Ho Chi Minh City University of Technology

Faculty of Computer Science and Engineering

Computer Network Lab (CO3094)

Assignment Report

H6 Network Design

Lecturer: Nguyễn Lê Duy Lai

Group name: Ignorant Spider

Team members: Trương Tân Hào Hiệp – 2011211

Ho Chi Minh city, 10 December, 2022

Table of Contents

1. OVERVIEW

1.1. Requirements Background

Due to global warming and many environmental problems these days, HCM University of Technology wants to rebuild the campus into a modern, friendly, and energy-saving place for all the students and tutors. To achieve that purpose, a system monitoring activity of students in buildings needs to be built and in addition, in each classroom, measurement devices such as temperature, humidity, and light sensors also need to be implemented to calculate the energy usage in order to adjust the device and reduce the cost.

To start deploying this project, HCMUT decided to build the system in building H6 of campus 2. However, in order to make the operation of the system work better, the network design of the current building H6 needs to be reworked with a new design to utilize the features of the new system therefore, a group of students studying computer networks course is invited to counsel to offer appropriate solutions with the minimum cost.

1.2. Requirements Elicitation

1.2.1. From the initial idea

In campus 2, the H6 building will implement ***a system of surveillance cameras*** at some point and ***the camera's data will be stored centrally in server room 106 H6***. There are also *computer rooms on floors 6 and 7*.

To cater for monitoring, the University will invest in every classroom in the building H6 IoT devices include: ***6 temperature sensors***, ***6 light sensors for large theory rooms*** (an area larger than 60 m2), the light control equipment; ***3 temperature sensors***, ***3 light sensors for the remaining rooms*** (the smaller area of 60 m2), light control equipment.

Each operating spread on ***each floor*** will be fitted with ***4 surveillance cameras***. The classrooms will be equipped with desktop computers. In practice, ***the computer room*** will be fitted with ***air conditioner equipment control***. The measurement device will collect data continuously every 1 minute in real-time and send it to the processing server every 5 minutes.

1.2.2. Data processing

– **Server room (106H6):** The cameras only transmit data to the server room and their record can only be accessed by the admin in the administrative office or users in the server room. Data transfer rate: 100 Mbps.

– **Administrative office:** The computers download about 200MB per day and send 10 emails per day with a maximum capacity of 10 MB per email. Consists of 10 computers.

– **Small theory room:** Height: 3m, Width: 10m, Depth: 5m.

– **Large theory room:** Height: 3m, Width: 20m, Depth: 5m.

– **Computer room (Lab):** Height: 3m, Width: 20m, Depth: 5m. The computers will download about 200MB per day in peak hours.

– **Camera system:** Include 4 surveillance cameras (wire connected) on each floor. Each camera will store the data directly on a central server.

– **Sensors:** Collect data for one minute once and after 5 minutes they send this data to the central server over the WIFI network; measure a different index but their data format size is 32 Kb.

– **Air conditioner equipment control:** Collect data continuously every 1 minute in real-time and send it to the processing server every 5 minutes.

– **Electrical devices:** Have a maximum speed of 256 Kbps when connecting to the wireless connection.

1.2.3. Requirement specifications

The design should meet following specifications:

– The subnet calculation is for each target device or is split across the entire network.

– The system runs stably, efficiently and calculate the capacity.

– Calculate the total cost of the devices used.

– Ensure network connection speed.

The network system should be designed to include 3 main features:

– Monitor student activities through the system of cameras.

– Monitor the elements of temperature, humidity, and light in classroom with sensors.

– Connect network-capable devices to each other using a network system.

1.3. System Architectural Design from Hypothesis

1.1.1. Floors and rooms

Floor	Element	Amount	Description
1	– Server room (106H6) – Administrative office – Small theory room – Large theory room – Camera	1 1 6 3 4	– 4 Server – 10 computers – 3 temp sensors and 6 light sensors – 6 temp sensors and 6 light sensors
2	– Small theory room – Large theory room – Camera	6 3 4	– 3 temp sensors and 6 light sensors – 6 temp sensors and 6 light sensors
3	– Small theory room – Large theory room – Camera	6 3 4	– 3 temp sensors and 6 light sensors – 6 temp sensors and 6 light sensors
4	– Small theory room – Large theory room – Camera	6 3 4	– 3 temp sensors and 6 light sensors – 6 temp sensors and 6 light sensors
5	– Small theory room – Large theory room – Camera	6 3 4	– 3 temp sensors and 6 light sensors – 6 temp sensors and 6 light sensors
6	– Small theory room – Large theory room – Computer room – Camera	4 2 6 4	– 3 temp sensors and 6 light sensors – 6 temp sensors and 6 light sensors – 32 computers and 1 air conditioner
7	– Small theory room – Large theory room – Computer room – Camera	4 2 6 4	– 3 temp sensors and 6 light sensors – 6 temp sensors and 6 light sensors – 32 computers and 1 air conditioner

1.1.2. Guidelines

– The cameras only transmit data to the server room and their record can only be accessed by the admin in the administrative office or users in the server room. Therefore, our team network design must have separate VLAN between normal computers, devices with cameras, and admin devices, server room.

– The camera will be implemented in the corridor of each floor.

– Each camera will have a data transfer rate of 1 Mbps.

– Maximum port when connecting to the switch is 1 GB.

– Each room will have an access point for devices to connect to the WIFI network through a wireless connection.

– Each floor will have a switch for the camera and an access point from each room to connect.

– Each switch from each floor then will connect to the main switch on floor 1.

– The main switch then will connect to the final router before going out to the network.

– Each computer in the server room will have a data transfer rate of 10 Mbps (to prevent the bandwidth to balance the network even though those computers connect to the same switch at the server and may have data transfer rate at 100 Mbps).

2. DEVICES

2.1. List of Devices

2.1.1. Servers

– **Internet:** Enable outsider to access and retrieve data from H6 building.
– **Security server:** To protect from malicious access to the system.
– **Mail server:** To send and receive emails.
– **DHCP server:** To assign IP addresses to devices within the network.
– **Database server:** To store data.
– **Backup server:** To backup data in case of emergency.

Those servers are essential to the operation of H6 building so they must have suitable configuration for transferring data consistently.

2.1.2. Routers

Using **CISCO ISR4331/K9** for internal and external connection.

Figure 1. Router CISCO ISR4331/K9.

Technical details:

– Provide a 4GB DRAM (combined up to 16 GB) and a 4GB flash memory (up to 16GB).
– Has 3 gigabit Ethernet ports, 2 network interface module slots and 1 service module slot. These 3 ports include one dedicated RJ-45 port, one dedicated SFP port, and one dual mode RJ-45/SFP port (can only be used as either copper of SFP at any given time, not both).
– Has a total transfer rate from 100 Mbps to 300 Mbps.
– The total number of WAN and LAN 10/100/1000 ports is 3.
– Price: $3000.

2.1.3. Switches

Main switch:

Using **CISCO WS-C3560V2-24PS-S** as a main (multilayer) switch.

Figure 2. Core switch CISCO WS-C3560V2-24PS-S.

Technical details:

Cisco Catalyst 3560V2 Series switch WS-C3560V2-24PS-S is the next-generation energy-efficient Layer 3 fast Ethernet switches. This 3560V2 switches supports Cisco Energy Wise technology, which enables companies to measure and manage power consumption of network infrastructure and network-attached devices, thereby reducing their energy costs and their carbon footprint which is the ideal for enterprise, retail, and branch-office environments, as it maximizes productivity and investment protection by enabling a unified network for data, voice, and video.

- 24 Ethernet 10/100 ports and 2 SFP-based Gigabit Ethernet ports.
- 370W available for PoE, allowing 15.4W to all ports.
- 1RU fixed-configuration, multilayer switch.
- IPv6.
- IP Base software feature set.
- Price: $1500.

Support switch:

Using **CISCO Catalyst 2960 WS-C2960-24TT-L** as a support (floor) switch. It is one of the Cisco Catalyst 2960 Series switches. Cisco Catalyst 2960 Series switches support voice, video, data, and highly secure access.

Figure 3. Support switch CISCO Catalyst 2960 WS-C2960-24TT-L.

Technical details:

Due to using larger bandwidth than switch 2950-24, we decide to use switch 2960IOS15 which have 2 interface gigabit Ethernet (with large bandwidth) in order to ensure the throughput for each floor at any time.

- 24 Ethernet 10/100 ports and 2 Ethernet 10/100/1000 ports.

– Throughput 6.5 Mpps.

– DRAM 16 MB.

– LAN based and support up to 255 VLANs.

– Price: $1500.

*Note: for room layer, another type of support switch **CISCO Catalyst 2950-24** is used. Because the total traffic of whole room is not too large, we do need to use switch supporting gigabit Ethernet (with large bandwidth). Moreover, we only use under 24 devices so we decide to choose this switch.*

2.1.4. Access points

Using **Wireless-G Access Point LINKSYS WAP54G** as an access point.

Figure 4. Wireless-G Access Point LINKSYS WAP54G

Technical details:

– Wireless-G is the upcoming 54Mbps wireless networking standard that's almost five times faster than the widely deployed Wireless-B (802.11b) products - but since they share the same 2.4GHz radio band, Wireless-G devices can also work with existing 11Mbps Wireless-B equipment.

– To protect your data and privacy, the Wireless-G Access Point can encrypt all wireless transmissions, and supports the industrial-strength security of WPA. The MAC Address filter lets you decide exactly who has access to your wireless network. Configuration is a snap with the web browser-based configuration utility.

– Price: $20.

