CHAPTER 1

INTRODUCTION

1.1 Background of Study

Security cameras are predicted to be in operation for about 25 millions worldwide. [1]Some countries such as Great Britain are trying to cover places with cameras. The Privacy International CCTV stated that between 225 and 450 million Dollars are spent on surveillance technology in Britain per year, which involved an estimated of 300, 00 cameras. [2]Security cameras are used to monitor safety and security of the people as well as to deter the criminal activities. However, the security camera systems are not being implemented widely in universities. For example, San Francisco State University has formed a police patrol to protect the campus community from criminal activities which include the loss and damages of lab equipments. This would cost the university in terms of time and money to spend on replacing the stolen equipments. [3]

Cost and installation are the major drawbacks of having a security camera system. It takes a number of complex procedures in order to install one complete security camera system. First, the camera needs to be mounted to the nearby power supply. Then the supplied cable needs to be connected between the video outputs on the back of the DVR to the video input connector on the monitor. Then, few holes need to be drilled in order to route the wiring. [4]Besides of the complex installation, the cost of having a security camera is quite high. The price starts at no less than RM350 and can go up to over RM1300.[5]

Therefore, this project will introduce an alternative method to build a more flexible, portable and affordable security camera system by using a Power Line Communication (PLC). The proposed system will be introduced by focusing on the security systems in Communication Labs in Building 22, UniversitiTeknologiPetronas (UTP).

1.2 Problem Statement

1.2.1 *Problem Identification*

The security camera surveillance is not widely used in most of the universities in Malaysia. The function of this system is not only limited to monitor safety and security of the students but it also helps to prevent losses and damages of the lab equipments. A number of cases had been reported in which related to theft of lab equipments and computers. [6]

In this case, UniversitiTeknologiPetronas (UTP) will be the main subject since not all the labs and buildings in UTP are equipped with security and monitoring system. An improvisation of UTP security system is needed by introducing alternative devices such as Power Line Communication (PLC) and IP Camera.

The current security system in the market is very expensive and it has to go through a complex installation process in order to set up the system. This project was meant to design a security camera system which focused on avoiding the high cost of installing the wired security camera system and at the same time to analyze the performances of the system in comparison of the limitation that most of the security camera system have in market today.

1.2.2 *Significance of the Project*

The alternative device to implement the security camera system in UTP is very attractive due its expected low cost in mass production, and its simplicity in using existing power wires as communication media. [7]

The system will help to improve the current security in the building by monitoring the main areas, to record any events, and to deter the criminal activity. By using power line as a major focus in this project, it is believed that the PLC networking is viable not only for the access network but also for the in-building network. The PLC has a big potential to succeed in the in-building networking area due to the fact that electrical wiring is available in most buildings and various application devices can be easily networked via PLC network.

1.3 Objective and Scope of the Project

1.3.1 *Main Objective*

The objectives of this project are to study and design the architecture of the security camera system by using the PowerLineCommunication (PLC). The study of the system will investigate the performances and analysis of the data rate, image quality, average time response and the effect of the length of the wire cable to the data rate of connection. The current security technology which uses wireless system tends to create problems such as limited range, weak wireless signals and cannot penetrate the thick concrete wall. [8] Besides that, it can be interfered by other devices operating in the same unlicensed such as Bluetooth, microwave ovens as well as harmonics from other equipments. [7]In this context, an alternative method of using PLC is introduced.

The sub objective of the project is to design a security camera system in Building 22, UTP by using the suggested system.

1.3.2 *Scope of the Project*

This project is focused on the architecture of the security camera system in Building 22, Electrical and Electronics Department, UniversitiTeknologiPetronas. The camera is located in Design and Project Laboratory 1, at the first floor of Building 22. The proposed captured frame is 24 hours of duration. The findings of the PLC technology usage will be further discussed in this project.

The equipments which will be used in this project are listed as the following:

I. TP-LINK, 200Mbps Powerline Ethernet Adapter, Model No TL-PA201
II. Net Gear Prosafe Dual Band Wireless Access Point, Model No.WAG102, with Frequency rate of 2.4 GHz and 5.0 GHz
III. TP-LINK Surveillance Camera, Model No TL-SC3130G with wireless 2 way audio camera.

1.4 Relevancy of the Project

The project explained the idea of having an alternative device to implement a security camera system in UTP. The security camera surveillance system by using PLC in Building 22 will help to monitor the security in the lab as well as to prevent from any loss and damages of the lab equipments.

Since wireless signal can easily get interfered by other operating devices such as Bluetooth and microwave, PLC technology is very useful and applicable to be located in the Communication Labs in Building 22.

Other than that, this project can be an initial research for the future smart-building architecture system as well as an early platform for the future students to do more investigation related to the usage of the PLC technology.

1.5 Feasibility of the Project

The project will be done in two semesters which include three areas; research, development and improvement. The objective is to introduce an alternative device to implement a security camera system in Building 22, UTP. The equipments and hardware will be tested in the Design and Project Laboratory 1 and the value of several parameters will be taken throughout the experiments. Based on the description, it is clear that this project will be feasible to be carried out within the time frame.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of the security camera system using Powerline Communication (PLC) device

In the world of Information Technology, it focuses on creation as well as the spreading of information. In order to reach the end users for the provision of information, the popular technologies currently being used are include telephone wires, Ethernet cabling, fiber optic, wireless and satellite technologies. However, each has its limitations; such as cost and availability to reach the maximum number of users. [9]

In this project, Power Line Communication is introduced as an alternative device to be used in the security camera system. The overview of the security camera system using PLC device is illustrated as Figure 1.

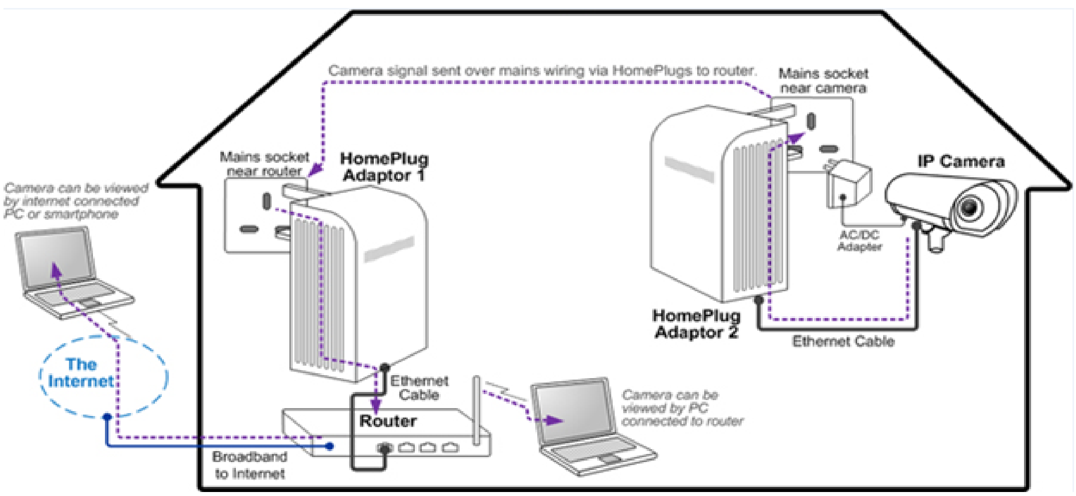

Figure 1: Overview of the system security camera system using PLC device [10]

The PLC adaptor is plugged into a main socket near to the router and the Ethernet cable is connected to the PLC adapter near to the router. The second PLC adaptor is then plugged into a main socket near to the IP Camera and the Ethernet Cable is connected from the PLC adaptor to the camera's Ethernet connector. [10]

Signals from the camera will be sent to the router via the connected PLC adaptor so that the camera can be seen from any laptop connected to the router or from the remote laptop connected to the router via the internet. [11]

2.2 Power line Communication (PLC) technology and device

The Power Line Communication technology has matured in the last few years in terms of communication speed and reliability in such to an extent that it has become a method of choice in many applications. Power line was originally devised to transmit electric power from a small number of sources (the generators) to a large number of sinks (the consumers) in the frequency range of 50-60Hz. [12] In the recent event, PLC technology, for example HomePlug AV could manage a peak rate of 200Mbps and traded on the ability to cope with video and voice. [13]

In order to provide interoperability between consumers,Homeplug standard strives by setting out a media access control (MAC) protocol and the physical signaling techniques to be used by the devices. It allows multiple devices to be connected to the network within the building. It also controls the specification includes data encryption levels, priority communications and latency control. [14]

Table 1 provides an overview of PLC technologies, comparing listed PHY speeds and the measured MAC speeds.[13]

Table 1: Overview of PLC technologies [13]

Technology	PHY Bit rate (Ideal)	Modulation	MAC Data rate (Empirical)	Standard/ Propriety	Application Space
X10	20 bps	ASK	N/A	Standard	Basic Home Control
Insteon	2,880 bps	BPSK	N/A	Propriety	Basic Home Control
Ariane	30 kbps	FSK	N/A	Propriety	Building Control
HomePlug 1.0	14 Mbps	OFDM	1-5 Mbps	Standard	IPoP
HomePlug AV	200 Mbps	OFDM	45 –80 Mbps	Standard	IPoP

This project will prove that PLC is a promising technology for networking which could transform all power outlet sockets in the building into broadband connections not only for security purposes but for other electric appliances. In most cases, developing a building networking by using the existing electrical wiring is easier than trying to run wires, more secure and more reliable than radio wireless system such as 801.11b and it is relatively inexpensive as well. [15]

Figure 2 illustrates the concept of Powerline Communication (PLC) technology in a building.

