DEVELOPMENT OF COST-EFFECTIVE HOME APPLIANCES CONTROL SYSTEM USING WIRELESS EMBEDDED LINUX

MUHAMMAD FAEZ BIN MUSA

This Report Is Submitted in Partial Fulfilment of Requirements for the degree of Bachelor of Electrical Engineering (Control, Instrumentation & Automation)

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2015

STUDENT'S DECLARATION

"I hereby declare that this report entitled "Development of cost-effective home appliances control system using wireless embedded Linux" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature: …………………………………….

Author: MUHAMMAD FAEZ BIN MUSA

Date : 1st June 2015

SUPERVISOR'S DECLARATION

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms scope and quality as a partial fulfilment of Bachelor of Electrical Engineering (Control, Instrument and Automation) With Honours

Signature: ……………………………………….

Name: Encik Ahmad Fairuz bin Muhammad Amin

Date: 1st June 2015

ACKNOWLEDGEMENT

First and foremost, this thesis would not be completed without the kindness and generosities of my supervisor, Encik Ahmad Fairuz bin Muhammad Amin. He was very patient with me and willing to guide me in order to accomplish this final year project. Besides, he gave me valuable knowledge and a lot of information in completing the project. His willingness to help me contributed tremendously to my progress, and he had inspired me greatly with his encouragement and motivation to carry on with my project. Besides, I would also like to thank other lectures and staffs of Faculty Electrical Engineering that willing spends their time to help me to solve the problem. Besides, thank for the cooperation and great commitment during complete the project. Moreover, special thanks go out to my family and friends, especially my parents. They have shown me the virtue of endurance in the face of extreme adversity. On the other hand, their wonderful support and understanding throughout completing this project. Besides, I would like to thank the authority of Universiti Teknikal Malaysia Melaka (UTeM) for providing me with a good and more convenient environment and facilities to complete this project.

Abstract

One of a way to reduce living cost is by reducing the uses of electrical energy. Objective of this project are to develop a cost-effective home appliances control system using Arduino UNO and OpenWrt that will be installed in a router. The term cost-effective in this project means to reduce the energy consumption and cost implementation of the system. With the automatic control of light and fan from the hardware design can reduce the energy consumption used. Using a cheaper wireless router that will be installed with OpenWrt rather than Wi-Fi shield will reduce the cost of implementation. The hardware consists of a 240VAC light bulb, a 9VDC light bulb and a 12VDC fan. The hardware control split into 2 types of control. That is manual control and automatic control. User can choose either one by using a switch. Manual control means user can control on and off fan and light bulb using webserver. Automatic control means the fan speed will be control by temperature sensor using Pulse Width Modulation (PWM) concept. The light bulb 1 and light bulb 2 will be control by Crontab in OpenWrt using timer concept. For monitoring, the temperature data read by temperature sensor will be sending to MySql database every 5 minutes. The data then can be viewed from Teraterm software or temperature data logger on webserver. For the result and discussion, data from temperature sensor being recorded and for a day and being analyzed. From the data and graph obtain, this project was proved reduce energy consumption and cost. The automatic control of fan and light were suitable for a house"s owner that wants a home automation system that effective and affordable.

Abstrak

Salah satu cara untuk mengurangkan kos sara hidup adalah dengan mengurangkan penggunaan elektrik. Objektif projek ini adalah untuk menghasilkan sebuah sistem kawalan peralatan rumah yang kos-efektif menggunakan Arduino Uno dan router yang dipasang system OpenWrt. Terma kos-efektif di dalam projek ini bermaksud projek ini mengurangkan penggunaan tenaga dan kos pelaksanaan. Dengan kawalan automatik lampu dan kipas boleh mengurangkan penggunaan tenaga elektrik. Dengan menggunakan router yang lebih murah dipasang dengan system OpenWrt berbanding Wi-Fi shield boleh mengurangkan kos pelaksanaan. Hardware ini merangkumi satu lampu mentol 240VAC, satu lampu mentol 9VDC dan satu kipas 12VDC. Kawalan hardware terbahagi kepada 2 jenis. Iaitu kawalan automatik dan kawalan manual. Pengguna boleh memilih salah satu kawalan menggunakan suis. Kawalan manual bermaksud pengguna boleh menghidupkan lampu dan kipas menggunakan pelayan pelayar web. Kawalan automatik bermaksud kelajuan kipas akan dikawal oleh sensor suhu menggunakan konsep nadi modulasi lebar (PWM). Manakala lampu mentol 1 dan lampu mentol 2 dikawal oleh Crontab di dalam sistem OpenWrt menggunakan konsep pemasa. Dari segi pemantauan, data suhu daripada sensor suhu akan dihantar ke pangkalan data MySql setiap 5 minit. Data tersebut boleh dilihat melalui software teraterm ataupun melalui logger data suhu di dalam pelayan internet. Dari segi keputusan dan perbincangan, data suhu telah direkod selama sehari dan dianalisis. Daripada data dan graf yang diperolehi, projek ini terbukti mengurangkan penggunaan tenaga dan kos. Kawalan automatik lampu dan kipas amat sesuai untuk digunakan oleh pemilik rumah yang mahukan sistem rumah automasi yang efektif dan mampu milik.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	TURNITIN	58