2.2. Distribution and Quantity

Room		Num. Room	Equipment	Amount
Floor 1	Server room	1	Server	3
	Admin room	1	Computer	10
	Class room (small)	6	Temperature sensor	3
			Light sensor	3
			Light controller	1
			Computer	1
	Class room (large)	3	Temperature sensor	6
			Light sensor	6
			Light controller	1
			Computer	1
			Camera	4
Floor 2 - 5	Class room (small)	6	Temperature sensor	3
			Light sensor	3
			Light controller	1
			Computer	1
	Class room (large)	3	Temperature sensor	6
			Light sensor	6
			Light controller	1
			Computer	1
			Camera	4
Floor 6 - 7	Computer room	6	Computer	32
			Air conditioner	1
	Class room (small)	4	Temperature sensor	3
			Light sensor	3
			Light controller	1
			Computer	1
	Class room (large)	2	Temperature sensor	6
			Light sensor	6
			Light controller	1
			Computer	1
			Camera	4

2.3. Cost calculation

Equipment name	Type name	Total No.	Price	Total cost
Server	Server-PT	3	2000	6000
MCU board	MCU-PT	57	20	1140
Access point	AccessPoint-PT	69	20	1380
Switch	2950-24	33	350	11550
Switch	2960 IOS15	7	1500	10500
Switch	3650 24PS	1	5000	5000
Router	ISR4331	1	3000	3000
Coper straight-through/ coper cross-over		8000* (m)	0.5 (/m)	4000
Total cost				42570

**Estimating copper length for the whole network: Server Room. Admin room, small Classroom 50m; large Classroom 100m; Computer room 200m; space between Floors 100m.*

→Total cost expected: $\$42570 \approx 980{,}000{,}000\ VND$.

Equipment name	Type name	Total No.	Price	Total cost
PC	PC-PT	451	1000	451000
Temperature sensor		228	5	1140
Photo sensor		228	5	1140
Light		57	40	2280
Camera		28	20	560
Air conditioner		12	250	3000
Total cost				459120

→Total cost expected: $\$459120 \approx 10{,}837{,}527{,}600\ VND$.

3. COMPUTATION

3.1. Storage Capacity

3.1.1. Cameras

Base on the requirement, each camera will have a data transfer rate of 1 Mbps.

Suppose that the data of camera will be stored within 30days, after this period data will automatically eliminated. In the other hand, camera data is transferred to server continuously. Thus, storage capacity of camera could be:

$$SCamera = Time \times Bitrate = (30 \times 24 \times 60 \times 60) \times 1 = 2592000(M\,b) \approx 317(GB)$$

There are 7 Floor and each floor has 4 camera, so total number of them would be $4 \times 7 = 28$, and the storage capacity of server for cameras' data should be:

$$STotalCamera = 28 \times SCamera = 28 \times 317 = 8876(GB)$$

3.1.2. IoT devices

Base on the requirement we have:

– Data format size is: 32 Kb.

– Collecting data frequency: 1 time/minute

Suppose that the data of IoT devices will be stored within 7days (don't need to store in long period because such kind of data mostly used for the real-time analyzing and decisions).

In total there are 38 classrooms (Floor 1 to 5: 6 classroom per floor and Floor 6 to 7: 4 classrooms per floor) and 19 large rooms (Floor 1 to 5: 3 per floor and Floor 6 to 7: 2 classrooms per floor).

We have 6 temperature sensors, 6 light sensors for large theory rooms and 3 temperature sensors, 3 light sensors for the remaining rooms.

Thus, total number of sensors in H6 building will be:

$$NSensor = 38 \times 6 + 19 \times 12 = 456(sensor)$$

And also, we can imply the total storage capacity of a sensor for a week would be:

$$SSensor = 7 \times (24 \times 60) \times 32 = 322560(KB) = 315(MB)$$

Finally, the storage capacity of server for IoT devices' data should be:

$$STotalSensor = SSensor \times NSensor = 315 \times 456 = 143640(M\,B) = 141(GB)$$

3.2. Network traffic

3.2.1. Cameras

– Each camera will have a data transfer rate of: $1\ Mbps$.

– At each operating spread on each floor will be fitted: $4\ surveillance\ cameras$.

– Bandwidth for cameras in each floor: $1\ Mbps\ x\ 4\ =\ 4\ Mbps$.

– Number of floors in H6 building: $7\ floors$.

– Bandwidth for cameras of whole H6 buildings is $4\ x\ 7\ =\ 28\ Mbps$.

3.2.2. IoT devices

Base on the requirement:

– Data format size for collecting in 1 minute is: $32KB\ =\ 256Kb$

– Collecting data frequency: $1\ time/\ 5\ minutes$

Thus, the bandwidth of sending data for each sensor is $\frac{256\times1024\times5}{5\times60}\ =\ 4370(bps)$.

So, for each type of room in H6 building we have

	Large room	Small room
Sensors	12	6
Bandwidth	52440 (bps)	26220 (bps)

- **Floor 1 to 5:**

	Large room	Small room
Num. Rooms	3	6
Bandwidth	157320 (bps)	157320 (bps)

The total bandwidth of 5 floors 1, 2, 3, 4, 5 is

$$(157320\ +\ 157320)\times5\ =\ 1573200(bps)\ =1.5(M\ bps)$$

- **Floor 6 and 7:**

	Large room	Small room
Num. Rooms	2	4
Bandwidth	104880 (bps)	104880 (bps)

The total bandwidth of 2 Floor 6 and 7 is

$$(104880 + 104880) \times 2 = 419520(bps) = 0.4(M\ bps)$$

Finally, we have the total bandwidth for transmitting data of IoT devices in H6 building is

$$1.5 + 0.4 = 1.9(M\ bps)$$

3.2.3. Computers

Base on the requirement, the parameters related to ***downloading:***

Peak hours for the classroom computer are 7:00 to 17:30	$10\ h\ 30\ m = 37800\ (s)$
Peak hours for administration computer (8h00 - 11h40, 13h00 - 16h30)	$(3h40m + 3h30m) = 25800\ (s)$
Download capacity	$200\ MB$
Bandwidth for downloading in 1 day	$200\ MB\ /\ 86400s = 19.4\ Kbps$

Base on the requirement, the parameters related to ***sending Email*** of administration office computers:

Maximum capacity per email	$10\ MB$
Maximum capacity for each computer sends 10 emails each day	$10\ MB \times 10 = 100\ MB$
Bandwidth for sending email in a day	$100\ MB\ /\ 86400s = 9.7\ Kbps$

– Supposing, 75% of data downloaded in the period from 7h00 to 17h30.

– The average amount of data downloaded in this period time: $200 \times 75\% = 150MB$

– Bandwidth needed for downloading in a day: $19.4\ Kbps$

– Maximum bandwidth for classroom computer: $150MB/37800(s) = 31.1\ Kbps$

– The computers download about 200MB per day in total 25800 seconds. Thus, the maximum bandwidth:$150(MB)/25800(s) = 47.63\ Kbps$

– Bandwidth for sending email in 1 day: $9.7\ Kbps$

– Maximum bandwidth for administration computer: $9.7 + 47.63 = 57.33\ Kbps$

3.2.4. Wi-Fi router network

Base on the requirement, each device when connected to the WIFI network is used with $256Kbps$. So, maximum amount of data transferred that 1 access point have:

$$MAX_{data} = 256 \times (24 \times 60 \times 60) = 22118400(Kb) = 2700(MB)$$

In addition, each device when connected to the WIFI network is used with maximum speed in terms of time 7h30 to 17h30, supposing there were 90% amount of data of a day be transferred in this period of time so:

$$2700 \times 90\% = 2430(MB)$$

Base on that we can have the bandwidth for each Wi-Fi router in peak hours could be:

$$\frac{2430}{10 \times 60 \times 60} \approx 675(Kbps)$$

4. PHYSICAL DESIGN

4.1. Floor 1

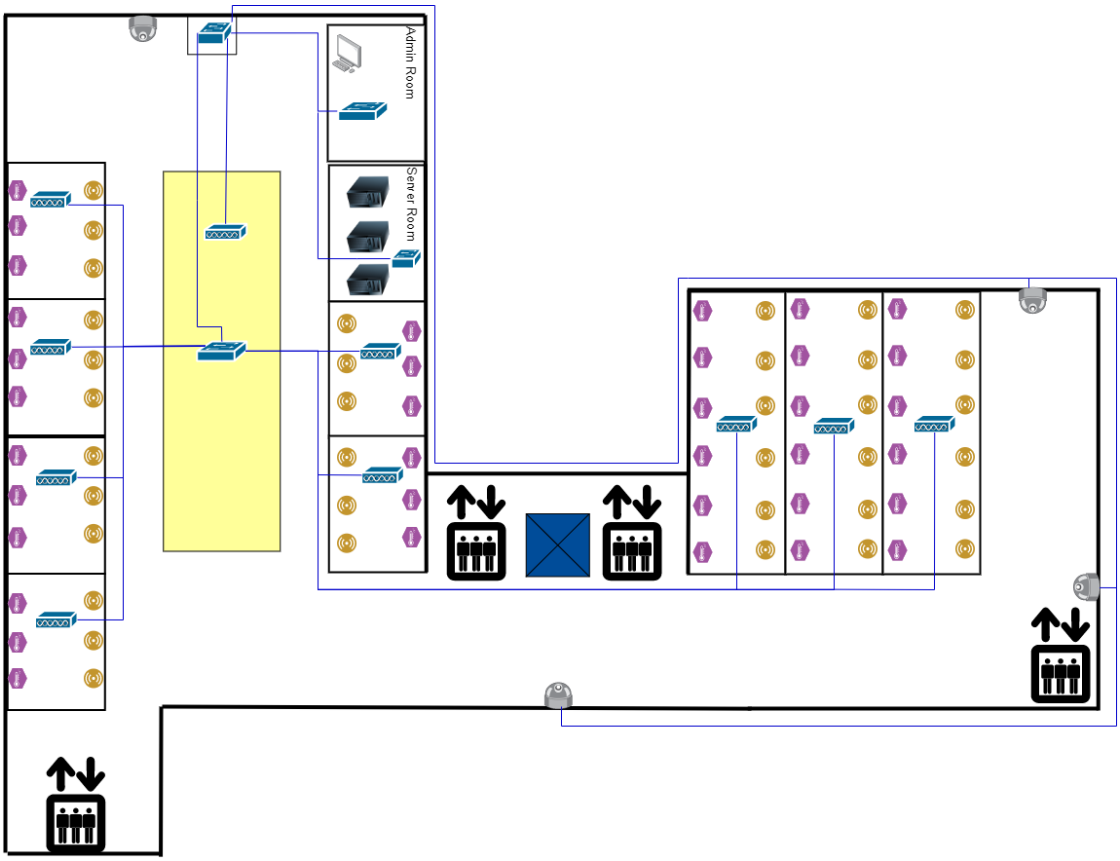

Figure 5. Physical design of Floor 1.