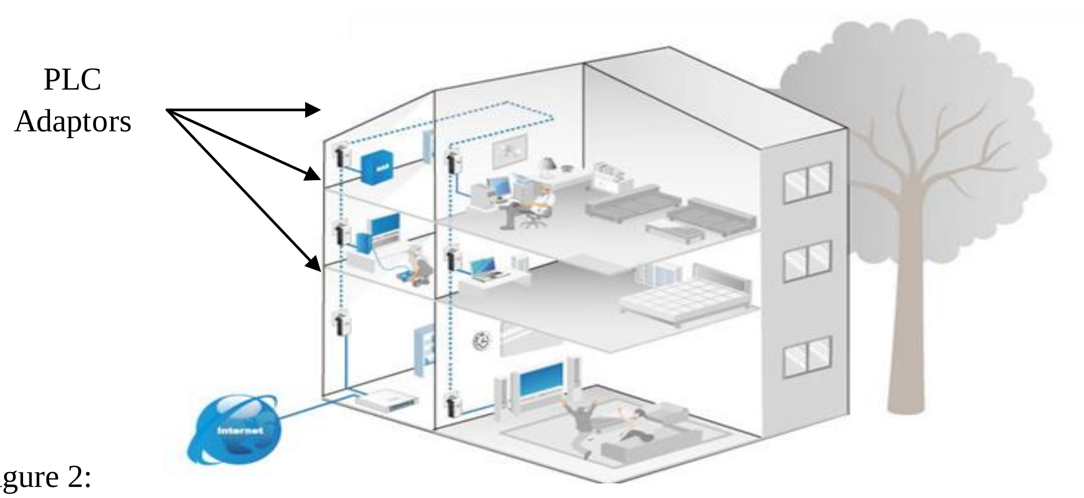

Figure 2:
Concept of PLC in a building [14]

2.3 IP Surveillance and NetworkCamera (Wired and Wireless)

The ability to monitor and record video or audio over an IP (Internet Protocol-based) computer network such as Local Area Network (LAN) or over the internet is the definition of IP Surveillance. It is a security system that involves the use of a network camera, a network switch, a PC/laptop for viewing, managing and storing video and video management software.[16]

The projectfocuses the implementation of a security camera system using both wired and wireless camera. The overall concept of this project can be narrowed down by connecting the wired cameras to the PLC adaptors inside the Communication Labs in Building 22 and the wireless cameras are located in other main parts of the buildings.

This network camera is a compression of chip, an operating system, a built-in web server, FTP (File Transfer Protocol) server, FTP client, e-mail client, alarm management and much more. In comparison of the current webcam, the cameras do not need to be attached to the PC/Laptop. It functions independently and connects directly to an IP network. [16]
The example of IP surveillance is shown in Figure 3.

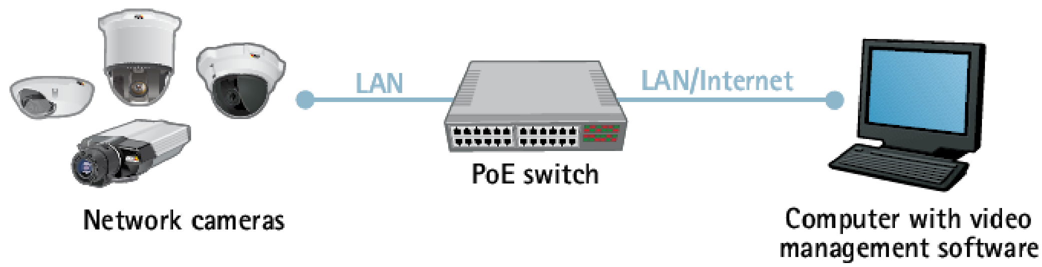

Figure 3: Example of IP Surveillance connection [16]

The standard analog video system that uses point-to-point analog cabling from the camera location to the monitoring place has numerous disadvantages to compare with IP surveillance. IP surveillance uses the IP network technology as the backbone of transporting the information and data. In this context, the digitized video or audio streams can be sent to any location via a wired or wireless IP network which lead to an enabling video monitoring and recording from anywhere with network access. [17]

Other than that, the IP cameras can work as a standalone surveillance system. In case the main controller fails, the surveillance subsystem will still work as it is directly connected to the internet router. The footage from the camera can be viewed from popular and standard web browsers. [8]

Thus, the person who is in charge of monitoring the system will be able to view the real-time video by using mobile phone or with an internet connected PC/laptop. This proved that the IP cameras are flexible and remote accessibility to compare with the traditional analog CCTV system, where the person in charge has to be in a specific, on site monitoring location to view and manage the video. [17]

Glasgow study found that statistics of the crime rate fell from 64 % to 60 % because of the usage of the low resolution model of cameras. [17] The image quality projected by the IP camera is also vital in this project. In 2007, a study of Britain's found that 80 % of CCTV in Britain footage is in poor quality. [17]

The difference of the image quality projected by IP camera and the low resolution camera is shown in Figure 4.

IP camera	Low resolution camera
	

Figure 4: Difference of the image quality between IP camera and Low resolution camera [23]

The IP cameras have distinct advantage because any transmitted digital images will be recorded without any necessary analog conversion inside the camera. Besides that, they do not suffer any loss of quality. [17] Thus, the blocky and blurry images are not a major problem anymore.

2.4 Wifi Router

A Wifi Router is a host (node) with more than one interface to network. It works in a network layer and in most basic form; it takes packets sent it on one interface (link), looks at its destination IP address and send it to the destination if it is directly accessible. [18]

Routers usually consist of several network interfaces to the attached network such as processing module, buffering module and an internal interconnection unit. Typically, the received packets are at an inbound network interface, processed by the processing module. The buffering module will stored the packets and forwarded them through the internal connection unit to the outbound interface. It later then transmit them to the final destination. [19]

2.5 The systems connections

In order to develop a security camera system, a step-by-step procedure is desired to ensure the equipments and hardware is working properly. Thus, a correct connection is needed to implement this structure.

The followings are the connections of the system:

2.5.1 Wifi Router broadcasting

A Wifi router is one of the major devices in this system. It functions to pass data between multiple networks and it works at "layer 3" which is Network Access Layer in the TCP/IP Layers and Protocols. Layer 3 in this context is concerned with access to and routing data across a network for two end system attached to the same network. [20]A router attempts to send its packet from the source to its final destination in the fastest way as possible. [21]
Figure 5 shows the connection of the Wifi Router.

Figure 5: Connection of Wifi Router [10]

In this project, a Wifi router is needed to receive signal and information from the camera and send them to the monitoring device, which can be a PC or a laptop.

2.5.2 The connection of Wifi Router and IP Camera

The connection of an IP camera and a PC/laptop can be done easily by connecting an Ethernet cable from IP camera to the laptop. The method is similar to the application of a webcam. The PC/laptop which attached to the camera can directly view the video. On the other hand, any PC/laptop that is connected to the internet via Wifi Router also has the accessibility to view the video. Figure 6 shows the connection of Wifi Router and IP Camera.

p Figure 6: Connection of Wifi Router and IP Camera [10]

2.5.3 The connection of PLC Adaptors

Each connection of the Power line Communication (PLC) adaptors to the laptop must be connected via Ethernet cable. The PLC adaptors use the electrical wiring in the building to create a network and send a data from one laptop to another laptop in another room without using any extra wires. This networking is based on the concept of no new wires. The convenience is obvious because the phone jack is not available in every part of the building but the electrical socket outlet is always available near a computer.

In this context, the data can be transmitted from one laptop to another laptop via power line.In comparison to the wireless communication, PLC adapters is not suffering from radio interferences and it is more portable where it can be removed from one room and installed into another room without much trouble. [7]

Figure 7 shows the connection of two PLC Adaptors.

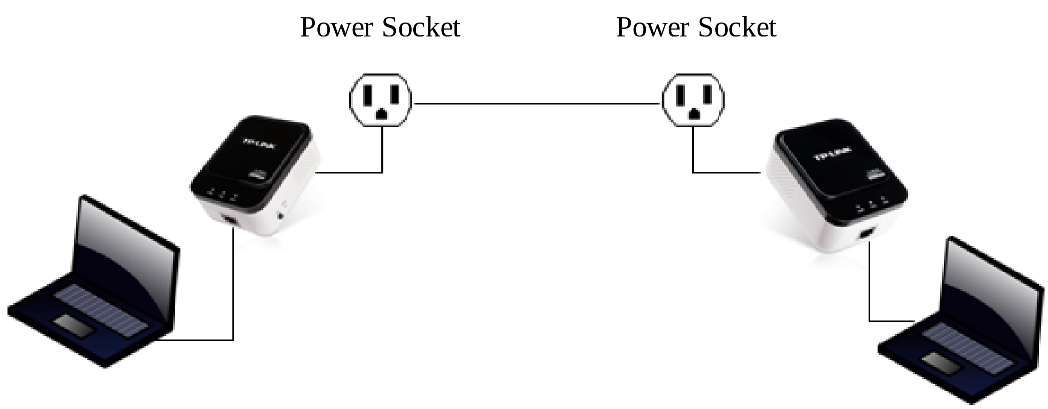

Figure 7: Connection of PLC Adaptors [10]

2.5.4 The connection of Wifi Router and PLC Adaptors

PLC adaptor A is connected to the router where it will broadcast an internet and on the other hand, PLC adaptor B is connected to the laptop. This connection would allow the laptop to access to the internet without connecting it to the router. Other than that, the laptop which is located near to the router can also be access to the internet.

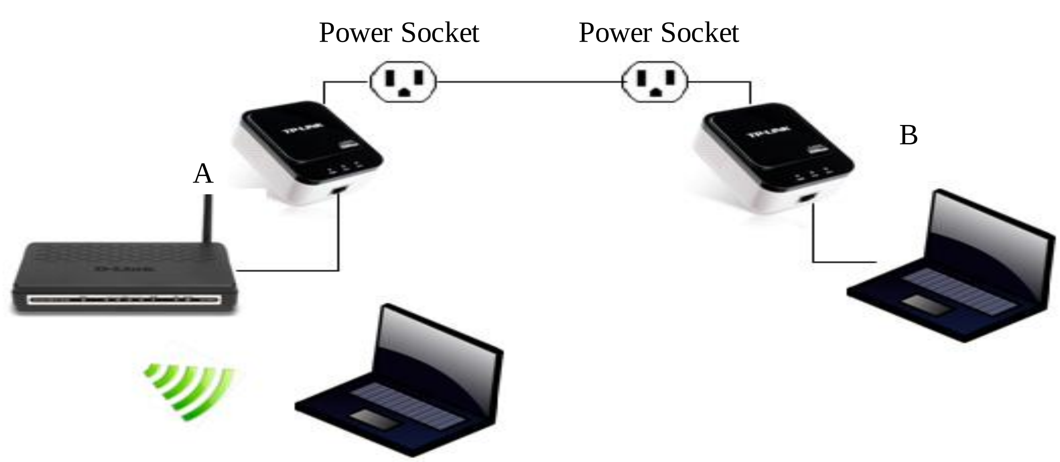

Figure 8: Connection of Wifi Router and PLC Adaptors [10]

2.5.5 The connections of Wifi Router, PLC Adapters and IP Camera

The camera records its video and sends the video signals via the power line adaptor to a master device, which is the laptop.[11] The laptop which is connected to the internet can access the net to view the video, at any place as long as it is accessible to the internet. Figure 9 shows the connection of Wifi Router, PLC Adaptors and IP Camera.

