UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Light Control System Using Z-Wave

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree of Electronic Engineering Technology (Telecommunications) with Honours.

by

MUHAMMAD AMEERUL AFIQ BIN SAIDIN

B071310578

940112-10-6193

FACULTY OF ENGINEERING TECHNOLOGY

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DECLARATION

I hereby, declared this report entitled “Light Control System Using Z-wave” is the results of my own research except as cited in references.

Signature **:……**

Name **: MUHAMMAD AMEERUL AFIQ SAIDIN**

Date **: ……**

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

.....

(Aziean Binti Mohd Azize)

ABSTRAK

"*Sistem Pengawalan Lampu menggunakan Z-wave*" adalah dicipta untuk mengawal lampu menggunakan protocol Z-wave. Projek ini memberi tumpuan kepada protocol Z-wave dan fungsi-fungsinya, penggunaan Hub serta hubungannya dengan protocol Z-wave. Sistem suis lampu juga akan dihasilkan. Hasil kajian ini akan melihat jika lampu berjaya dibuka serta ditutup. Diharapkan hasil kajian ini dapat memperluaskan penggunaan protocol Z-wave di negara ini.

ABSTRACT

"Light Control System Using Z-wave" was created to control the light using Z-wave protocol. This project studied about Z-wave protocol and it functions, the usage of hub and its relationship with Z-wave. A light switch system also is created. The project will see whether the light can be switched on and off. With the outcome of this project, hope that Z-wave protocol will be widely used in this country.

DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time. They also helped me financially and supported throughout finishing this project report.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This Chapter discusses about the project background, the problem statements, objectives of this project and the scope of the project

1.2 Background

Imagine if everyone can control everything by using one single remote control. With just one click at your smartphone, all of the electrical appliances can be control. Now everyone can throw away all those unecessary remote controls that they always misplace and out of battery.This is what we called home automation.

For many years, Home Automation is mainly used as a feature of science fiction writing, but it is also becoming more practical since the early of the 20th Century .This is because of the introduction of electricity and rapid improvement in information technology.

Home automation or smart homes is described as a technology which is used within the home environment to provide comfort, security, convenience, and energy efficiency to its user or occupants. By inclusion of the Internet of Things (IoTs), the research and development of home automation are going to become more and more

popular. Different wireless technologies that supports remote data transfer, control and sensing such as RFID, Wi-Fi, Bluetooth, and also cellularnetworks have been evolved to add intelligence at various levels in the home.

It is also the residential extension of building automation. It is automation of the home, housework or household activity. Home automation may include centralized control of lighting, HVAC (heating, ventilation and air conditioning), appliances, and other systems, to provide improved convenience, comfort, energy efficiency and security.

Z-Wave is a wireless communications protocol for home automation. It is oriented to the residential control and automation market and is intended to provide a simple and reliable method to wirelessly control lighting, HVAC, security systems, home cinema, automated window treatments, swimming pool and spas controls, and garage and home access controls. There are hundreds of interoperable Z-Wave products marketed under different brands, and over 35 million have been sold since 2005. Z-Wave was developed by a Danish startup called Zen-Sys that was acquired by Sigma Designs in 2008.

As with many systems, Z-wave also supports two-way communication so devices can report their status back to the controller. This project will use Z-wave as it communication protocol as Z-wave is a new type of communication protocol in home automation system.

A Hub naturally is a gateway or a home controller that act as a central connection from a device to another device. A hub also can be used as a standalone device or can be connected to another hub and create a link between the two hubs

1.3 Problem Statement

As the cost of living is getting higher day by day, users are desperate to cut all of those living costs. Electrical power is one of the cost that its price keep increasing each passing year. One of the easier way to control the cost of users electrical cost is to control the usage of the light around the house.

In this new era of technology, a lot of new technologies have been developed to ease the user to become more comfortable and live easier life than before. Z-wave is a wireless home control technology that is retrofit-able into existing homes. Z-wave consists of low power radio waves that travel through the walls and floors of user house.