4.1.1. Overview

– There is a switch to connect all equipment in floor 1 (connect to multi-layer switch).

– There is a switch to connect all classroom, and it connects to floor 1's switch.

– There are 4 camera connecting to floor 1's switch.

– There is an access point for all sensor including light sensor and temperature sensor, and it connects to floor 1's switch.

– There is a multi-layer which is used to connect switch in each floor.

– There is a router of H6 building.

4.1.2. Classroom

– There is a desktop computer connecting to switch using for all classroom (to increase the speed of transfer data between each floor).

– There is access point in each class for connecting wireless devices, and it connects to switch of all classroom.

4.1.3. Administrative office

There are 10 desktop computers connecting to switch using for administrative office, and it connects to floor 1's switch.

4.1.4. Server room

Consists of 4 main servers:

– Mail server (use to send and receive mail).
– DHCP server (use to assign IP address to devices within the network).
– Database server (use to connect and store database of camera and sensor).
– Backup server (use to store database to prevent the case of IoT server destroyed)

4.2. Floor 2 to 5

Because the structure and the number of devices from floor 2 to floor 5 are similar, so we only specify one floor.

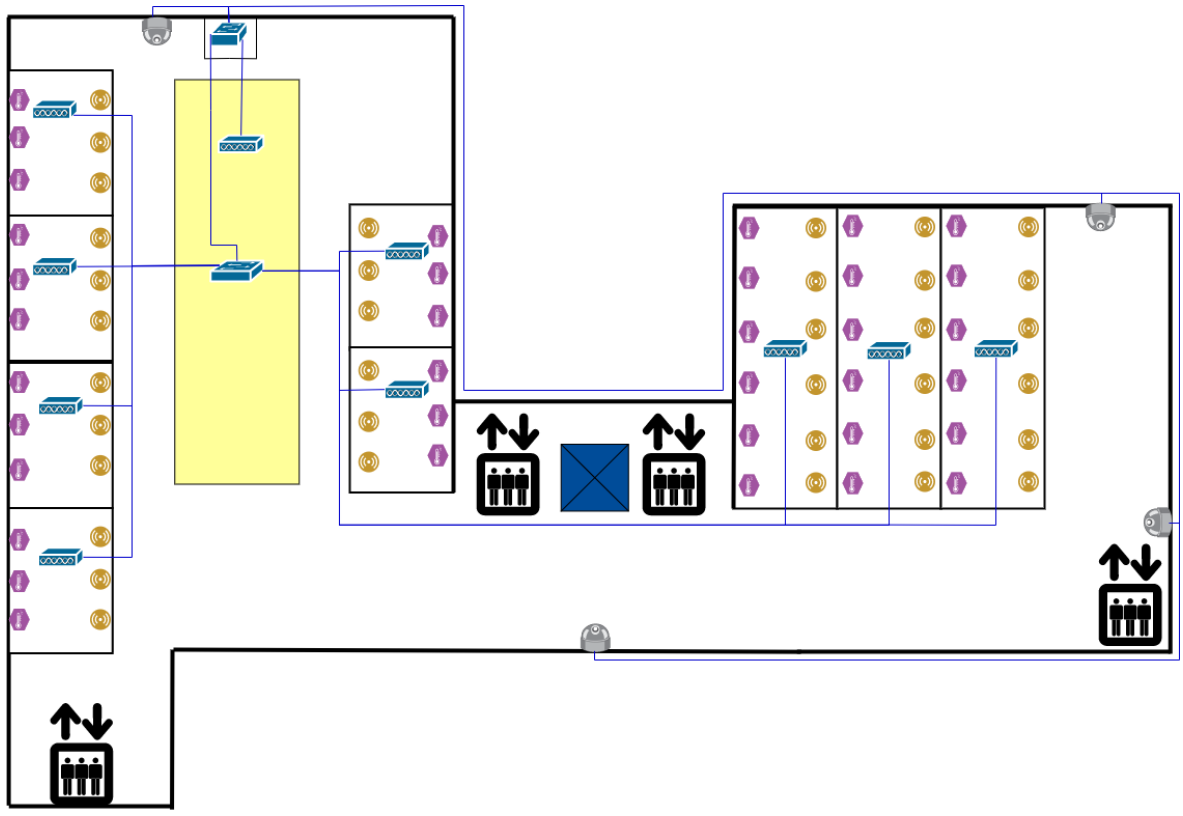

Figure 6. Physical design of Floor 2 to 5.

4.2.1. Overview

– There is a switch to connect all equipment in floor (connect to multi-layer switch in floor1).

– There is a switch to connect all classroom, and it connects to floor's switch.

– There are 4 camera connecting to floor's switch.

– There is an access point for all sensor including light sensor and temperature sensor, and it connects to floor's switch.

4.2.2. Classroom

– There is a desktop computer connecting to switch using for all classroom (to increase the speed of transfer data between each floor).

– There is access point in each class for connecting wireless devices, and it connects to switch of all classroom.

4.3. Floor 6 and 7

Because the structure and the number of devices from floor 6 to floor 7 are similar, so we only specify one floor.

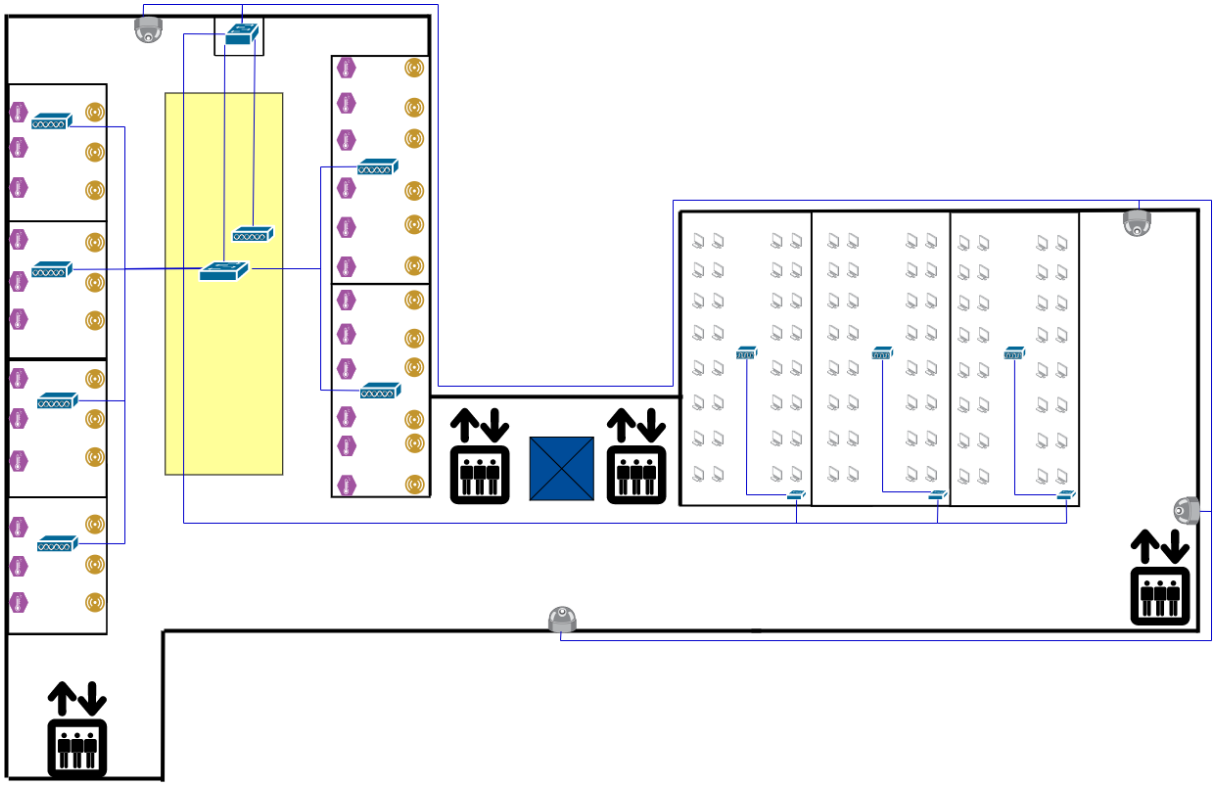

Figure 7. Physical design for Floor 6 and 7.

4.3.1. Overview

– There is a switch to connect all equipment in floor (connect to multi-layer switch in floor1).

– There is a switch to connect all classroom, and it connects to floor's switch.

– There are 4 camera connecting to floor's switch.