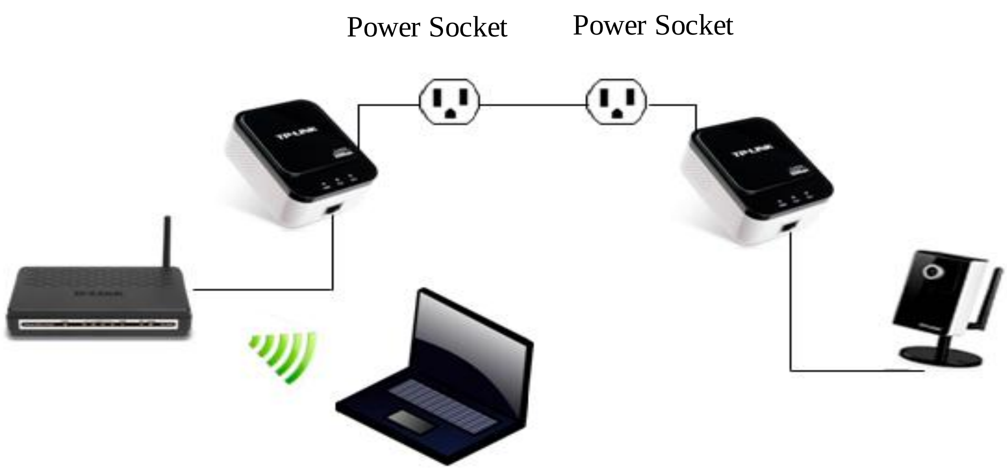

Figure 9: Connection of Wifi Router, PLC Adaptors and IP Camera [10]

2.6 The electrical power distribution in a building

The electrical power distribution systems commonly encountered in residential, commercial and industrial buildings. [24] The one-line diagram shows the electrical connections of the electrical connection systems components, ratings and type of over current protection devices. An example of one line diagram for a commercial building is shown in Figure 10. [25]

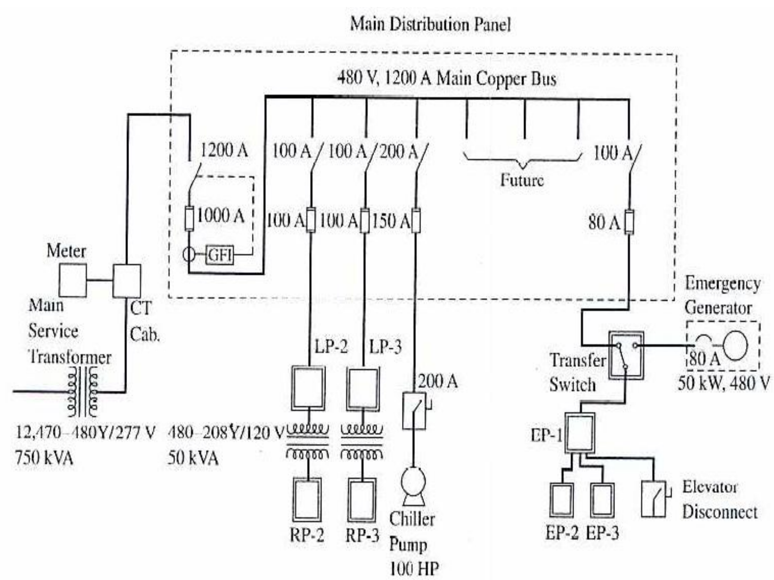

Figure 10: One-line diagram of Commercial Building [25]

The electrical company in this example provides a 3-phase 480V main supply to the building. The input is fed into several different transformers depends on which logical and physical section of the building is being fed.

Besides that, there are several different system voltages that may be available for the power supply and these must be determined from the utility supplying the electric service. The common service voltages available are shown in Figure 11.

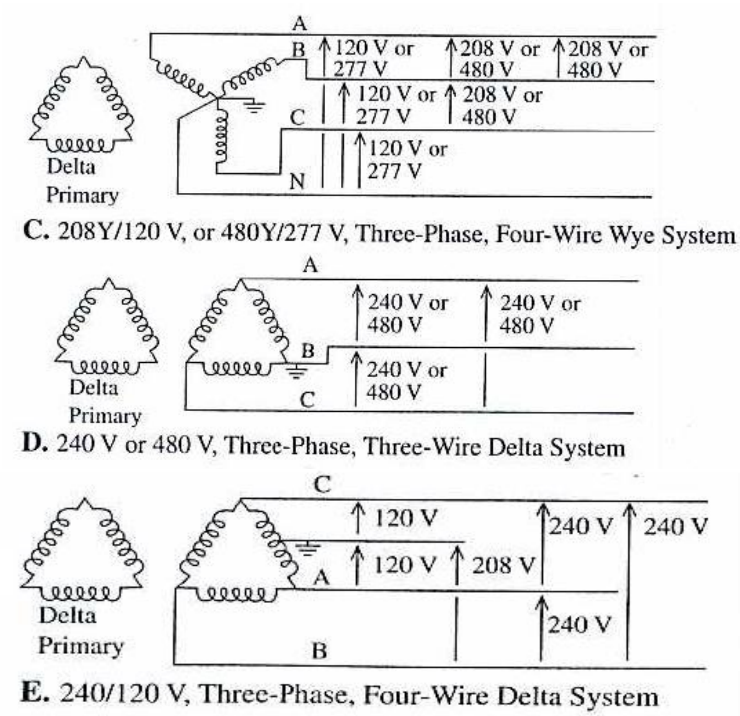

Figure 11: Common Service Voltages [25]

Focusing on 208/120V or 480/277 V, Three-Phase, Four-Wire Wye System as illustrated in figure above, the "outlet power" is fed by a 480 V/208 Y/120 V 3-phase transformer, which indicates 480 V to 208 Y Delta-Wye 3-phase transformers, with 120 V between each output phase and neutral. Each floor of the building is supplied with several transformers and each distribution transformer power two step-down transformers. [13]

In addition, each floor is divided into several "electricity isolated" regions. Every region has its own section and subsection whereby within subsection consists of node which represent 2 or 4 outlets on a wall somewhere in the building. If connection is made between two devices, nodes on the same electrical subsection are all capable of communicating with one another but node on different subsection will only sometimes capable of weak communication. [13]

2.7 Application Example

In this section, the selected papers that contain high citations will be reviewed. The selection of the papers is based on the objective itself which is the application of Power line Communication (PLC) in security camera system. The papers are listed as the following:

2.7.1 Power line Communication based Home Automation and Electricity Distribution System[8]

The aim of the paper is to design the next generation home automation system that used the power line communication (PLC) techniques. In this paper, the PLC is classified into two categories; narrowband PLC and broadband PLC. Narrowband PLC offers low data rates and is typically used for home automation and metering purposes. Broadband PLC is popularly used for home networking (LAN)

A large number of home automation solutions currently are PLC based. The sensors, controllers and actuators are connected to each other through the electrical wiring of the home. The concept of PLC based home automation is shown in Figure 12.

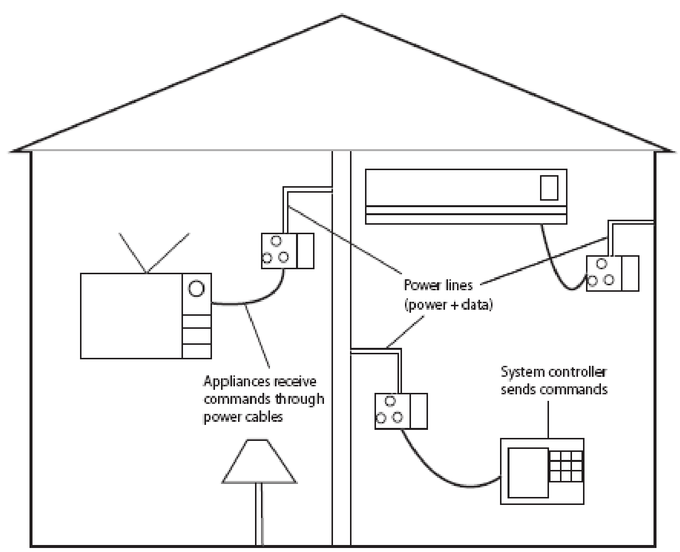

Figure 12: Example of home automation using PLC concept [8]

The concept of a "Smart Home" is the main focus and the applications of home automations such as heating ventilation and air conditioning (HVAC), lighting as well as safety and security are the application areas of home automation. The function of PLC in these applications gives huge advantage as it reduces re-wiring in house and the PLC adaptor can be removed from one home and installed into another without much trouble.

2.7.2 Broadband Power line Communications System [14]

The objective of the paper is to study the current status of broadband power line communication system and reports on the regulatory arrangement which is currently in place. It also elaborated on the overview of the system. The paper stated the applications of broadband power line communication system are fall into two broad categories; in house applications and last mile applications.

For in house applications, it occurs within a single building with both ends of the communications link within the same building. The path of the transferring the data within the building is relatively short which is less than 100m between devices. The broadband power line communication system is an attractive mean retrofitting the data services to the existing building because no additional wiring is needed. The networking of computers, printers and other telecommunication services can simply been access by plugging into the existing power supply socket.

On the other hand, the last mile applications include the distribution of internet and other services by broadband service suppliers to homes or offices. These broadband distribution systems are intended to also provide voice, video, surveillance system, entertainment and utilities metering (electricity, water, gas) services. The major proportion of cost to provide broadband service to the public is associated with the last mile connection between the network and the individual user.

The connection of the last mile application is shown in Figure 13.

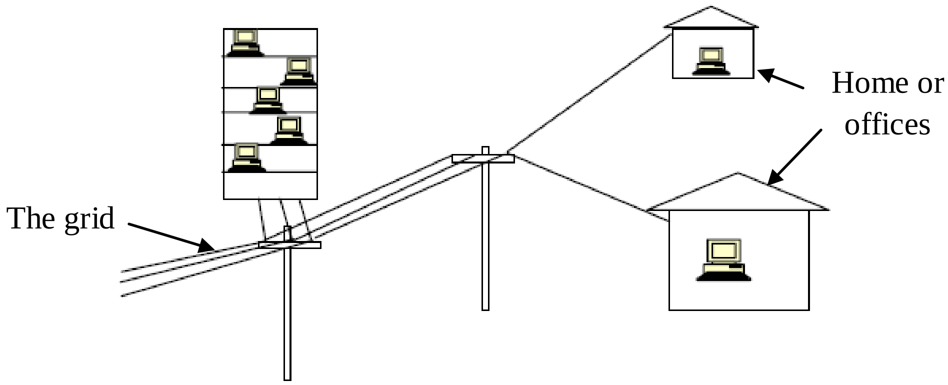

Figure 13: Connection of last mile application [14]

CHAPTER 3

SCOPE OF THE PROJECT

3.1 The Proposed Location.

The project focuses on the security camera system in Design and Project Laboratory, First floor, Building 22, UniversitiTeknologiPetronas. The building consists of several Communication Labs on the Ground Floor, First Floor and Second Floor. The lecturer rooms and meeting rooms are on the Third Floor. In order to design architecture of this system, the location of each room need to be considered.

