SCHOOL OF ENGINEERING AND TECHNOLOGY ASSIGNMENT

COVER SHEET COURSE: NET1014 – Networking Principles

LEVEL: BCNS, BIT, BCS, BSE, BDS - Year 1

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#	Name	Student ID	Percentage of contribution
1	Tan Han You	23031925	100%
2	Chong Wei Tai	23080005	100%
3	Teo Khei Shen	23060130	100%
4	Oscar Choong Tian Ling	23062722	100%
5	Jarren Kho Guan Leong	23071830	100%
6	Kam Qi You	23086523	100%

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The 7 Layers of the OSI model

Layer 1: Physical Layer

The physical layer is the lowest layer of the OSI model, this layer is responsible for physical transmission of data. Physical layer defines the hardware characteristics of network connections, this includes connectors, transmission techniques, radio signals and cables. Compared to the other layers, the physical layer does not understand the meaning of data as it only can understand the movement of the raw bits which is 0s and 1s between devices.

The physical later includes all of the hardware which involved in transmitting data, here are some examples of physical layer components: cables, Connectors, Network Interface Cards (NICs), Hubs and Repeaters and Wireless Signals

Functions of the physical layer:

- **Transmission of bits**. It converts digital data such as binary 0s and 1s into radio signals or optical for transmission.
- **Physical media specification**. Physical layer defines wireless transmission methods. Examples such as Wi-Fi signals and ethernet cables such as twisted pair, fiber optics and coaxial.
- **Data Rate Contro**l. Data rate control is also known as bit rate, it establishes the data transmission speed, expressed in bits per second (bps). For instance, Gigabit Ethernet (1 Gbps) and Fast Ethernet (100 Mbps).

Layer 2: Data Link Layer

The data link layer is the second layer of the OSI model, and it offer error-free data transfer between adjacent network nodes. It manages access to the physical medium and packages unprocessed data into frames. The data link data is divided into 2 sub-layers, the first being MAC and the second being LLC. MAC is known as Media Access Control sub layer; it handles access to the physical network medium like wireless and cables. MAC also controls how devices avoid collisions and network (CSMA/CA for Wi-Fi, CSMA/CD for Ethernet), it uses MAC address to identify devices. LLC which is Logical Link Control sub-layer, it ensures

frame synchronizations, error checking and flow control and provides interface between network layers and data link.

Devices that operate at the data link layer is Switches, Bridges and Network Interface Cards (NICs) and the Protocols used in the data link layer is the Ethernet (IEEE 802.3) which is a wired LAN communication, Wi-Fi (IEEE 803.11) which is a wireless LAN communication, PPP (Point-to-Point Protocol) which is used for direct communication between 2 devices.

Functions of the Data Link Layer

- **Mac Addressing**. It helps identify the destination and source devices within a local network (LAN) by assigning a unique MAC (Media Access Control) address to each network device.
- **Logical Link Contro**l. Work with higher layers by providing service access points (SAPs) for protocol identification. It ensures error-free communication between network devices for instance it allows IPv4 and IPv6 to work over Ethernet.
- **Media Access Control (MAC)**. With the 2 implements methods, it determines how devices share access to the Ethernet and Wi-Fi. The 2 implements methods is CSMA/CD (Carrier Sense Multiple Access with Collision Detection) where it is used in wired networks like Ethernet to avoid data collisions and CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) which is used in Wi-Fi to prevent interface.
- **Flow Control**. It uses sliding window protocols and stop-and-wait to manage data flow as it prevents a fast sender from overwhelming a slow receiver by regulating data transmission speed.

Layer 3: Network Layer

The third layer of the OSI model is the Network Layer. Unlike the data link layer, this layer enables devices in different networks to communicate. This layer is responsible for routing data packets between different networks. It identifies the best path for data to travel from the source device to the destination device across multiple networks.

Routers and Layer 3 Switches are the examples of the network layer components devices that operate at the network layer where the routers direct packets between different networks a while layer 3 switches advanced switches that perform routing functions. Besides that, here are the

protocols used in the network layer: IPv4 and IPv6, ICMP (Internet Control Message Protocol) and ARP (Address Resolution Protocol)

Functions of the Network Layer:

- **Routing**. Uses routing protocols to dynamically update and optimize paths by choosing the best route for data to travel across different networks
- **Logical Addressing**. It assigns unique IP addresses to devices for network identification. Identifies the devices at the source and the destination across various networks. Uses IPv4 and IPv6for addressing.
- **Congestion Control and Error Handling**. Prevents network congestion by adjusting packet transmission rates, uses ICMP to inform and report errors example “Destination Unreachable” or “Time Exceeded”

Layer 4: Transport Layer

The transport layer is the fourth layer of the OSI model, it functions as a data flow control and end-to-end communication. Ensuring that the data is smooth and reliably sent and received between application on different devices.

Functions of the Transport Layer:

- **End-To-End communication**. Connects the source and destination devices in a direct and reliable connection. Ensures that data is properly delivered without loss or duplication
- **Segmentation and Reassembly**. Divides large messages into smaller segments for efficient transmission, where each segment is assigned a sequence number to ensure proper reassembly at the destination. For instance, if a 10MB file is send over a network that only allows 1MB packets, then the transport layer will split it into 10 segments.
- **Flow Control**. It uses technique like Stop-and-Wait-Protocol where sender waits for acknowledgment before sending the next segment and Sliding Window Protocol which sender can transmit multiple segments before waiting for acknowledgment. This is to prevent a fast sender from overwhelming a slow receiver by regulating data transmission speed.

- **Correction and Error Detection**. Uses checksums and acknowledgments (ACKs) to ensure data integrity by detecting corrupted or lost data segments during transmission. If an error is found, it requests retransmission of the affected segment.

Layer 5: Session Layer

Session layer is the fifth layer of the OSI model, this layer ensures that data exchanges between 2 devices remain synchronized and organized even if interruptions occur. This layer allows device to resume communications from the point of failure instead of starting it over. It responsible for managing, establishing and terminating communication sessions between applications on different devices.

Functions of the Session Layer:

- **Synchronization**. Inserts a synchronization point in data to allow recovery in case of failure. For instance, if a user started downloading a 20GB file and a connection issue occurs thus interrupting the download at 12GB, the session layer will resume the download from 12GB instead of starting over at 0GB when the connection is back online thereby preventing data loss.
- **Session maintenance. E**stablishment and termination. Establishes a session between 2 devices before communication start and maintain it while data is being transmitted and lastly terminates when the communication is complete. For example, when a user log into a website, the session remains active until the user log out.
- **Dialog Control**. It managed how data is exchanged between 2 devices. First is half duplex where devices take turns sending and receiving data and full duplex is when both devices can send and receive data simultaneously.
- **Authentication and Authorization**. Uses login method for secure communication such as logging into banking websites where it requires authentication before a session is established, so it ensures that only authorized devices and users can access the session.

Layer 6: Presentation Layer

Presentation layer is the sixth layer of the OSI model, and it is responsible for data encryption, translation and compression to ensure that information sent by one device is readable by another.

Functions of the Presentation Layer:

- **Data Formatting and Translate**. By using EBCDIC and ASCII, it converts data into a format that can be understood by the receiving device.
- **Data Decryption and Encryption**. Examples like the SSL and TLS secures web browsing session where it encrypts data before transmission for security and decrypts data at the receiving end
- **Data Compression and Decompression**. When facing large files, it will compress the large files before transmission to reduce bandwidth usage and decompress data at the receiving end
- **File Format Conversion**. Converting data between different file format such as .DOCX file to .PDF if necessary before transmission

Layer 7: Application Layer

The application is the topmost layer of the OSI model. This layer provides networking services directly to users and applications, enabling communication, data exchange, and resource sharing. It serves as the interface between end user application. This layer does not handle data transmission but relies on the lower layers to deliver data across the network.