– There is an access point for all sensor including light sensor and temperature sensor, and it connects to floor's switch.

4.3.2. Classroom

– There is a desktop computer connecting to switch using for all classroom (to increase the speed of transfer data between each floor).

– There is access point in each class for connecting wireless devices, and it connects to switch of all classroom.

4.3.3. Computer room

– There is a switch for connecting all equipment in computer classroom.

– There are 32 desktop computers connecting to switch using for all classroom.

– There is access point in each class for connecting wireless devices, and it connects to switch of all classroom.

– There is an air conditioner equipment control.

5. LOGICAL DESGIN

5.1. Equipment

Floor	Name	Number	Description
0	- Main switch	1	- Switch used for all floors
1	- Support switch	4	- 1 main floor + 1 server + 1 admin + 1 class
	- Access point	10	- 9 class + 1 sensor
2	- Support switch	2	- 1 main floor + 1 class
	- Access point	10	- 9 class + 1 sensor
3	- Support switch	2	- 1 main floor + 1 class
	- Access point	10	- 9 class + 1 sensor
4	- Support switch	2	- 1 main floor + 1 class
	- Access point	10	- 9 class + 1 sensor
5	- Support switch	2	- 1 main floor + 1 class
	- Access point	10	- 9 class + 1 sensor
6	- Support switch	5	- 1 main floor + 1 class + 3 lab
	- Access point	13	- 12 class + 1 sensor
7	- Support switch	5	- 1 main floor + 1 class + 3 lab
	- Access point	13	- 12 class + 1 sensor
		99	- 23 switches - 76 access points

5.2. VLAN Distribution

Floor	VLAN	VLAN name	IP address
1	11	Camera	192.168.11.0/24
	12	Server	192.168.12.0/24
	13	Administrative office	192.168.13.0/24
	14	Classroom	192.168.14.0/24
	15	Sensor	192.168.15.0/24
2	21	Camera	192.168.21.0/24
	22	Classroom	192.168.22.0/24
	23	Sensor	192.168.23.0/24
3	31	Camera	192.168.31.0/24
	32	Classroom	192.168.32.0/24
	33	Sensor	192.168.33.0/24
4	41	Camera	192.168.41.0/24
	42	Classroom	192.168.42.0/24
	43	Sensor	192.168.43.0/24
5	51	Camera	192.168.51.0/24
	52	Classroom	192.168.52.0/24
	53	Sensor	192.168.53.0/24
6	61	Camera	192.168.61.0/24
	62	Classroom	192.168.62.0/24

	63	Sensor	192.168.63.0/24
	64	Computer room	192.168.64.0/24
7	71	Camera	192.168.71.0/24
	72	Classroom	192.168.72.0/24
	73	Sensor	192.168.73.0/24
	74	Computer room	192.168.74.0/24

5.3. Design of the whole building

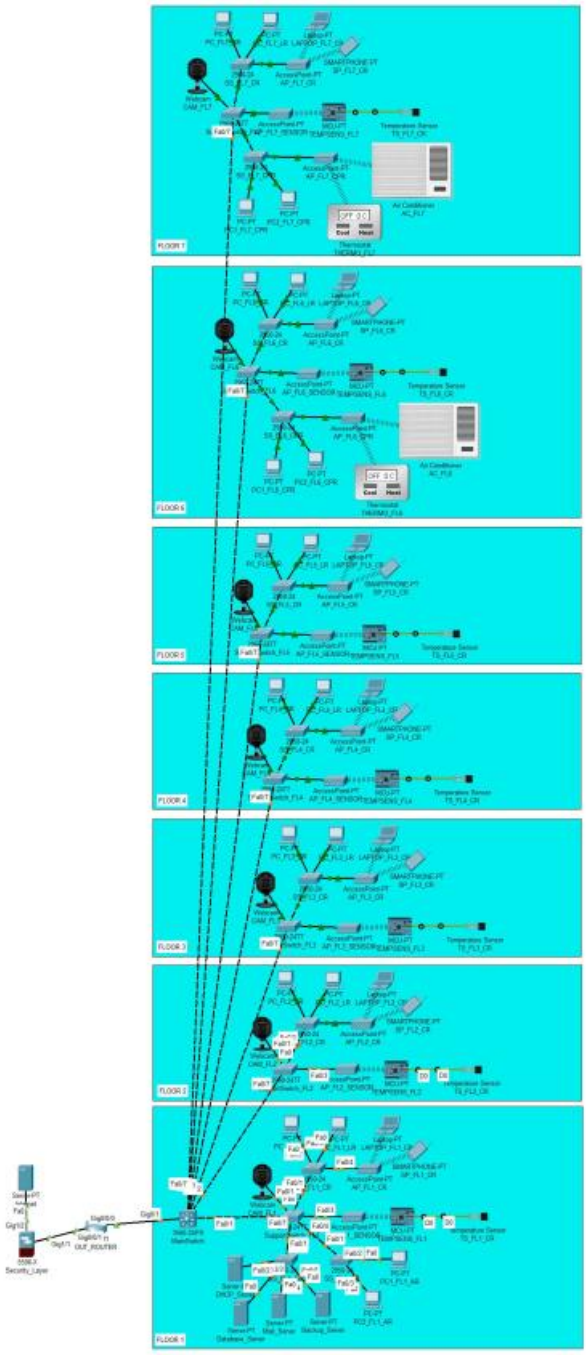

Figure 8. Logical design for whole building.

5.4. Design of each floor

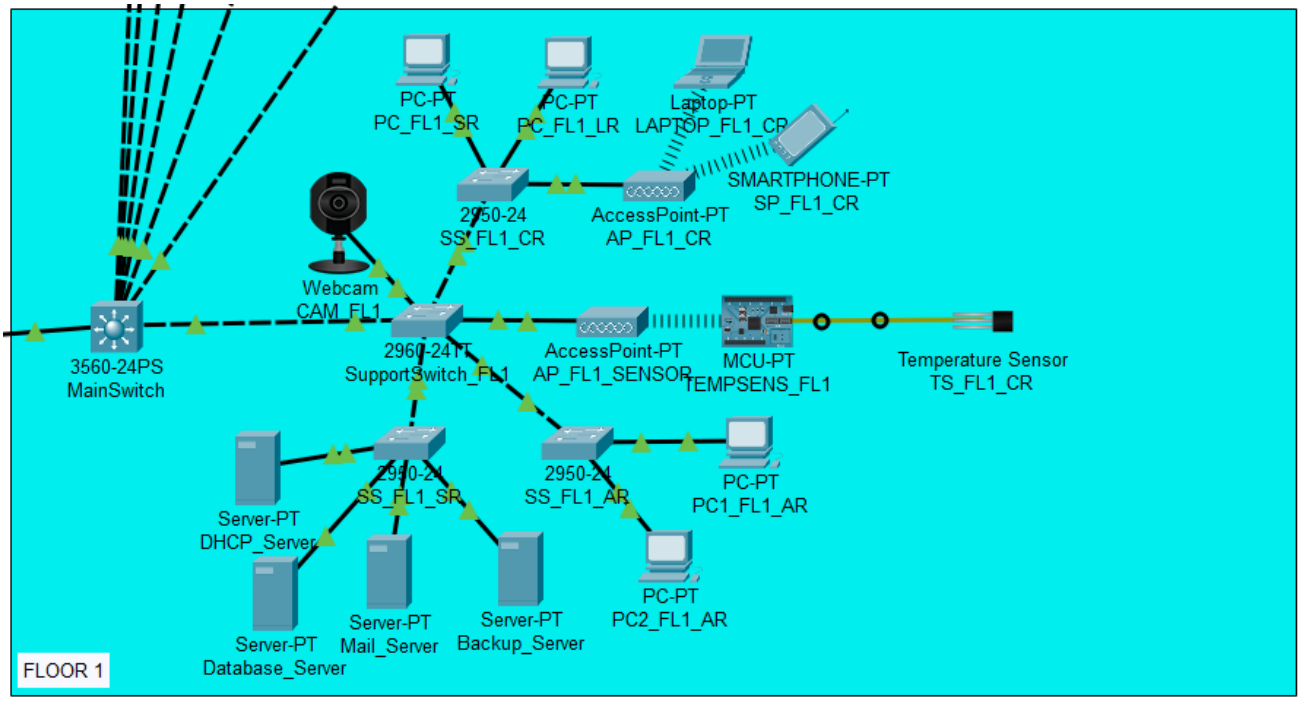

Figure 9. Floor 1.

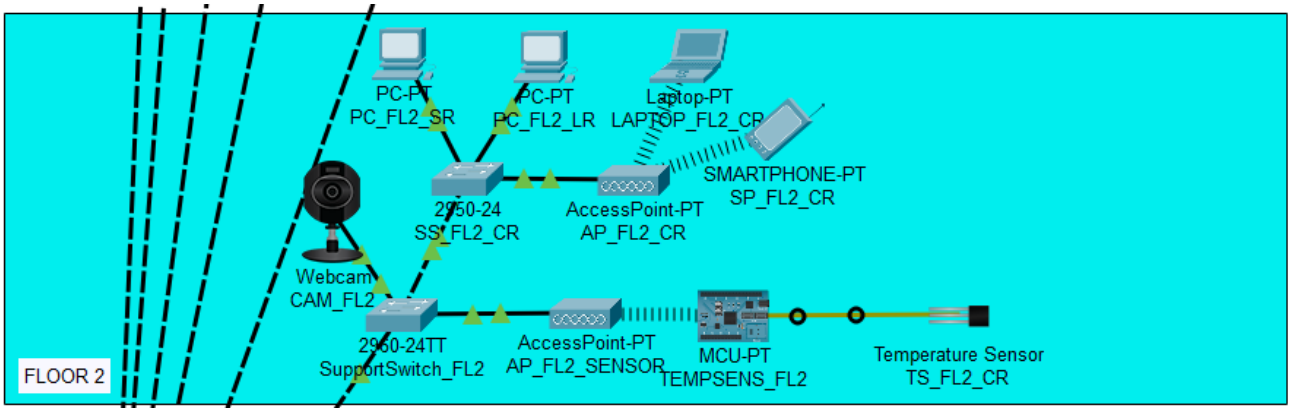

Figure 10. Floor 2.