In this case study, the application of PLC adapters will be used in the Design and Project Laboratory 1. The wireless communication in this context may not be suitable in every situation. For example, some frequencies of wireless communication can interfere with certain types of labs equipments in Communication Labs and the building structure may create dead zones that interfere with data transmission. [22]

3.2 PLC (Powerline Communication) Adaptor.

In the recent market, a number of PLC adaptors are being sold and TP-LINK 200MpsPowerline Ethernet Adaptor, TL-PA201 is chosen to be used in this project. Compliant with HomeplugAV standards, the TL-PA201 can share the network at speed of up to 200Mbps, together with built-in QoS. Moreover, it will automatically switch from its regular “working” power mode to “standby” mode when there is no Ethernet link, which reduces energy wasting for up to 65% when comparing to the adaptors. [10] Figure 14 shows the working mode and power saving mode.

Figure 14: Working mode and Power-saving mode [10]

3.2.1 The product specifications

Table 2 shows the specifications of the product:

Table 2: The specification of PLC adaptor [10]

HARDWARE FEATURES	
Standards and Protocols	HomePlug AV 200Mbps,IEEE 802.3,TCP/IP
Interface	10/100Mbps Ethernet Port
Plug Type	EU, UK, AU, US
Button	Pair Button Reset Button
Dimensions (W X D X H)	3.6×2.8×1.7 in.(92×70×44 mm)
Weight	125 Grams
LED Indicator	PWR, PLC, ETH
Power Consumption	< 4 W
Range	300M in house
SOFTWARE FEATURES	
Modulation Technology	OFDM
Advanced Functions	Build-In Qos Feature, Intelligent Channel Adaptation
Encryption	128bit AES
OTHERS	
Certification	CE, FCC, RoHS
Package Contents	200Mbps Powerline Ethernet Adapter, Ethernet cable (RJ45), Resource CD Quick Installation Guide
System Requirements	Windows 2000/XP/2003/Vista, Windows 7, Mac, Linux
Environment	Operating Temperature: 0℃~40℃ (32℉~104℉) Storage Temperature: -40℃~70℃ (-40℉~158℉) Operating Humidity: 10%~90% non-condensing Storage Humidity: 5%~90% non-condensing

3.2.2 The product features

1. No new wires and drilling required as it uses the existing electrical wiring to build the high speed network connection.
2. No setup or configuration required, simply “Plug and Play”.
3. Turn every power sockets into a LAN port.
4. Deliver up to 200Mbps over electrical wires.
5. Energy consumption is reduced by 65% in standby mode.
6. IGMP managed multicast IP transmission optimizes the performances of IPTV and VOD.
7. Up to 300 m range over the power circuit for better performance through walls or across floors.
8. 128-bis AES encryption at a push of “Pair” Button.
9. Built-in QoS assures the performance of VoIP/IPTV streaming and online gaming.

3.2.3 The diagram

Figure 15 shows the overview diagram of PLC usage in this project.

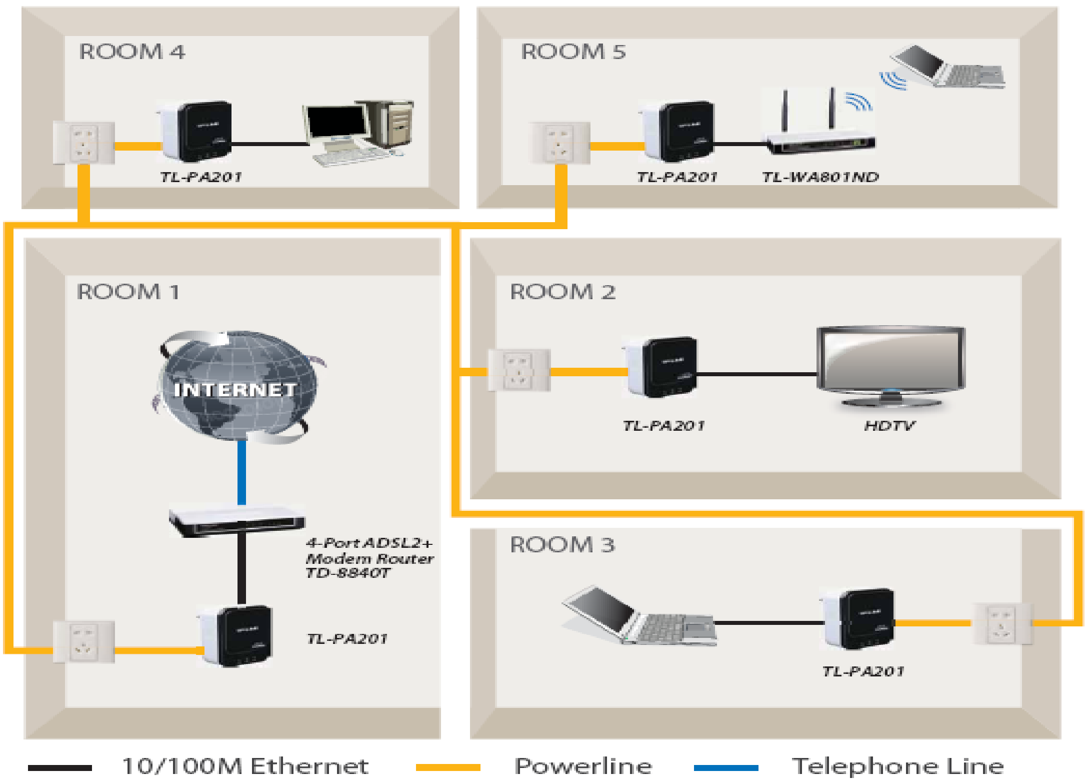

Figure 15: The overview diagram of PLC usage [10]

3.3 The Surveillance Camera

The chosen product for the surveillance camera in this project is TL-SC3130G surveillance camera. It is known as its versatility for home and office monitoring as it can be viewed and controlled from a Web browser, bundled software or compatible cell phone. The surveillance software coming with the IP camera can manage multiple cameras at the same time. The streaming video and audio can be archived straight to the hard drive, playback video and monitor up to 16 cameras on a single screen. In addition, the low-light-sensitive CMOS sensor on this camera can boost the performance greatly, providing good image quality.

3.3.1 The Product Specifications

Table 3 shows the specifications of the product used in this project.

Table 3: The specification of IP camera [26]

CAMERA	
Image Sensor	1/4" Progressive scan CMOS sensor
Lens	F: 2.0, f: 4.0mm
Viewing Angle	Diagonal 67°, Horizontal 53°, Vertical 40°
Digital Zoom	10x Digital
Minimum Illumination	0.5 Lux
VIDEO/IMAGE	
Video Compression	Motion JPEG; MPEG-4
Frame Rate & Resolutions	Up to 30(NTSC) / 25(PAL) fps at 640x480, 320x240, 160x120
Video Streaming	Simultaneous Motion JPEG and MPEG-4 (Dual streaming)
Image Settings	Rotation: Mirror, Flip, Mirror Flip brightness, contrast, saturation, hue Overlay capabilities: time, date, text and privacy image
AUDIO	
Audio Communication	Two-way (full duplex)
Audio Input	Built-in microphone
Audio Output	Audio line output connector for external speaker
Audio Compression	G.711 PCM, 8 kHz, 64 kbit/s

ALARM AND EVENT MANAGEMENT	
Events Trigger	Built-in motion detection, schedule
Notification Method	E-mail, FTP, HTTP

NETWORK	
Standards and Protocols	Bonjour, TCP/IP, DHCP, PPPoE, ARP, ICMP, FTP, SMTP, DNS, NTP, UPnP, RTSP, RTP, RTCP, HTTP, TCP,UDP, 3GPP/ISMA RTSP
Security	Multiple user access levels with password protection, HTTPS encryption

WIRELESS	
Wireless Data Rates	IEEE 802.11 b/g , Up to 54Mbps
Frequency	2.4-2.4835GHz
Wireless Transmit Power	<20dBm(EIRP)
Receive Sensitivity	270M: -68dBm@10% PER 130M: -68dBm@10% PER 108M: -68dBm@10% PER 54M: -68dBm@10% PER 11M: -85dBm@8% PER 6M: -88dBm@10% PER 1M: -90dBm@8% PER
Wireless Encryption	64/128/152-bit WEP / WPA / WPA2,WPA-PSK / WPA2-PSK

INTERFACES	
Network Interface	1 RJ- 45 for Ethernet 10/100 Base-T
Power Connector	DC power jack
Audio Output	3.5 mm jack for Speaker out
Button	Reset push button

SURVEILLANCE MANAGEMENT	
Users	5 simultaneous users Unlimited number of users using multicast
Bundled Management Software	Viewing and recording up to 16 cameras

MINIMUM SYSTEM REQUIREMENTS	
CPU	Pentium4 1.8GHz (or equivalent AMD)
Graphic Card	64MB RAM graphic cards (or equivalent on-board graphic cards)
Memory	512MB RAM
Supported Browser	Internet Explorer; Firefox; Chrome; Safari
Supported OS	Windows 98/ME/2000/2003/XP/Vista/7, Mac OS Leopard 10.5

3.3.2 The Product Features

1. Flexible placement as it featured with 54Mbps wireless connectivity.
2. MPEG-4/MJPEG dual streams can be used for simultaneous remote recording and local surveillance.
3. Frame rate at 30fps in VGA resolution (640 x 480) for smooth video.
4. The motion triggered e-mail to alert the update of the situation on the ground.
5. Clear and crisp images produced by ¼ inch progressive scan CMOS sensor.
6. 2-way audio which allow the user to talk and listen remotely.

3.3.3 The diagram

Figure 16 shows the overview diagram of IP camera usage in this project.

