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M.Sc. in Electrical and Electronics Engineering

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**UNIVERSITY OF GAZIANTEP
GRADUATE SCHOOL OF
NATURAL & APPLIED SCIENCES**

**SMART ENERGY MANAGEMENT FOR RESIDENTIAL BUILDINGS
BASED ON WIRELESS EMBEDDED SYSTEM**

M. Sc. THESIS

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

BY

AYMEN HUSAM AHMED ALADHAMI

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**Smart Energy Management for Residential Buildings Based on Wireless
Embedded System**

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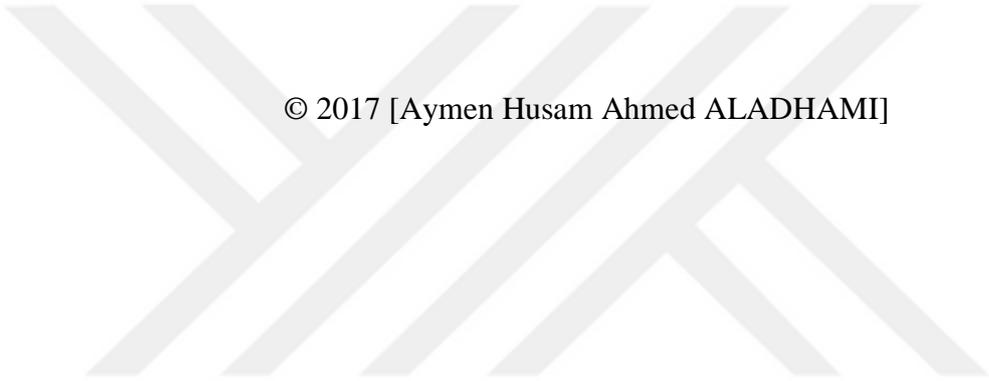
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by

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September 2017



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ABSTRACT

SMART ENERGY MANAGEMENT FOR RESIDENTIAL BUILDINGS BASED ON WIRELESS EMBEDDED SYSTEM

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In the thesis, a smart power strip has been developed to save electric power consumption at home. Also, developed power strip allows user to manage power at their home by turning on/off electricity of home appliances. The developed system utilizes wireless power monitoring devices and controls units. The electronic wireless power monitoring devices has been designed to monitor electrical parameter as the current of the household appliances. The developed smart power strip integrates many hardware components, embedded software and application program for access the power strip over internet. XBee module as wireless module has been used to make communications between central control unit and smart power strip. The measured electrical parameters are transmitted to a central controller via the ZigBee node. Raspberry pi card (mini computer) has been configured to play vital role as a web server and coordinator to switch ON/OFF smart strip power and measure power consumption of plugged home appliances that are collected from power sensor using XBee protocol. In addition to, software has been developed using HTML, PHP, Javascript and Phyton to design web page as platform compatible with any internet browser in any smart phone or personal computer. However, our developed system requires static IP number. We have evaluated our design under different conditions. We have found the results are satisfactory.

Key words: power strip, standby power, Raspberry Pi, Xbee.

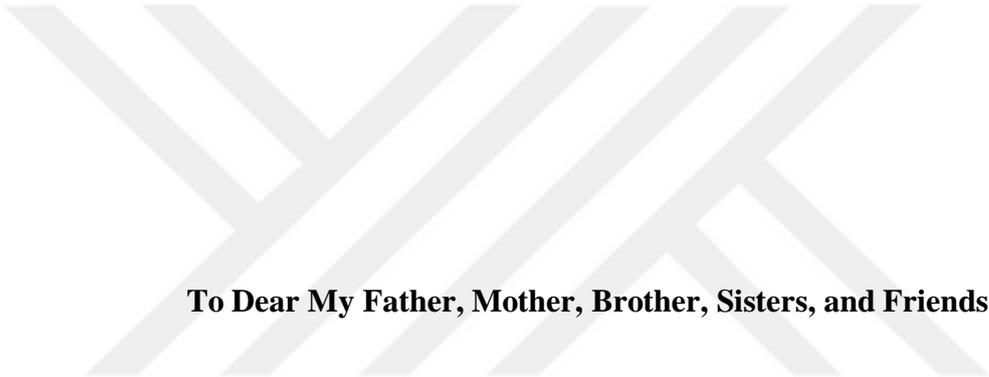
ÖZET

KONUT BİNALARI İÇİN KABLOSUZ GÖMÜLÜ SİSTEME DAYALI AKILLI ENERJİ YÖNETİMİ

ALADHAMI, Aymen Husam Ahmed
Yuksek Lisans Tezi, Elektrik ve Elektronik Mühendisliği
Danışman: Prof. Dr. Ergun ERÇELEBİ
Eylül 2017
59 Sayfa

Tezde evde elektrik tüketimini azaltmak için akıllı bir elektrik prizi geliştirildi. Ayrıca, geliştirilen güç şeridi, kullanıcıya ev aletlerinin elektriğini açıp / kapatarak evdeki güçleri yönetmesine olanak tanır. Geliştirilen sistem kablosuz güç izleme cihazlarını kullanır ve üniteleri kontrol eder. Elektronik kablosuz güç izleme cihazları, ev aletlerinin akımı gibi elektriksel parametreleri izlemek üzere tasarlanmıştır. Geliştirilen akıllı güç şeridi, internet üzerinden güç şeridine erişmek için pek çok donanım bileşenini, gömülü yazılımı ve uygulama programını bütünleştirir. XBee modülü kablosuz modül olarak merkezi kontrol ünitesi ve akıllı güç şeridi arasında iletişim kurmak için kullanılmıştır. Ölçülen elektriksel parametreler ZigBee düğümü vasıtasıyla merkezi bir denetleyiciye iletilir. Raspberry pi kartı (mini bilgisayar), XBee protokolünü kullanarak güç sensöründen toplanan güç tüketimi ölçmek ve akıllı prizi açmak/kapatmak için bir web sunucusu ve koordinatör olarak hayati bir rol oynamak üzere yapılandırılmıştır. Buna ek olarak, herhangi bir akıllı telefon veya kişisel bilgisayardaki bir internet tarayıcısı ile uyumlu bir platform olarak web sayfasını tasarlamak için HTML, PHP, Javascript ve Python kullanılarak yazılım geliştirildi. Bununla birlikte, geliştirilen sistemimiz statik IP numarasını gerektirir. Tasarımımızı farklı koşullar altında değerlendirdik. Sonuçları tatmin edici bulduk.

Anahtar kelimeler: Elektrik şeridi, Raspberry Pi, Xbee kablosuz modül.



To Dear My Father, Mother, Brother, Sisters, and Friends

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By starting with In the name of my creator, the most gracious and merciful and I give many thanks for Allah, all praises to my creator for the strengths which he gives and his blessing in encourage me in this thesis.

First of all, I pay my gratitude to my guide **Prof. Dr. Ergun ERÇELEBİ** for providing necessary infrastructure and resources to accomplish my research work. My work maybe not be possible unless his guidance, support and encouragement. By his guidance, I successfully get over many obstacles and have a lot of experience.

At this Juncture, I direct all my thanks for my **parents** whose stand by me, sacrificial life and their great efforts with pain and tears and unceasing prayers has made me to reach my goal in life.

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LIST OF ABBREVIATIONS

HEMS	Energy Management System
IP	Internet Protocol
HTTP	Hypertext Transfer Protocol
MCU	Microcontroller Unit
GPIO	General-purpose Input/ Output
USB	Universal Serial Bus
HDMI	High-Definition Multimedia Interface
WSN	Wireless Sensor Nodes
PAN	Personal Area Network
IIS	Internet Information Server
PIR	Pyroelectric Infrared
SMS	Short Message Service
LAN	Local Area Network
WLAN	Wireless Local Area Network
WSN	Wireless Sensor Network
PL	Power Level
SP	Sleep Period
HV	Hardware Version
CGI	The Common Gateway Interface
WAP	Wireless Application Protocol
PLC	Programmable Logic Controlle

CHAPTER 1

INTRODUCTION

1.1 Background and Purpose

Evolution and growth economy in some countries led to increase purchasing power. Turkey accompanied by increasing in the number of electric home appliances. Residential sector in Turkey accounts for about 25% of the national electricity consumption [1]. These days, a lot of appliances and devices use standby power. We can mention several common examples which contain television sets, computer peripherals, cordless telephones and so on. Because these appliances take a lot of power when they do not work, to save power is being consumed by unplugging them from the utility outlet. When they are together, the total watts is made by like appliances and devices which may be 100 or 200 watts. Although this seems little, the energy consumption include far-reaching implications in the tow, the economically and the environmentally when it is multiplied over hundreds of thousands of households through a lot of years. Reducing energy consumption, users can stop working standby devices when they do not need. The problems are the way changing user behavior to get more energy efficiency. Many electrical companies are trying to develop products and services to help people reducing their consumption and in the same time, making daily life much easier. There are devices connected to the telephone line that can switch the power outlet on and off when one calls the device with a conventional telephone. This technology has evolved to devices connected to the Internet and controlled on a website. So far, these devices are mostly designed for companies or very advanced home users. Recently, the development of these types of devices has continued to include more sophisticated solutions like washing machines that are turned on during the night when power is cheap, or electrical cars that use the same principle when it is charging. Overall, companies at home electronics business put a great effort into reducing their products energy consumption and lowering stand-by consumption. TVs, DVDs, stereos, gaming consoles and similar products are often consuming under one Watt of power in stand-by mode in order to efficiently reduce

the amount of electricity waste in the residential side. The consumer needs to change the usage behavior. Project designs to monitor energy in real-time [2]. Smart home has been developed to provide technical solution to meet the comfort needs like energy management. Energy management began when it reduced useless power (standby power) when home appliances do not perform the primary function or even when they are turned off [3]. It is known that the Smart home is a convenient home preparing in the place of appliances and devices can be automatically observed remotely from anyplace in the world by utilizing a mobile or other network device. A smart home includes a lot of its devices, namely, which are connected to each other through the Internet which setup the functions like security access to the home, temperature, lighting, and home theater. Increasing popularity of smart homes, and people need more smart home appliances to upgrade their living spaces and enjoy a high-tech life. Previously, when the computer was developed for personal and domestic purposes, the purpose of it was to perform simple coding and calculations. After the advent of the Internet, Computers become more effective and desirable resulting in the usage of new technologies like web server. A Web server is a computer program which uses HTTP to serve the files that make web pages for a lot of users, by responding to what they needs, who clearly were forwarded by their computers HTTP clients. Dedicated computers and appliances maybe stand for Web servers too. This is the machine that gives a response to the request and send the page's content back to the user. This is very easy because each device that bond to the internet which contain a uniquely identifying number, called an Internet Protocol address, or IP address for short. With the rapid development in the field of computers, the emergence of a new generation of computers it has the ability to perform conventional computer tasks. These devices have small in size and very low power consumption. Raspberry pi is a portable single-board minicomputer, and controlled by method for an adjusted variety of Debian a Linux upgraded for the ARM engineering. ARM technology is used on the board to reduce cost, heat and power consumption. Features of the board is very weighing about 50gm and operate on 5 V, 700 mA power rating. The Raspberry Pi 3 is the third generation Raspberry Pi. It runs on 64-bit quad-core ARMv8 CPU processor with 1GB RAM operating at 1.2 GHz frequency [4] [5]. In computer networking, there is a great value of wireless networking because it has lot of ways to save money and time besides it has no difficult installation or more expenditure. In the field of wireless networking, there is another form of networking which is called wireless sensor network.