Functions of the Application Layer:

- **Network Based Application Services**. It enables email communication, remote access, file transfer and more that provides direct network access to user applications.
- **Authentication and Authorization.** When logging into a website, it verifies the identity of users and applications before allowing access by requiring user authentication like username and password
- **Error Handling and Data Synchronization**. It makes sure reliable communication by managing synchronization and error messages. For instance, if an email fails to send, the application layer provides an error message

Examples Protocol and data receives and send for each OSI layer

OSI Layer	Receives Data From	Processes & Converts	Sends Data To	Example Protocols
7. Application	User Applications (Web, Email, Chat)	Creates messages & requests	Presentation Layer	HTTP, FTP, SMTP, DNS
6.Presentation	Application Layer	Encrypts, compresses, formats data	Session Layer	SSL, TLS, JPEG, MPEG
5. Session	Presentation Layer	Establishes and manages communication sessions	Transport Layer	NetBIOS, PPTP, RPC
4. Transport	Session Layer	Segments data, ensures reliable/unreliable delivery	Network Layer	TCP, UDP
3. Network	Transport Layer	Adds IP addresses, determines best path	Data Link Layer	IP, ICMP, OSPF, RIP
2. Data Link	Network Layer	Adds MAC addresses, converts data into frames	Physical Layer	Ethernet, MAC, PPP, ARP
1. Physical	Data Link Layer	Converts frames into electrical, radio, or optical signals	Transmission Medium (Cable, Wi-Fi)	Cables, Wi-Fi, Bluetooth

Real Scenario (Web Browsing Example)

1. **Application Layer (Creates HTTP Request)**
   - When a user enters "www.google.com" in a browser, the HTTP/HTTPS protocol is used to request the webpage from Google's web server.
   - The browser constructs an HTTP GET request and sends it to the server.
2. **Presentation Layer (Secures Data)**
   - If HTTPS is used, the request is encrypted using TLS/SSL to ensure secure transmission.
   - Encryption scrambles data so that only Google's server can decrypt it.
   - Example: TLS Handshake, which authenticates the server before data exchange.
3. **Session Layer (Manages Connection)**
   - A session is established between the browser and Google's web server.
   - Session tokens are exchanged to maintain user authentication (e.g., logged-in accounts).
   - Example: session IDs manage stateful browsing.
4. **Transport Layer (Ensures Reliability)**
   - TCP segments the HTTP request into packets and ensures reliable delivery.
   - Example: TCP three-way handshake (SYN → SYN-ACK → ACK).
   - If a user downloads an image from Google, TCP guarantees all data arrives correctly.
5. **Network Layer (Routes Data)**
   - The request is assigned an IP address and forwarded through multiple routers.
   - Example:
     - User IP: 192.168.1.5 (Local IP)
     - Google Server IP: 142.250.190.14
   - Routers determine the best path for data to travel across the internet.
6. **Data Link Layer (Prepares for Transmission)**
   - The request is converted into frames and given a MAC address before being sent over the local network.
   - Example:
     - Source MAC: 00:A0:C9:14:C8:29 (User's Network Adapter)

- Destination MAC: 00:1B:44:11:3A:B7 (Router's Interface)

7. **Physical Layer (Transfers Data Physically)**
   - Data is transmitted as electrical signals (Ethernet) or radio waves (Wi-Fi) to the nearest network device.
   - Example: A Wi-Fi signal transmits data at 2.4 GHz or 5 GHz frequencies.

Advantages and Challenges of the OSI models

Advantages

- Interoperability:
  It enables the use of standardized protocols for communication across distinct networking hardware and software from different suppliers.

- Flexibility and Scalability:
  It is simpler to update or change technologies thanks to the layered structure, which keeps the system as a whole intact.

- Standardized Procedures:
  guarantees interoperability across various software and hardware implementations worldwide.

Challenges

- Intricacy:
  Since the paradigm is theoretical, it may be challenging to properly apply it in actual networking situations.

- Not Always Effective:
  Performance may be impacted by some layers' needless overhead.

- Slow Adoption :
  Compared to more straightforward models like TCP/IP, the OSI paradigm was not extensively used in actual networks.

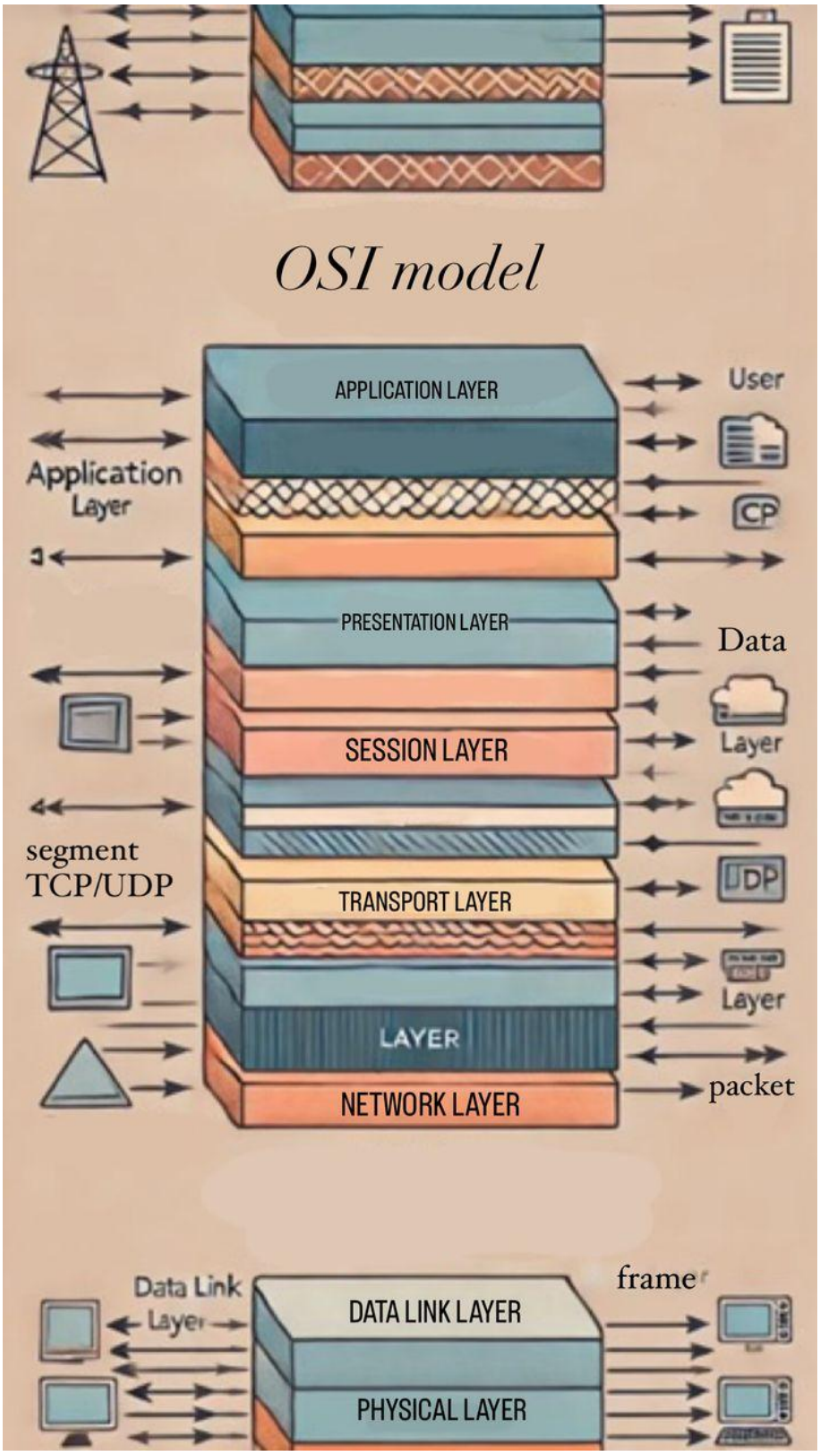

Figure 1 Diagram of data flow in OSI models

Design and Implementation of a Network

Part A

Required Equipment and Justification

1. Routers (total quantity: 2)

- **Router 0 – Quantity: 1**
- **Router 1 – Quantity: 1**

Justification: Routers are used to connect two or more packet-switched networks or subnetworks. It functions by managing the traffic between these networks by forwarding network packets to the intended ip addresses, allowing multiple devices to connect to the same network.

2. Switches (total quantity: 4)

- **Switch 0 – Quantity: 1**
- **Switch 1 – Quantity: 1**
- **Switch 2 – Quantity: 1**
- **Switch 3 – Quantity: 1**

Justification: Switches act as central hubs, it allows two or more IT devices to communicate with each other. It is responsible for relaying data from a computer network to the destination using packet switching, MAC address identification and a multiport bridge system.

3. Network Modules (total quantity: 2)

- **HWIC-2T – Quantity: 2**

Justification: High-Speed WAN Interface Cards (HWIC-2T) are required to provide serial interfaces on the routers, allowing them to establish WAN connections through serial communication.