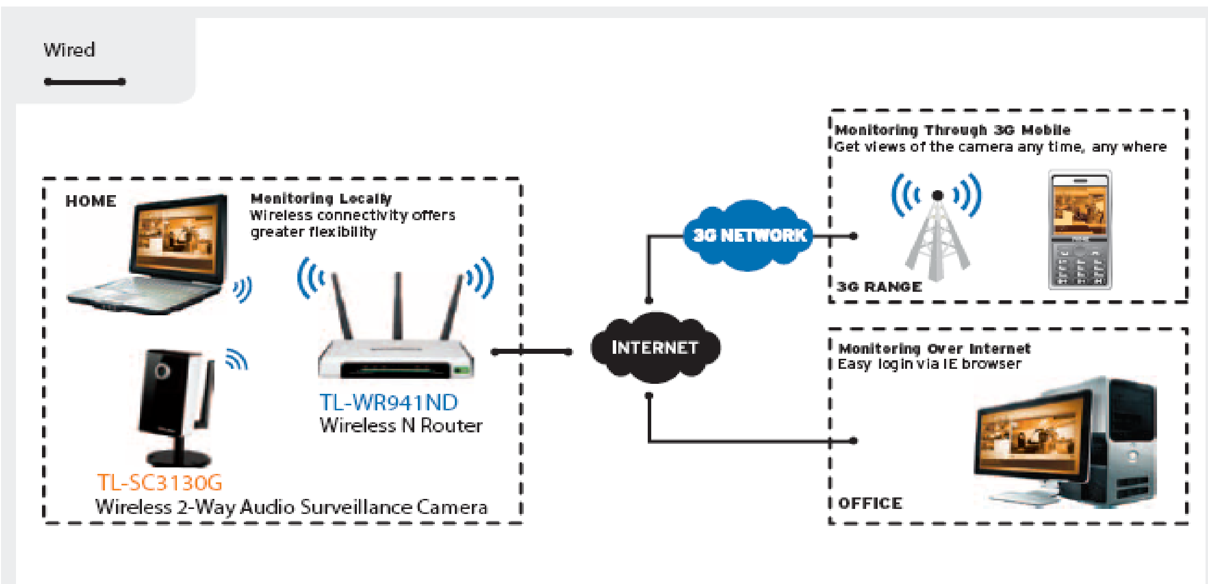

Figure 16: The overview diagram of IP Camera usage [26]

3.4 The Router

The product chosen for the router in this project is WAG102 Prosafe Dual Band Wireless Access Point. It provides connectivity between Ethernet wired network and notebook system, desktop system, printer servers and other devices within a fixed range or area of coverage, interacting with a wireless network interface card (NIC) via an antenna. The WAG102

Prosafe Dual Band Wireless Access Point can support a small group of users in a range of several hundred feet. The auto-sensing capability of the product allows packet transmission at up to 108 Mbps, or at reduced speeds to compensate for distance or electromagnetic interference.

3.4.1The Product Specification

Table 4 shows the specification of router used in this project.

Table 4: The specification of router [27]

General

Device Type	Wireless access point
Width	7.5 in
Depth	4.9 in
Height	1.3 in
Weight	1.3 lbs
Localization	North America

Processor / Memory Storage

Processors Installed	Intel IXP422
RAM Installed (Max)	16 MB
Flash Memory Installed (Max)	8 MB Flash
Hard Drive	none.
Floppy Drive	None
Optical Storage	None
Storage Removable	None

Networking

Form Factor	External
Connectivity Technology	Wireless
Data Transfer Rate	54 Mbps
Data Link Protocol	Ethernet ,IEEE 802.11b ,IEEE 802.11g ,Fast Ethernet
Spread Spectrum Method	DSSS
Network / Transport Protocol	TCP/IP
Remote Management Protocol	HTTP, SNMP, Telnet
Communication Mode	Full-duplex, Half-duplex
Frequency Band	2.4 GHz
Status Indicators	Test mode, Link activity, Power, Link OK, Port transmission speed
Features	WPA upgradable ,Auto-uplink (auto MDI/MDI-X) , MAC address filtering ,Manageable
Encryption Algorithm	SSL, TLS, 40-bit WEP, 152-bit WEP, PEAP, TTLS, 128-bit WEP, 64-bit WEP
Authentication Method	Secure Shell (SSH), RADIUS
Compliant Standards	IEEE 802.1x ,IEEE 802.3af ,IEEE 802.11g , IEEE 802.11b

3.4.2 The Product Features

1. Standard Compliant.
    - The Wireless Access Point compiles with IEE 802.11a/g for Wireless LANs.
2. WEP support.
    - 64-bit, 128-bit and 152-bit keys are supported.
3. DHCP Client Support.
4. Multiple Operating Modes.
    - *Wireless Access Point*

      It operates as a standard 802.11a/g.
    - *Point-to-point bridge*

      The WAG102 only communicates with another bridge mode wireless station. MAC addresses (physical address) need to be entered.
    - *Point-to-multi-point bridge*

      Select this mode when WAG102 is desired to be the "Master" for the group of bridge-mode wireless stations.
5. Simple configuration
6. Secure Telnet Command Line Interface
    - Enables direct access over the serial port and easy scripting of configuration of multiple WAG102 across and extensive network via the Ethernet interface.

CHAPTER 4

METHODOLOGY

4.1 Research Methodology

In order to achieve the main objective of this project, the goals highlighted in the objective need to be accomplished. To design a security camera system in Building 22, UniversitiTeknologiPetronas using the suggested system, brief research and literature review needs to be done on the selected papers that concentrate on the Power Line Communication (PLC) application development the performances and the architecture of the system. The relevancy between selected papers and project objectives need to be taken into account to ensure the credibility of the project.

All the equipments then need to be set up for testing and monitoring of the system. The connections for each equipment need to be taken in considerations as each connection will result in the completion of the task.

4.2 Flow Chart

The following flow chart, as shown in Figure 17 explains the methodology in executing the project.

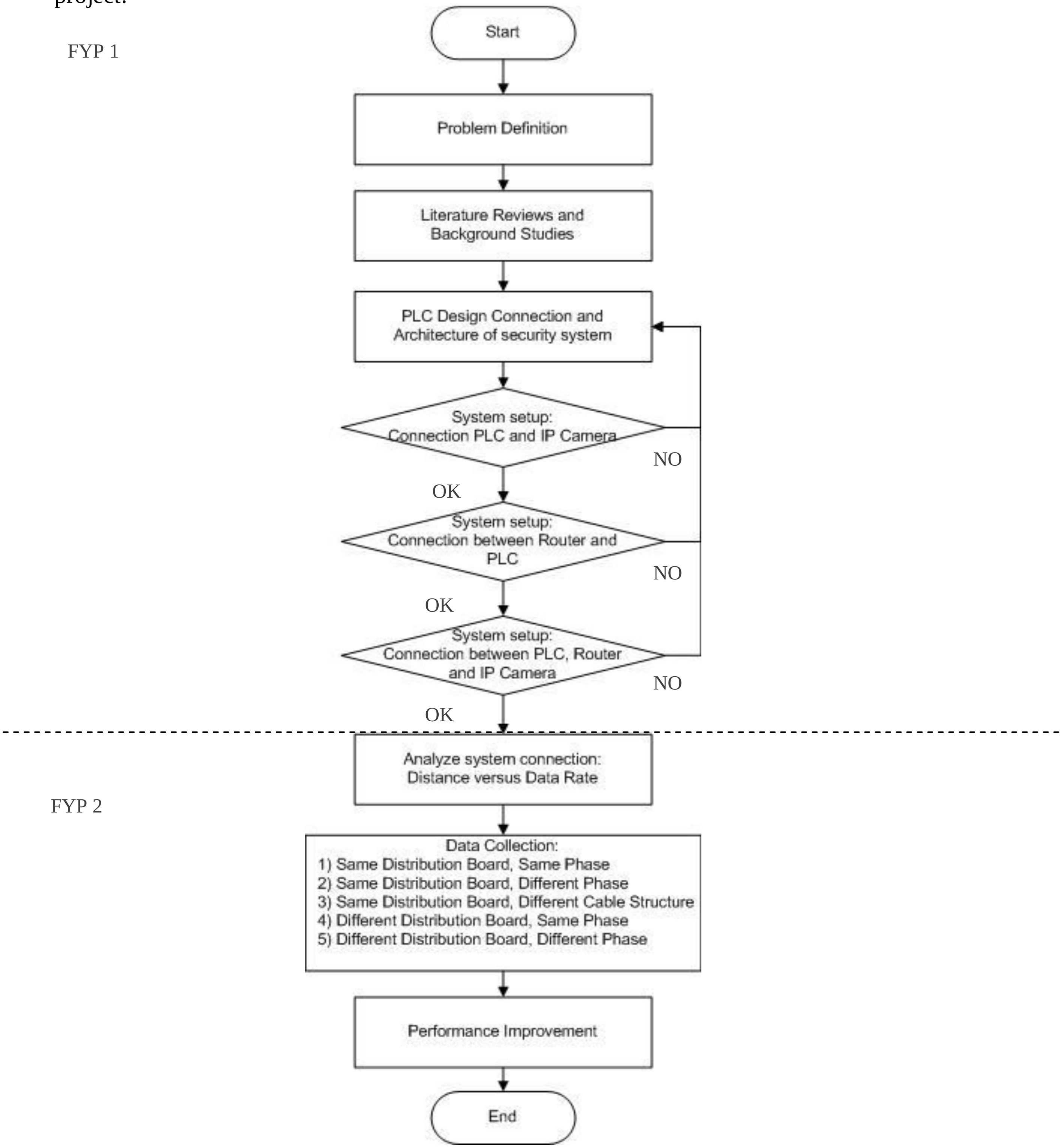

Figure 17: The project methodology

4.3 Elaboration of the Flowchart

Problem statement is one of the first elements in conducting a project. It is important to define the research area, which includes a quick synopsis on how the hypothesis was arrived at. Then, the project begins with literature review and background studies on the fundamental and the overview studies about the security system using power line communication.

Next step is designing connections and architecture of the security system. The design of the connection is very important as the equipments need to be tested and the result will prove the hypothesis whether the alternative device can be used in implementation of the new system.

The next procedure is by setting up the system. First, is the connection between Wifi Router and PLC.The followings are the procedures to set up the connections.