ZigBee standard for wireless sensor network is given more opportunities to build wireless control and monitoring applications that can guarantee low power, low cost and large and high reliability.

[6] As it is accepted in the world literature, it is a device that enables remote monitoring and recording of the power consumed by the household or office equipment connected to the power outlet by means of communication infrastructure and the possibility of opening and closing the power of the device remotely according to a certain energy management algorithm when it is necessary. Moreover, smart sockets nowadays have become an important part of smart homes and buildings that are compatible with smart networks. Especially for demand control that can be implemented with smart network infrastructure. Smart sockets have a great deal of control so that existing devices can be controlled. Studies related to the management of electricity demand is gaining great importance for demand side management at the end user. The main contribution of this thesis is to implement an electronic card which can control household equipment such as television, light and so on through the internet under any operating system environment. Despite the increasing demand for energy, monitoring of the energy consumed is not enough. The platform consists of developing programs that allow communication between a remote user and household network. User can remotely unplug household devices when they are not being used. Therefore, we have developed Remote controllable power strip based on ZigBee wireless protocol and minicomputer (Raspberry pi) to allow home owners to control and monitor power usage of home appliances.

1.2 System Overview

In the last few years, Conflict of Interest Researchers in at home automation for developing various systems to allow several convenience features effectively managing energy in at home [7] [8] [9]. The overall purpose of the project is to develop a smart power strip with the functionalities of measuring power and switching power socket on/off, and using that functionality through a user-friendly web interface. The Smart Power Strip will connect and upload data to a remote server to which users will be able to log in through their Internet browser or phone app to access power statistics and control the switching functionality. The ability to view energy consumption statistics together with an encouraging web interface should help the users taking control over and optimizing their power usage. Users will be presented with an easy

way of controlling electrical devices with an online accessible tool for scheduling or instantly turning on and off power sockets. The project has two parallel design tracks: the first one is for hardware and the second one is for software. Regarding hardware design, the aim is to create a safe, dependable, low-cost and energy efficient device that can work as a prototype for construction of commercial products. The software development will firstly, focus on the main features including straight forward handling of several hardware units and presentation of data. The amount of available time resources will determine what additional features will be implemented in a later stage. The main objective of this project is to produce a system less complicated that may attract consumers for home automation technology through low cost and simplicity. In line with this philosophy, the system should require minimal infrastructure or additional expertise to install and use. Major components and their relationship can be seen below in Figure 1.1. Generally, Home automation system has architecture content in three main components:

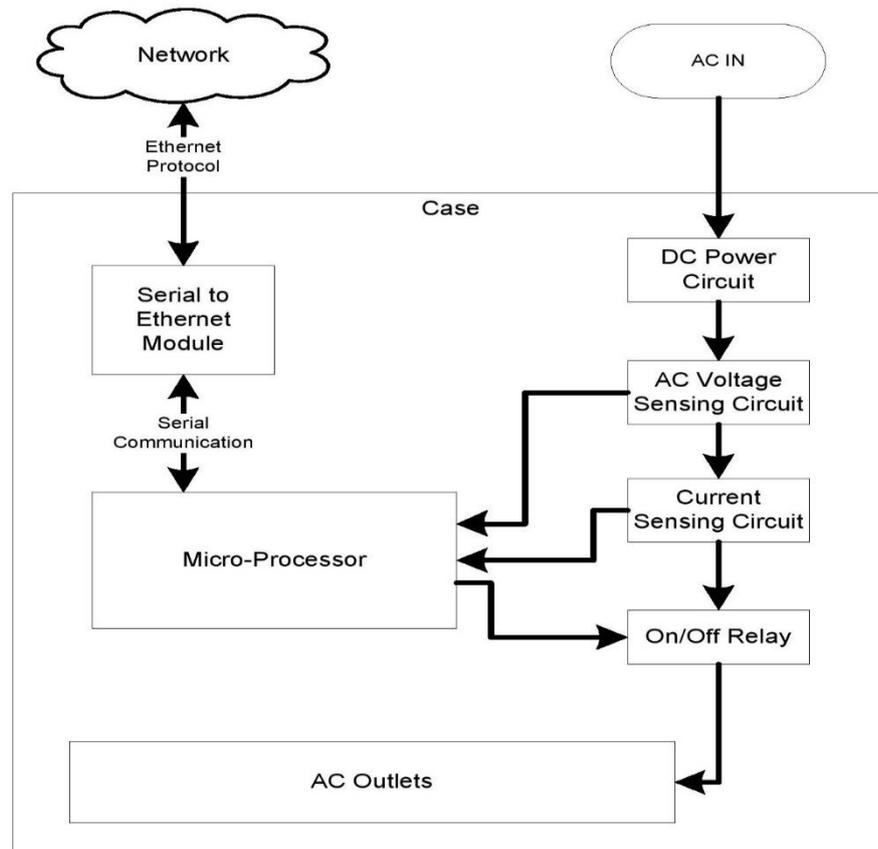


Figure 1.1 : Early system design flowchart

1.2.1 Central Control Unit

In order to implement the needed features for the Smart Power Strip, a microcontroller unit (MCU) is used as a base. A lot of researches have been proposed to use central of gateway as an intermediary between the user and the internal network [10] [11] [12]. This unit has the ability to control the nodes located within the network via different communication protocols. At the same time, it can access to the Internet by modem or router. There are many ways to access gateway that is able to connect the Internet using an Ethernet connection or Wi-Fi connection. A few standard computer researchers have used custom programs, while others have designed low-power embedded devices with sufficient resources. In our development, we have used minicomputer Raspberry pi 3 card as shown in Figure 1.2. The latest Raspberry Pi computer features has a powerful quad core ARM Cortex processor including integrated wireless LAN and Bluetooth, USB and HDMI ports. Easy accessible GPIO pinouts opens up the platform to a whole host of impressive add-ons boards. All of these are packed onto a single PCB and no bigger than a credit card. Exploring the many of varied and exciting possibilities of this fantastic single board computer today.

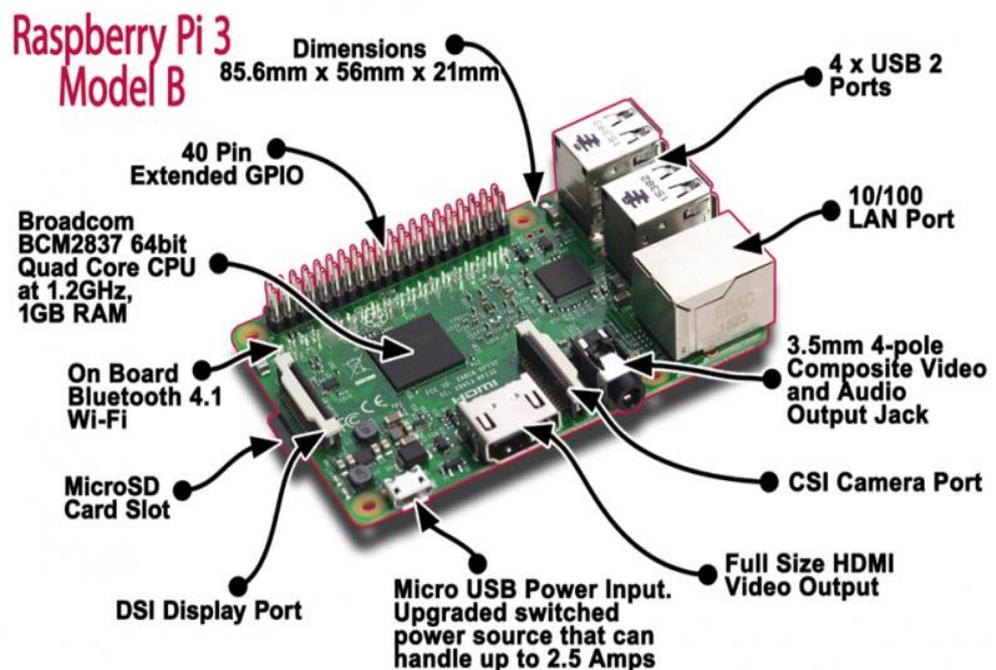
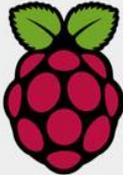


Figure 1.2 : Raspberry Pi 3 Model B

A lot of generations sort of Raspberry Pies have sent free as shown in the Table 1.1. The first sort (Pi 1) was sent free in February about 2011-2012 in normal model A and

a great specification model B. A+ and B+ models were sent free before 1 year. Second type of 2 model B was sent free in February 2015 and the third one is model B in February 2016. The third one is the same as anticipated from the modern Raspberry Pi 3 there is no SATA or a PCI connectors. The aim of the Raspberry Pi Foundation is to be produced in a very cheap computer towards people. The Pi Foundation has done their performance very well and pleased everyone. The second one is last year, the third one features are a new CPU a Broadcom BCM2837 quad-core 64-bit ARM Cortex A53 running at 1.2 GHz.

Table 1.1 : Raspberry Pi versions comparison



	Raspberry Pi 3 Model B	Raspberry Pi Zero	Raspberry Pi 2 Model B	Raspberry Pi Model B+
Introduction Date	2/29/2016	11/25/2015	2/2/2015	7/14/2014
SoC	BCM2837	BCM2835	BCM2836	BCM2835
CPU	Quad Cortex A53 @ 1.2GHz	ARM11 @ 1GHz	Quad Cortex A7 @ 900MHz	ARM11 @ 700MHz
Instruction set	ARMv8-A	ARMv6	ARMv7-A	ARMv6
GPU	400MHz VideoCore IV	250MHz VideoCore IV	250MHz VideoCore IV	250MHz VideoCore IV
RAM	1GB SDRAM	512 MB SDRAM	1GB SDRAM	512MB SDRAM
Storage	micro-SD	micro-SD	micro-SD	micro-SD
Ethernet	10/100	none	10/100	10/100
Wireless	802.11n / Bluetooth 4.0	none	none	none
Video Output	HDMI / Composite	HDMI / Composite	HDMI / Composite	HDMI / Composite
Audio Output	HDMI / Headphone	HDMI	HDMI / Headphone	HDMI / Headphone
GPIO	40	40	40	40
Price	\$35	\$5	\$35	\$35

1.2.2 Wireless Sensor Nodes

A sensor network typically consists of a number of sensor nodes which each of them acquires signals from a sensor or multiple sensors and a system to transmit and process the data acquired from sensors. The sensor nodes can communicate the data through one to another or to a centralized location over a wired or wireless network. The sensor network can be ordered as the following: a data acquisition network and data distribution network. The data acquisition system include sensors and circuitry to deal with the real-world information which they exist. The data distribution network took part the connection protocols, network topology, and methodology to move and deal with the data. The main uses of this network topologies is star, ring and mesh as shown in Figure 1.3.

