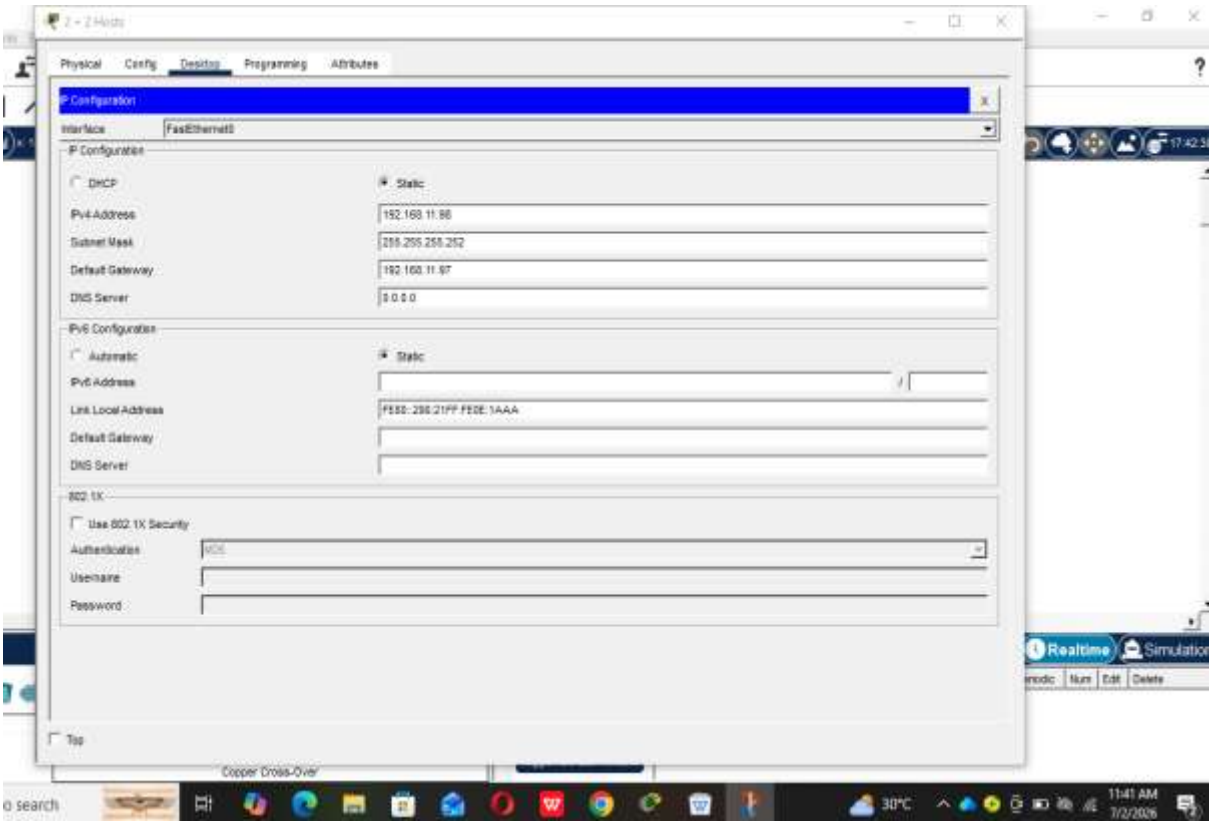

Figure 14: Configuring 2 + 2 Hosts

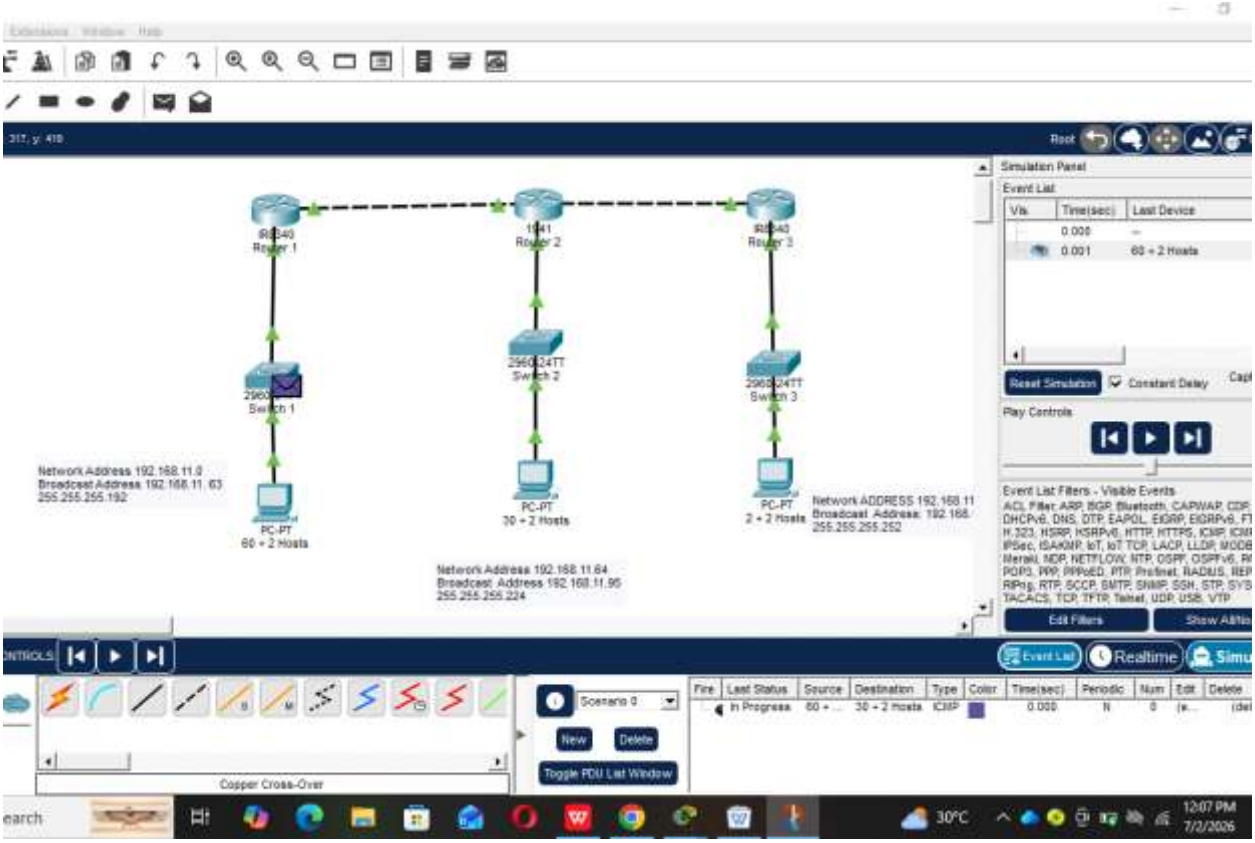

Figure 15: VLSM SIMULATION

3.0 The Open Shortest Path First (OSPF)

The Open Shortest

Path First (OSPF) protocol, defined as an Interior Gateway Protocol is used to distribute routing information within a single Autonomous System [10]

Steps in Simulating OSPF

Launch Cisco Packet Tracer

Step 1. Adding hardware

- Point to the bottom left corner of the Cisco Packet Tracer interface
- Click on End Devices, Click and drop three Routers (Router 0, Router 1 and Router 2) of the Router PT-Empty generic brand.
- Click on switch and Drag three switches (Switch 1, Switch 2 & Switch 3) respectively into your workspace placing them in a horizontal line
- Click and drop Six PCs (PC0, PC1, PC2, PC3, PC4, PC5, & PC6) on the workspace.

