**HO CHI MINH UNIVERSITY OF TECHNOLOGY**
**FACULTY OF COMPUTER SCIENCE & ENGINEERING**

# COMPUTER NETWORK

## ASSIGNMENT 2
## Design and build a system monitoring activities of students in the buildings and including measurement devices in building H6, HCMUT's campus 2

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**Class: CC02**

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## 1. 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 for the current building H6. Now, before getting into the requirements, our team needs to note that:

- To make the design more practical and suitable for real-life purposes, much information had been confirmed by the computer network tutor and moreover, our own team had also added some trivial details in order to make the assignment logically work in real life.
- Actual data of this assignment is gathered from the actual tutor's knowledge about building H6 and our own research for devices, and materials that were used to build the network design.

## 2. Request

The Consultants will provide specific designs that the construction people can rely on it to implement the building H6. To convince the investors to choose their solutions, the consultants should also analyze the data in order to demonstrate the reasonableness of solutions. Specifically:

- Network architecture of the system in building H6 and the IP settings for this network.
- Based on the architecture above, calculate the division of subnets for each target device or divide by departments.
- Capacity needed to ensure the system operates efficiently
- The system of switches, routers, and cost estimates
- Line speed internet connections

## 3. VLAN List

| vlan | Location | IP address | IP start | IP end |
|---|---|---|---|---|
| vlan 10 | Floor 1 | 192.168.1.0/24 | 192.168.1.1 | 192.168.1.254 |
| vlan 20 | Floor 2 | 192.168.2.0/24 | 192.168.2.1 | 192.168.2.254 |
| vlan 30 | Floor 3 | 192.168.3.0/24 | 192.168.3.1 | 192.168.3.254 |
| vlan 40 | Floor 4 | 192.168.4.0/24 | 192.168.4.1 | 192.168.4.254 |
| vlan 50 | Floor 5 | 192.168.5.0/24 | 192.168.5.1 | 192.168.5.254 |
| vlan 60 | Floor 6 | 192.168.6.0/24 | 192.168.6.1 | 192.168.6.254 |
| vlan 70 | Floor 7 | 192.168.7.0/24 | 192.168.7.1 | 192.168.7.254 |
| vlan 80 | Camera | 192.168.8.0/24 | 192.168.8.1 | 192.168.8.254 |
| vlan 90 | Administrative | 192.168.9.0/24 | 192.168.9.1 | 192.168.9.254 |
| vlan 100 | server | 192.168.10.0/24 | 192.168.10.1 | 192.168.10.254 |
| vlan 110 | computer room | 192.168.11.0/24 | 192.168.11.1 | 192.168.11.254 |
| vlan 120 | air conditioner | 192.168.12.0/24 | 192.168.12.1 | 192.168.12.254 |

## 4. Structure of the bulding

There are 8 switches for Administrative Office and 7 floors, the core switch is on the 1st floor. Each floor has 9 rooms so there are 9 access points, one for every floor. On every floor, there are also 4 cameras through the corridor. There are 4 types of room:

- Small room: area < $60m^2$, each has 3 temperature sensors, 3 light sensors
- Large room: area > $60m^2$, each has 6 temperature sensors, 6 light sensors
- Server room: area < $60m^2$, each has 3 temperature sensors, 3 light sensors, 2 servers
- Computer room: area > $60m^2$, each has 6 temperature sensors, 6 light sensors, 32 computers

On the 1st floor, there is a device which is directly connected to server. 1st floor has got 6 small rooms, 3 large rooms and 1 server rooms.

From 2nd to 5th floor, there are 6 small rooms and 3 large rooms each floor

6th and 7th floor have 4 small rooms, 2 large rooms and 3 computer rooms, each room also has 1 atr conditioner.