As this Z- wave can travel through those obstacles. It is suitable technology to control all the appliances in user house. It is also can be control by android application.

1.4 Objectives

The objective of this project are shown below:

i. To study about z-wave protocol and its function

ii. To study the relationship between a hub and z-wave device

iii. To develop a light system that can be control by z-wave

1.5 Scope

Although there are various platform that can be used to control the lights in the house, this project is focusing on z-wave. Z-Wave uses the Part 15 unlicensed ISM band. It operates at 908.42 MHz in the U.S. and Canada but uses other frequencies in other countries depending on their regulations. In malaysia, we used 868.1 MHz frequency for Z-wave. The modulation is Gaussian frequency shift keying (FSK). Available data rates include 9600 bits/s and 40 kbits/s. Output power is 1 mW or 0 dBm. As with any wireless technology, the range of transmission depends on the environment. In free space conditions, a range of up to 30 meters is possible..This

project also will develop an android application to control the light. The z-wave device will be connected and control by the hub.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will provide the review of previous researches that is related to this final year project. There are previous researches understanding on the z-wave, home automation system, and android based applications.

2.2 Z – Wave

Z-Wave is a wireless communications protocol for home automation. It is oriented to the residential control and automation market and is intended to provide a simple and reliable method to wirelessly control lighting, HVAC, security systems, home cinema, automated window treatments, swimming pool and spas controls, and garage and home access controls. There are hundreds of interoperable Z-Wave products marketed under different brands, and over 35 million have been sold since 2005. Z-Wave was developed by a Danish startup called Zen-Sys that was acquired by Sigma Designs in 2008. Z-Wave automation system can be remote controlled via the Internet, using a Z-Wave gateway or central control device which serves as both the Z-Wave hub controller and portal to the outside.

A Z-Wave automation system can be remote controlled via the Internet, using a Z-Wave gateway or central control device which serves as both the Z-Wave hub controller and portal to the outside. The main purpose of this project is to ease the users to control the light in their houses. A Z-Wave controller uses radio signals to communicate with devices installed around your home, and usually with an app which you can use to control your system. It is a popular system amongst DIYers because it is relatively simple to install - no special technical knowledge needed but can also be hacked and modded by enthusiasts with more advanced knowledge.

One of the most important technical features of Z-Wave technology is the fact that it uses a 'mesh network'. The mesh network topology simply means that every communication is broadcast to all devices within range, and each device then acts as a 'repeater', passing on the message to all of its neighbors. There are two major advantages to the use of a mesh network. The first is that it improves reliability. The fact that a message between, for example, a controller in the living room and a radiator in an upstairs bedroom can take multiple routes simultaneously means that it is less likely to get lost or suffer from interference during its journey.

The second is range extension. Most systems will require the use of dedicated repeaters if there is a large spatial separation between a controller and the device to be controlled. Because each device in a Z-Wave network acts as a repeater this is usually not necessary - as long as there is another device in between the two (a stairway light for example).

Table 1.1：Summary of Pros and Cons of different radio technologies

Technology	Pro	Con
Analog	inexpensive	Unreliable, not interoperable
Digital	Proprietary	Not interoperable
WLAN	Widely used, available in cell phones, etc, low price	Not interoperable, high energy consumption / no batteries possible
ZigBee	Stable standard, lots low cost chips	Not interoperable
Z-Wave	Interoperable, reliable	Cost higher than analog systems, not (yet) available in notebooks, cell phones, ...
DECT ULE	Interoperable, reliable	no devices yet, a late comer
EnOcean	No batteries, interoperable	High price, low security

Christian Paetz said that Z- wave was designed for a standard microcontroller and a radio transceiver (Paetz, 2015). Table 1.1 shows a variety of technologies with their pros and cons.

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Figure 1.1 : Z-wave alliance logo

The author also said that the development of Z-wave alliance consisting more than 250 manufactures enhance the standard and quality and also managing of central marketing events such as trade shows.This alliance also maintain the interoperability of the devices on the basis of Z-wave protocols. Figure 1.1 show the logo for the Z-wave alliance.