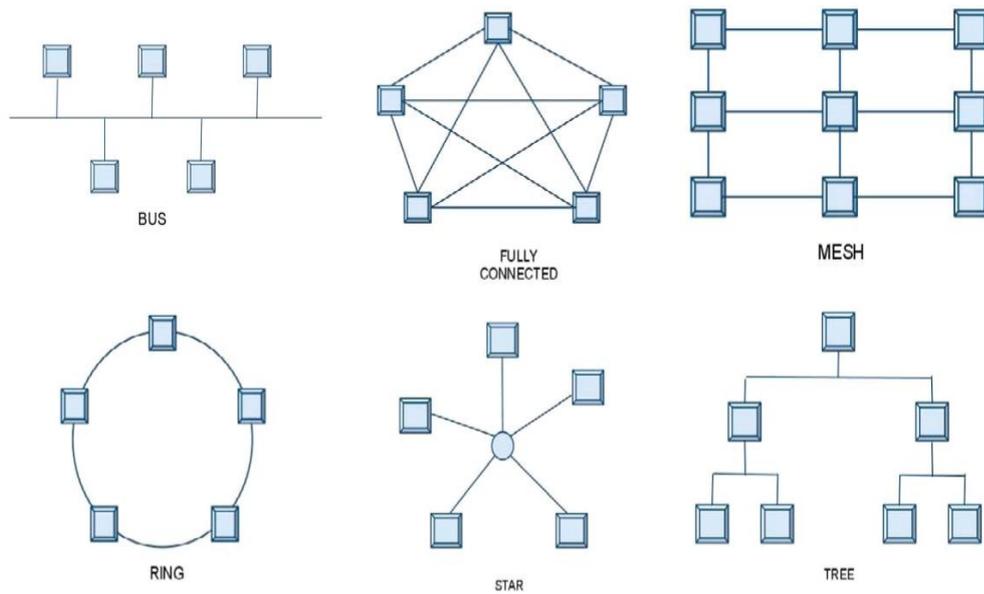


Figure 1.3: Various network topologies.

The choice of the sensor network topology depends on the application and kind of processing and handling require data for improving connectivity from PCs to the real continuing world which get momentum. A lot of sensors and actuators are used and interconnecting them by combining the data which exist and has become very important. The end device, each node in the network, is responsible for collecting data from the environment around it and sending that data to processors in the network, which sized the power consumption of the various loads and move it to the Central Control Unit. All devices are connected to each other at a smart home environment system by using several type of networking and types of network protocols. Some of these technologies provide more economical uses and better performance. Growth and increased interest in the development of these technologies have increased to be less expensive and low power during offering features [13] [14]. There are four main wireless Personal Area Network (PAN) standard for data transmission as shown in the Figure 1.4: Wi-Fi (based on IEEE 802.11/a/b/g), ZigBee (based on IEEE 802.15.4), Bluetooth (based on IEEE 802.15.1), and UWB (based on IEEE 802.14.3) are depended upon each of the aforementioned in their intended use cases, the 802.15.4 IEEE protocol was developed specifically for low rate, low power signal transmission [15] and is ideal for industrial level sensor network applications [16].

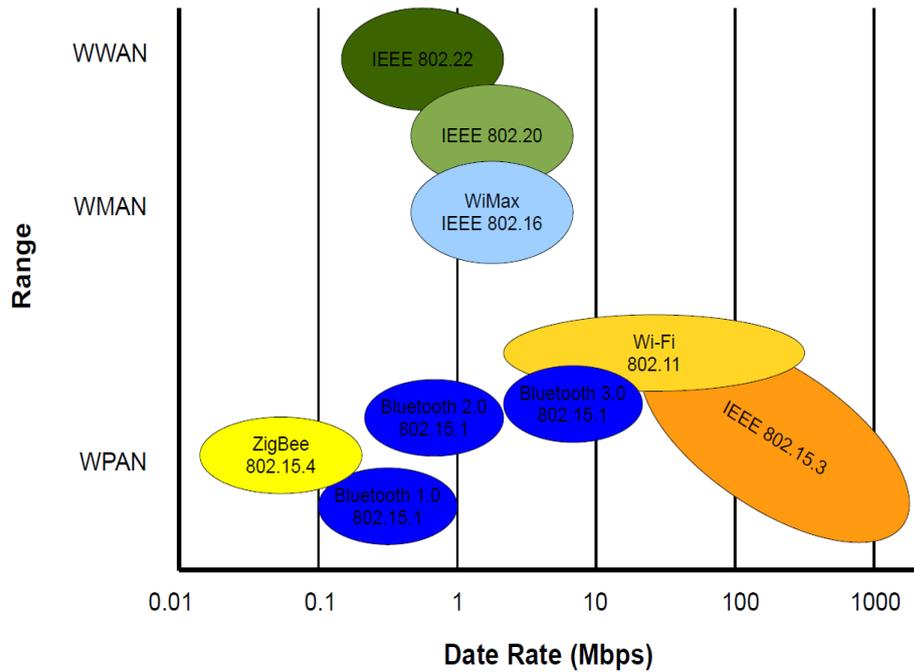


Figure 1.4: Range vs Data Rate for various IEEE standards.

There are many Smart Home Communication Technologies in the market. Most popular is (X10, Z-Wave, ZigBee, INSTONE, EnOcean) [17]. The most relevant communication technologies is used in smart home systems ZigBee protocol as shown in the Figure 1.5. Xbee Series 1 and Series 2 modules operate on the 802.15.4 and ZigBee standards respectively with small variations for specific uses. Due to its intended development for low power and cost rate sensor networks, it has become widely used, which makes it a great alternative to batteries and gives it an edge over Bluetooth and Wi-Fi wireless technologies. In fact, ZigBee and ZigBee Pro consume 1/10,000th of the energy required by a Wi-Fi network.



Figure 1.5: ZigBee network deployment.

1.2.3 Remote Web Interface

The Internet Of Things is the most trending technology today. That stands alongside with wearable and robotics. It is a very simple concept where devices in our home or anywhere they are, they have the capability to communicate with each other via the internet. Usually sensors are used with this technology to pass data to the internet. You can imagine a sensor installed in your garden which uploads data to the internet like temperature, humidity, soil purity etc. These data will be visible to you from anywhere around the world or imagine home automation systems connecting to the net, which

can be used to control appliances in your home like lights, door locks, air conditioning etc, and through a web interface or smartphone application, a lot of technologies are being developed around this concept such as independent light-weight IoT networks and protocols for passing data etc. For the smart features of the Smart Power Strip which utilized, additional software must be presented. This software should provide storage for consumption data and a way for the user to interact with the system. This has done as it is explained in in the section 1.2 and It is shown in the Figure 1.1 by a web application, a database and a communication server. The communication server acts relay between the Smart Power Strip and the web application. It relays data from the power strip to the database and control signals from the web interface to the power strip. Hypertext Transfer Protocol is a Web server that is utilized to serve the files that form Web pages to users in responding to their orders and which are sent by their computers (HTTP) clients. Devoted computers and appliances might be stood for to as Web servers too. The process is an idea of the client/server model. Most computers that receive Web sites need to Web server programs. Leading Web servers include Apache (used widely-installed Web server), Microsoft Internet Information Server (IIS), and Nginx (articulated engine X) taken NGNIX. Other Web servers include Novell's NetWare server, Google Web Server (GWS) and IBM's family of Domino servers. All web browsers have been set up tools for this goal. Gadgets gave a permission to the web developer to utilize HTML, CSS and JavaScript etc. These are charged by hovering over an item on a web page and choosing the “Inspect Element” from the context menu.

1.6 Thesis Outline

Chapter 1: Providing a brief description of the purpose of smart power strip and setting up the purpose of research project.

Chapter 2: Previous studies about the field of smart outlets and the used Technologies.

Chapter 3: Extra details about the project of hardware parts.

Chapter 4: Description of the software processes and the database structure.

Chapter 5: Outlining the process followed in developing each major component as well as the integration and tested system.

Chapter 6: Summarising the key findings of the project and examining the opportunities for future improvement and development

CHAPTER 2

LITERATURE SURVEY AND PREVIOUS WORK

2.1 Overview

The concept “Smart Home” was known for the first time in 1984. It was first used in an official way by the American Association of House Builders [18]. The device or system early home automation firstly, start working with labor-saving machines. Here we have two types: “gas with powered home appliances” or “Self-content electric “which would be viable in the 1900s with the starting of electric power distribution and brought about the onset of washing machines in 1904, several water heaters (1889) and finally sewing machines [19]. In recent times, the consumption and conservation of energy have become very important. And the non-renewable resources are depleting day by day. The need for energy conservation has been increasing. Recently, solar energy panel installations are on the rise and more in the domestic household level. But this puts a condition on Smart usage of the available or rather harnessed power.

The researchers have been working in developing different strategies and approaching to manage power consumption in automation household. This information clarify a new three-layer household energy controlling system capable, both of them are to satisfies the maximum available electrical energy constraint and to increase the user satisfaction aspects. This way brings more interaction to make it suitable for the power provider needs. Energy control system capable can do for both: to satisfy the maximum existed in electrical energy constraint and to increase user satisfaction criteria [20]. But there are things that affect the design system and one of these requires functionalities. It affects on increasing complexity in the system and difficulty in maintenance and development [21]. Therefore, for alternatives less complex and less costly, they used low cost microcontrollers with multi-tasks and over internet controllable [22].

Authors in [23] have designed and implemented power socket to reduce the standby power based on low cost MCU microcontroller that receives signal from pyroelectric infrared (PIR) sensor when the user turns the appliances off the socket automatically

turn off. Saving energy can be achieved by unplug devices when they are not in use. In addition, the consumption of some devices used in commercial buildings has been monitored and it has been determined that almost half of the consumed amount is realized outside working hours, namely, saving up to 60% by avoiding unnecessary energy consumption with smart outlet. It is easy to solve the problem by eliminating the standby power consumption of an appliance and would be unplugging switch from the power outlet or for instance switching off the switch [24]. The best way to do that, users need to communicate directly with the appliance for manual control. This will bring about incompatible for users. Several of commercial products [25] see carefully the device's operation of standby mode automatically and they make the power easy to cut off in standby mode. In turn, the products only can be cut off the power and the people who use them have to activate them by their hands, namely, the power supply as the power supply impossible to be controlled automatically or remotely. The paper in [26] proposed remote controllable and energy saving room architecture for periodically monitor the power consumption via ZigBee controller with IR code learning functionality. User can control the power outlet and the dimming light, with the advent of mobile phones containing techniques including Bluetooth as well as Short Message Service (SMS). The Wireless Power-Controlled Outlet Module (WPCOM) is shown in the Figure 2.1 allows to implement home power management, and develop controllable power socket based on microcontroller.