## 5. List of equipment and cost estimation

| Area | Equipment | Quantity (units) | Unit price (USD) | Amount (USD) | Amount per area (USD) |
|---|---|---|---|---|---|
| Admin | Switch - 3560 | 1 | $1,500 | $1,500 | $11,500 |
| | PC | 10 | $1,000 | $10,000 | |
| Floor 1 | Laptop | 20 | $1,000 | $20,000 | $28,900 |
| | Light | 39 | $40 | $1,560 | |
| | Temperature monitor | 39 | $40 | $1,560 | |
| | Access point | 10 | $20 | $200 | |
| | Server | 2 | $2,000 | $4,000 | |
| | Switch | 1 | $1,500 | $1,500 | |
| | Webcam | 4 | $20 | $80 | |
| Floor 2 | Laptop | 18 | $1,000 | $18,000 | $22,640 |
| | Light | 36 | $40 | $1,440 | |
| | Temperature monitor | 36 | $40 | $1,440 | |
| | Access point | 9 | $20 | $180 | |
| | Switch - 2960L | 1 | $1,500 | $1,500 | |
| | Webcam | 4 | $20 | $80 | |
| Floor 3 | Laptop | 18 | $1,000 | $18,000 | $22,640 |
| | Light | 36 | $40 | $1,440 | |
| | Temperature monitor | 36 | $40 | $1,440 | |
| | Access point | 9 | $20 | $180 | |
| | Switch - 2960L | 1 | $1,500 | $1,500 | |
| | Webcam | 4 | $20 | $80 | |
| Floor 4 | Laptop | 18 | $1,000 | $18,000 | $22,640 |
| | Light | 36 | $40 | $1,440 | |
| | Temperature monitor | 36 | $40 | $1,440 | |
| | Access point | 9 | $20 | $180 | |
| | Switch - 2960L | 1 | $1,500 | $1,500 | |
| | Webcam | 4 | $20 | $80 | |
| Floor 5 | Laptop | 18 | $1,000 | $18,000 | $22,640 |
| | Light | 36 | $40 | $1,440 | |
| | Temperature monitor | 36 | $40 | $1,440 | |
| | Access point | 9 | $20 | $180 | |
| | Switch - 2960L | 1 | $1,500 | $1,500 | |
| | Webcam | 4 | $20 | $80 | |
| Floor 6 | Laptop | 18 | $1,000 | $18,000 | $25,370 |
| | Light | 24 | $40 | $1,680 | |
| | Temperature monitor | 24 | $40 | $1,680 | |
| | Access point | 9 | $20 | $180 | |
| | Switch - 2960L | 1 | $1,500 | $1,500 | |
| | Webcam | 4 | $20 | $80 | |
| | Air conditioner | 9 | $250 | $2,250 | |
| Floor 7 | Laptop | 18 | $1,000 | $18,000 | $25,370 |
| | Light | 24 | $40 | $1,680 | |
| | Temperature monitor | 24 | $40 | $1,680 | |
| | Access point | 9 | $20 | $180 | |
| | Switch - 2960L | 1 | $1,500 | $1,501 | |
| | Webcam | 4 | $20 | $80 | |
| | Air conditioner | 9 | $250 | $2,250 | |
| | | | | | **Total: $181,700** |

## 6. Calculation of storage capacity and network capacity

A sensor will measure a different index but their data format size is 32 KiB. Sensors will collect data for one minute once and after 5 minutes they send this data to the central server over the WIFI network. Which means the server room in 106 H6 will receive this data every 5 minutes. Due to that fact, this type of device must be able to be connected from the server room.

The operation system of 24/7 surveillance cameras 1 will store the data directly on a central server with a data transfer rate of 100 Mbps.

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. At each operating spread on each floor will be fitted 4 surveillance cameras.

Floors 2 to 5 will have only a normal room with 6 small rooms (Height: 3m, Width: 10m, Depth: 5m), 3 large rooms (Height: 3m, Width: 20m, Depth: 5m). Floor 1 besides two types of rooms above will have 1 server room (Height: 3m, Width: 10m, Depth: 5m) so the total equipments IoT is (6 * 6 + 3 * 12) = 360.

Floors 6 and 7 will have 4 small rooms (Height: 3m, Width: 10m, Depth: 5m), 2 large rooms (Height: 3m, Width: 20m, Depth: 5m), 3 computer room (Height: 3m, Width: 20m, Depth: 5m) so the total equipments IoT is (4 * 6 + 2 * 12 + 3 * 13) * 2 = 174.

Total equipments IoT in H6: 360 + 174 = 534.

With 1 equipment:

- Transmission capacity: $32.24.60 = 46080\ Kb/day$
- Bandwidth: $\frac{46080}{24.\ 60.60} \approx 0.533\ Kbps$

With 534 equipments:

- Transmission capacity: $\frac{46080.534}{1024} = 24030\ Mb/day$
- Bandwidth: $\frac{24030}{24.60.60} \approx 0.278\ Mbps$