Table 1.2: Different Regions With Different Z-Wave Frequency

Region	Standard	Z-Wave Frequency
Australia	AS/NZS 4268	921.4 MHz
Brazil	ANATEL Resolution 506	921.4 MHz
CEPT*	EN 300 220	868.4 MHz
China	TBD	868.4 MHz
Hong Kong	HKTA 1035	919.8 MHz
India	N/A	865.2 MHz
Japan 950	ARIB T96	951-956 MHz
Japan 920	ARIB STD-T108	922-926 MHz
Malaysia	N/A	868.1 MHz
Mexico	FCC CFR47 Part 15.249	908.4 MHz
New Zealand	AS/NZS 4268	921.4 MHz
Russia	GKRCh/EN 300 220	869.0 MHz
Singapore	TS SRD/EN 300 220	868.4 MHz
South Africa	ICASA/EN 300 220	868.4 MHz
UAE	EN 300 220	868.4 MHz
USA/Canada	FCC CFR47 Part 15.249	908.4 MHz

Z-wave usually uses license free but regulated frequency bands.The first is important from the cost point of view, the second ensures a fair usage of the frequency band and reliable transmission even for low energy wireless technologies such as Z-wave. There is one multinational regulation driven by the CEPT organization. Table 1.2 shows different region have different standards and different z-wave frequencies.

This shows that every region have their own frequency but there are a few region that are or almost the same with each other. So, they can use devices from the other region that have almost the same frequency.

Z-wave also required to bridge a minimum of 25m in a close buildings witout any loss. A maximum distance to bridge with a wireless technologies depends on the radio frequency, the transmitting power and the antenna.

Cheng Wen Yuan, Hai Rui Wang, Jun Ying He said that currently embedded remote monitoring technology step into a rapidly developing period. With the advancement of related technology, low cost remote monitoring system which is web-based, powerful and reliable at the same time will become the mainstream (Cheng, Hai, Jun, 2010). The overall system established a LAN using zensys's Z-WAVE module ZW0301, then select Freescale 16-bit microcontroller MC9S12NE64 with which the OpenTCP protocol built-in to implement the networking of the embedded wireless LAN. Thus realized the remote monitoring and controlling of the embedded devices within the wireless LAN.

Miya Knight said that a rival technology to ZigBee, called Z-Wave, has received the support of chip giant Intel, as well as networking heavyweight Cisco. In many ways, Z-Wave and ZigBee are similar (Knight,2006). Both are wireless standards. Both use mesh networks. Both are designed for low power. Though ZigBee provides for a higher data rate than Z-Wave, both standards provide for relatively low throughput. But proponents of ZigBee claim that Z-Wave is considerably less robust.

Stefan Ultes, Florian Nothdurft, Tobias Heinroth, Wolfgang Minker reported that Z-wave based driver is an OSGi offering application interfaces for creating, managing and controlling Z-wave networks (Ultes, Nothdurft, Heinroth Minker, 2015). It enables the user to create, maintain, control,and monitor networks of Z-wave devices. OSGi bundle offers both a command-lines shell tool over the Z-wave based

driver OSGi bundle in order to provide control, monitor and simple test scenarios execution on Z-wave devices.

2.2.1 ZigBee and Z-wave

The ZigBee and Z-Wave short-range wireless technologies are used for remote monitoring and control. However, their specifications and applications are different. Both technologies are ideal for home-area networks (HANs), which are becoming more widespread in the world. Here is a comparison of these two widely used wireless technologies.

ZigBee has a higher bandwidth, so it can accommodate richer information, such as metadata from your music library. Z-Wave has the benefit of being a real "standard," meaning Z-Wave products from one manufacturer are interoperable with those from other vendors (with a few exceptions). ZigBee is trying to get there, but currently you cannot mix-and-max ZigBee products from multiple vendors. The latest version, ZigBee 3.0, promises better interoperability between devices and versions.