4. Cables (total quantity: 39)

- **Serial DTE Connection Wire – Quantity: 1**
- **Copper Straight-Through Connection Wire – Quantity: 38**

Justification:

- **Serial DTE Connection Wire** is used to connect routers via serial interfaces for WAN communication.
- **Copper Straight-Through Cables** are used to connect PCs to switches and switches to routers.

5. PCs (End Devices) (total quantity: 34)

Humac PCs:

- **PC-PT host_humac0 to host_humac11 – Quantity: 12**

Advanced Wireless Lab PCs:

- **PC-PT host_advanced_wireless_lab0 to host_advanced_wireless_lab6 – Quantity: 7**

Communications Lab PCs:

- **PC-PT host_communications_labs0 to host_communications_labs4 – Quantity: 5**

IoT Lab PCs:

- **PC-PT host_iot_lab0 to host_iot_lab9 – Quantity: 10**

Justification: These PCs represent end devices that will be connected to switches and VLANs to simulate different user environments.

Estimated Cost of Equipment

DEVICE	PRICE PER UNIT (RM)	QUANTITY	TOTAL (RM)
SERIAL DTE CONNECTION WIRE	115.71	1	115.71
ROUTER 0	2385.40	1	2,385.40
ROUTER 1	2385.40	1	2,385.40
HWIC-2T	1731.20	2	3,462.40
Switch 0	983.53	1	983.53
COPPER STRAIGHT-THROUGH CONNECTION WIRE	8.90	13	115.70
PC-PT humac 11	1,939.00	1	1,939.00
PC-PT humac 9	1,939.00	1	1,939.00
PC-PT humac 0	1,939.00	1	1,939.00
PC-PT humac 5	1,939.00	1	1,939.00
PC-PT humac 10	1,939.00	1	1,939.00
PC-PT humac 2	1,939.00	1	1,939.00
PC-PT humac 1	1,939.00	1	1,939.00
PC-PT humac 7	1,939.00	1	1,939.00
PC-PT humac 4	1,939.00	1	1,939.00
PC-PT humac 8	1,939.00	1	1,939.00
PC-PT humac 6	1,939.00	1	1,939.00
PC-PT humac 3	1,939.00	1	1,939.00
Switch 1	983.53	1	983.53
COPPER STRAIGHT-THROUGH CONNECTION WIRE	8.90	8	71.20

PC-PT host _advanced _wireless_lab0	1,939.00	1	1,939.00
PC-PT host _advanced _wireless_lab1	1,939.00	1	1,939.00
PC-PT host _advanced _wireless_lab2	1,939.00	1	1,939.00
PC-PT host _advanced _wireless_lab3	1,939.00	1	1,939.00
PC-PT host _advanced _wireless_lab4	1,939.00	1	1,939.00
PC-PT host _advanced _wireless_lab5	1,939.00	1	1,939.00
PC-PT host _advanced _wireless_lab6	1,939.00	1	1,939.00
Switch 2	983.53	1	983.53
COPPER STRAIGHT-THROUGH CONNECTION WIRE	8.90	6	53.40
PC-PT host_communications_labs0	1,939.00	1	1,939.00
PC-PT host_communications_labs1	1,939.00	1	1,939.00
PC-PT host_communications_labs2	1,939.00	1	1,939.00
PC-PT host_communications_labs3	1,939.00	1	1,939.00
PC-PT host_communications_labs4	1,939.00	1	1,939.00
Switch 3	983.53	1	983.53
COPPER STRAIGHT-THROUGH CONNECTION WIRE	8.90	11	97.90
PC-PT host_iot_lab0	1,939.00	1	1,939.00
PC-PT host_iot_lab1	1,939.00	1	1,939.00
PC-PT host_iot_lab2	1,939.00	1	1,939.00
PC-PT host_iot_lab3	1,939.00	1	1,939.00
PC-PT host_iot_lab4	1,939.00	1	1,939.00
PC-PT host_iot_lab5	1,939.00	1	1,939.00

PC-PT host_iot_lab6	1,939.00	1	1,939.00
PC-PT host_iot_lab7	1,939.00	1	1,939.00
PC-PT host_iot_lab8	1,939.00	1	1,939.00
PC-PT host_iot_lab9	1,939.00	1	1,939.00
TOTAL PRICE		81	78,547.23