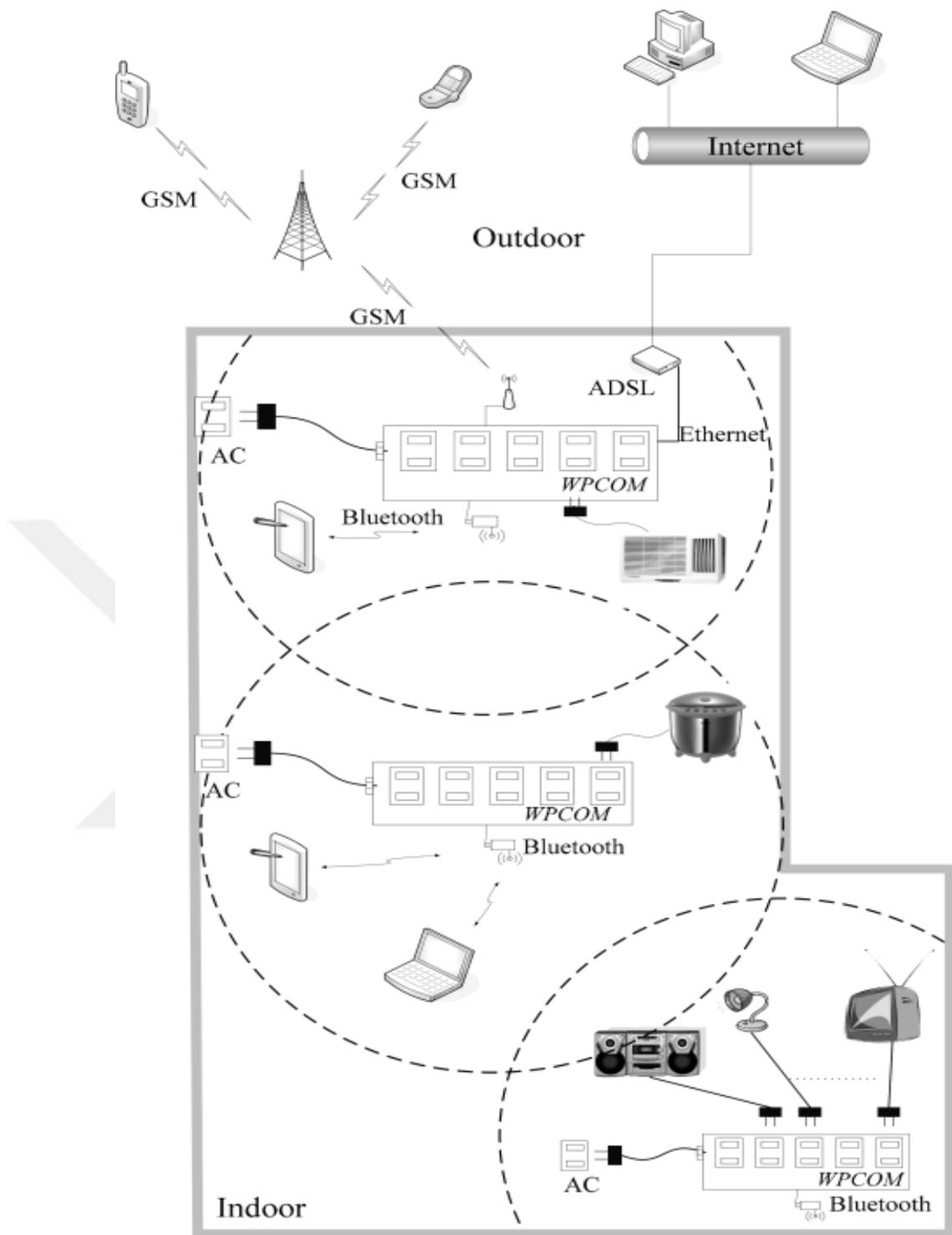


Figure 2.1: Remote-controllable power outlet system.

In the same context, due to the characteristics of cross-platform and faster development life cycle, java becomes one of the most important language in the mobile application development. Development platform (JADP) based on java is designed to S68 mobile phone for smart home. As a result, it could be more flexible remote debugger and easy to develop [27].

Recently, many wireless communication technologies have been developed and they led to renovation in smart home. In addition, a wireless controllable power outlet has to work with and depend on ZigBee radio compatible with smart phone. A practical application of wireless sensor and actuator network is as a matter of fact, the proposed home automation network. As shown in Figure 2.2, the home automation network is consists of several sensor nodes, several wireless power outlet modules and a base station. Every one of the power outlet module is formed to be an actuator node added to the home automation network. The sensor nodes and the actuator nodes are deployed in the home environment and they autonomously form a multi-hop mesh network. The base station can provide multiple interfaces to the mesh network for local user interactions and remote network management [28].

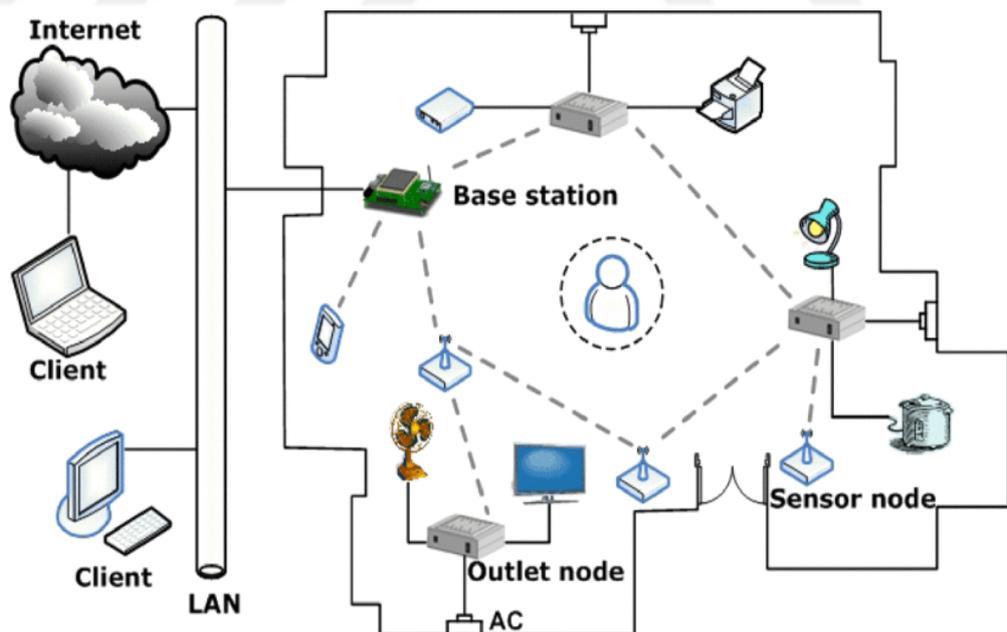


Figure 2.2: The wireless power outlet system in home environments.

With increasing number of internet users, researchers began using the Internet as interface between remote users and the home network. A smart socket was developed that could be controlled over the internet. This socket is able to control air conditioners

in peak times. The peak time is heavily loaded networks attracting high power network devices such as when we turn off and relief air conditioning for 15-30 minutes, it does affect too much on the comfort of the user. The explanation in this paper clarify the consistency of a smart outlet network as a way of work, system for automated energy-aware services using several sensor information. This study describes the construction of a smart outlet network as a system for automated energy-aware services utilizing various sensor information as shown in the Figure 2.3, the power strip contains 4 sockets in addition to power sensors and depend for on-off control of every socket, an ARM-based CPU, two USB interfaces for extendibility and runs Debian Linux OS for embedded systems. Existing smart power socket's sensors (light, temperature, humidity, movement) are also used in the studies for adding more features. It also has an HTTP service for the visualization of power consumption. The server periodically generates a graph showing power usage based on gathered data. A user can see the data and the graph through accessing the server with web browsers [29].



Figure 2.3: Smart outlets with Wi-Fi interfaces and sensors

This study clarifies and gives a clear explanation about a Remote control of a domestic tools taken from an Android application centered on Raspberry pi card. The architecture adopted which is used for the application (side: Android application, web service and database) is simply the three-tier architecture. An android platform program made has buttons to control relays. There are several connections to (GPIO) of raspberry pi to control the remote shutter ON/OFF and java application that turn on the Raspberry pi. This application has been designed to be from a far distance accessing every X seconds to MYSQL database. The used language is PHP language to command Shutter (open) in the Rest Web Service [30]. They developed EMU by depending it on Wireless Sensor Network (WSN) using Xbee-pro ZigBee, Arduino Uno microcontroller and current sensor (ACS712) can be seen in the Figure 2.4 for controlling energy consumption and monitoring the system in real-time using NILABVIEW software. The EMS is prepared and used to lessen the energy consumption of the clients at specific peak load hours by changing the load aspect of peak to off-peak periods i.e. lessen peak load demand. ThingSpeak Website issued as Cloud to store and clarify sensor data [31]. ThingSpeak is at no charge only for few projects. Cost is based on a numbers of messages to be continual and saved a year. ThingSpeak is free and you can use it at any time for non-commercial small projects (<3 million messages/year or ~8200 messages/day).

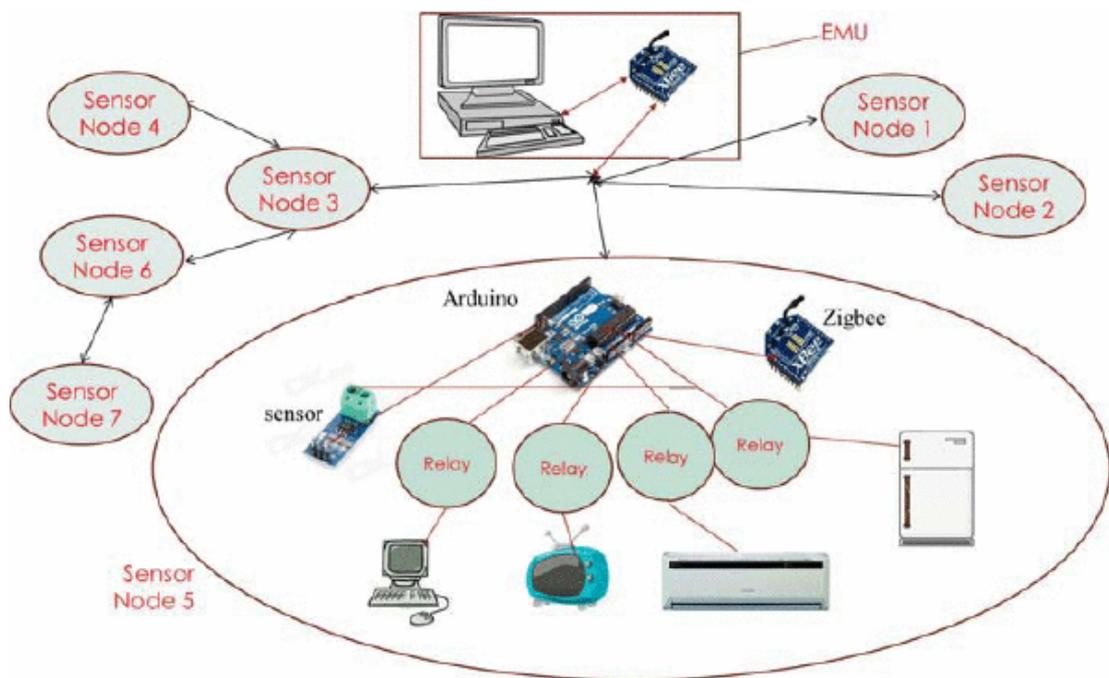


Figure 2.4 : Energy management system

The former techniques had made internet by depending remote controlling and monitoring. Those systems form a relations with other and a web server as the connection between remote users and the home network. Even though, the use of web server gives several useful helps in term of User Interface (UI). Researchers faced several obstacles and difficulties by these approach such as faced remote users need high speed internet connection and a fix IP (Internet Protocol) address. Therefore they developed the lightweight system which can be seen in the Figure 2.5, e2Home that make the way easy to mobile users to control their smart home appliances in connection scarce environment. In this system, you can use an email as the essential medium of communication to keep in touch with the home server by using email [32].