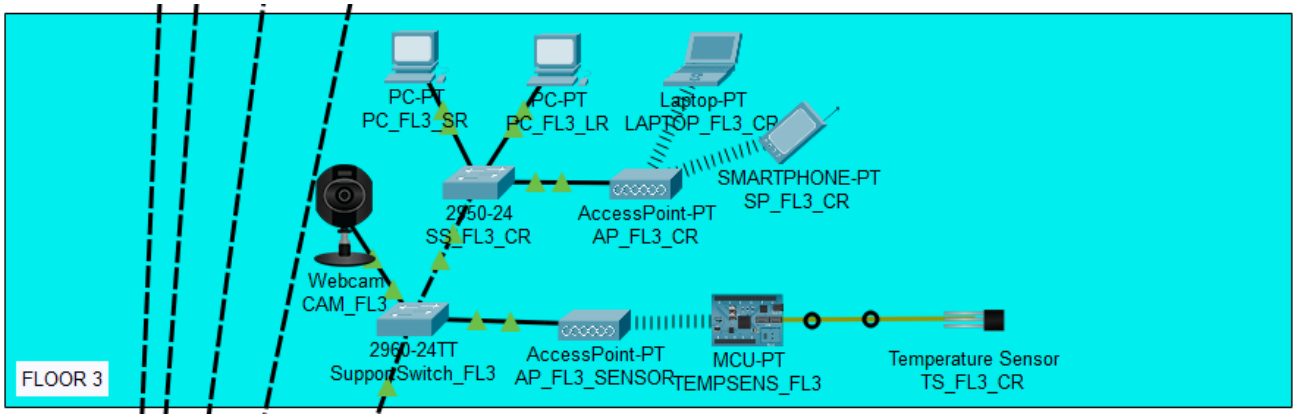

Figure 11. Floor 3.

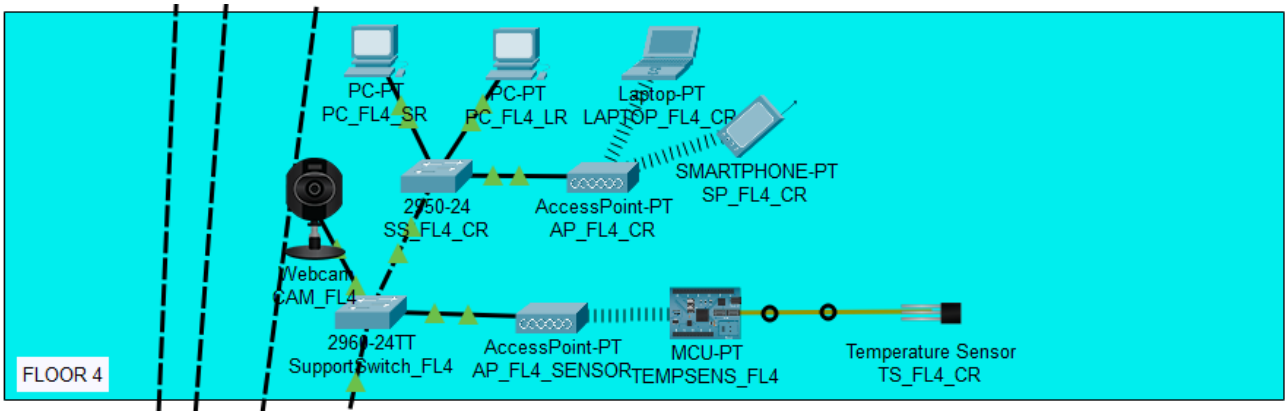

Figure 12. Floor 4.

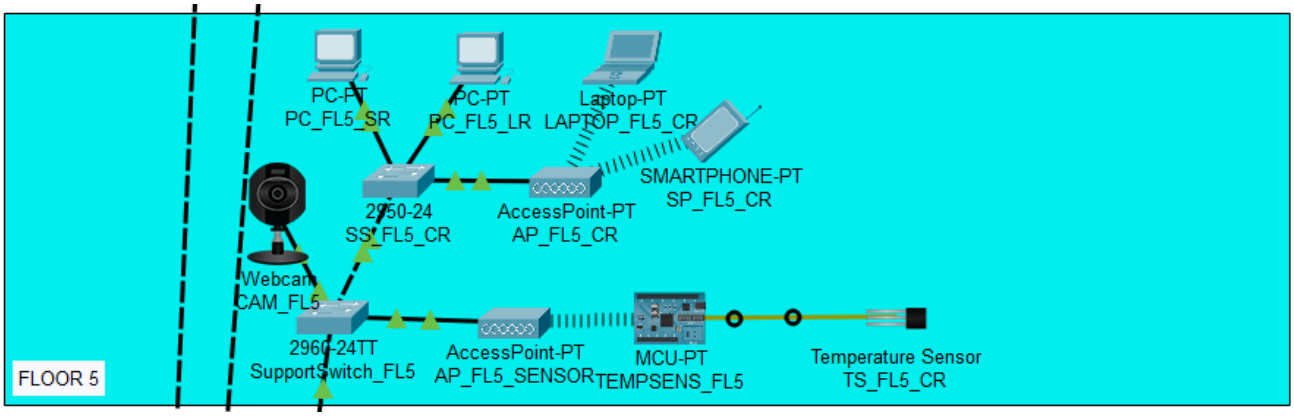

Figure 13. Floor 5.

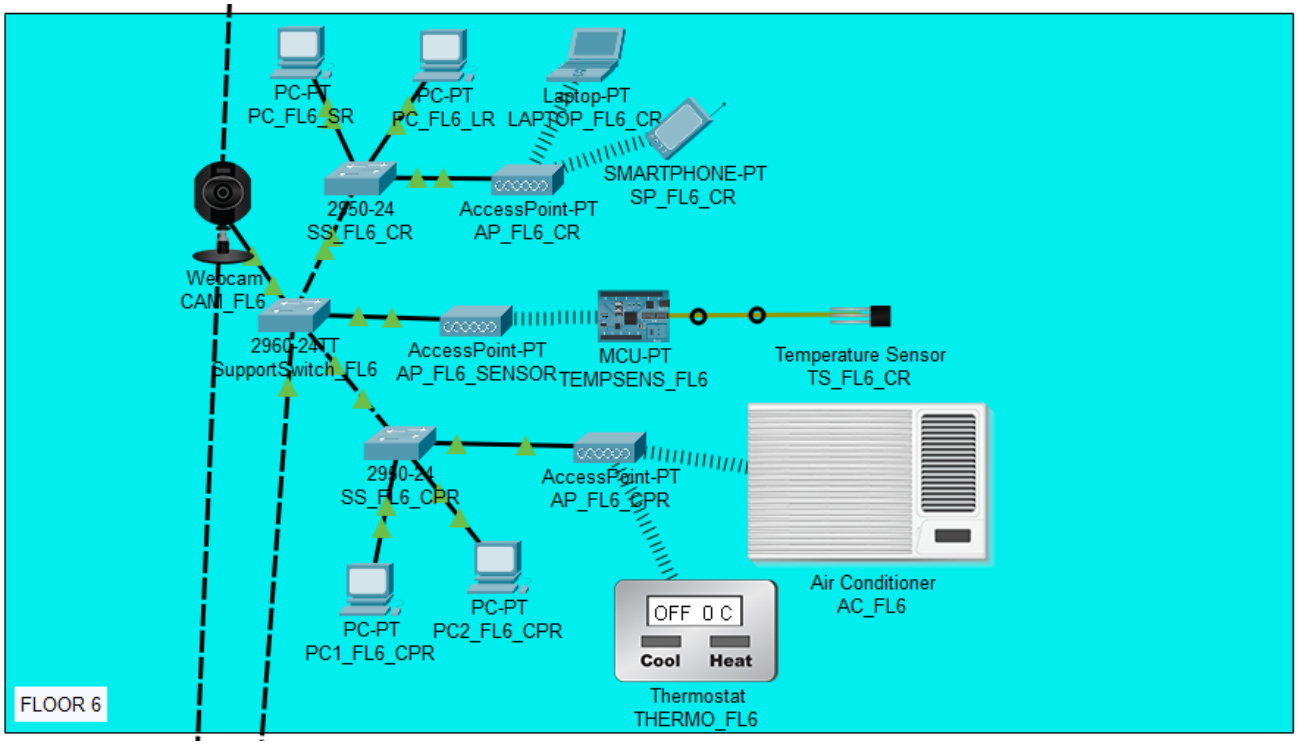

Figure 14. Floor 6.