Proponents from both camps claim they will own the market for "smart meters" and therefore will become the de facto standard. Price-wise, the common perception is that Z-Wave is cheaper than ZigBee, but that really is not the case. It just so happens that most of the ZigBee implementers in the home-control space (AMX, Crestron, Colorado vNet, for example) serve higher-end markets. Yet a ZigBee dimmer from Control4 can cost less than a Z-Wave dimmer from Leviton.

Lou Frenzel said that ZigBee and Z-Wave target the same general applications. Of the two, ZigBee is by far the more versatile since it can be configured for virtually any short-range wireless task (Frenzel,2012). Profiles are readily available to minimize development time for common applications. On the other hand the protocol is far more complex, resulting in longer development times. Z-Wave uses a far simpler protocol, so development can be faster and simpler.

Z-Wave chips are available from only one source, Sigma Designs. They sell only to OEMs, ODM, and other major clients. More than 500 consumer home control

products are available in stores like Home Depot and Lowes, but many don't state that Z-Wave is used. ZigBee chips are available from Ember, Freescale, Microchip Technology, and Texas Instruments. Complete, ready to use ZigBee modules are also available from multiple sources like Atmel, CEL, Digi, Jennic, Lemos, and RFM.

For a given power level of 0 dBm, Z-Wave's range is greater than ZigBee simply because the lower operating frequency supports it with pure physics (Friis formula). That also translates into a more reliable connection in some applications.

ZigBee uses the widely populated 2.4-GHz ISM band, which it must share with Wi-Fi, Bluetooth, and other radios that can produce interference. Most ZigBee devices have co-existence features that help mitigate interference, yet the potential is greater in the 2.4-GHz band than the 908.42-MHz channel of Z-Wave.

2.3 Home Automation

Home automation is the use and control of home appliances remotely or automatically. Early home automation began with labour-saving machines like washing machines. Some home automation appliances are stand alone and do not communicate, such as a programmable light switch, while others are part of the internet of things and are networked for remote control and data transfer.

Hardware devices can include sensors (like cameras and thermometers), controllers, actuators (to do things), and communication systems. Remote control can range from a simple remote control to a smartphone with Bluetooth, to a computer on the other side of the world connected by internet. Home automation systems are available which consist of a suite of products designed to work together. These typically connected through Wi-Fi or power line communication to a hub which is then accessed with a software application.

Popular applications include thermostats, security systems, blinds, lighting, smoke/CO detectors, and door locks. Popular suites of products include X10, Z-Wave, and Zigbee all of which are incompatible with each other. Home automation is the domestic application of building automation.

Carles Gomez said that Wireless home automation networks comprise wireless embedded sensors and actuators that enable monitoring and control applications for home user comfort and efficient home management (Gomez, 2010). This article surveys the main current and emerging solutions that are suitable for WHANs, including ZigBee, Z-Wave, INSTEON, Wavenis, and IP-based technology.

Per Printz Madsen said that in the last couple of year's computer based home control systems are getting more and more common in modern homes. For instance these systems take care of light control, heat control and security systems (Madsen, 2009). The latest trend is to use wireless communication like Z-Wave and ZigBee to interconnect different components in these systems. One of the characteristics is that each system, like for instance heat and light, has their own specific way of using the communication system. This paper describes a way to connect different home control systems through an intelligent gateway, called a HomePort. The HomePort consists of a number of subsystem communication drivers, a virtual communication layer, an interpreter and a PC-based compiler for a high level control language, called GIL (gateway intelligence language). The focus in this paper will be on the upper two layers in the HomePort, the interpreter and the application layer.

John Walko said that home automation is not a new concept. It has been around for a couple of decades in some form or other. Early commercial systems focused on the control of lighting, security, climate and appliances around the house. Adoption rates have hardly set the world alight, and the networks have tended to be quite sophisticated and, consequently, on the expensive side (Walko, 2006). While the industry is getting smarter about developing the wireless technologies and protocols needed (and thinking up innovative names for the options) it is clear that those at the cliff face of product and applications marketing face a major challenge in customer education. The battleground is set between the leading players in the home automation - chief among these are ZigBee and Z-Wave.