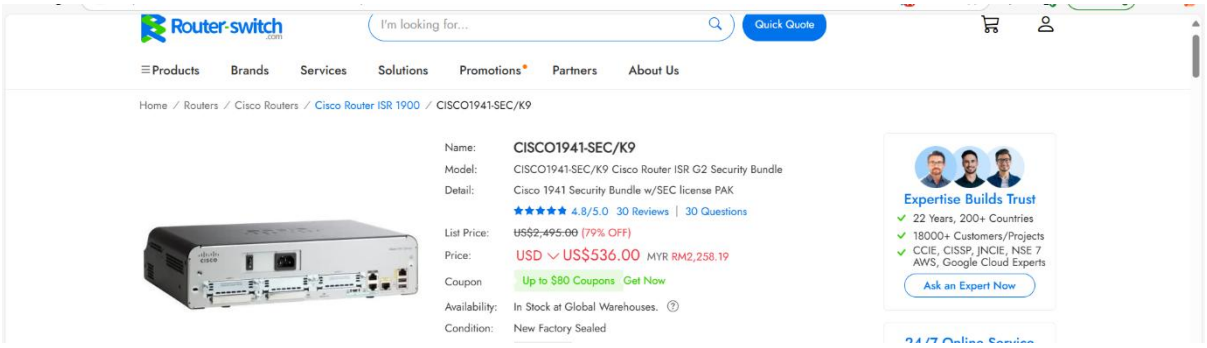

Figure 2 Router Cisco 1941-SEC/K9

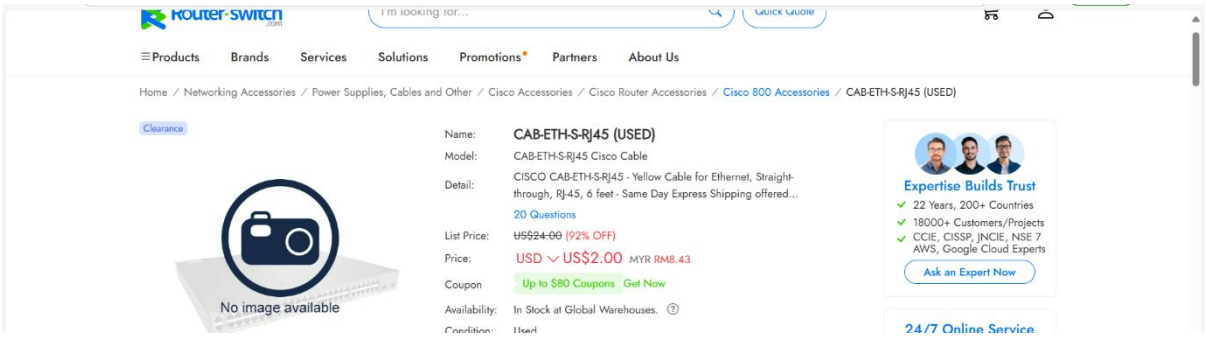

Figure 3 Cisco Router Cable CAB-ETH-S-RJ45

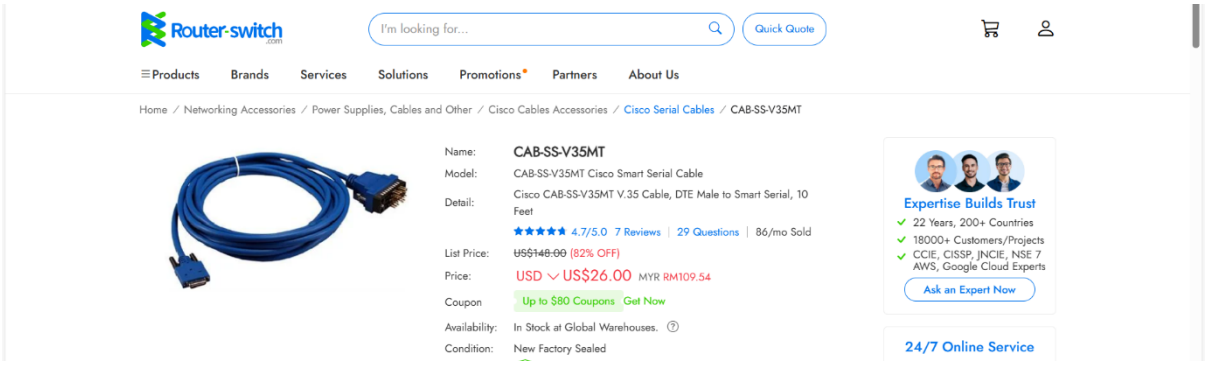

Figure 4 Cisco CAB-SS-V35MT

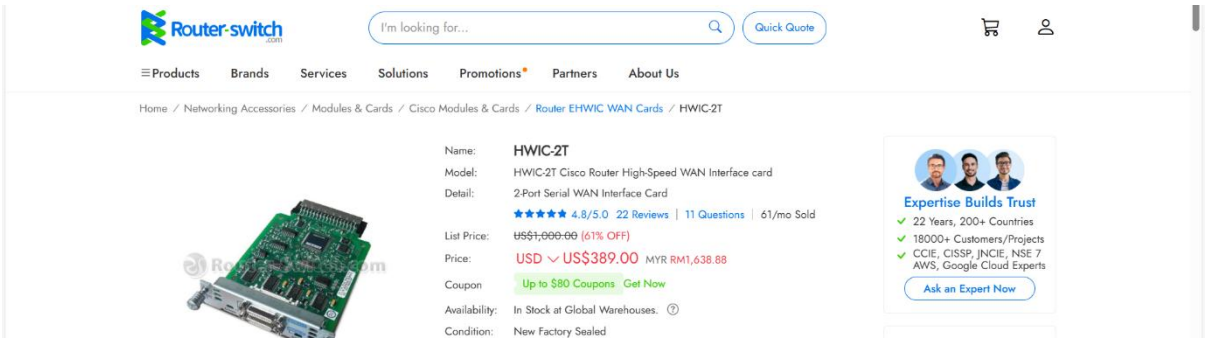

Figure 5 Cisco HWIC-2T

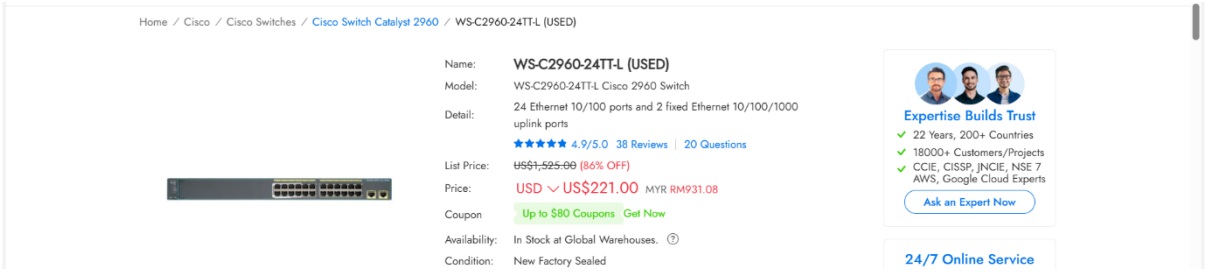

Figure 6 Cisco WS-C2960X-24TS-L

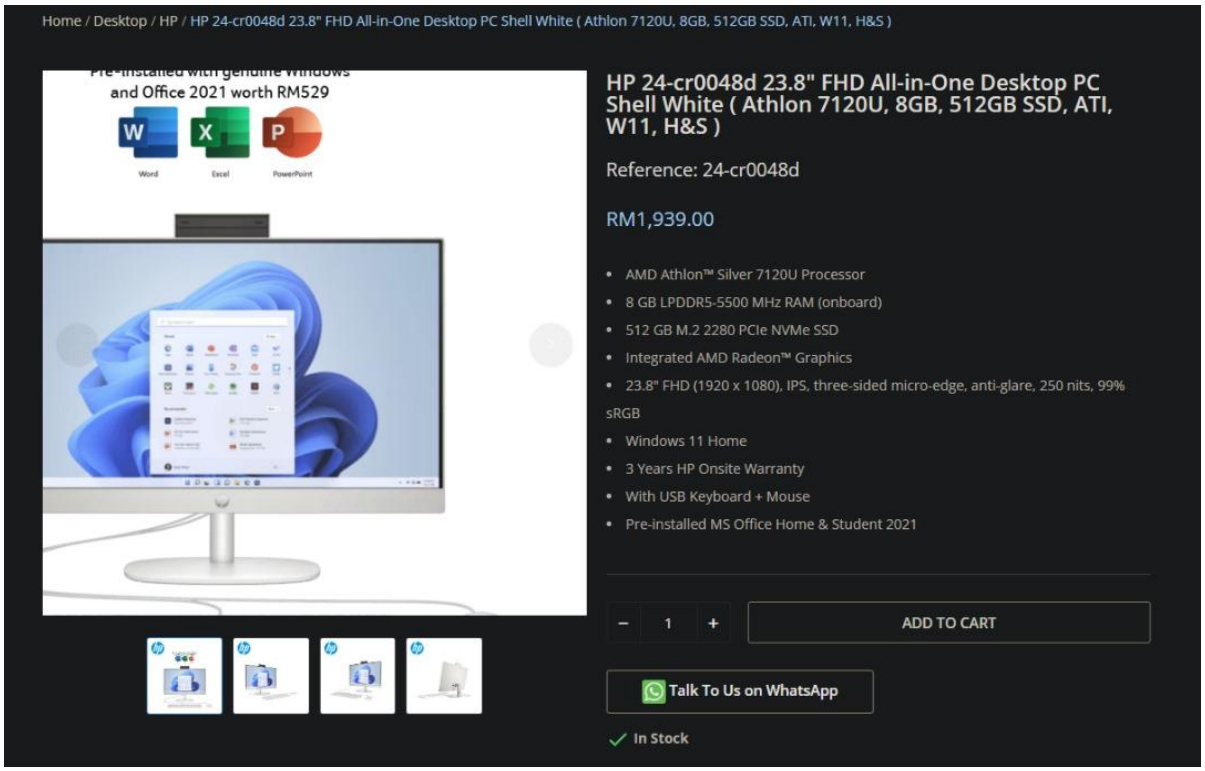

Figure 7 HP 24-cr0048d

Addressing Table

DEVICE	INTERFACE	IP ADDRESS	SUBNET MASK	DEFAULT GATEWAY
ROUTER 0	GIGA 0/0	192.168.10.1	255.255.255.192	N/A
	GIGA 0/1	192.168.10.129	255.255.255.192	N/A
	SERIAL 0/0/0	192.168.11.1	255.255.255.252	N/A
ROUTER 1	GIGA 0/0	192.168.10.65	255.255.255.192	N/A
	GIGA 0/1	192.168.10.193	255.255.255.192	N/A
	SERIAL 0/0/0	192.168.11.2	255.255.255.252	N/A
Switch 0	**VLAN 1**	**192.168.10.61**	**255.255.255.192**	**192.168.10.1**
PC-PT humac 11	FA 0/1	192.168.10.60	255.255.255.192	192.168.10.1
PC-PT humac 9	FA 0/2	192.168.10.27	255.255.255.192	192.168.10.1
PC-PT humac 0	FA 0/3	192.168.10.18	255.255.255.192	192.168.10.1
PC-PT humac 5	FA 0/4	192.168.10.23	255.255.255.192	192.168.10.1
PC-PT humac 10	FA 0/5	192.168.10.28	255.255.255.192	192.168.10.1
PC-PT humac 2	FA 0/6	192.168.10.20	255.255.255.192	192.168.10.1
PC-PT humac 1	FA 0/12	192.168.10.19	255.255.255.192	192.168.10.1
PC-PT humac 7	FA 0/11	192.168.10.25	255.255.255.192	192.168.10.1
PC-PT humac 4	FA 0/10	192.168.10.22	255.255.255.192	192.168.10.1
PC-PT humac 8	FA 0/9	192.168.10.26	255.255.255.192	192.168.10.1
PC-PT humac 6	FA 0/8	192.168.10.24	255.255.255.192	192.168.10.1
PC-PT humac 3	FA 0/7	192.168.10.21	255.255.255.192	192.168.10.1
Switch 1	**VLAN 1**	**192.168.10.189**	**255.255.255.192**	**192.168.10.129**
PC-PT host _advanced _wireless_lab0	FA 0/1	192.168.10.188	255.255.255.192	192.168.10.129
PC-PT host _advanced _wireless_lab1	FA 0/4	192.168.10.133	255.255.255.192	192.168.10.129