- The computers in the classrooms will download about 200MB per day (peak hours are 7:00 to 17:30).
- In floors 6,7 will have 6 computer rooms, each room will have 32 computers. Total 6 * 32 = 192.
- Peak hours are 7:00 to 17:30 so the total time is 17:30 – 7:00 = 10.5 hours.
- Bandwidth: $\frac{200.8.192}{10{,}5.60.60} = 8.127\ Mbps$
- Each device when connected to the WIFI network is used with 256 Kbps maximum speed in terms of time 7h30 to 17h30. Assume there is 50 devices connect the WIFI in peak hours. So that the bandwidth: 0.25 * 50 * 7 = 87.5 $Mbps$
- The Administrative office will have 10 computers. The computers download about 200MB per day (peak hours are 8:00 am to 11:40 pm, 13h to 16h30) and send 10 emails per day with a maximum capacity of 10 MB per email.
- Peak hours: (11:40 – 8:00) + (16:30 – 13:00) = 3 hours and 40 mins + 3 hours and 30 mins = 7 hours and 10 mins = $\frac{43}{6}$ hours.
- Total exchange data of 10 computers in the administration room = (200 + 10*10)*10 = 3000 Mb/day.
- Bandwidth: $\frac{3000.8}{\frac{43}{6}.60.60} \approx 0.93\ Mbps.$
- Each camera will have a data transfer rate of 1 Mbps
- The camera system will include 4 surveillance cameras on each floor. So the total cameras: 7(floors) * 4 = 28 cameras.
- Bandwidth: 28 * 1 = 28 Mbps.
- 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).

- Bandwidth: 10 * 10 = 100 Mbps.
- Bandwidth can reach the peak value is: $100 + 0.278 + 8.127 + 87.5 + 0.93 + 1 + 28 + 100 = 325.835\ Mbps$

## 7. Logic design by Packet Tracer

- 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 floor is the VLAN configuration and the system can connect to H6.