1- Turn off the power to the modem by unplugging the power supply to the modem.
2- Locate the network cable that is connected between the modem and the laptop/PC and unplug it from the laptop/PC, leaving the other end connected to the modem.
3- Plug the loose end of the cable which just has been unplugged into the port on the back of the Wifi Router labeled “Internet/WAN”.
4- Connect a new network cable from the back of the computer to one of the ports labeled “1-4”.
5- Turn the cable or modem by reconnecting the power supply to the modem.
6- Before plugging the power cord into the Wifi Router, plug the cord into the wall, then plug the cord into the Wifi Router’s power jack.
7- Then, attached the PLC adaptor to the power socket and connect it to the Wifi Router via Ethernet cable.
8- Verify the modem is connected to the Router by checking the lights in the TOP of the Router.
9- Connect the other PLC adaptor to PC/Laptop to verify the connections.

After the connection between Wifi Router and PLC is complete, the set up for PLC and Camera need to be implemented. The followings are the procedure to set up the system:

1- Turn off the power connected to the PC/laptop and IP Camera.
2- Connect the PLC Adaptors to the power socket at the desired locations. (Note: PLC adaptors work in pairs)
3- Connect the first PLC Adaptor via Ethernet cable to the PC/laptop for monitoring.
4- Connect the second PLC Adaptor via Ethernet cable to the IP Camera at the desired location.
5- Verify the connection by checking the lights at the PLC Adaptors.

The next step is by setting up connections between Wifi Router, PLC and IP Camera. The followings are the procedure to set up the system.

1- Turn off the power to the modem by unplugging the power supply to the modem.
2- Locate the network cable that is connected between the modem and the laptop/PC and unplug it from the laptop/PC, leaving the other end connected to the modem.
3- Plug the loose end of the cable which just has been unplugged into the port on the back of the Wifi Router labeled "Internet/WAN".
4- Connect a new network cable from the back of the computer to one of the ports labeled "1-4".
5- Turn the cable or modem by reconnecting the power supply to the modem.
6- Before plugging the power cord into the Wifi Router, plug the cord into the wall, then plug the cord into the Wifi Router's power jack.
7- Then, attached the PLC adaptor to the power socket and connect it to the Wifi Router via Ethernet cable.
8- Verify the modem is connected to the Router by checking the lights in the TOP of the Router.
9- Connect the other PLC Adaptor via Ethernet cable to the IP Camera at the desired location.
10- Verify the connection by checking the lights at the PLC Adaptors.

11- The camera can be monitored at the PC/Laptop by using both wireless connection or from the WLAN connection.

The completion of setting up the system for each connection indicates the accomplishment of Final Year Project 1. The Final Year Project 2 started with analyzing system connection which includes five different cases. The length of the cable wire became the main subject as it represents the distance for the data to travel from one point to another point through power line. The cases which include the analyzing of distance versus data rate are as follows:

- Case 1: Same Distribution Board, Same Phase
- Case 2 : Same Distribution Board, Different Phase
- Case 3: Same Distribution Board, Different Cable Structure
- Case 4: Different Distribution Board, Same Phase
- Case 5: Different Distribution Board, Different Phase

4.4 Project Schedule and Milestone

In order to effectively monitor the project progress, a Project Schedule consist of Final Year Project 1 duration has been constructed, as depicted in Table 5.

Table 5: Project Schedule for Final Year Project 1

TASK AND ACTIVITIES	**FINAL YEAR PROJECT I**													
	WEEK NO.													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Topic Selection														
Literature Review and Background Study														
Designing connections and architectures of security camera system by using PLC														
System Setup: Connections between Wifi Router and PLC														
System Setup: Connections between PLC and Camera														
System Setup: Connections of Wifi Router, PLC and camera														
Documentation, report writing														

Table 6 is the expected milestones for Final Year Project 1.

Table 6: Milestone for Final Year Project 1

TASK	WEEK
Completion of Literature Review and Background Study	7
Completion of designing and architecture of security system by using PLC	11
Completion of setting up system: Connections of Wifi Router and PLC	12
Completion of setting up system: Connections of PLC and Camera	13
Completion of setting up system: Connections of Wifi Router, PLC and Camera	14
Completion of writing report/documentations	14

Besides that, a Project Schedule consist of Final Year Project 2 duration also has been constructed, as depicted in Table .

Table 7: Project Schedule for Final Year Project 2

TASK AND ACTIVITIES	**FINAL YEAR PROJECT 2**												
	WEEK NO.												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Analyze system connection; Distance vs. Data Rate													
Data collection 1)Same DB, same phase 2)Same DB, different phase 3)Same DB, different cable structure 4)Different DB, same phase 5) Different DB, different phase													
System performance improvement													
Documentation, report writing													

Table 8 is the expected milestones for Final Year Project 2.

Table 8: Milestones for Final Year Project 2

TASK	**WEEK**
Completion of analyzing system connection ; distance versus data rate	4
Completion of data collection for five different cases	11
Completion of system performance improvement	13
Completion of writing report/documentations	13

4.5 Final Year Project 1 and Final Year Project 2 Schedule/Timeline

The Final Year Project 1 schedule/timelines are depicted in Table 9.

Table 9: Project schedule throughout FYP 1

NO.	COMPONENTS	DATE
1	Extended Proposal	28th February 2012
2	Proposal Defense	7th – 21st March 2012
3	Draft Report	16th April 2012
4	Interim/Final Report	23rd April 2012

The Final Year Project 2 schedule/timelines are depicted in Table 10:

Table 10: Project schedule throughout FYP 2

NO.	COMPONENTS	DATE
1	Progress Report	11th July 2012
2	Draft Report	8th August 2012
3	Final Report (soft cover)	15th August 2012
4	Technical Paper	15th August 2012
5	Final Report (Hard Cover Dissertation)	19th September 2012

4.6 Tools and Equipments Required

The equipments which will be used in this project are listed as the following:

1- TP-LINK, 200Mbps Powerline Ethernet Adapter, Model No TL-PA201

2- Net Gear Prosafe Dual Band Wireless Access Point, Model No.WAG102, with Frequency rate of 2.4 GHz and 5.0 GHz

3- TP-LINK Surveillance Camera, Model No TL-SC3130G with wireless 2 way audio camera.

CHAPTER 5

RESULT AND DISCUSSION

5.1 Power Distribution

The experiment was conducted in Building 22, UniversitiTeknologiPetronas. It has four usable floors that include lecturer's offices, tutorial rooms and design laboratories. All floors have almost the same architecture except for the third floor where the entire lecturers' rooms are located.

Throughout the experiment, the power distribution of Building 22 was investigated and based on understanding; the power distribution scheme for this building is not typical of many modern building.

The building's power distribution is mainly coming from two transformers, TX MB1 and TX MB2. The initial power that comes from Gas District Cooling District UTP (GDC-UTP) to UniversitiTeknologiPetronas is 11kV.

HV (High Voltage):

$$s = \sqrt{3}\ V\ \ I$$

$$3000 = \sqrt{3}(11k)I$$

$$I = \mathbf{157A}$$

Thus, the current produce at HV is 157A with 11kV.
Both transformers, TX MB1 and TX MB2 will step down the voltage from 11kV to 415V

LV (Low Voltage):

$$s = \sqrt{3}\ V\ \ I$$

$$3000 = \sqrt{3}(415)I$$

$$I = \mathbf{4200A}$$

The main intake HV for TX-MB1 is from HV board no.2, from Block 5 and from MB1 (Main Building 1). It leads the power to SSB 22/01/02 (Sub-Switch Board) which is located underneath the right side wing of Building 22.

On the other hand, the main intake HV for TX-MB2 is from HV board no. 1, from Main Building 3A and from MB2 (Main Building 2). It leads the power to SSB 22/01/01 which is located underneath the left side wing for Building 22.

The wires from both SSB are routed to every Riser Board (RB) at each floor for each wing. For example, SSB 22/01/01 is connected to four Riser Board (Ground floor, First floor, Second floor and Third floor), and the same distribution is applied to SSB 22/01/02.

From the Riser Board at each floor, the wire is routed to the Distribution Board (DB) in all the laboratories and tutorial rooms. This indicates that all the wire routing for the rooms in the same wing on the same floor are connected to each other at the Riser Board.

In theory, the data can be transmitted between the rooms and laboratories as long as they are on the same wing. In addition, there is also path of power line connected to each other, from floor to floor where the connections from the Riser Board are fixed at the SSB underneath the building.

5.2 Connectivity

In order to implement a security camera system in Design and Project Laboratory 1, a connection between two PLC adaptors need to be confirmed. However, the exact distance or the length of the wire cable routed in Building 22 is very subjective. Thus, an external wire cable has been routed in order to study and observe the effect of the distance of the wire cable to the value of data rate of connection. Other than that, a study on the building electrical system that involved a connection between two PLC adaptors either connected in the same phase or different phase are also have been conducted.

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5.2.1 Case 1: Same Distribution Board, same phase

The first experiment was conducted within one Distribution Board, and both PLC adaptors are connected at the same phase. The data on distance versus data rate areas depicted in Table 11.

Table 11: Result on connection for one Distribution Board, same phase.

Distance (m)	Data Rate (Mbps)	Image Quality	Average Time Response (ms)	Cable Resistance (Ω)
50	196	80% - 100%	3	0.8
100	194	80% - 100%	3	1.4
150	193	80% - 100%	3	1.7
200	189	80% - 100%	3	2.2
250	174	80% - 100%	3	3.3
300	127	60% - 80%	3	4.2
350	82	40% - 60%	4	5.1
420	35	20% - 40%	4	6.5
500	10	20% - 40%	9	7.2

The result shows that an increasing value of distance led to a decreasing value of data rate. This can be explained by the longer the distance, the higher the resistance. Thus, the data rate drops. However, there is no much difference in terms of average time response. The image captured for this experiment displayed a very good quality and there is no buffer detected.

The images captured for Case 1 are shown in Figure 18.