PC-PT host _advanced _wireless_lab2	FA 0/7	192.168.10.134	255.255.255.192	192.168.10.129
PC-PT host _advanced _wireless_lab3	FA 0/8	192.168.10.135	255.255.255.192	192.168.10.129
PC-PT host _advanced _wireless_lab4	FA 0/3	192.168.10.136	255.255.255.192	192.168.10.129
PC-PT host _advanced _wireless_lab5	FA 0/6	192.168.10.138	255.255.255.192	192.168.10.129
PC-PT host _advanced _wireless_lab6	FA 0/2	192.168.10.137	255.255.255.192	192.168.10.129
Switch 2	**VLAN 1**	**192.168.10.125**	**255.255.255.192**	**192.168.10.65**
PC-PT host_communica tions_labs0	FA 0/5	192.168.10.89	255.255.255.192	192.168.10.65
PC-PT host_communica tions_labs1	FA 0/4	192.168.10.91	255.255.255.192	192.168.10.65
PC-PT host_communica tions_labs2	FA 0/3	192.168.10.90	255.255.255.192	192.168.10.65
PC-PT host_communica tions_labs3	FA 0/2	192.168.10.92	255.255.255.192	192.168.10.65
PC-PT host_communica tions_labs4	FA 0/1	192.168.10.100	255.255.255.192	192.168.10.65
Switch 2	**VLAN 1**	**192.168.10.253**	255.255.255.192	**192.168.10.193**
PC-PT host_iot_lab0	FA 0/3	192.168.10.239	255.255.255.192	192.168.10.193

PC-PT host_iot_lab1	FA 0/2	192.168.10.247	255.255.255.192	192.168.10.193
PC-PT host_iot_lab2	FA 0/1	192.168.10.200	255.255.255.192	192.168.10.193
PC-PT host_iot_lab3	FA 0/4	192.168.10.241	255.255.255.192	192.168.10.193
PC-PT host_iot_lab4	FA 0/5	192.168.10.240	255.255.255.192	192.168.10.193
PC-PT host_iot_lab5	FA 0/6	192.168.10.244	255.255.255.192	192.168.10.193
PC-PT host_iot_lab6	FA 0/7	192.168.10.242	255.255.255.192	192.168.10.193
PC-PT host_iot_lab7	FA 0/8	192.168.10.246	255.255.255.192	192.168.10.193
PC-PT host_iot_lab8	FA 0/9	192.168.10.243	255.255.255.192	192.168.10.193
PC-PT host_iot_lab9	FA 0/10	192.168.10.245	255.255.255.192	192.168.10.193