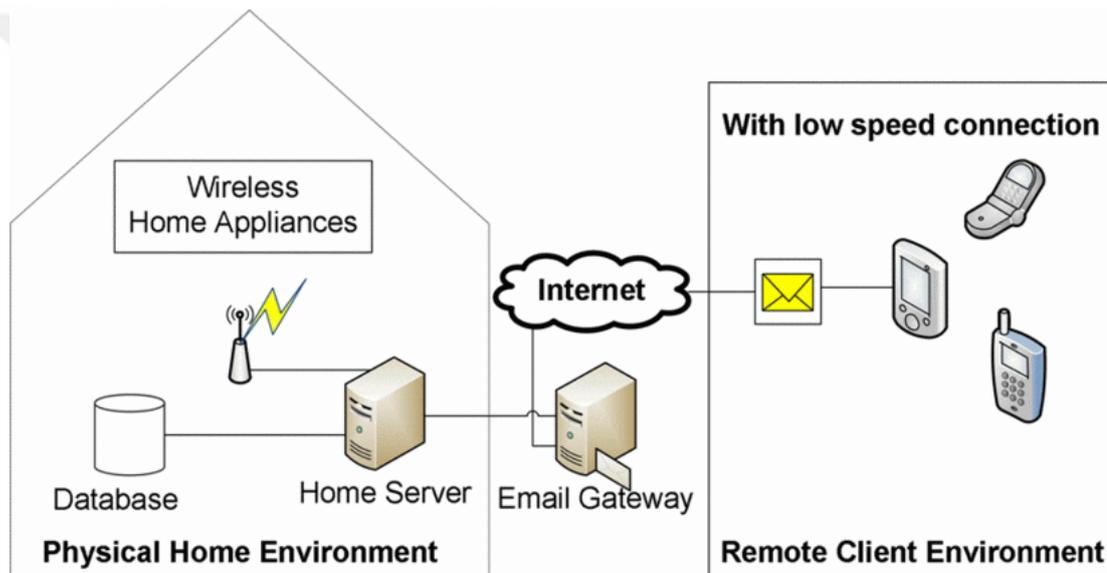


Figure 2.5: e2Home Infrastructure

A small, simple and smart power strip is in Figure 2.6, has a built-in electric power measurement sensor for every exit and they have been improved because of this reason. The design characteristic also contain a gateway that facilitate to two connector and more smart power strips. System software on a server that collects power consumption data from the gateway integrates individual action data and individual power consumption and makes these visible. Specifically, the real-time input of those systems develops the difficulties of controlling all devices within a singular interface and platform. The gateway is used in order to minimize the overall system cost and to reduce the number of IP addresses required for system operation [33].

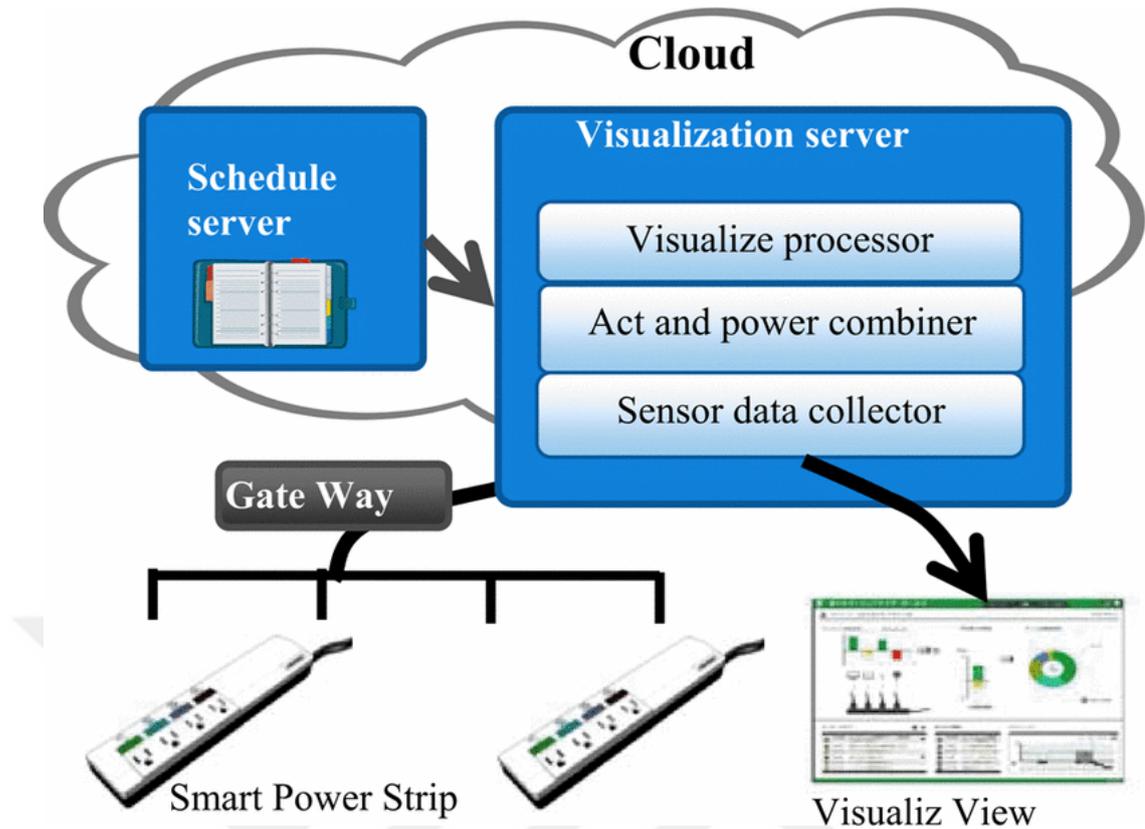


Figure 2.6: Outline of the smart power strip

Many of voice controlled wireless smart home systems are promoted for old people and people who are disabled. The voice controlled work on voice recognition system and Zigbee wireless communication to control home devices by utilizing human voice. The system can use further software as a processing facility and voice inside the data detection command to be sent by Zigbee. Data sent will control home appliances in accordance with the data format intended This research is introduced for people with specific needs. The system can be widely and easy to enlarge remotely control the home appliances within smart devices as iPhone or and others phones [34]. Web-based power board using raspberry Pi is assigned to be used for monitoring and controlling and is supplied by two modes: the first one is Standard Mode and the second one is Timer-enabled Mode. Standard Mode gives conventional functionalities of a standard power board that could be turned on/off. The web-controlled functionality has a difference. You can set the time on how long a socket will be active In Timer-enabled Mode. The time remaining is displayed in each socket. The Raspberry Pi will serve as the microcontroller and will receive signals from the relay board always the user toggles the on or off switch. The General-purpose input/output (GPIO) pins will help

and serve as a connection between the relay board and the Raspberry Pi. RPi linked to internet by using A Wi-Fi USB dongle attached to it [35].

Wired sensor networks reached before and been organized and ready recently in different applications, the reason may be the wireless extension. Smart Grids recently took and conveyed a huge increase clearly in interests and also in activities. The important of getting wireless sensor networks because of automation in addition to control that the cabling price may be left out and you can install the wireless system rapidly. The respond in WSNs is not low sharing the minimal variance inside the packet delay because of somewhat little network in sizes. The consumer price can be step by step reduced by the application of "WSNs" in energy of management when we turn ON/OFF appliance loads within carbon emissions in addition to peak hours which organized with electricity use within peak times [36].

Researchers prepared and developed an automated wireless irrigation system by using WSN and raspberry Pi as an embedded Linux board. They used The ZigBee protocol here for wireless communication and that will create network in an easy way and by collecting of Arduino that will aid to make the consumption of the fresh water little. By giving the web interface and automation, a user in an easy way can monitor the system and minimize the human intervention. The database based on MySQL that is installed on Rpi, Database stores the soil parameter information (Temperature, moisture) directed by a sensor node [37].

Researches have attained on smart home architecture for lighting and commercial goods which are not enough, and proposes a smart home lighting system with improving security features with each other with economical solution for daylight harvesting by using the user's personal smart phone. There are three factors in the intelligent lighting system: the smart phone application, the luminaries and the main controller. The smartphone application gives the user connection for the user to save the lighting system. The main controller is a Raspberry Pi which is assigned to act as the connection between the mobile application and the luminaires as shown in the Figure 2.7. The luminaire include red, green and blue LED channels controllable by pulse-width modulation (PWM) by using an on-board Arduino Uno. The trait of this algorithm is to make the system with little price by using the built in sensor light in the smart phones. XBee modules are prepared and assigned to make a connection to Arduino Uno with the main controller (Raspberry pi). One of the trait of that system

contain an Internet server to control it from a long distance and the possibility of working with other smart homes as a platform into the future [38].

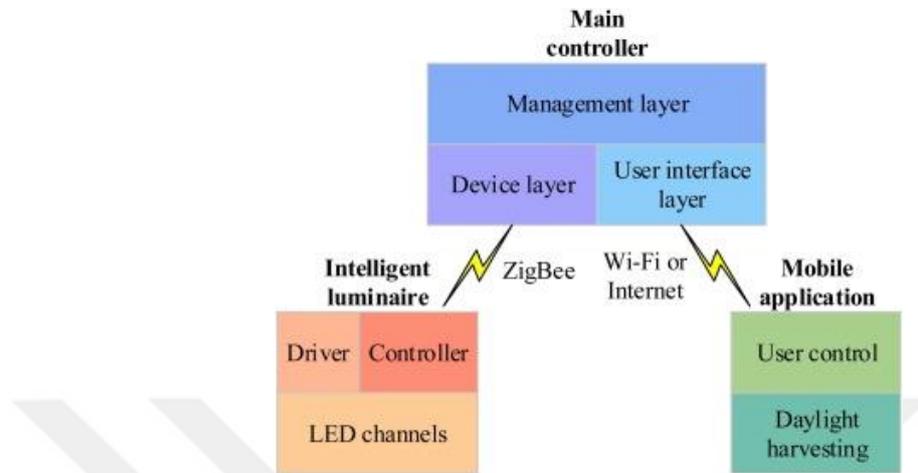


Figure 2.7: Architecture of the proposed smart home lighting control system.

2.2 Remote Controlling Technologies

This subchapter reviews the techniques and hardware that were used during the development of the gateway. Personal computer has been used by a lot of people and researches as a home server and improved to attain the purpose of the home energy management system, server collects and inspect the information of electricity consumption on electrical outlet. PC has a high scalability to interact many different network devices within several ports (for instance , USB and serial port) [39]. Real time table controller for home energy management system (HEMS) comprises PC as a control center with Matlab software to get and send data to the home appliances and signal to turn ON/OFF the power socket which is clearly shown in the Figure 2.8 [40].