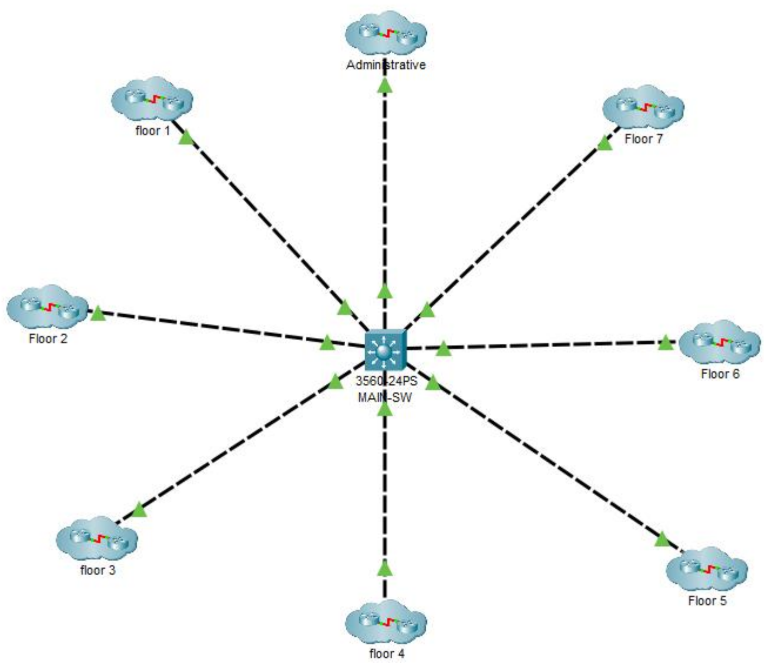


*Figure 1. An overview of the network*

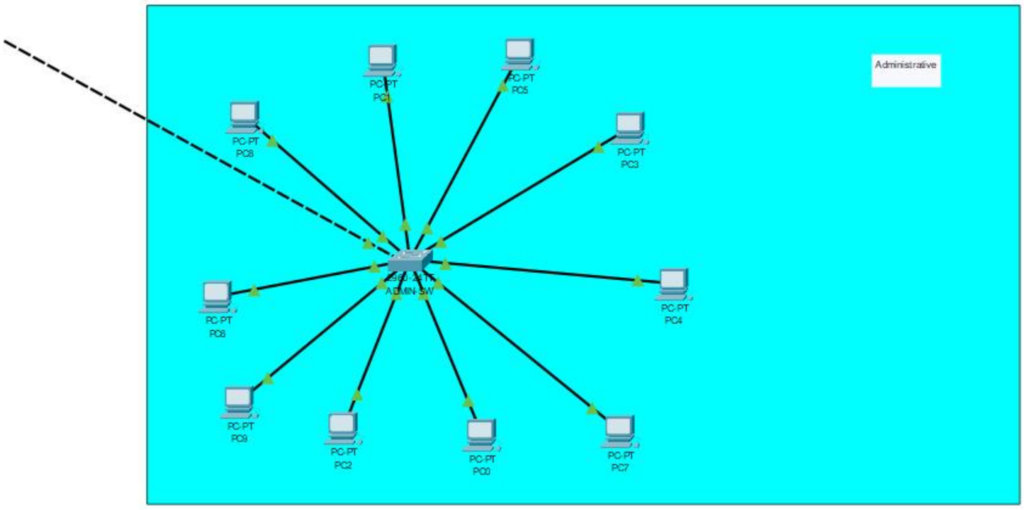


*Figure 2. Administrative Office*

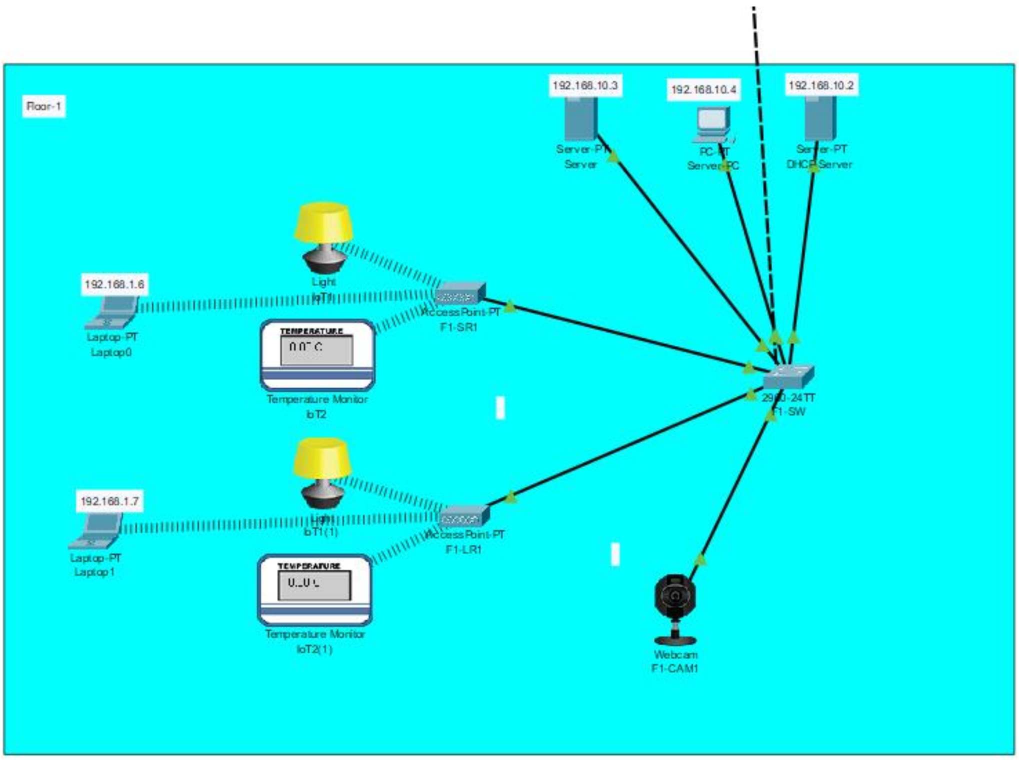


*Figure 3. Floor 1*

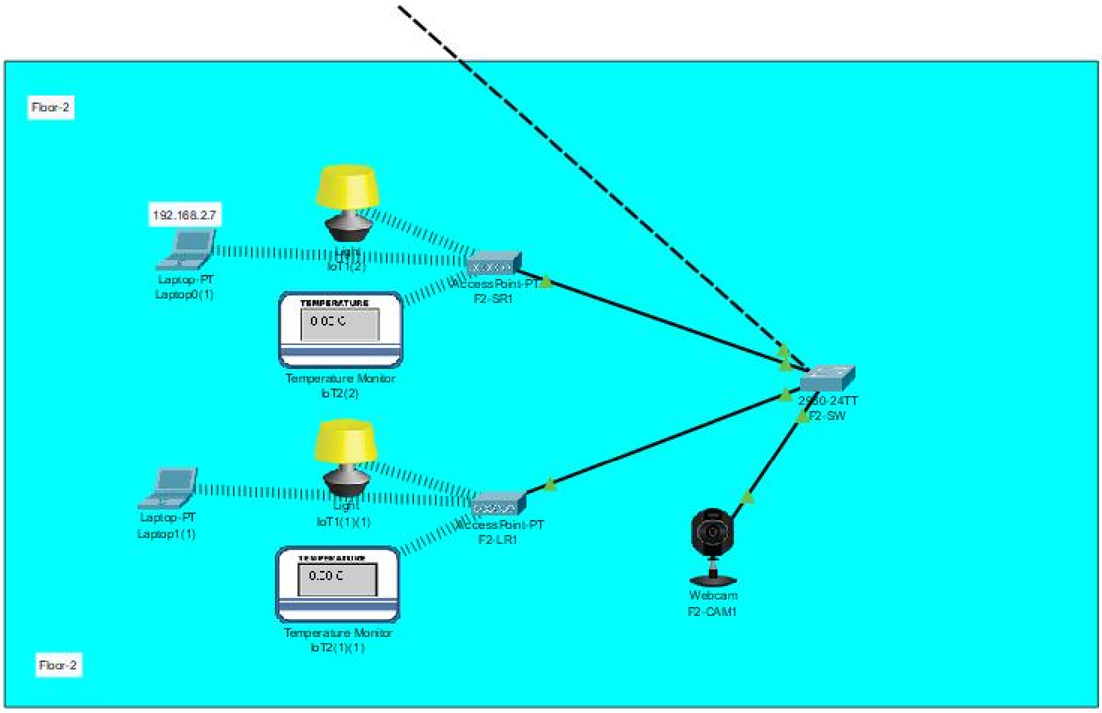


*Figure 4. A represent of Floor 2-5*