Physical Topology

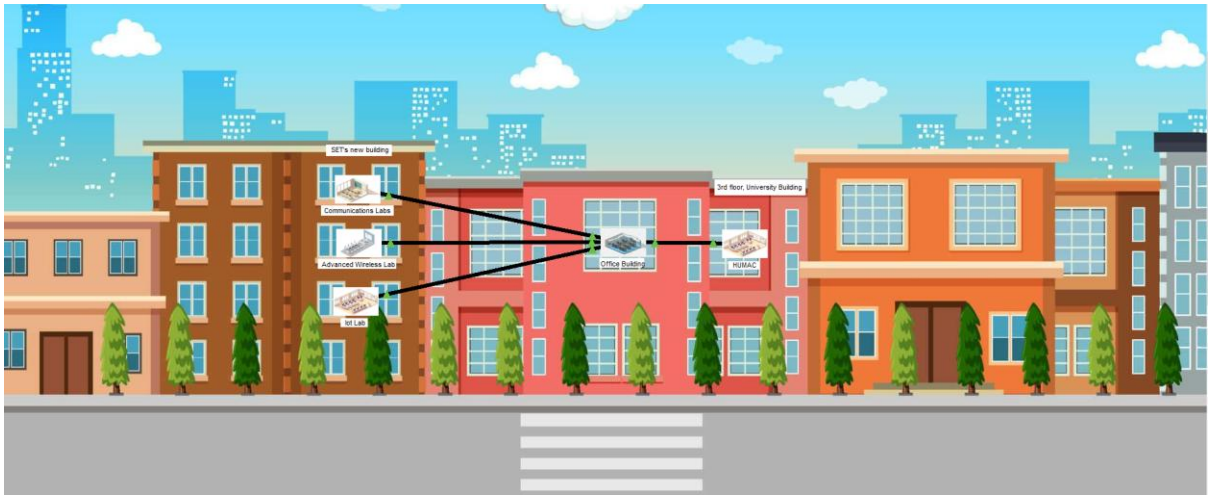

Figure 8 Physical topology city view

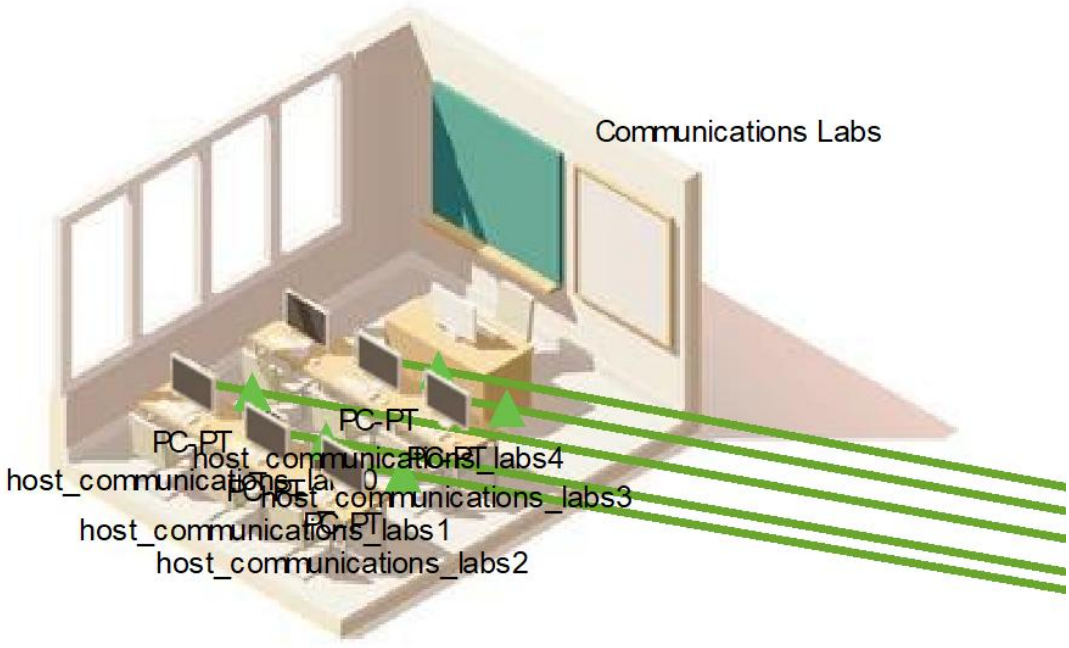

Figure 9 Communications labs view

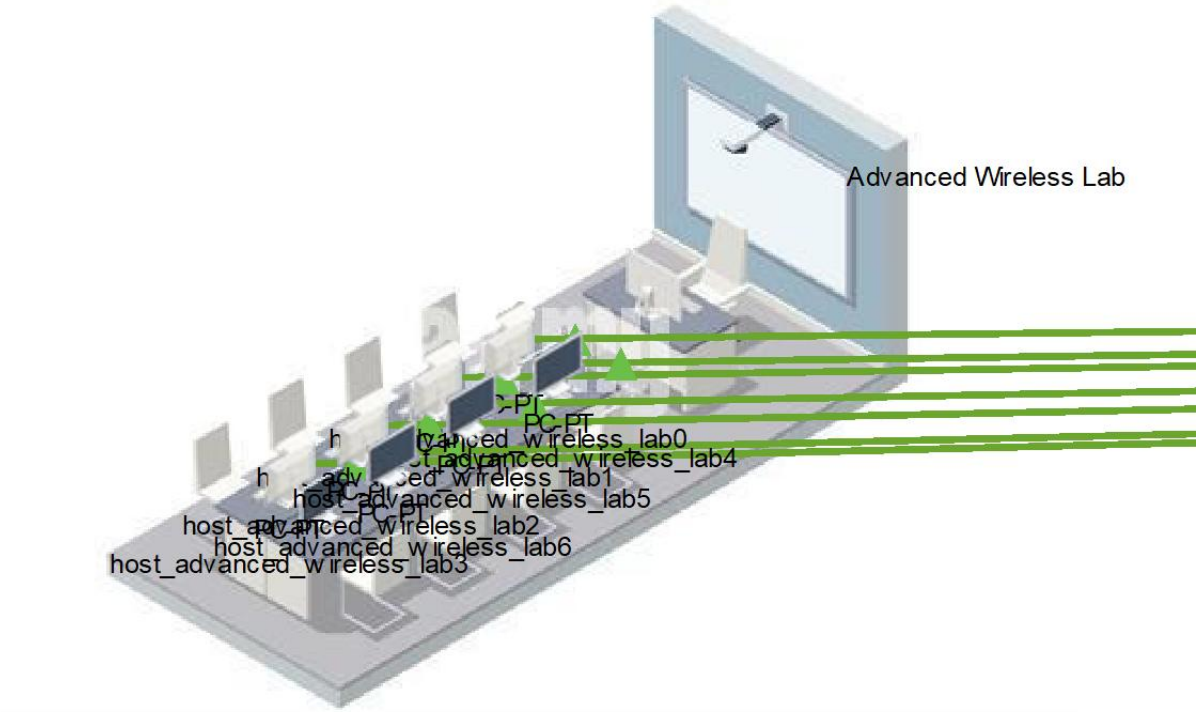

Figure 10 Advanced wireless lab view

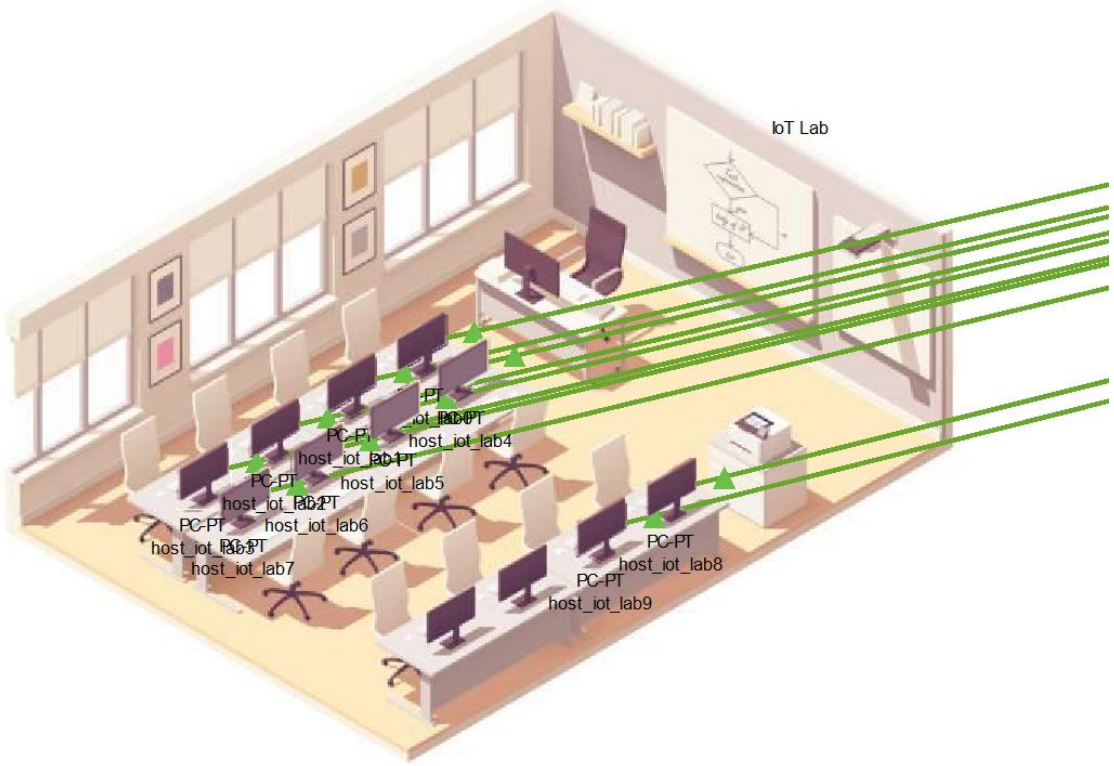

Figure 11Iot lab view

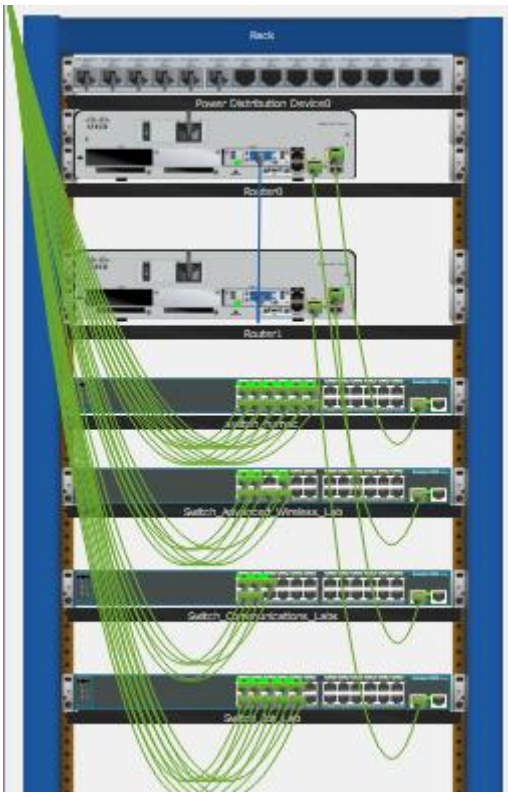

Figure 12 Main wiring closet

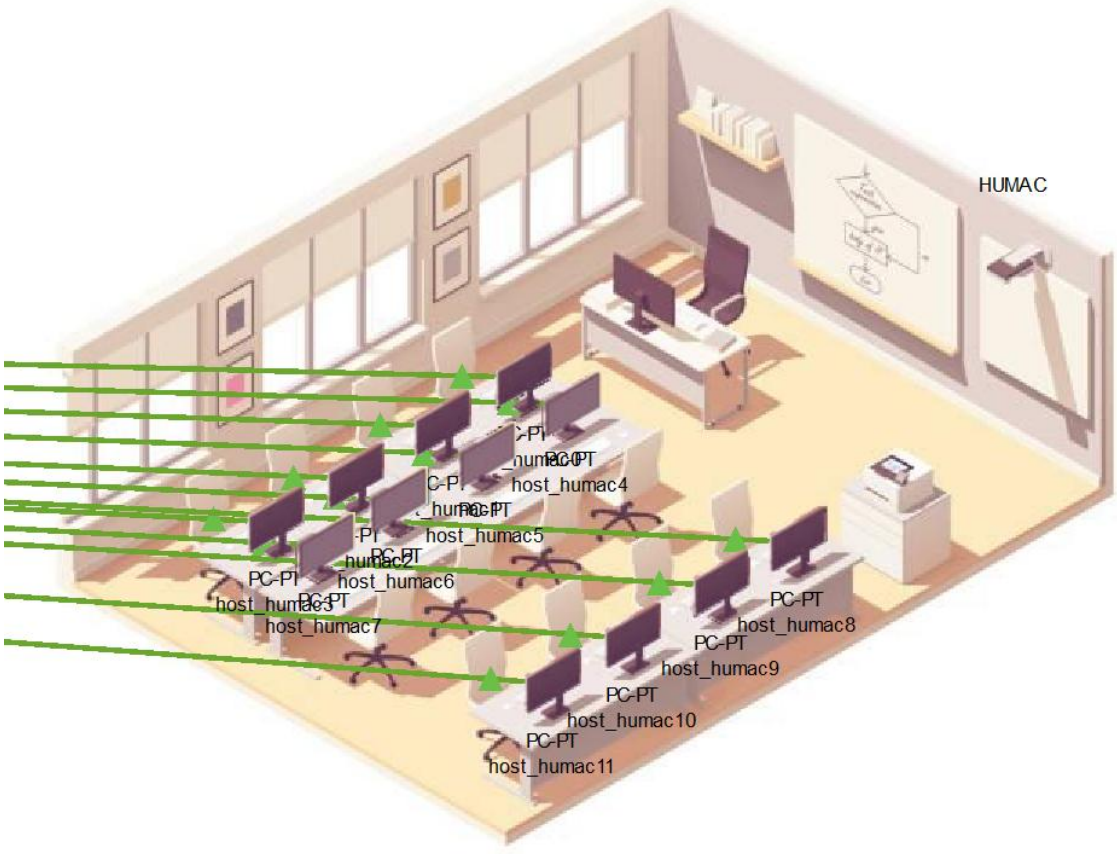

Figure 13 Humac view