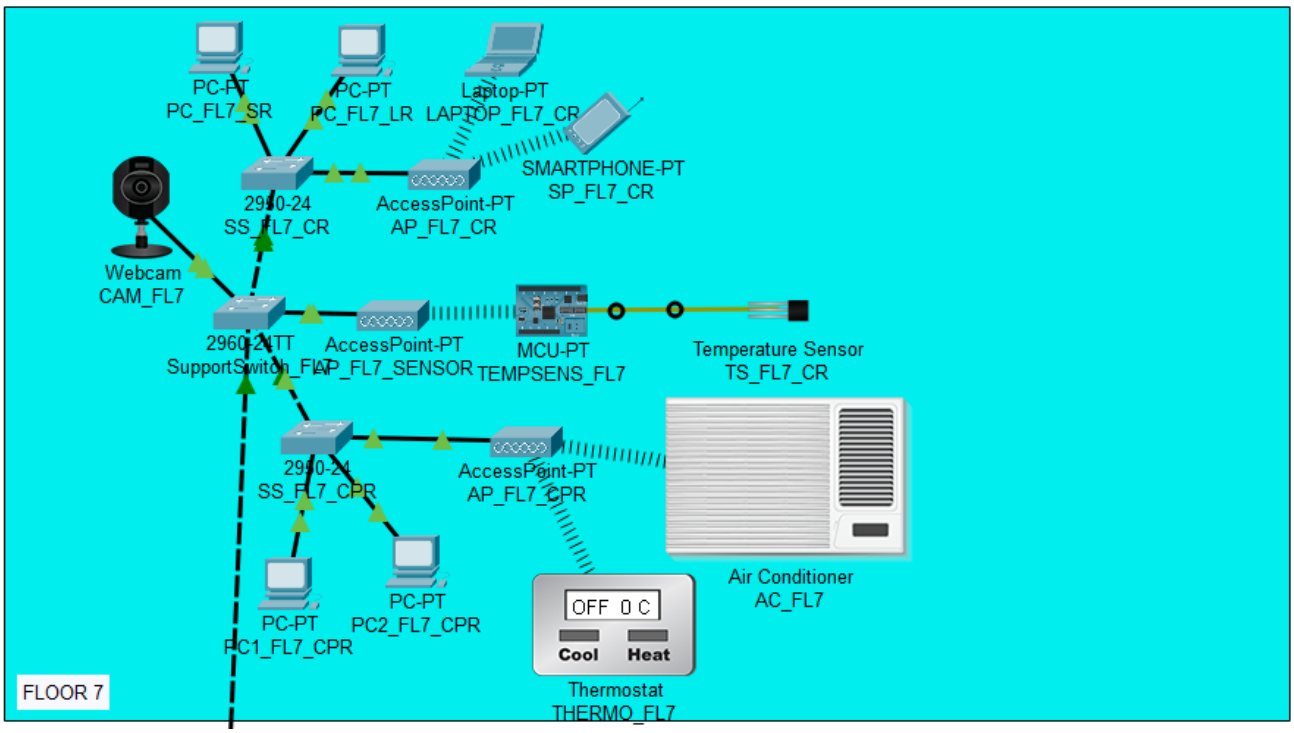

Figure 15. Floor 7.

5.5. Design of multilayer switch

In multi-layer switch, we will trunk each wire in terms of floor and set up VLANs (with IP address). Then, for each VLAN, we set up an IP helper-address direct to the DHCP server.

VLAN	Type	SAID	IP-Address
1	enet	100001	unassigned
11	enet	100011	192.168.11.1
12	enet	100012	192.168.12.1
13	enet	100013	192.168.13.1
14	enet	100014	192.168.14.1
15	enet	100015	192.168.15.1
21	enet	100021	192.168.21.1
22	enet	100022	192.168.22.1
23	enet	100023	192.168.23.1
31	enet	100031	192.168.31.1
32	enet	100032	192.168.32.1
33	enet	100033	192.168.33.1
41	enet	100041	192.168.41.1
42	enet	100042	192.168.42.1
43	enet	100043	192.168.43.1
51	enet	100051	192.168.51.1
52	enet	100052	192.168.52.1
53	enet	100053	192.168.53.1
61	enet	100061	192.168.61.1
62	enet	100062	192.168.62.1
63	enet	100063	192.168.63.1

64	enet	100064	192.168.64.1
71	enet	100071	192.168.71.1
72	enet	100072	192.168.72.1
73	enet	100073	192.168.73.1
74	enet	100074	192.168.74.1

5.6. VLAN of Floor 1

VLAN	Name	Port	Function
11	CAMERA_FL1	Fa0/1	Use for camera
12	CLASSROOM_FL1	Fa0/2	Use for desktop computer and wireless devices in classroom
13	SENSOR_FL1	Fa0/3	Use for sensors
14	ADMIN_ROOM	Fa0/4	Use for admin administrative office
15	SERVER_ROOM	Fa0/5	Use for server room

5.7. VLAN of Floor 2 to 5

Floor 2

VLAN	Name	Port	Function
21	CAMERA_FL2	Fa0/1	Use for cameras
22	CLASSROOM_FL2	Fa0/2	Use for desktop computer and wireless devices in classroom
23	SENSOR_FL2	Fa0/3	Use for sensors

Floor 3

VLAN	Name	Port	Function
31	CAMERA_FL3	Fa0/1	Use for cameras
32	CLASSROOM_FL3	Fa0/2	Use for desktop computer and wireless devices in classroom
33	SENSOR_FL3	Fa0/3	Use for sensors

Floor 4

VLAN	Name	Port	Function
41	CAMERA_FL4	Fa0/1	Use for cameras
42	CLASSROOM_FL4	Fa0/2	Use for desktop computer and wireless devices in classroom
43	SENSOR_FL4	Fa0/3	Use for sensors

Floor 5

VLAN	Name	Port	Function
51	CAMERA_FL5	Fa0/1	Use for cameras
52	CLASSROOM_FL5	Fa0/2	Use for desktop computer and wireless devices in classroom
53	SENSOR_FL5	Fa0/3	Use for sensors

5.8. VLAN of Floor 6 and 7

Floor 6

VLAN	Name	Port	Function
61	CAMERA_FL6	Fa0/1	Use for cameras
62	CLASSROOM_FL6	Fa0/2	Use for desktop computer and wireless devices in classroom
63	SENSOR_FL6	Fa0/3	Use for sensors
64	COMPUTER_ROOM_FL6	Fa0/4	Use for desktop computer, wireless devices and AC equipment in classroom

Floor 7

VLAN	Name	Port	Function
71	CAMERA_FL7	Fa0/1	Use for cameras
72	CLASSROOM_FL7	Fa0/2	Use for desktop computer and wireless devices in classroom
73	SENSOR_FL7	Fa0/3	Use for sensors
74	COMPUTER_ROOM_FL7	Fa0/4	Use for desktop computer, wireless devices and AC equipment in classroom

6. ASSESSMENT

6.1. Features Testing

6.1.1. Ping between computers

Computers with same VLAN

From **PC_FL1_SR** (192.168.12.6) to **PC_FL1_LR** (192.168.12.3):

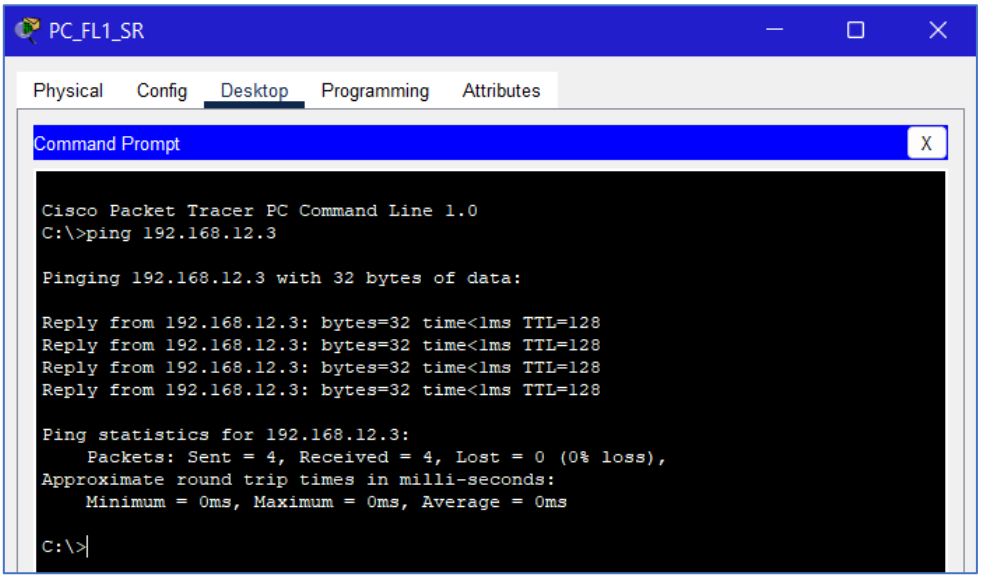

Figure 16. Ping computers with same VLAN through gateway.

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	PC_FL1_SR	PC_FL1_LR	ICMP		0.000	N	0	(edit)	

Figure 17. Ping computers with same VLAN directly.

Computers with different VLANs

From **Database_Server** (192.168.15.3) to **PC1_FL1_AR** (192.168.14.3):

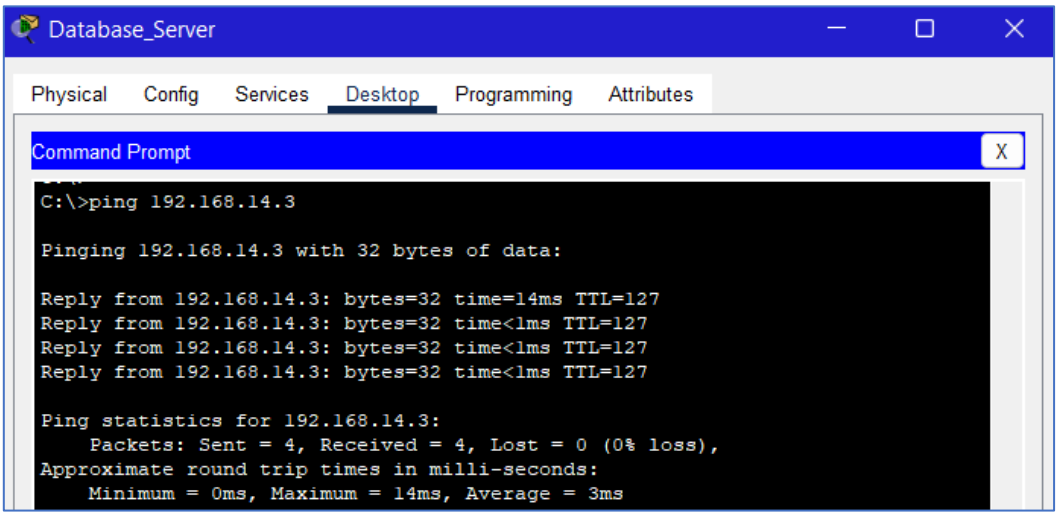

Figure 18. Ping computers with different VLANs through gateway.