LIST OF ABBREVIATIONS

PHP   Hypertext Prepocessor

MySQL   My Structured Query Language

PWM   Pulse Width Modulation

WinScp   Windows Secure Copy

SPDT   Single Pole Double Throw

HTML   Hypertext Markup Language

CHAPTER 1

INTRODUCTION

1.1 Project Background

Nowadays, the cost of living continuously increases. People always find a way to decrease living cost. At the same time, home automation system have been gaining popularity, people want to live in the low cost living but enjoy the convenience and comforts brought by smart living. One of the ways to decrease living cost is by saving energy. This paper introduces a cost-effective home appliance control system based on a small embedded system. It means the purpose of this project is to develop a cost-effective home appliances control system using embedded Linux i.e. wireless router and arduino which can be monitored and controlled through internet. The significance of this research had been supported by many academic publications. One of the academic papers [1] written by Cheong Gil Kim and Kuinam J. Kim which is about Implementation of a cost-effective home lighting control system on embedded Linux with OpenWrt.

1.2 Problem Statement

In commercial building lighting is one of the main contributors of energy consumption, so reducing this energy consumption become the perfect solutions to reduce electricity cost. One of the solution to reduce energy consumption is by replaced the light with more energy sufficient lightning sources such as LED. The second solution are control amount of energy used like turning off lights when they are not needed, optimizing light levels to suit worker needs and reducing overall demands for lighting energy. Third solution is turn on and off fan based on the threshold level. Therefore with this project, the combinations of fan and energy control have been created. Purpose of this project is to develop a cost-effective home appliances control system on embedded Linux with OpenWrt and using wireless router, arduino, light bulb and fan.

1.3 Objective

The main objectives for this project are:

1. To propose a model of cost-effective home appliances control system on embedded linux with OpenWrt to give benefits of saving energy and cost through lighting and fan control.
2. To develop coding for Arduino to run the system.
3. To develop PHP and Python programming to communicate with arduino.
4. To compare with other home automation technologies and other OpenWrt research.

1.4 Scope of Project

The scopes of projects are:
1. Using wireless router with OpenWrt as a gateway for data transfer.
2. Develop a program to control light bulb and fan using Arduino UNO based on environment.

1.5 Summary of Methodology

The methodology is made to achieve the objectives of this project and also to ensure it follow project scope. The project is started by doing all research on home automation system. Then, follows with study of the OpenWrt control system and serial communication between Arduino Uno and router. Next, the study of Arduino coding, PHP and Python program to run the project. After that development of the hardware based on the proposed design been conduct. Lastly, the data result of the project being analysed and discussed.

1.6 Report Structure

This report consists of five chapters which are Chapter 1: Introduction, Chapter 2: Literature Review, Chapter 3: Methodology, Chapter 4: Result and Discussion, and Chapter 5: Conclusion and Recommendation.

In chapter 1 that is Introduction, discusses about the Project Background, Objectives, Problem Statement, Scopes of Project and also Summary of Methodology. Chapter 2 is Literature Review which is review the previous project and comparison between the previous projects. Chapter 3 is all about Methodology where flows process of project; it consists of the flowchart of work conducted at PSM 1 and PSM 2, flow process of hardware system and software used in this project. The hardware and software implementation also being discuss in this chapter. Chapter 4 is Result and Discussion. Lastly Chapter 5 is Conclusion and Recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the factual and theoretical aspects of the project. It is pertaining to the fundamental of home automation. In order to obtain complete and accurate information, in-depth research should be done especially through reading articles and journals.

2.2 Home Automation System

Home automation is a system target to assist human in control home appliances. It is computerization of the home to control the home appliances automatically. As example, home automation may include consolidate control of lighting system, heating, ventilation and air conditioning (HVAC) appliances, security locks of doors and other systems, to provide better accommodation, energy saving, comfort, and safety measures. The main function of home automation systems in smart home has to allow users to access and control all the devices at home either manually or remotely via the internet. To do that, all gadgets at home need to have common interface and connect it to system and services remotely.