Logical Topology

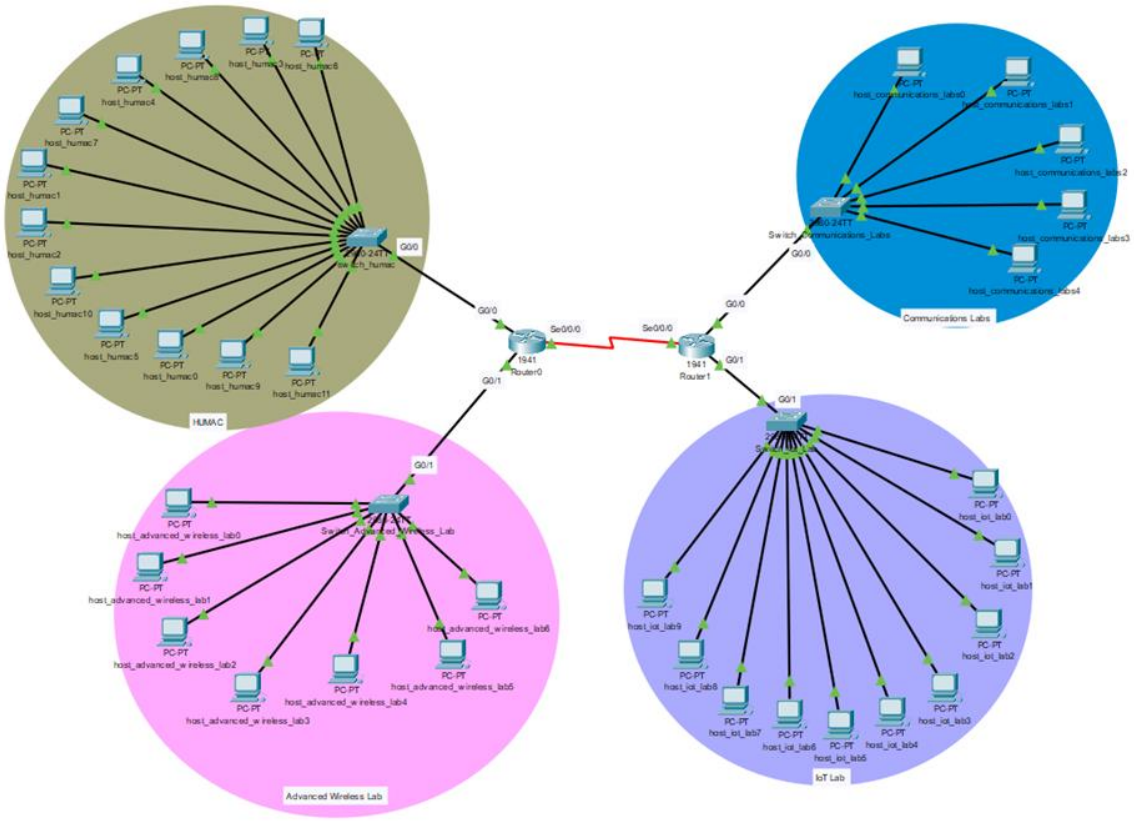

Figure 14 Logical Topology

Part B : Screenshots as proof for configuration

Routers **(Router0)**

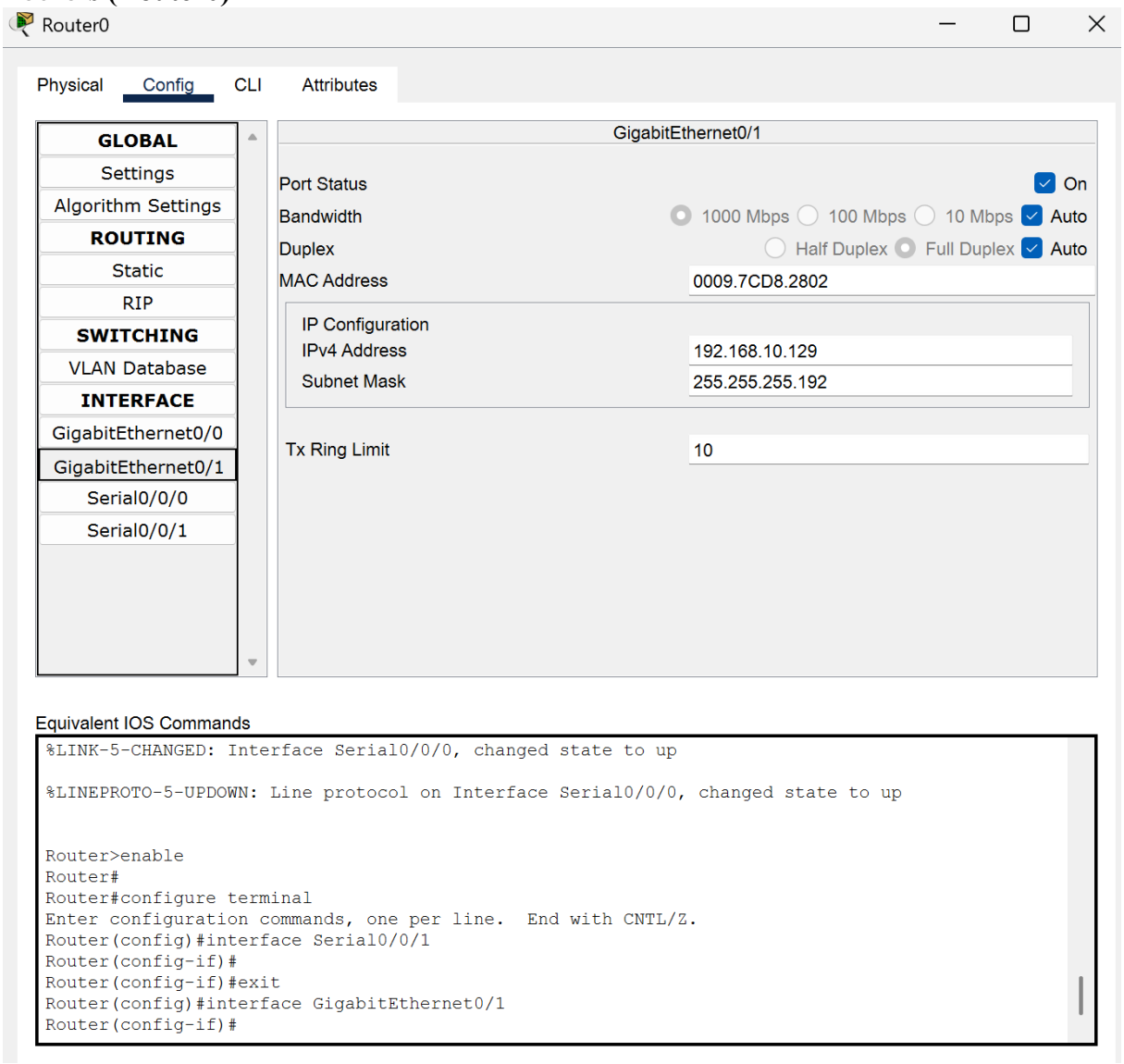

Figure 15 configuration of router0

```
Router#ping 192.168.11.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.11.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 18/21/28 ms

Router#
```

Figure 16 router0 ping router1

Switches (Switch_humac)