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	PC_FL1_SR	PC_FL1_LR	ICMP		0.000	N	0	(edit)	
	Successful	Database_...	PC1_FL1_AR	ICMP		0.000	N	1	(edit)	

Figure 19. Ping computers with different VLANs directly.

Computers have inter-VLANs

From **PC_FL7_LR** (192.168.72.3) to **PC_FL2_LR** (192.168.22.5):

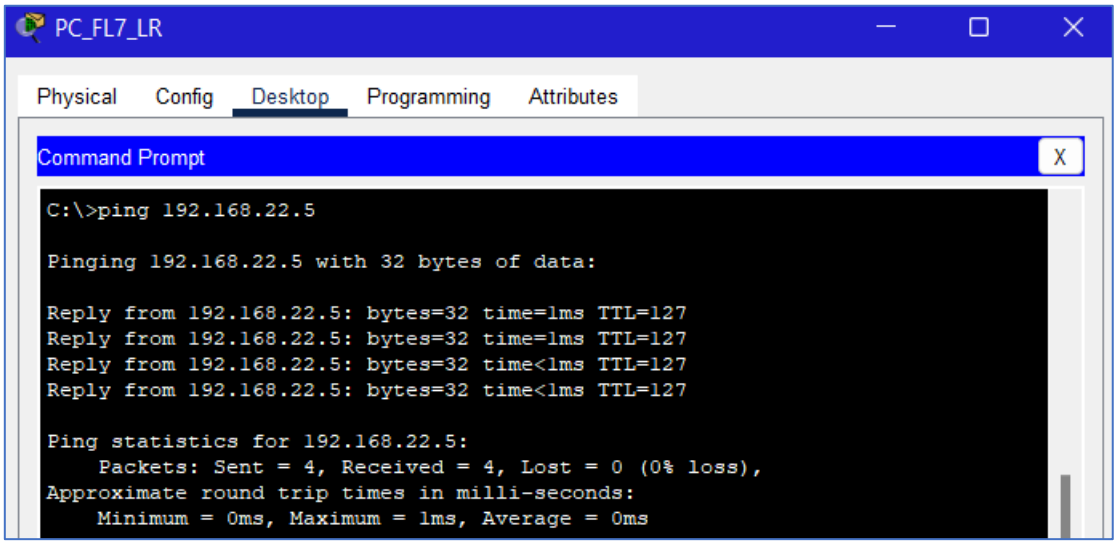

Figure 20. Ping computers have inter-VLANs through gateway.

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	PC_FL1_SR	PC_FL1_LR	ICMP		0.000	N	0	(edit)	
	Successful	Database_...	PC1_FL1_AR	ICMP		0.000	N	1	(edit)	
	Successful	PC_FL7_LR	PC_FL2_LR	ICMP		0.000	N	2	(edit)	

Figure 21. Ping computers have inter-VLANs directly.

6.1.2. Security

To ensure the security of the system, we need to consider 3 things:

– Only computers from the admin room and the server can access the cameras.

– Only computers from the administrative office can access the server.

– Computers and equipment in classrooms cannot access cameras, computers at administrative office or server.

An ***access−list*** is used at the multilayer switch to prevent unauthorized access disallow access and grant permissions for specific allowed accesses.

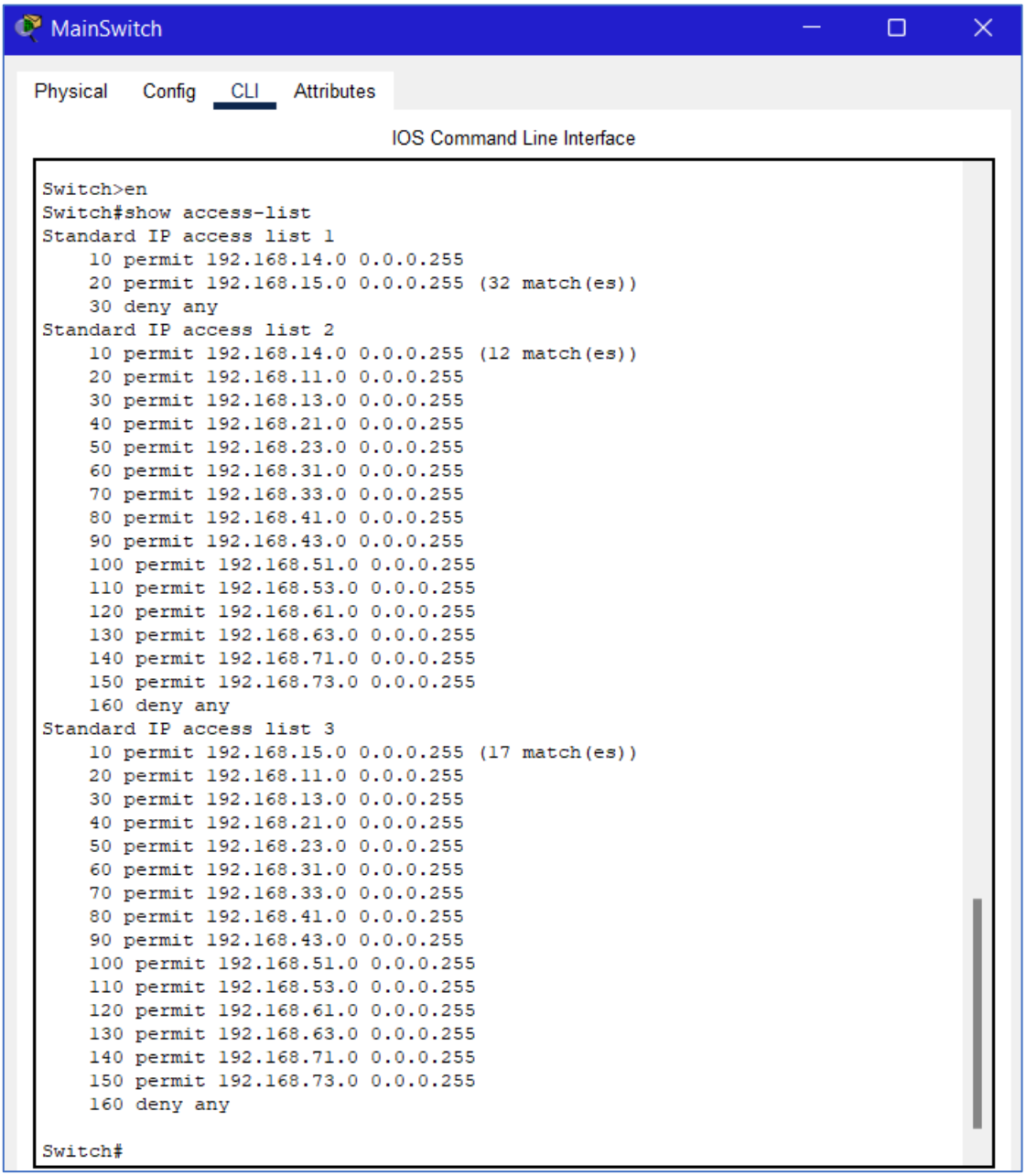

Figure 22. Access-list at multilayer switch.

No.	Target	Description
1	IoT Sensor	Computers in this address are allowed to access the IoTs sensor. Others will be denied.
2	Server	Computers in this address are allowed to access the server. Others will be denied.
3	Admin room's computers	Computers in this address are allowed to access the IoT sensors. Others will be denied.

6.1.3. Authenticate server and transmit data from camera & IoT sensors

6.1.4. Send and Receive emails

Mail_Server can be set up to enable sending email between admins in administrative office through *E-mail* feature. We will demonstrate with PC1_FL1_AR and PC2_FL1_AR.

1. Create account in Mail_Server's EMAIL service.

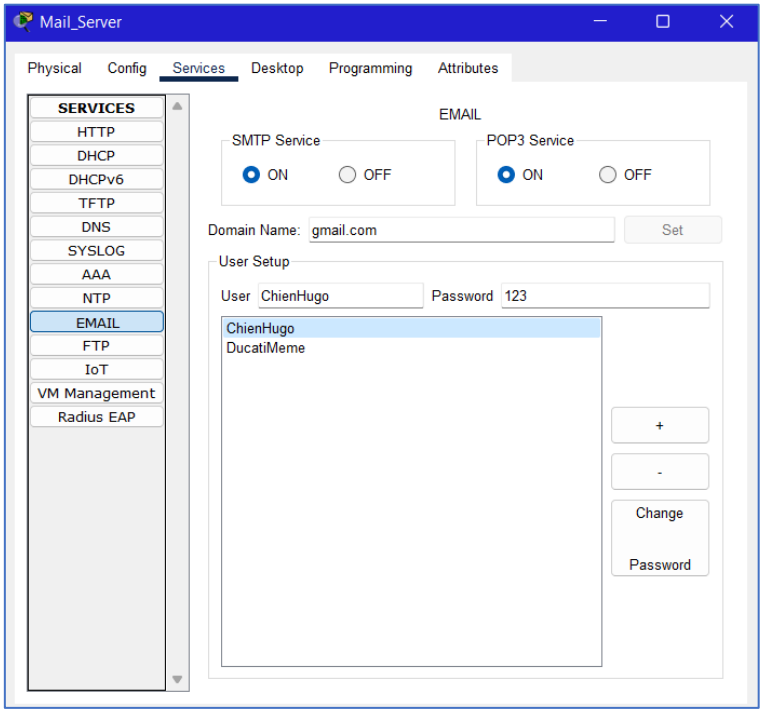

Figure 23. Create account in EMAIL service.