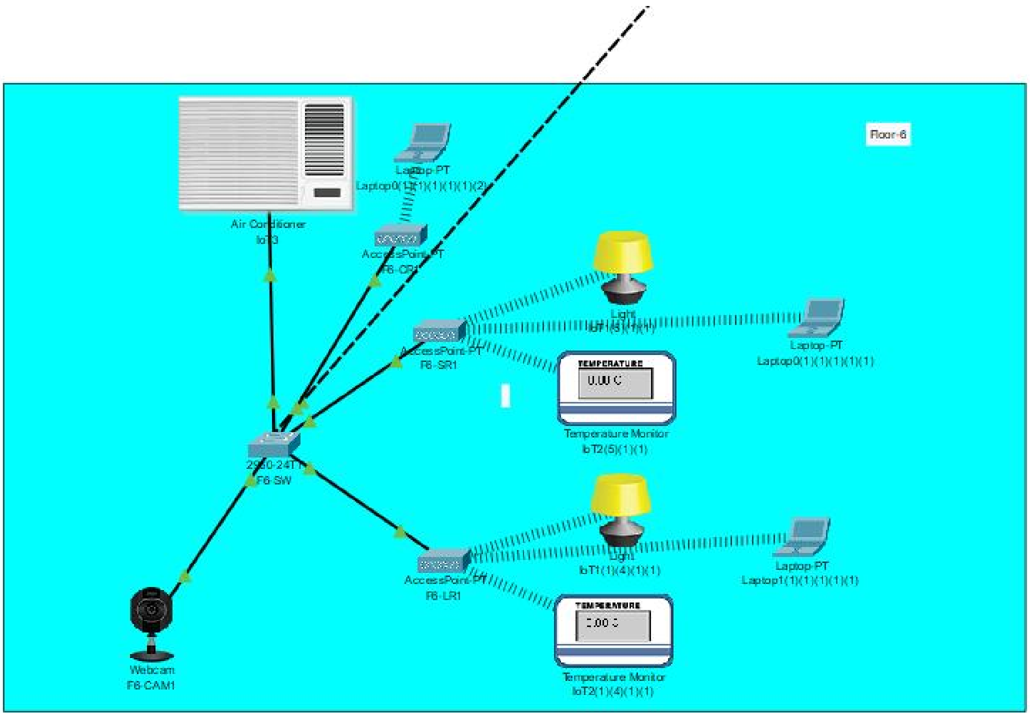


*Figure 5. A represent of Floor 6 and 7*

## 8. Ping

Delay calculation

First, we calculate the delay between the administrative room and the first-floor server. We conclude that the delay is less than 1ms between the devices