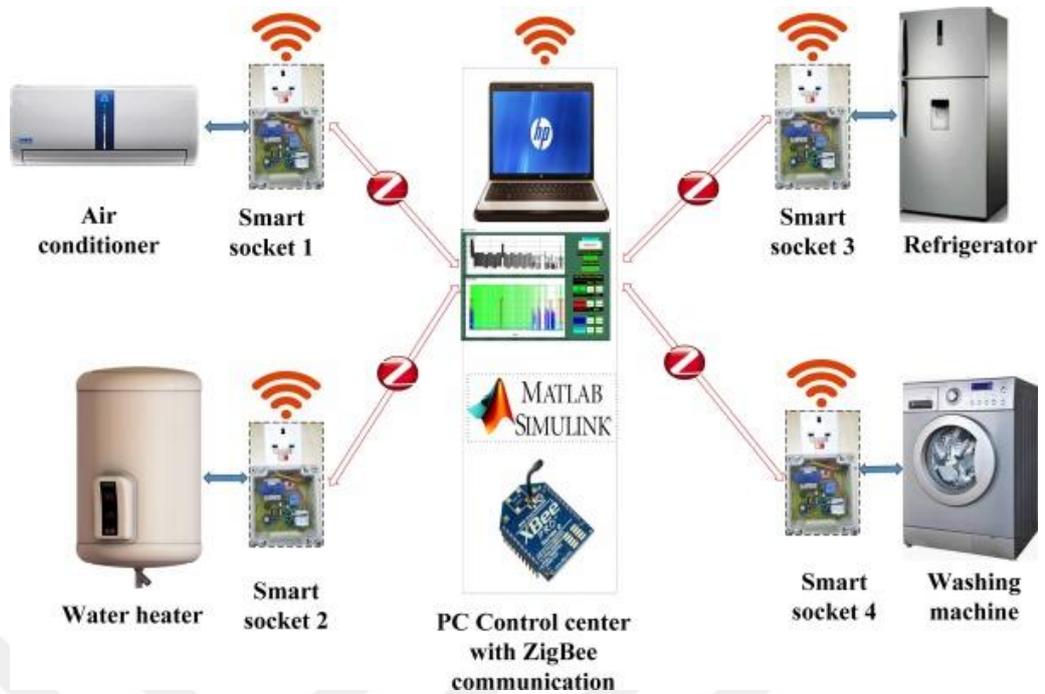


Figure 2.8: setup of the HEMS.

In this paper [41], designing smart home-based local network using Arduino as the central control serveries shown in the Figure 2.9 by selecting either net Arduino board connect to internet. We can use interface by reading and sending commands to Arduino via a local network. ACS172 current sensors 5A lined to Arduino to size current measurements could be at home. We can connect Web hosting from PC browser to display the power data use and to rule home devices at home. Web hosting can access form PC bowser to display the power data usage and to control home devices.

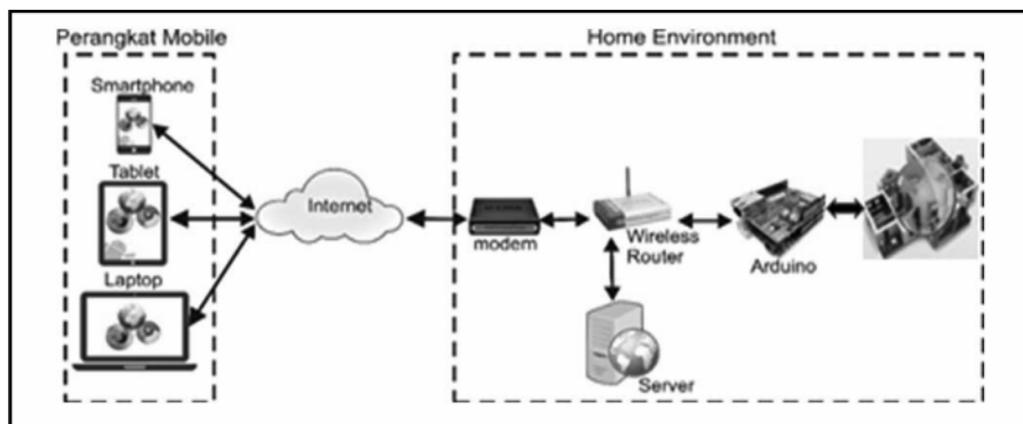


Figure 2.9: Smart home-based local network using Arduino System

BeagleBone preferred in order to manage the sensors and devices a communication protocol between a Mobil devices-embedded PC based control unit and sensors/actuators node which are designed implemented. A handshaking mechanism between a mobile device and control unit, and packet structure for messaging between control unit and sensors/actuators are explained shown in the Figure 2.10. Which enables monitoring and control of the smart home system with mobile devices operating with the Android operating system. Communication protocol of smart home management system and mobile devices are defined by using TCP / IP communication protocol [42].

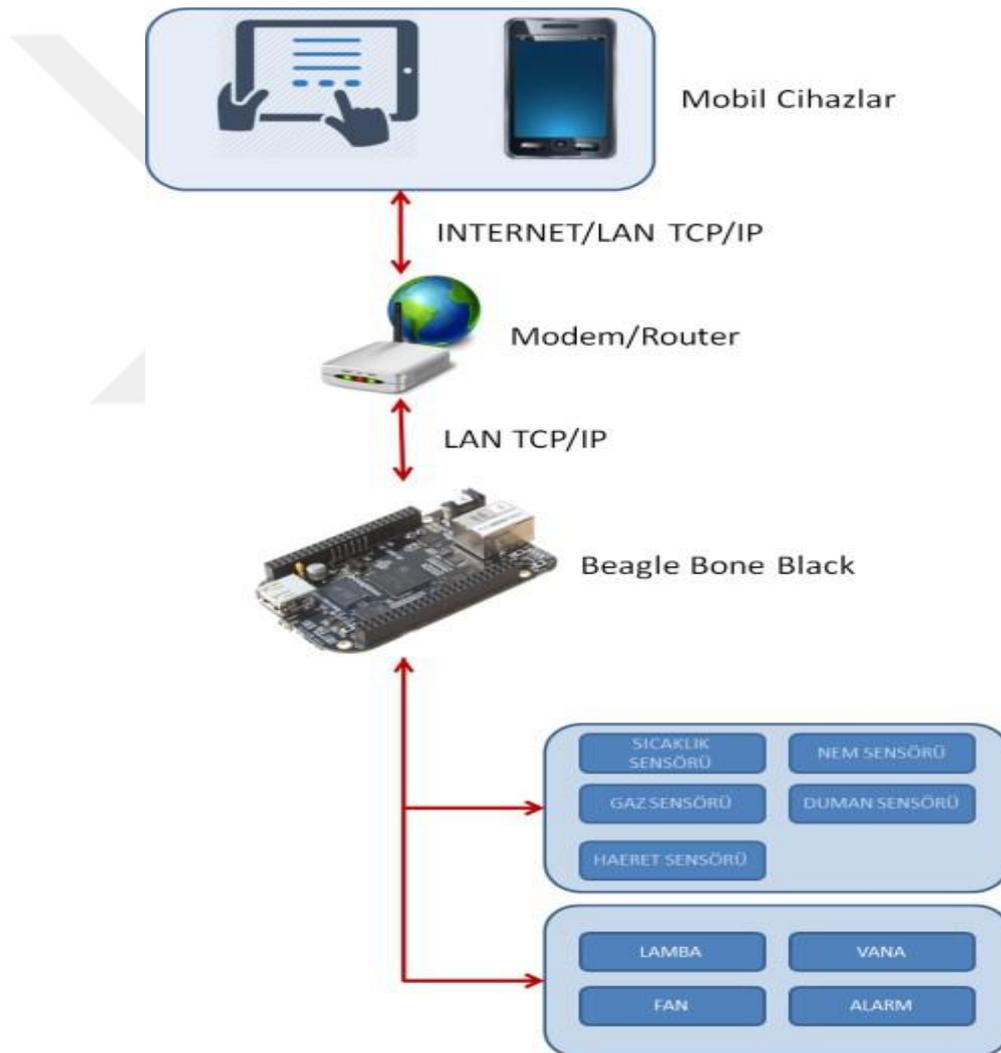


Figure 2.10: Beagle Bone based smart home.

This study present a mobile monitoring prototype employed on a Wi-Fi remote-controlled (RC) car to surveillance dangerous areas or areas that cannot be accessed

by humans. The RC car is driven by a Raspberry Pi and remotely controlled by the user via the Internet. The user is provided an interface via the browser to view the live video captured by the camera attached to the car. A control panel is also provided, allowing the user to remotely control the movement of the car. The live video streaming from the camera provides a dynamic surveillance view, which can be moved around the area to get a closer look of the current suspicious event. In general, this prototype exploits the concept of Internet of Things (IoT), where the RC car will be controlled via the web by the user, while the transmission of data from the car will be sent via the wireless network to the online server [43].

A remote medical monitoring system was presented by [44], which is monitoring continuous Physiological necessary parameter for elderly and ill patients. There is a need for a Web-based Patient health monitoring system, when the patient is not in the Hospital. A prototype of basic physiological parameter monitoring system based on Arduino and Raspberry Pi microcontroller boards are implemented. Different parameters are measured using relevant sensors and sent to the Arduino microcontroller board for further processing. The computed parameters are then sent to a Raspberry Pi based Web server for display on the web page. ZigBee is used for communication between Arduino and Raspberry Pi.

2.3 Remote Monitorings using Wireless Sensors Networks

Wireless sensor networks (WSNs) enable new applications and require non-conventional paradigms for protocol design due to several constraints. Owing to the requirement for low device complexity together with low energy consumption (i.e., long network lifetime), (WSNs) can be defined as a self-configured and infrastructure-less wireless networks to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location or sink where the data can be observed and analyzed. Several Wireless Technologies such as RF, Zigbee, Wi-Fi, and Bluetooth have been developed.

This study [45] introduces the Bluetooth wireless communication technology and LabView into the daily management of street lamps and designs a new type of remote monitoring and control system. The concentrator module is responsible for sending

control commands and collecting information on the street lamp voltage which be sent to upper computer for displaying.

Researchers prepared and developed a complete solution for controlling and monitoring household products by using Bluetooth low energy Smart power socket as a referent device, and an application implemented on Android OS. The Bluetooth Low Energy allows controlling devices directly from a tablet or a smart phone, without any requirements for additional gateways [46].

This study [47] is proposing a wireless patients monitoring systems which integrates Bluetooth, an embedded ECG acquisition system based on Bluetooth wireless communication technology is introduced, facing the difficulty and the costliness of medical treatment. The portable ECG monitor is designed, which can realize the acquisition of human ECG and heart rate and other psychological parameters. By connecting the sensor to collect the ECG signal, the Bluetooth module completes the transmission of remote data management and real-time data.

Researchers study the smart home control system based on Z-Wave wireless transmission and mobile devices through the application program to realize electronic lock control remotely. The system be used the Raspberry Pi as a smart home controller. The mobile devices access the control system using internet protocol via local area network or wide area network. Fix IP solved by using NO-IP web-site. The control system can achieve to remotely control the electronic lock functions via Z-Wave wireless transmission [48].

This research [49] another approach has been used. We will show that the complexity of home automation system can be reduced by installing the system to the existing Wi-Fi routers, such as ones found in user houses and apartments, and by developing devices that are based on Wi-Fi. As a result, system will be easier to implement and its overall price will be lower.

2.4 Software and Services for Remote Management

This section explains the software and services used to provide the test solution. Below is a list of the programming languages used to control the home via web page and mobile application.

This study [50] presents the idea about how to combine a set of software and hardware resources available in literature to be used as support to control engineering education. The available tools allow to mix topics related to programming, communications, operating systems, and control theory. The well-known Raspberry Pi board is used as platform to exploit the deferent proposed concepts. SciPy, Matplotlib, and NumPy libraries, which are Python-based open-source libraries, this development is based on these tools and ideas to control a two-tank level process.

Robot for surveillance developed using an application built on Android platform. The Android application will open a web-page which has video screen for surveillance and buttons to control robot and camera. The Video Streaming is done using MJPG streamer program that gets MJPG data and sends it through a HTTP session. The Raspberry pi programming is done in python language [51].