2.3 Home Gateway

In a home automation system, different technologies used needs to be interconnected. Home gateway is act as the bridging. In other words, it connects the home system to external services and vice versa with the aid of Wi-Fi router. The link between home gateway and home appliances are accessible through wireless networks such as Bluetooth, Wi-Fi or wired network, Home PNA [2] and IEEE1394.

2.4 OpenWrt

OpenWrt [3] is a Linux distribution for the router. Like other Linux distributions, it provides a built-in package manager that permits installing packages from a software repository. It can be utilized for anything that an embedded Linux system can be utilized for, including working as an SSH server, VPN, activity forming framework, or even a BitTorrent client. Rather than trying to make an individual, fixed firmware, OpenWrt serve a completely writable file system with package management. This liberates users from the limitations of the application options and configuration provided by the vendor and permits users to utilize packages to customize an embedded device to fit any application. For developers, OpenWrt gives a structure to make an application without needing to construct a full firmware figure and distribution around it. For users, this implies the opportunity of full customization, permitting the use of an embedded device in style that past vendor imagination.

There are many advantages and benefit of OpenWrt. The first one is it is free and open-source. The project is completely free and open-source, authorized under the General Public License (GPL). The project is proposed to always be hosted at an easily accessible site, with full source code readily available and easy to create.

The second one is it is easy and free access. The project will always be open to new contributors and easy for participation. Anybody shall be able to contribute. The current developers actively give write access to anyone interested in having it. They

believe people are responsible when given responsibility. With a simple request people will be able to acquire the access they need.

The third one is it is community driven. What its mean is everyone coming together to work and collaborate towards a common goal.

OpenWrt has long been established as the best firmware solution in its class. It far exceeds other embedded solutions in performance, stability, extensibility, robustness, and design. It is the definitive objective of the OpenWrt developers to continue to expand development and ensure that OpenWrt is the foremost framework for ingenious and intelligence solutions [3].

2.5 Previous Study

This section discusses the previous study of the home automation system and OpenWrt. Most of the journals and papers state that home automation technologies have not been generally in use because of several barriers such as expensive cost of ownership, inflexibility, poor manageability and difficulty achieving security. These do not stop the research in this field and continue to improve it. Many researches have been conducted to enhanced capabilities of the technology into areas such as remote monitoring and control, power management, tracking and security systems to overcome those barriers.

The previous study on OpenWrt also discussed in this section. The researches have been studied and proposed by porting wireless router to OpenWrt as the home energy saver with remote control feature.

2.5.1   Previous study on home automation system

From Khusvinder Gill, Shuang-Hua Yang, Fang Yao, and Xin Lu, a ZigBee-Based Home Automation System [4] have been proposed. In this project, a ZigBee based home automation system is utilize for the checking and control of household devices. In this project, the household"s low data rate needs like control and monitoring are provide by using Zigbee. But not just Zigbee system used in this project, Wi-Fi network is also used to serve for the household"s high data rate needs as example multimedia entertainment. Because of that home gateway has been created to give bridging between these systems. The home gateway introduced a unified interface for users to locally and remotely access home networks. The security and safety of the home automation system is acknowledged through the development of the prior described virtual home on the Home Gateway. To develop the proposed system, 4 devices have been created and integrated with the home automation system that is light switch, radiator valve, Zigbee remote controller and safety sensor.
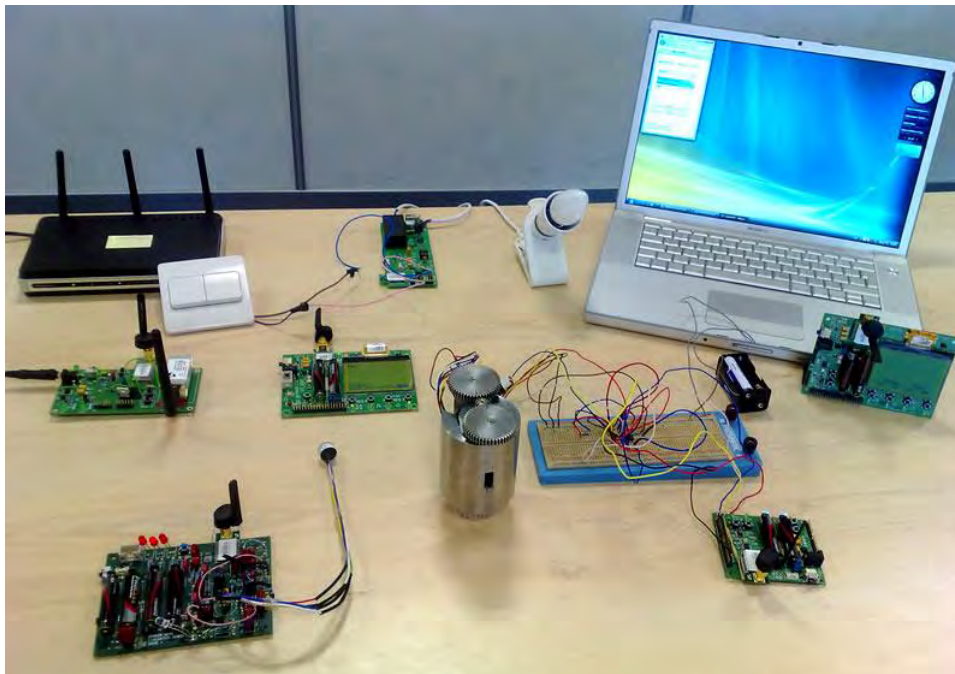