Step 2. Connect the Devices

- Using the Copper Straight through cable Connect PCS (PC0, PC1 & PC2) to Switch 1, PCs (PC3, PC4 & PC5 to Switch 2 and PCs (PC6, PC7 & PC8) to Switch 3
- Note that Router PT-Empty generic brand has no Ports, so it is important we add two serial Ports and one fast Ethernet port to each routers. This can be done by:
  1. Clicking on each Routers say Router R0
  2. Click on Physical and turn off Router
  3. Ck on PT Router NM 1S and drop on the appropriate segment of the Router
  4. Repeat step 4 above to get the second serial port

To Add Fast Ethernet PORT

5. Click on PT Router NM1 CFE an drop componet on router
6. Click and on Router

- Connect the Switches (Switch 1, 2 & 3) to Router0, Router1 and Router2 respectively using Copper Straight through cable
- Link the three Routers together using Serial DTE Cable.

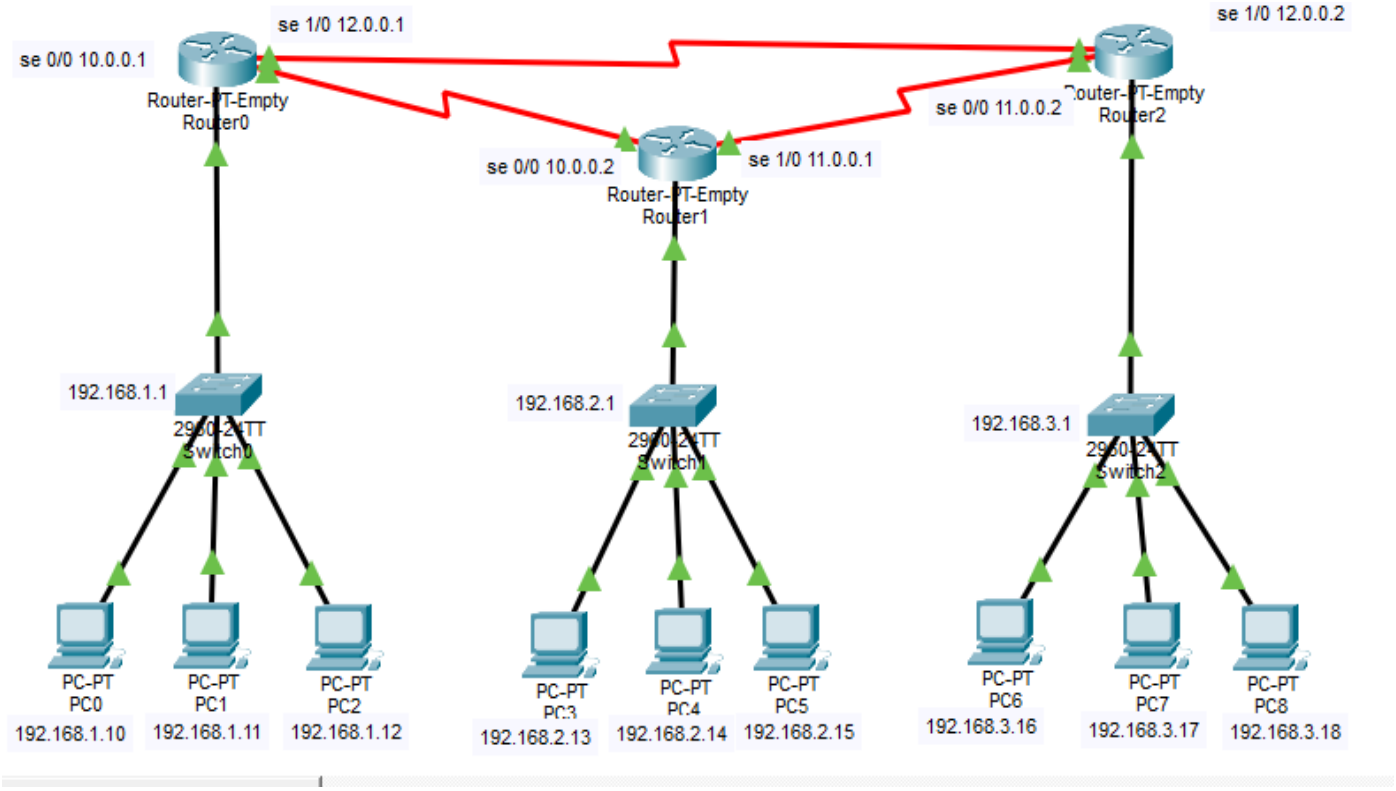

Figure 16: Connections of Hardware for OSPF Configuration

Step 3. Configurations

Configurations of the PCs:

- Click on PC0
- Click on Desktop
- Click on IP Configurations (Assign IP Address of 192.168.1.10 to PC0, Subnet Masks 255.255.255.0 fill automatically, use Gateway address as 192.168.1.1)

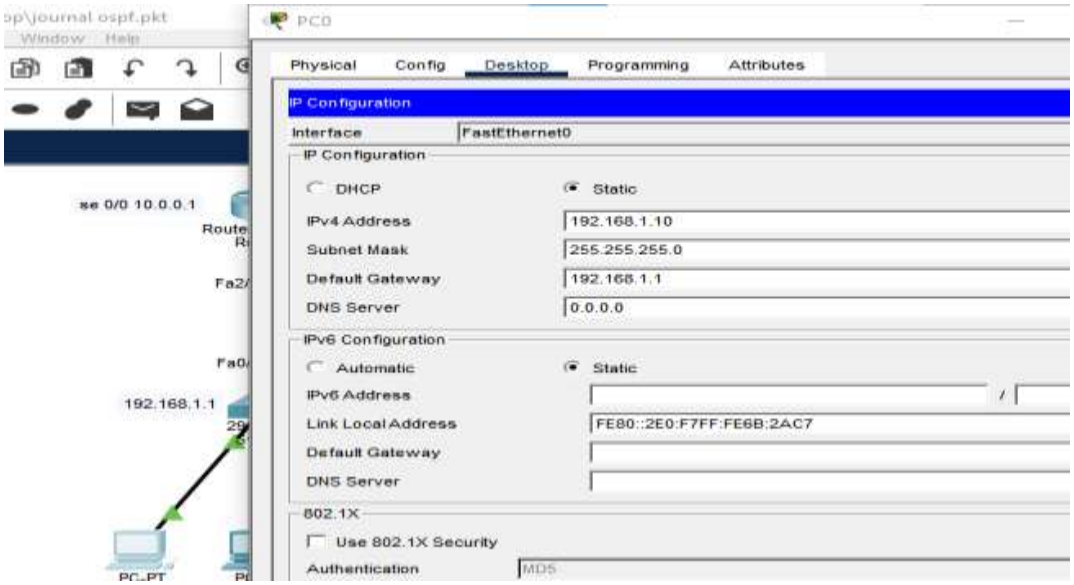

Figure 17: IPv4 Address configuration for PC0

- **Continue above steps for all Pcs using the following IPv4 and corresponding Gateway addresses:**

Table 2. PCs with their corresponding IPv4 and Gateway addresses

PC	IPv4 Address	Gateway Address	Switch
PC0	192.168.1.10	192.168.1.1	Switch 1
PC1	192.168.1.11		
PC2	192.168.1.12		
PC3	192.168.2.13		

PC4	192.168.2.14	192.168.2.1	Switch 2
PC5	192.168.2.15		
PC6	192.168.3.16	192.168.3.1	Switch 3
PC7	192.168.3.17		
PC8	192.168.3.18		

Router Configurations.

- Click on Router0
- Click on CLI (This takes you to the Configuration module)
- Click enter
- Type enable when command prompt "Router#" pops up.
- Type config t and enter, continue the command as pasted below, configuring each terminal and finally do the OSPF Configuration.