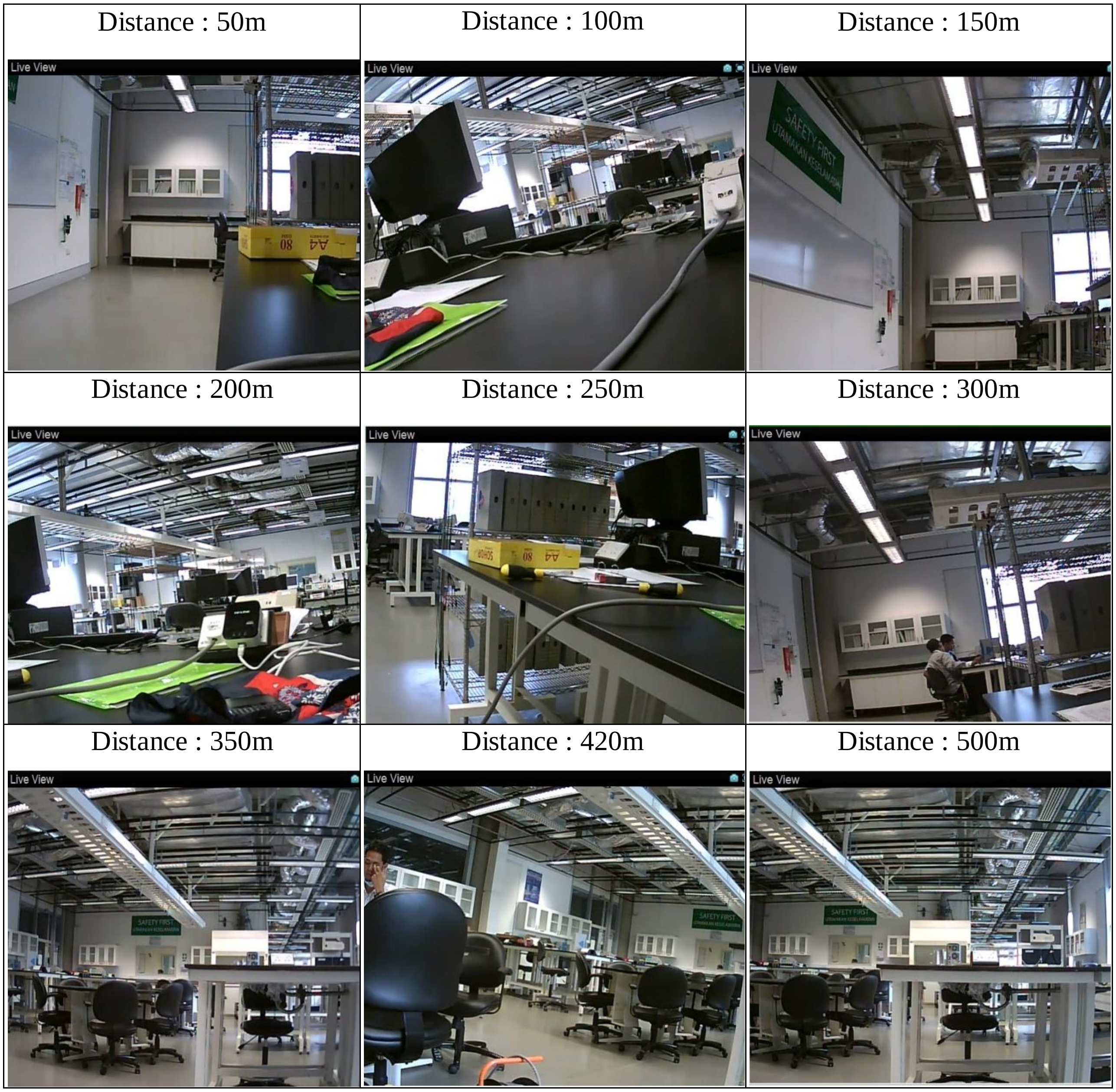


Figure 18: Images captured for same DB, same phase

5.2.2 Case 2: Same Distribution Board, different phase

The second experiment was conducted within one Distribution Board, and the PLC adaptors are connected between two different phases. The data on distance versus data rate are shown in Table 12.

Table 12: Result on connection for one Distribution Board, different phase.

Distance (m)	Data Rate (Mbps)	Image Quality	Average Time Response (ms)	Cable Resistance (Ω)
50	153	60% - 80%	3	0.8
100	150	60% - 80%	3	1.4
150	125	60% - 80%	3	1.7
200	122	60% - 80%	3	2.2
250	117	60% - 80%	3	3.3
300	92	40% - 60%	4	4.2
350	66	40% - 60%	4	5.1
420	26	20% - 40%	4	6.5
500	9	0% - 20%	15	7.2

The result shows an increasing value of distance led to a decreasing value of data rate. The increasing value of the resistance as the length of the cable increases has given an effect to the data rate value. In comparison to Case 1, this experiment has shown a significant drop of data rate because of the phase differences. In theory, all the three phases are connected at the neutral wire. Thus, the data from one phase has to travel to neutral line in order to get into another phase and this somehow explained the data drops

However, the average time response between the two PLC adaptors shows no big variation comparedto Case 1 result. The images captured are also in a good quality and no buffer is detected.

The images captured for Case 2 are shown in Figure 19.

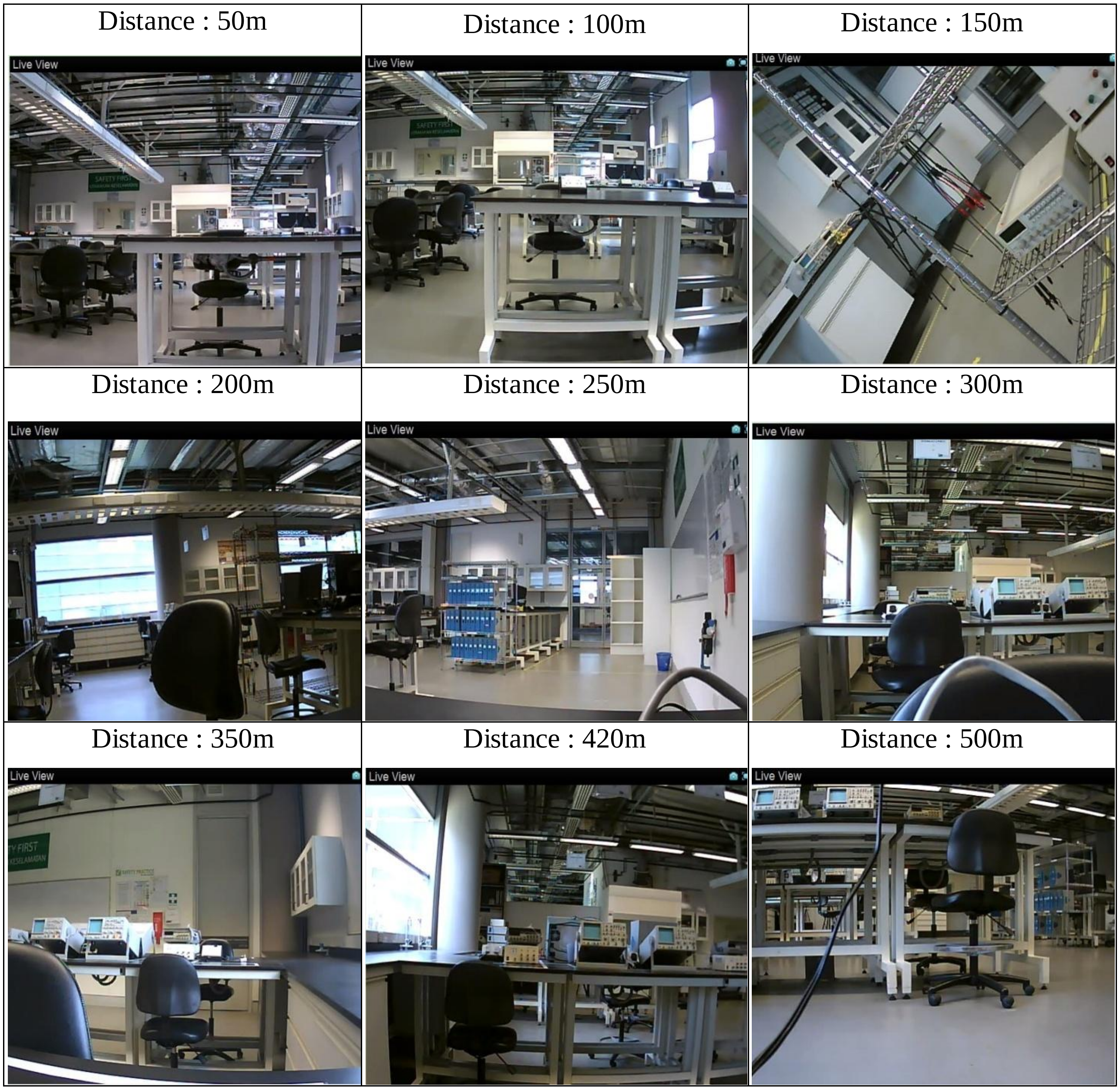
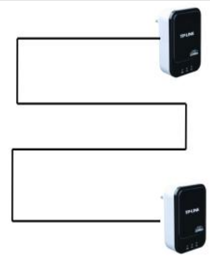
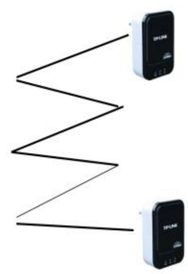
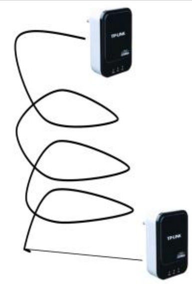


Figure 19: Images captured for same DB, different phase

5.2.3 Case 3: Same Distribution Board, different cable structure

The cable structure of the wire routed in a building is very subjective [30]. The exact plan for cable structure is not provided by the electrician to illustrate on how they route the wire. Thus, the third experiment is meant to study on the effect of cable structure to data rate of connection between PLC adaptors. Four different cable structures, as shown in Table 13 have been tested within one Distribution Board and the followings show the result of the cable structure versus data rate:

Table 13: Result on cable structure versus data rate

Cable Structure (100m)				
Data Rate (Mbps)	196	193	194	193
Average Time Response (ms)	3	3	3	3

The result shows that the four different cable structures do not give any effect on the data rate. The wire cable used to route the wiring in a building would not get affected by the cable structure, unlike fiber cable.

5.2.4 Case 4: Different Distribution Board, Same Phase

The fourth experiment is conducted between two different Distribution Boards. Two external Distribution Boards are been used in order to examine the connectivity between two different labs. In this case, it also represents two different houses. A wire cable up to 500m is also been used to study the effect of distance to data rate.

Figure 20 shows the two Distribution Boards which represent two different labs.

Figure 20: Two Distribution Boards

Both Distribution Boards are fixed to the same phases so that a connection between two PLC is linking at the same phase. Table 14 shows the result for the experiment; different Distribution Board, same phase:

Table 14: Result on connection for two Distribution Boards, same phase.