2.5 Current Measurement

It is mainly to do any of the research about different approaches which used in the sizement of electrical parameters like current. The flow of electrons is known as current in a wire. Here we can say that the main cause of the flow from electrons is easy to be understood as voltage within a very near loop electrical circuit. The opposition inside circuit would get down its amount of the current flow and bring about much heat to be gone out. The ampere is known as the unit of current, often named "amps". We can say here that electrical current is given by the code "I". Here we should keep in mind that the current sensing has big obstacles like the current waveforms have a relation does with consonant contents that based a big level of frequencies. They known in methods [52]: the current sizements, divert resistors, current transformers, and finally, the Hall Effect of current sensors. The way of measuring is made-up current by disconnecting little amounts of whole "magnetic flux" given by the sized current as a result the magnetic flux has difficulty in proportional to the sized current [53]. Here it is clear that the current shunt resistors, also has another definition is named the ammeter shunts and they are the reduced resistance precision resistors which is assigned to size AC or DC electrical currents by what so called a "voltage drop". A wide range of precision shunts is made to be used in addition to kilowatt-hour meters and various of the high-current applications ,namely, a big level of the accuracy is needed and they are a lot you can buy from the

market in these days. The basic Figure 2.11 is voltage drop through shunt resistors R_{sh} which sized and as a result, the sized" output voltage" is balanced to the continuous, namely , current and their number of occurrences.

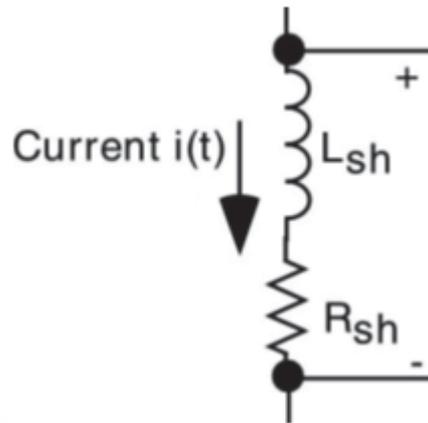


Figure 2.11: A Simple model of a Shunt Resistor

A range of methods for current measurements using electro mechanical ammeters, thermal type ammeters, multimeters, oscilloscopes and virtual instruments are presented in detail in [54]. The new energy meters is installed in the U.S. residential market need to measure a maximum current up to 200A.

2.6 Summary

The literature provides previous studies and techniques which is used to build power outlet (strip). The results of these studies show that three key factors identified such as low, cost and easy to deploy and maintain. The researchers tried a variety of approaches to resolve these issues. However, it sounds that centralized architecture will be the most common and convenient. Basically, this comprises of local home server or Gateway which includes other web server and other system management elements. Due to the spread and popularity of the Internet, it is the logical platform for the user interface. In addition, wireless technologies such as Wi-Fi and ZigBee provide a highly efficient and cost-effective network backbone network that provides smart energy management services with minimal installation difficulty. Consequently, these traits form are the basis of this Masters project.

CHAPTER 3

SYSTEM ARCHITECTURE

3.1 Analytical Model of The Design

Generally, a smart power strip architecture consists of three main components [55]: Central Control Unit, power socket and communication protocol shown in the Figure 3.1. Central Control Unit is the gateway between user and power strip. Our development is based on Raspberry Pi3 card. The power socket provides the interface between the developed home energy management and the non-smart load appliances in real time. It is designed to supply the remote control of non-smart loads, because of that giving a practical solution to interact the loads with the modern system and schedule on/off status of selected loads. The power socket is responsible for collecting data about the environment around it and sending that data to processor in the network which measures the power consumption of the different loads and transfer it to the Central Control Unit. For transmitting data from CCU to End node we need to Communication Protocol. There are many Smart Home Communication Technologies in the market which is most popular, (X10, Z-Wave, ZigBee, INSTONE and EnOcean) [56]. The most relevant communication technologies used in smart home systems are ZigBee protocol. This chapter introduces the design and the implement of the smart power strip. That is independent of ZigBee wireless networking protocol. It is scalable and easy to deploy and maintain.

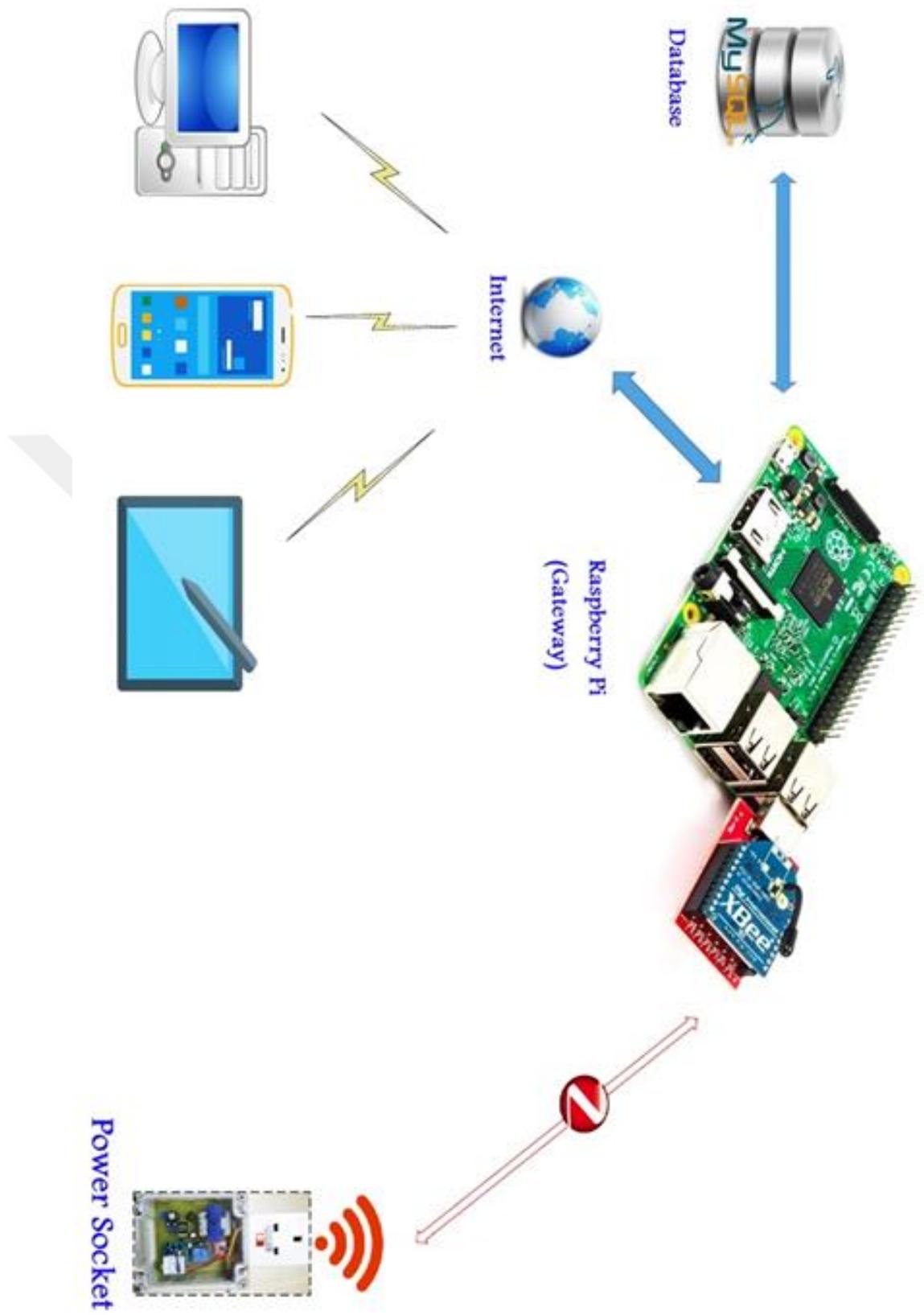


Figure 3.1: System Architecture

3.2 Raspberry Pi

We used Raspberry Pi3 which is shown in Figure 3.2 that contains built in 802.11n Wireless LAN that get more flexible and movable anywhere user want to put it. In our development, Raspberry Pi will be a mediator between user and power strip that connected to home appliances. The Raspberry Pi is used as the gateway which communicates to personal computer or Smartphone using http protocol. In the local home network Xbee S1 module has been connected to Raspberry pi via universal serial bus (USB) using XBee Explorer adaptor shown in Figure 3.3.



Figure 3.2: Central Control Unit using Raspberry Pi-3

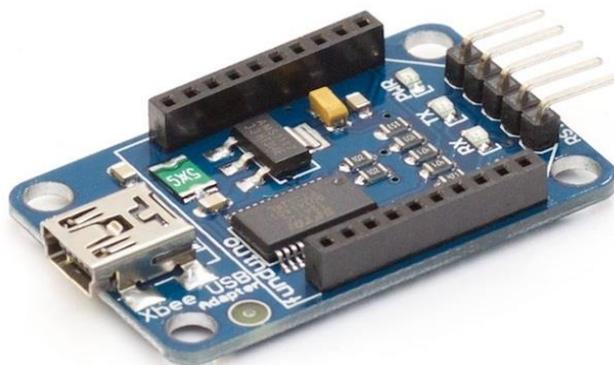


Figure 3.3: XBee Explorer

3.3 XBee Module

The advantages of this module is too small size as a coin and with low power usage. The ZigBee module communication concepts has either point-to-point or star communication concept [56]. In addition, it is compatible with many minicomputers and boards Since a USB port feasible with ZigBee as it is shown in Figure 3.4 where there are 11 digital I/O pins and 4 analog input pins in ZigBee. The ZigBee is linked to Raspberry Pi via USB working in coordinator mode and the other ZigBee are the End point mode. The pin-20- (DIO0) is set as digital output to control relay to turn ON/OFF, Pin-19- (AD0) is set to work as analog to digital converter which is connected to current sensor (ASC712) and convert the voltage (analog data) coming from V-out of sensor and send it to coordinator as a stream of digital data every 0.5 second.