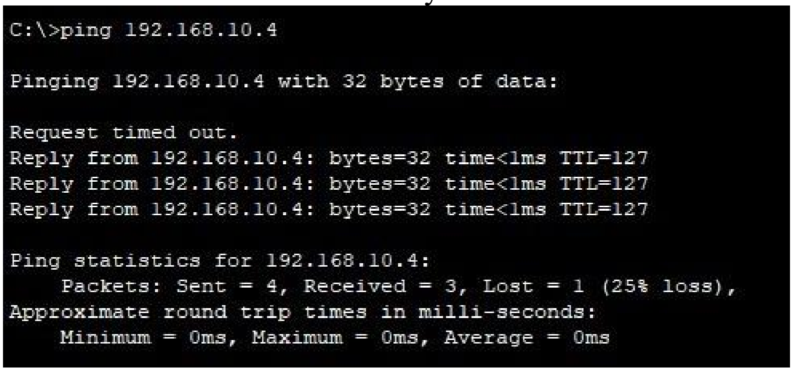


*Figure 6: Ping between PC0 on Admin and Server on Floor 1*

Later, we check out the delay between PCs in the Administrative room and conclude that the delay is less than 1ms.

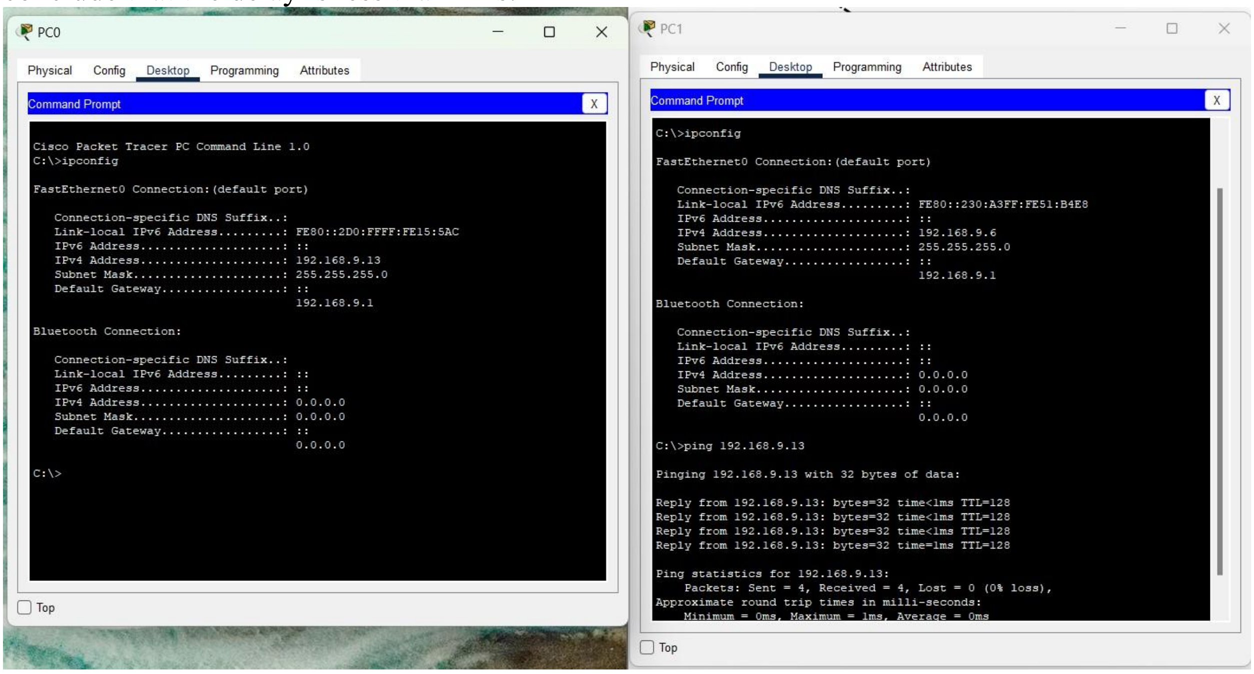


*Figure 7: The delay within PCs*

Therefore, we can assume based on the delay between the administrative room and floor 1 that serialization delay, propagation delay, queuing delay, forwarding/processing delay and shaping delay are negligible with the delay of less then 1ms

| | Administrative | Floor 1 | Floor 2 | Floor 3 | Floor 4 | Floor 5 | Floor 6 | Floor 7 |
|---|---|---|---|---|---|---|---|---|
| Administrative | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms |
| Floor 1 | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms |
| Floor 2 | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms |
| Floor 3 | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms |
| Floor 4 | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms |
| Floor 5 | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms |
| Floor 6 | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Floor 7 | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms | <1ms |

## 9. Pros and Cons of this design

*Advantages:*

- Low latency
- Expandability
- Secure
- Little to no maintenance

Disadvantages:

- High cost
- Require long set-up time between IP-cameras