Distance (m)	**Data Rate (Mbps)**	**Image Quality**	**Average Time Response (ms)**	**Cable Resistance (Ω)**
50	178	80% - 100%	3	0.8
100	170	80% - 100%	3	1.4
150	130	60% - 80%	3	1.7
200	87	40% - 60%	3	2.2
250	52	20% - 40%	4	3.3
300	31	20% - 40%	4	4.2
350	15	20% - 40%	19	5.1
420	-	-	-	-
500	-	-	-	-

The result shows that the connection between two different Distribution Boards for the same phases can only go up to 350m. Beyond that distance, no connection can be detected. This implies that the data that was being transmitted has to go through a longer path when it involved two Distribution Boards.

In this case, the average time response for both PLC adaptors to transmit and receive data to each other is excellent and the images captured shows a good quality and no buffer is detected.

Figure 21 shows the images captured for Case 4.

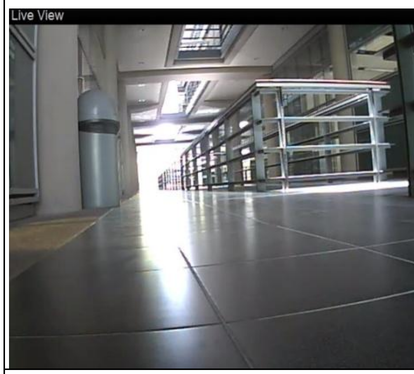
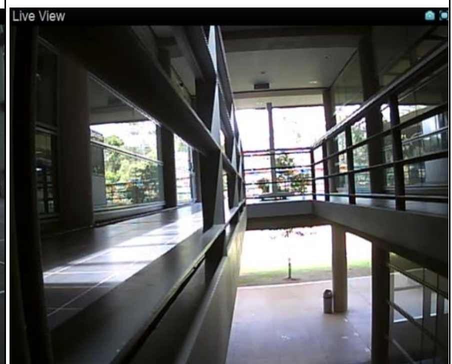
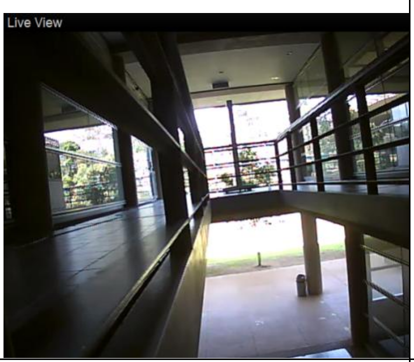
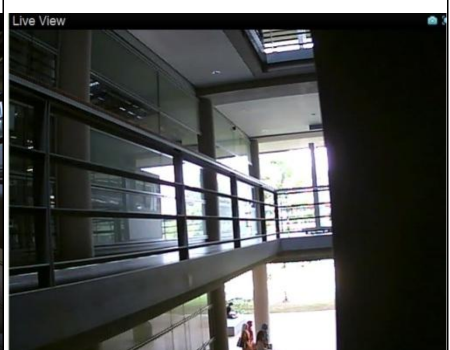
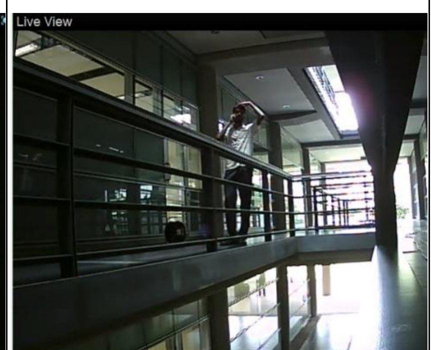
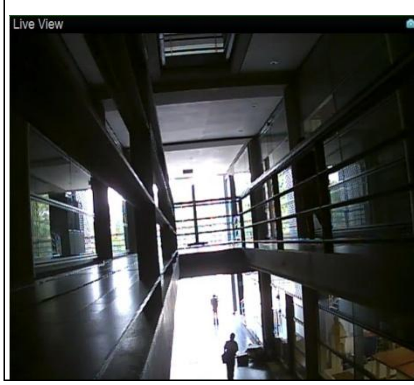
Distance : 50m	Distance : 100m	Distance : 150m
		
Distance : 200m	Distance : 250m	Distance : 300m
		
Distance : 350m	Distance : 420m	Distance : 500m
	No Connection	No Connection

Figure 21: Images captured for different DB, same phase

5.2.5 Case 5: Different Distribution Board, Different Phase

The final experiment conducted was to study the effect on the distance between two Distribution Boards, connected to different phase. The data on distance versus data rate are as shown in Table 15.

Table 15: Result on connection for two Distribution Boards, different phase.

Distance (m)	Data Rate (Mbps)	Image Quality	Average Time Response (ms)	Cable Resistance (Ω)
50	144	60% - 80%	3	0.8
100	131	60% - 80%	3	1.4
150	96	40% - 60%	3	1.7
200	60	40% - 60%	4	2.2
250	37	20% - 40%	4	3.3
300	18	20% - 40%	19	4.2
350	9	0% - 20%	155	5.1
420	-	-	-	-
500	-	-	-	-

The result shows a significant drop of data rate in comparison to Case 4 due to the phase difference. The connections between the PLC adaptors only can go up to 350m and no connection can be detected beyond that range. The average time response shows a good trending until 300m but drastically increased to 155ms when the distance reached 350m. The image captures started to buffer and a slower response is observed.

Figure 22 shows the images captured for different Distribution Board, different phase:

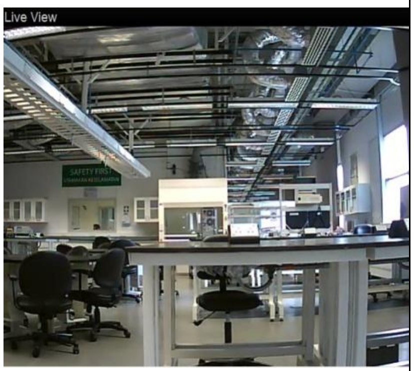
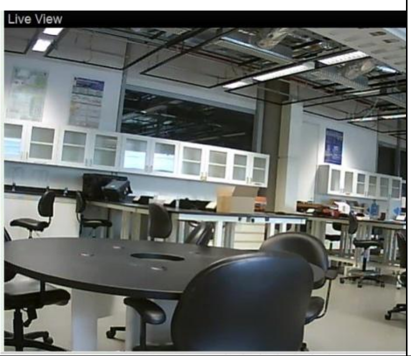
Distance : 50m	Distance : 100m	Distance : 150m
		
Distance : 200m	Distance : 250m	Distance : 300m
		
Distance : 350m	Distance : 420m	Distance : 500m
	No Connection	No Connection

Figure 22: Images captured for different DB, different phase

5.3 Discussion

The length of the cable definitely plays an important role in order to implement the security camera system via powerline communication [31]. According to the power distribution scheme, the power distribution in Building 22 has lead to a conclusion that connection cannot be established between two different wings (left and right wing) and between the floors as the distance of wire-routing is estimated to be very long. However, when the case involved the same Distribution Board (DB) which is within the same laboratory, the connection can be established well although there are from two different phases of three phase system.

Figure 23 shows an example of a topology that can be used for three phase system in order to get a good performance:

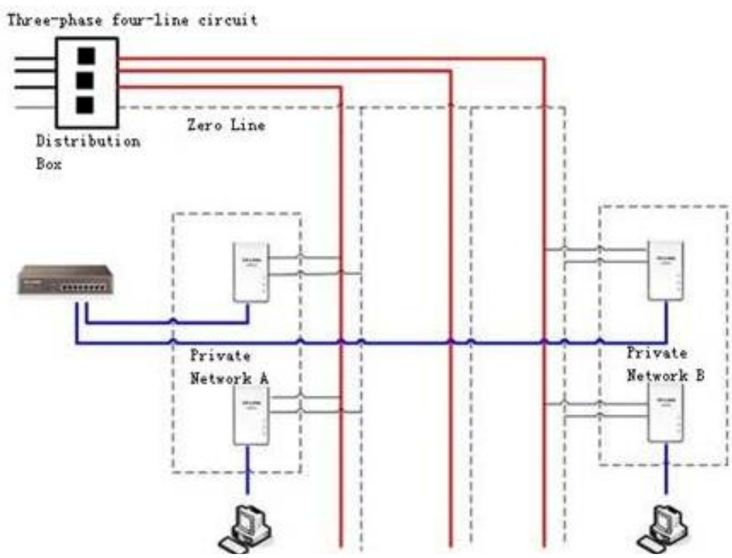


Figure 23: The topology for three-phase system [10]

The result shows that a connection via powerline within the same Distribution Board, whether it is connected at the same phase or different phase, would give an excellent result in term of data rate, average time response and also the images captured. This has proved that PLC is suitable to be used for security camera system as long as the wire routing does not exceed 500m, within one Distribution Board. But when it involved two different Distribution Boards, the wire routing can only be limited up to 350m in order to get a good display of images.

On the other hand, the experiment on the variety patterns of cable structure to data rate has proven that the difference in cable structure would not give any effect to cause the data rate to drop.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

PLC (Powerline Communication) recently has received a lot of attention from both industry and academia. It is an area where more effort is needed to develop technologies for faster, interference-free, reliable and secure communication as well as for in-building networks using power lines. PLC is viewed as a cost-effective method for realization networking and computing.

The results obtained from the experiment are sufficiently promising to warrant the new method of implementing a security camera system. It is to be concluded that PLC is suitable to be used for security camera system as long as the wire routing does not exceed 500m, within one Distribution Board. But when it involved two different Distribution Boards, the wire routing can only be limited up to 350m in order to get a good display of images.

It is believed that PLC has potential to succeed in the building networking area due to the fact that electrical wiring is available in most part of the building and various application devices can be easily networked via PLC network, in this case IP camera.

The current security technology which uses wireless system tends to create problems as well as to obstruct other devices operating in the same unlicensed. Unlike the proposed method, PLC has observed to be well-suited to be used in implementing security camera system.

6.2 Recommendations

From the result obtained, it is believe there are still rooms for improvement. Investigation on the interference caused by PLC as well as the interference affecting PLCis needed. Other than that, future studies need to be done as the result obtained showed that the data rate is not accurate as it decreases with distance. A larger scale of deployment would be needed to validate the preliminary result at the realistic scale and with realistic workloads.

In order to get a higher data rate for different Distribution Board, an implementation of Phase Bridge need to be done. With this implementation, the distance for the data to travels from one point to another will be shortened. Thus, the data rate of the connection would increase, and remain stable.

Other than that, a broader quantity of Building 22 noise floor data are needed to determine the improvement of SNR of PLC and to verify how common it happens. From the observation, it showed an excellent connectivity within the electrical divisions or subsections under certain circumstances but there are also some peculiarities with PLC technology, which include persistent network partitions, which must be addressed for the approach to be usable.

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