Physical Config CLI Attributes

IOS Co

```
Router>enable
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R0
R0(config)#interface fa2/0
R0(config-if)#ip 192.168.1.1 255.255.255.0
                 ^
% Invalid input detected at '^' marker.

R0(config-if)#ip address 192.168.1.1 255.255.255.0
R0(config-if)#no shutdown

R0(config-if)#
%LINK-5-CHANGED: Interface FastEthernet2/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/0, changed state to up
exit
R0(config)#interface se0/0
R0(config-if)#ip address 10.0.0.1 255.0.0.0
R0(config-if)#clock rate 64000
This command applies only to DCE interfaces
R0(config-if)#no shutdown

%LINK-5-CHANGED: Interface Serial0/0, changed state to down
R0(config-if)#exit
R0(config)#interface se1/0
R0(config-if)#ip address 12.0.0.1 255.0.0.0
R0(config-if)#clock rate 64000
This command applies only to DCE interfaces
R0(config-if)#no shutdown

%LINK-5-CHANGED: Interface Serial1/0, changed state to down
R0(config-if)#exit
R0(config)#router ospf 1
R0(config-router)#network 192.168.1.0 0.0.0.255 area 0
R0(config-router)#network 10.0.0.0 0.255.255.255 area 0
R0(config-router)#network 12.0.0.0 0.255.255.255 area 0
R0(config-router)#exit
R0(config)#exit
R0#
%SYS-5-CONFIG_I: Configured from console by console
```

Configuration of Router1

- Click on Router1
- Click on CLI (This takes you to the Configuration module)
- Click enter
- Type enable when command prompt "Router#" pops up.
- Type config t and enter, continue the command as pasted below, configuring each terminal and finally do the OSPF Configuration.

IOS Comi

```
Router>enable
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#interface fa2/0
R1(config-if)#ip address 192.168.2.1 255.255.255.0
R1(config-if)#no shutdown

R1(config-if)#
%LINK-5-CHANGED: Interface FastEthernet2/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/0, changed state to up
exit
R1(config)#interface se0/0
R1(config-if)#ip address 10.0.0.0 255.0.0.0
Bad mask /8 for address 10.0.0.0
R1(config-if)#clock rate 64000
R1(config-if)#no shutdown

R1(config-if)#
%LINK-5-CHANGED: Interface Serial0/0, changed state to up
exit
R1(config)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/0, changed state to up

R1(config)#interface se1/0
R1(config-if)#ip address 11.0.0.1 255.0.0.0
R1(config-if)#clock rate 64000
This command applies only to DCE interfaces
R1(config-if)#no shutdown

%LINK-5-CHANGED: Interface Serial1/0, changed state to down
R1(config-if)#exit
R1(config)#router ospf 1
R1(config-router)#network 192.168.2.0 0.0.0.255 area 0
R1(config-router)#network 10.0.0.0 0.255.255.255 area 0
R1(config-router)#network 11.0.0.0 0.255.255.255 area 0
R1(config-router)#exit
R1(config)#exit
R1#
%SYS-5-CONFIG_I: Configured from console by console
write memory
```

Above Steps Continue for Router 2 after which data packet Simulation is carried out.