Figure 2.5.1.1: System Implementation of Zigbee-Based Home Automation System

From R.Piyare and M.Tazil, a Bluetooth Based Home Automation System Using Cell Phone [5] have been proposed. In this project, they present a cheap secure cell phone based, adaptable home automation system. Appliances at home are joined to the Arduino BT board. The correspondence between the cell phone and the Arduino BT board is wireless. With a little modification, extra devices can be connected into the system. It is also convenient because the cell phone also can run on any Symbian Operating System platform since the cell phone script is composed in Python. This home automation systems comprise of two primary hardware components, that are a cell phone and an Arduino BT board. The user can access and control commands for the appliances using the cell phone that will be hosts the Python script. An ad-hoc communication protocol between the Python Script in the cell phone and Arduino BT board will be created which allows controlling the behaviour of the Arduino BT board

Figure 2.5.1.2: Block diagram of Bluetooth-Based Home Automation System

From A. R. Al-Ali, Member, IEEE & M. AL-Rousan, a Java-Based Home Automation System [6] have been proposed. In this project, an attractive low-cost solution for home automation via the Internet has been presented. The users can remotely monitor and control almost all appliances at home using internet access. The users also can local control it. The security procedures that being taken is user needs to log into the system using Java Beans and Java Server Pages (JSPs). The main part of the home automation system comprises of two hardware parts, which are the home server and the E-board. A high-end PC will act as home server that hosts the Java-based management and control algorithm that permit user to access home devices through the Internet. The home server will connected and communicate with the E-

board through the parallel port to upload the control commands and download the device"s status. Function of E-board is to control the home appliances locally when no internet service or high-end PC is turn off.
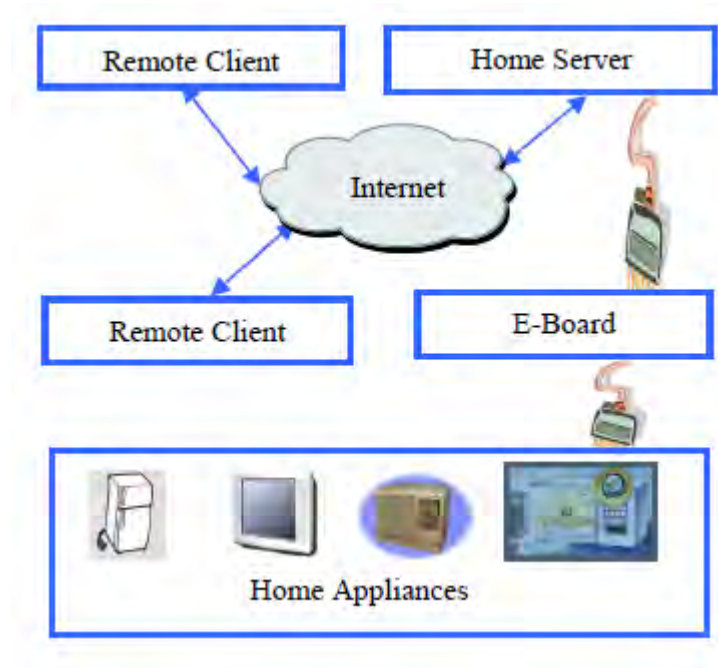

Figure 2.5.1.3: System hardware layout of Java-based Home Automation System

From Zhi-Ming Lin, a Remote Telephone-Controlled Home Automation System [7] have been proposed. In this paper, a Home Automation System using telephone lines been presented. The system comprises of two parts, which are the Remote Control system and the Phone Monitoring system. Function of the Remote Control system is to control the operation of various appliances using the Dual Tone Multi-frequency signals. The hardware and software are created following the standard telephone system. The function of Phone Monitoring system is to easier the users to monitoring the usage of their phone. To develop the proposed system, hardware used includes a power supply circuit, a programmable logic chip 895 1, a multifrequency MT8870 chip and a multifrequency decoder.