2. Open *Configure_mail* and register an email account.

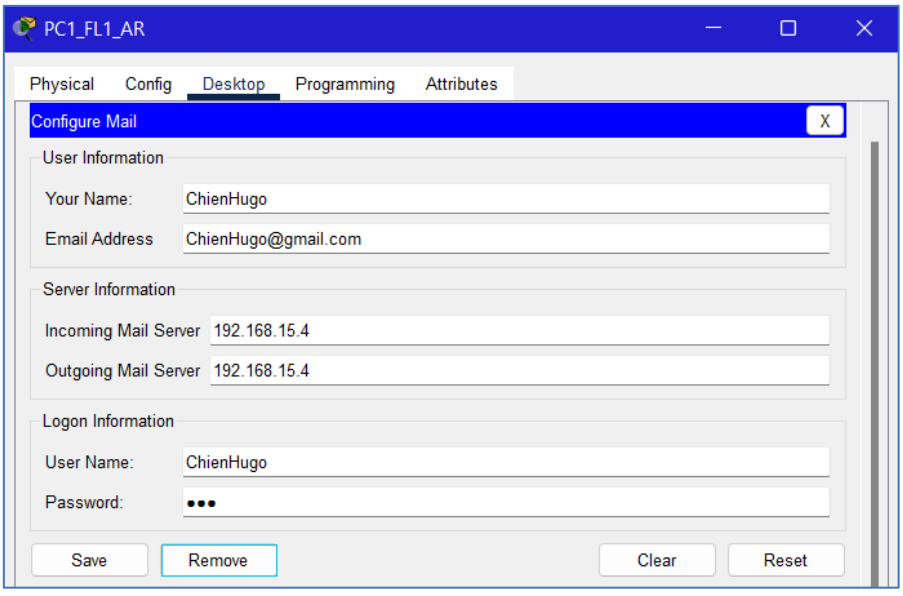

Figure 24. PC1_FL1_AR account.

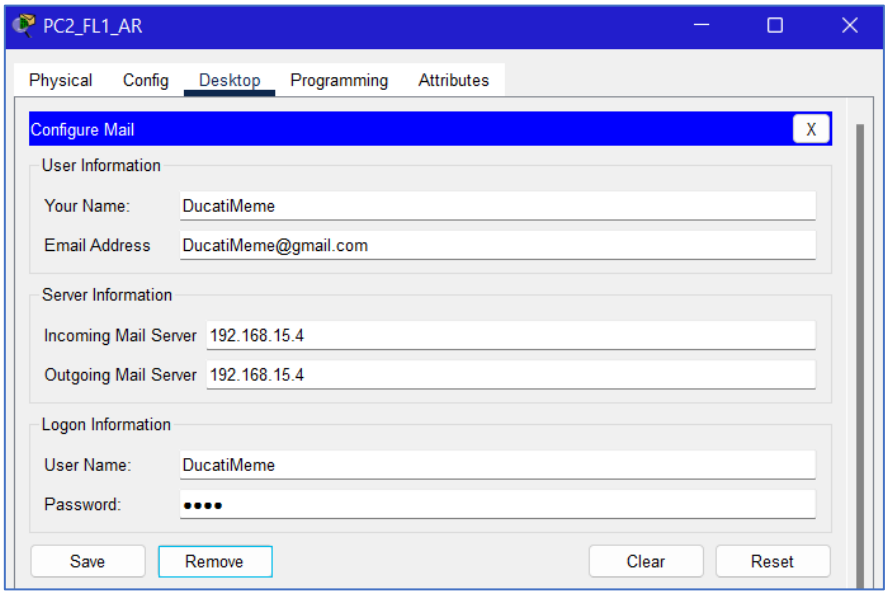

Figure 25. PC2_FL1_AR account.

3. Go to Mail_Browser and send an email to PC2_FL1_AR.

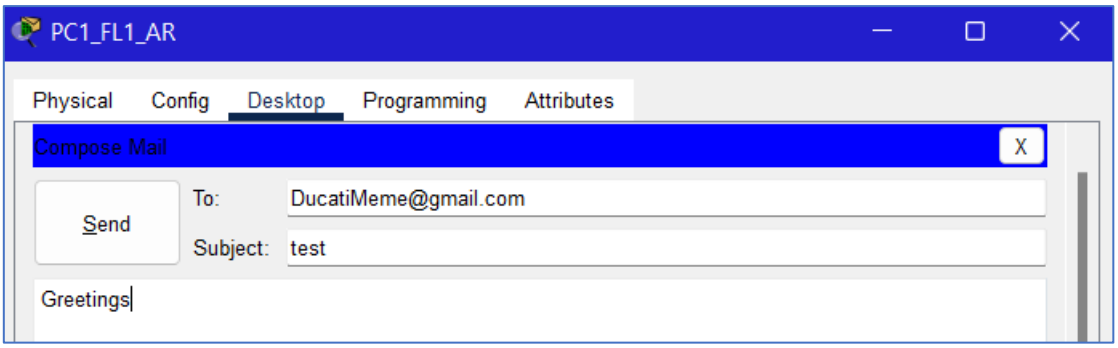

Figure 26. Write an email.

Figure 27. Email sends successfully.

4. Open Mail_Browser from PC2_FL1_AR to receive email.

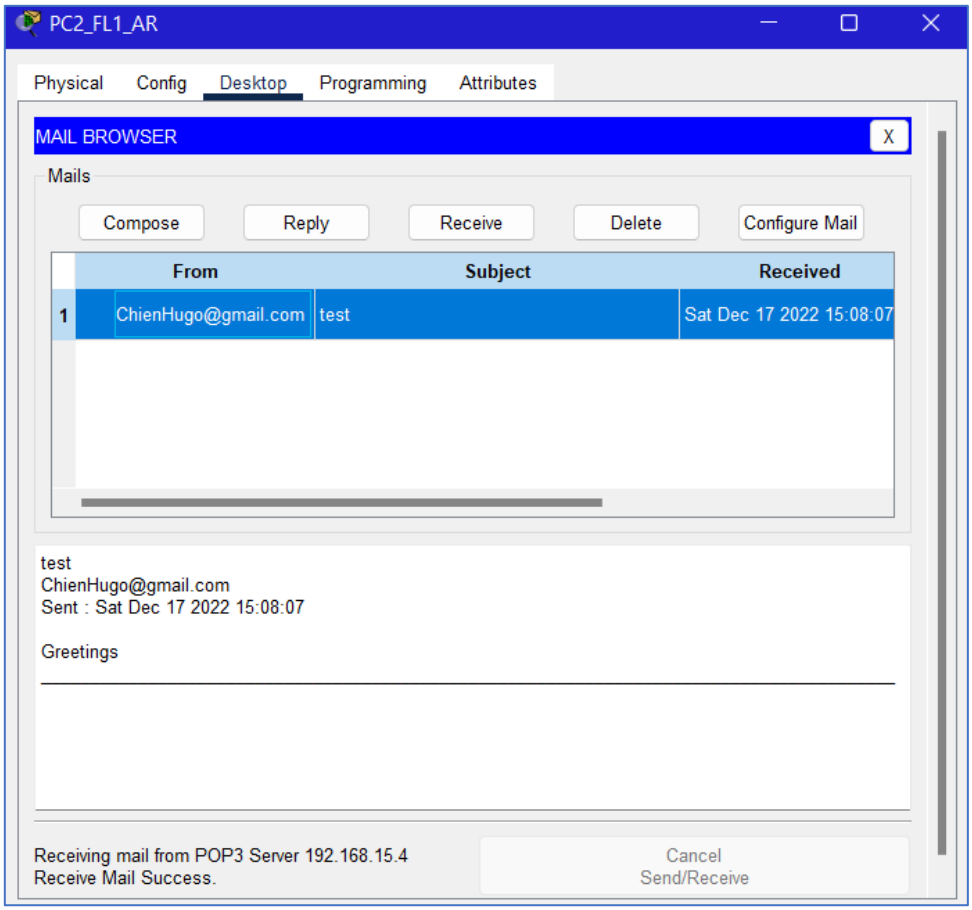

Figure 28. Receive email from PC1_FL1_AR.

6.2. Project Evaluation

6.2.1. Advantages

– VLANs are classified specifically for each layer for easy management.

– Ensure security for the access of cameras, IoT devices, servers, and administrative computers.

– Good scalability because of routing characteristic of multilayer switch.

– The selected devices ensure the required connection and bandwidth with appropriate cost.

6.2.2. Disadvantages

– There are specifications that can only be estimated (e.g. the length of cable used in one room).

– Some features have not been optimized due to practical experience limit.

– Lack of members result in incompleteness of product further development.

7. REFERENCES

Special thanks to the collaboration between Ignorant Spider and Team Khánh Duy in another class in charged by teacher Nguyễn Phương Duy.

Website:

1. community.cisco.com
2. thietbimangcisco.vn
3. cisco.com