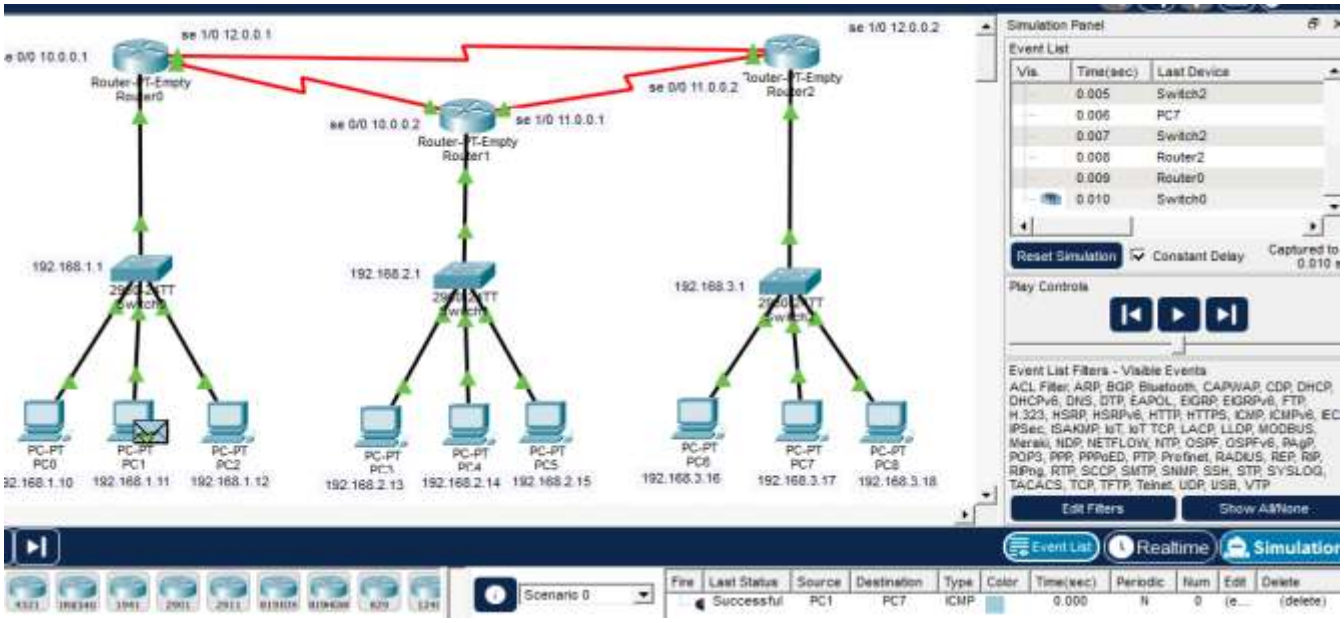

Figure 18: Successful Data Simulation in the OSPF Configuration.

CONCLUSION

From Figure 8, Data packet transfer from PC1 to PC8 was successful.

The event list on the simulation chat shows the path through which the data travelled.

REFERENCES

1. A S. Gillis, N, Andover / What is network topology/Published: Mar 21, 2025/ https://www.techtarget.com/searchnetworking/definition/network-topology
2. C. Okoh, W NTheophilus, P. Dawkins, S .Paheerathan. " Enhancing Data Security Through VLSM Subnetting and TCP/IP Model in an ENT," Applied Sciences, Vlo. 14, no. 23 2024, 10968. https://doi.org/10.3390/app142310968
3. Network Academy.io "What is VLSM" https://www.networkacademy.io/ccna/ip-subnetting/what-is-vlsm (accessed July 7, 2026).
4. M. J. Heath, "Mastering Enterprise Networks." 2023. doi: 10.15394/eaglepub.2023.1069.
5. M E. Mustafa & A. A. Abake . "The Impact of Network Topologies on OSPF Networks and Router's CPU Utilization," International Journal of Computer Networks, Vol (11) : Issue (1) : 2024 /ISSN: 1985-4129, https://www.cscjournals.org/journals/IJCN/description.php
6. N. Bhagat, "THE ROLE OF BGP IN MULTI-HOMED NETWORKS BEST PRACTICES FOR INTERNET REDUNDANCY AND TRAFFIC OPTIMIZATION," International Journal of Core Engineering & Management Vol6, Issue-12, 2021 ISSN No: 2348-9510
7. M. Alam, "UNIVERSITY NETWORK A Cisco Packet Tracer Showcase," ResearchGate, Nov. 2023. https://www.researchgate.net/publication/376513199_UNIVERSITY_NETWORK_A_Cisco_Packet_Tracer_Showcase
8. Lenovo.com, "Understanding What Is Bus Topology in Different Usage Scenarios," https://www.lenovo.com/us/en/glossary/bus-topology (Accessed Juky 1, 2026)
9. A. Abdullahi "SomNOG5 Workshops: Network Infrastructure," SomaliREN Event Management System, Oct. 23, 2021. https://events.somaliren.org.so/event/17/ (accessed July 06, 2026)
10. K. Krishna Chaitanya et al, "An Approach to Shortest Path Technique for BGP Using OSPF," International Journal of Computer Science and Information Technologies, Vol. 1 (5) , 2010, pp389-391