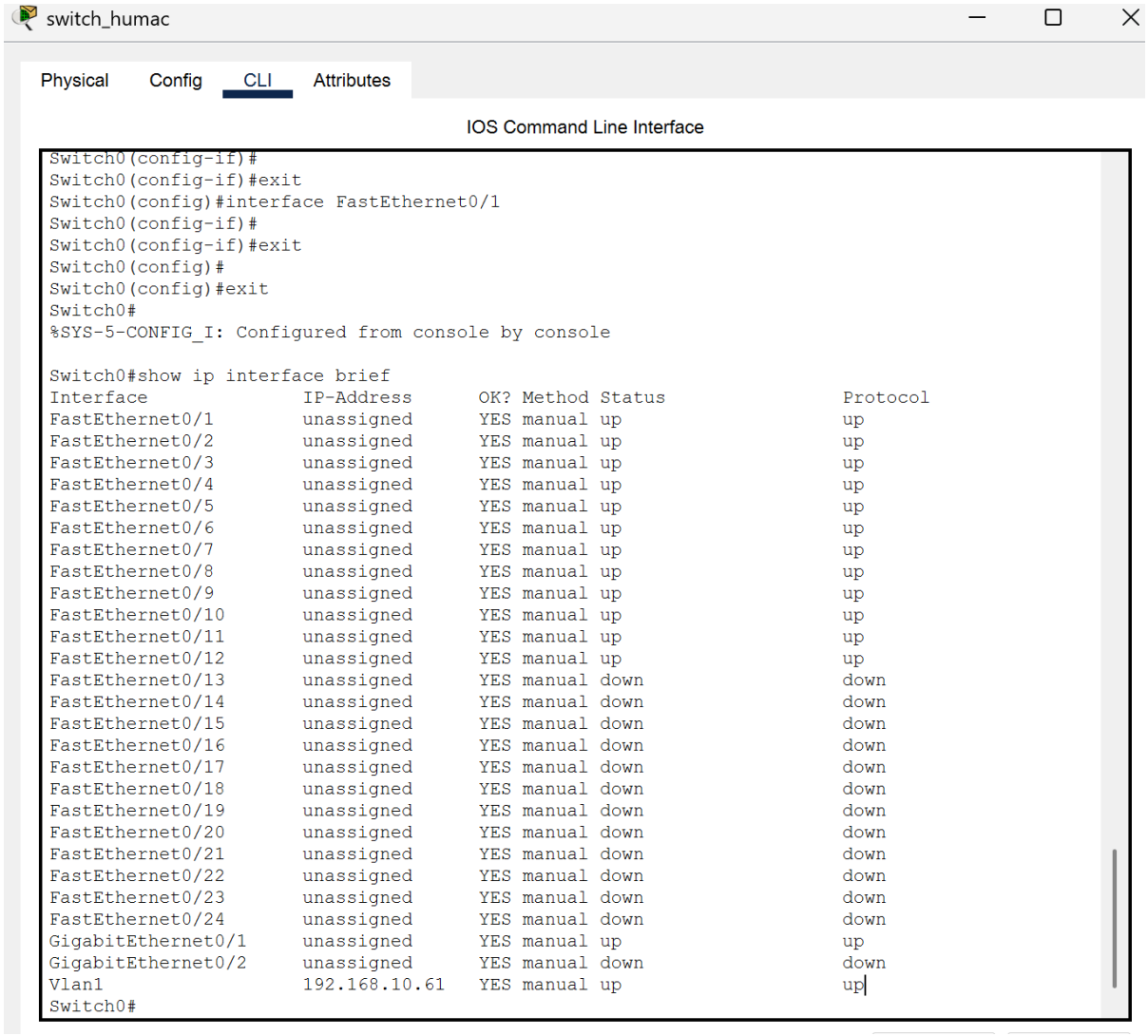

Figure 17 switch_humac show ip interface brief

```
Switch0#ping 192.168.10.18

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.18, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 0/0/0 ms

Switch0#ping 192.168.10.18

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.18, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms
```

Figure 18 switch_humac ping host

PC (host_humac7)

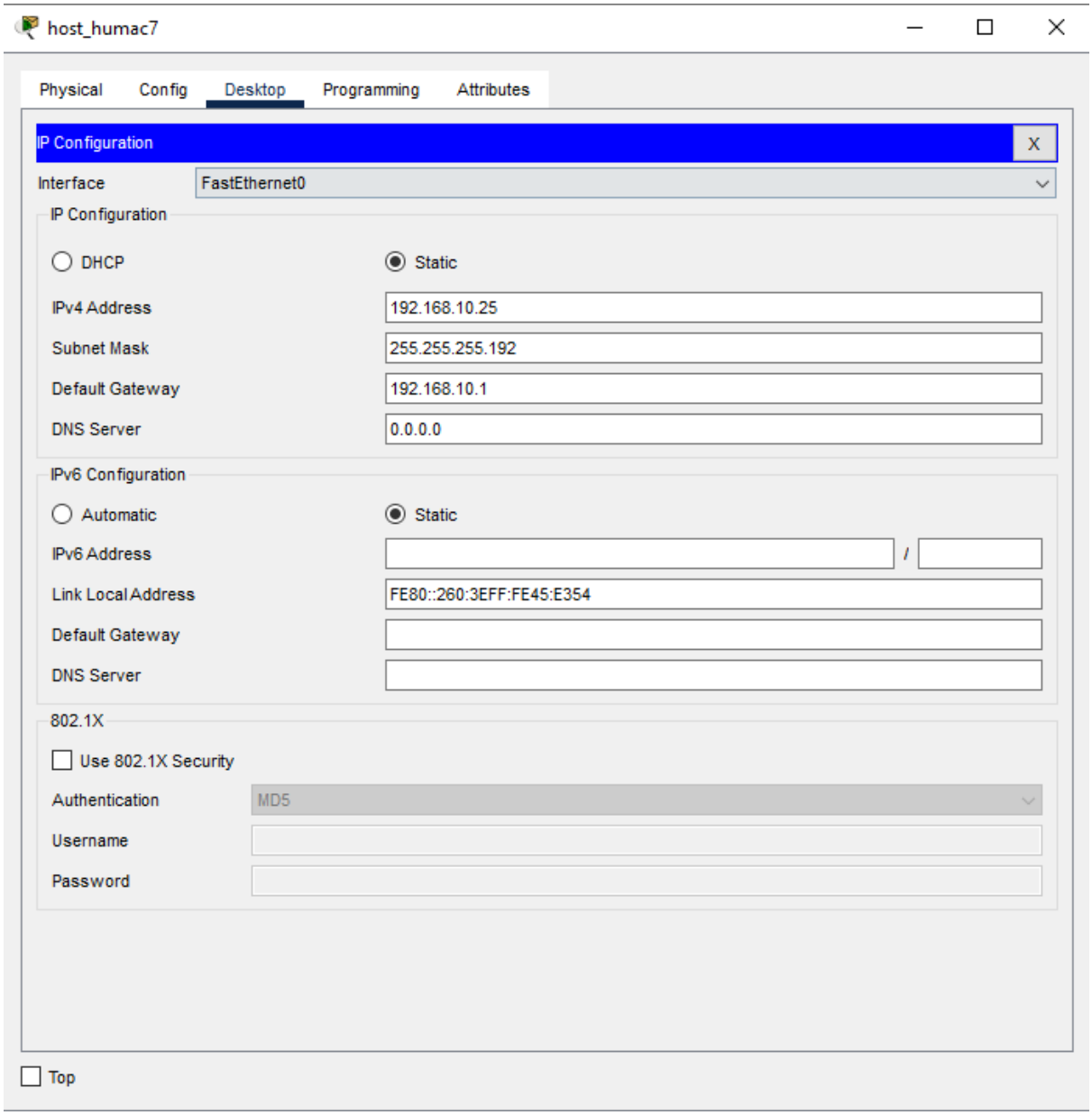

Figure 19 configuration of host

Part C: Lessons Learned

Teamwork Experience

- During our group project, we faced challenges when dividing task equally as most of the team member do not understand the tasks the group leader assigned which led to misunderstanding. So, to solve this issue we opened a zoom meeting and discussed about our strengths and workload more effectively.

Conflicting Opinions and Resolution

- While working on the assignment, each member in our group has different opinions on how the assignment can be better. The discussion about it became tense as there were too many opinions and objections about some opinions. Eventually, we reach a compromise that combined the best element of different idea.

Issue Resolution

- Throughout the assignment, our team faced issues such as finding a perfect time to discuss the assignment together and having issue using Cisco Packet Tracer. We discussed about the meet up problem in our WhatsApp group and came up with a solution by making it online meeting instead of physical meeting as most of our members have different timetable. During meeting we successfully discussed about the assignment on what should we do and what part is done by which member. Besides that, during the meeting we learned how Cisco Packet Tracer works by helping and teacher each other.

Overall Experience

- Overall, it was a great experience working this assignment as a team as everyone contributed to this assignment. Although we faced some issue throughout the assignment, it was not a big deal as everyone has their own opinion and idea and are willing to share, accept and help each other.