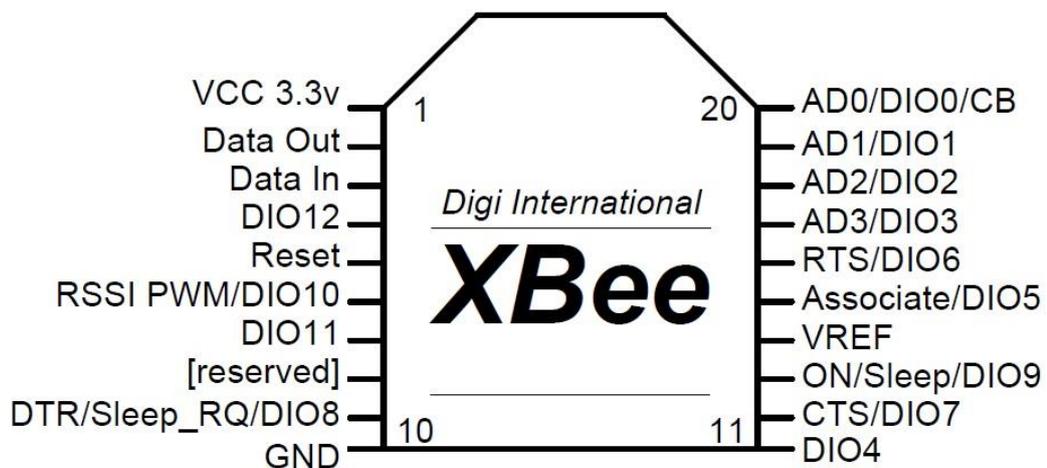


Figure 3.4: XBee Module Pin Diagram

3.4 Power Strip Hardware

The most important features of the power outlet development is to be simple and uncomplicated. It affects the cost, power consumption and easy to understand. As shown in the Figure 3.5, this transformer goes down the major voltage from 220 V AC to 5 V DC to supply voltage to the electromechanical relay and present sensor. The 5 V to 3.3 V is to give ZigBee wireless module in addition to power. Furthermore, the present sensor signal output is has a relation to the ZigBee pin-19- (AD1). The similarity to digital converter (ADC) of every ZigBee module includes a resolution conversion of 10 bit. Hall-Effect-Based Linear present Sensor sort ACS712 ± 5 A is

used and the output is linked to an operational amplifier (op-amp) based signal conditioning circuit so that to clearly read the required analog values to the pins of the similar input of the ZigBee module [57]. The (op-amp) IC circuit is used for the conversion from AC to root mean square (RMS) signal and to shift ACS712 sensor zero current from 2.5 V to 0 V. Since the ZigBee has a built in 10-bits analog-to-digital converter (ADC), therefore 10 bits = 1024 steps (0-1023). So the step size in case using ZigBee s2 $V_{ref} = (1.2 \text{ V})$ then the equation will be $(1.2\text{V}/1024 = 1.171875 \text{ mV})$. In the case using ZigBee type Xbee pro series 2 $V_{ref} = (3.3 \text{ V})$: $(3.3 \text{ V}/1024 = 3.22 \text{ mV})$ [40]. ACS712 $\pm 5 \text{ A}$ 185 mV/A output sensitivity, 100 mV/A for $\pm 20 \text{ A}$, and 66 mV/A for $\pm 30 \text{ A}$, sensor V_{out} data range between 1.5-3.5 V as the datasheet. So the form of the equation will be: $\text{Current} = (((3.5-1.5)*V_{out}) / (1024*0.185))$.

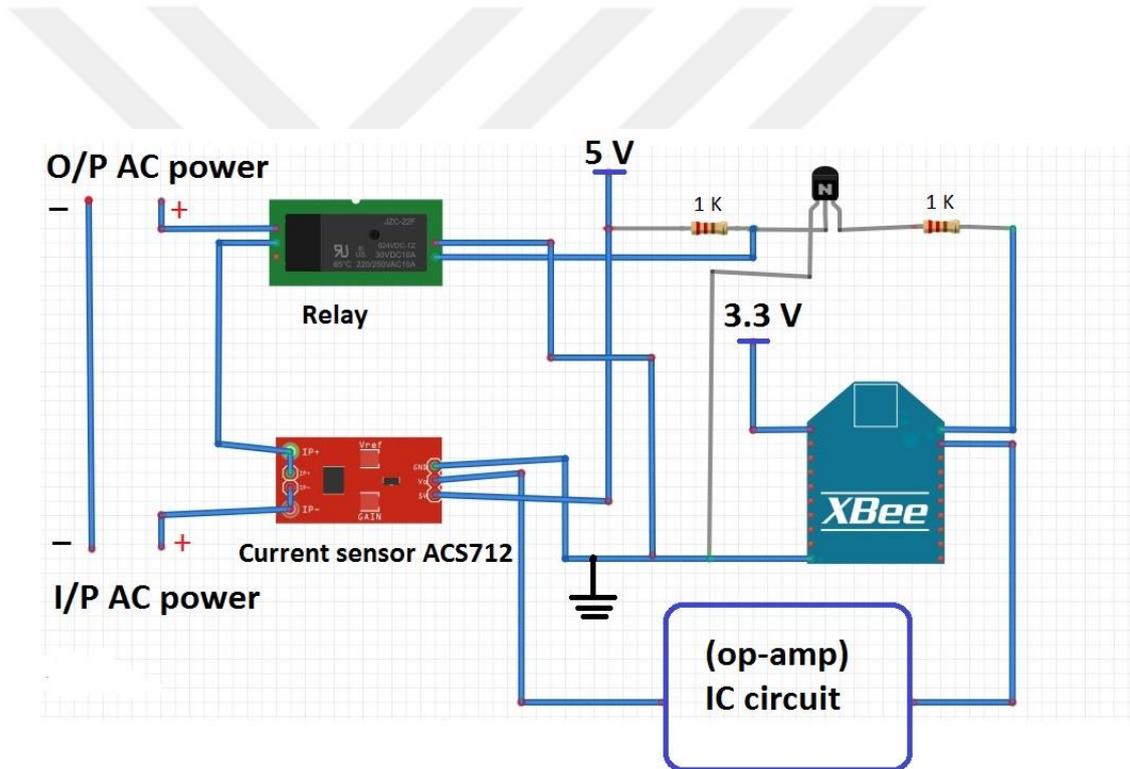


Figure 3.5: Circuit diagram

3.4.1 Current Measuring

Voltages can be measured directly by using analog to digital converters, but currents must first be converted into voltages before they can be measured. The corresponding currents are then calculated by logical circuits. There are several ways of measuring current. Three of these are resistive current sensing, Hall effect metering and current transforming as shown in the Figure 3.6. Hall Effect sensing when charge-

carriers like electrons in electric currents pass through a magnetic field they are effected by a force given by the following relation ($F = qv * B$).

The force, F , velocity, v , and magnetic flux, B , are all vectors. Hence, the force is right-angled to both v and B according to the cross product. The constant q is the charge of the charge-carrier, and qv could therefore also be written as I the current.

Integrated circuits that use the Hall Effect phenomenon is available. The current-carrying conductor and the Hall Effect element are only coupled magnetically in these types of sensors and are thus electrically isolated. Because of this they can be used with high voltages without endangering other electronic circuits present.

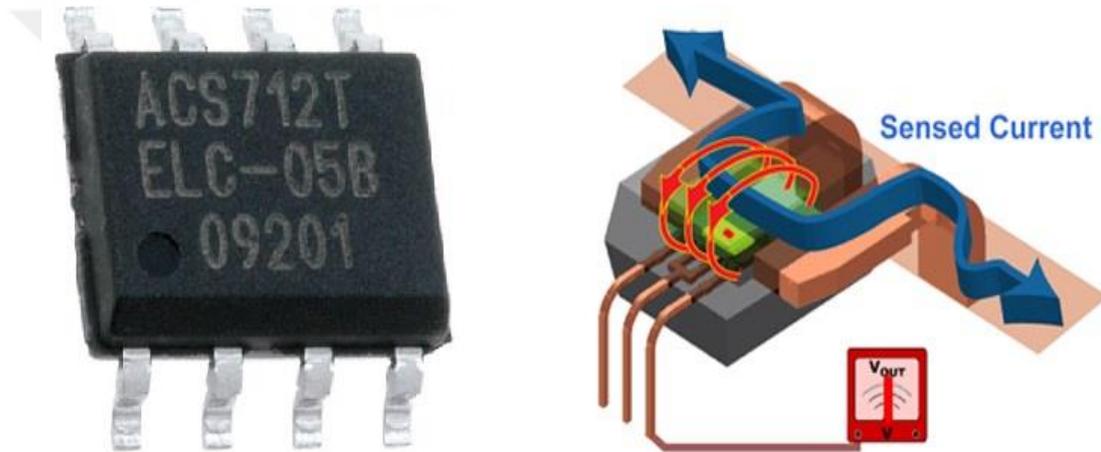


Figure 3.6: An integrated Hall-effect sensor based on magnetic coupling

3.4.2 Power Switching

It is common that electromechanical relays will be switches that clearly made to control high power electrical devices. Electromechanical relays are utilized in our days very much electrical machines and it is very essential to control a circuit, in two side the first one is with a low power signal and the second one is when multiple circuits and they have to be controlled by one single. Electromechanical relays contain electronic parts shown in the Figure 3.7 that makes it possible to operate them for many different applications. They are used mostly in the general aviation, aerospace, and wireless technology industries, but they have many other applications as well. In fact, thousands of electrical devices require electromechanical relays to make them work. Controlling high voltages though low voltage can be difficult. However, this can

be done using relays. The most common types of relays are electromechanical and consist of a coil that magnetically switches the main voltage and provides isolation. These types of relays generally require a relatively large current through the control inputs because of the coil even although, there are types that switch state permanently and thus, it needs a short voltage pulse for each on/off. However, these are expensive compared to ordinary momentary relays [58]. Another type of relay is the SSR (Solid State Relay). SSRs are switched electronically. SSRs require much smaller control currents compared to electromechanical relays because of the low power consumption of the LEDs with SSRs. you can control high-current devices such as lights or appliances with low-current signals [59].

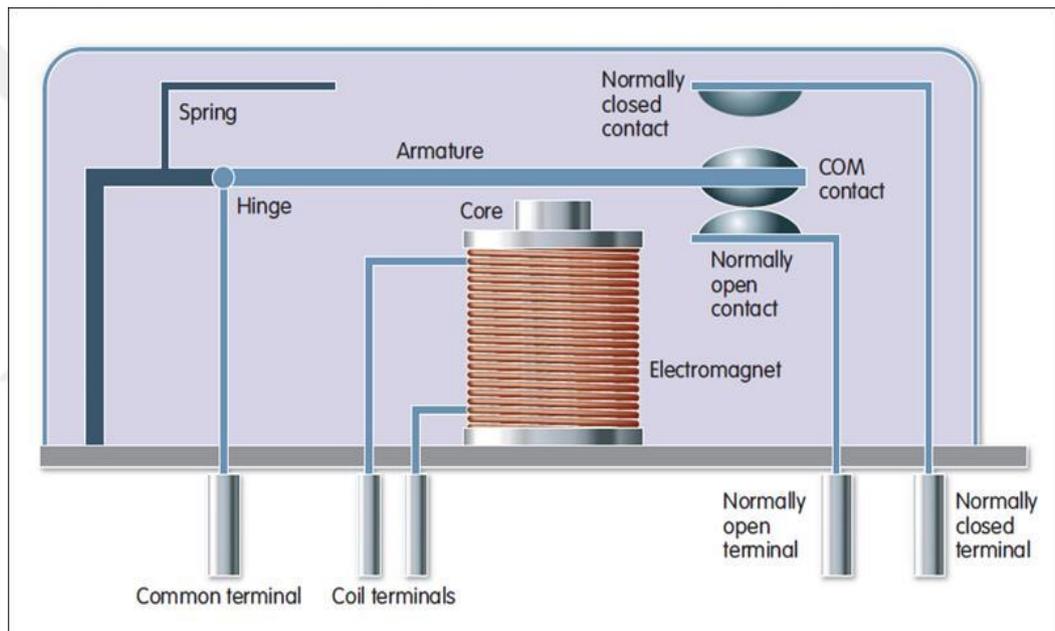


Figure 3.7: Electromechanical relay

CHAPTER 4

SYSTEM IMPLEMENTATION

4.1 Installing OS on Raspberry Pi

When the Raspberry Pi had arrived, the power was connected in conjunction with the screen (via HDMI) and a keyboard (via USB). An SD memory card was purchased and a disc image of Debian was uploaded to this. The disc image was taken from Raspberry Pi's website by using operating system installer NOOBS [60] and is a downloadable version of the operating system which is perfect for our purpose. After it was transferred to the SD 16GB class 4 SD card memory card, ideally preinstalled with NOOBS. HDMI cable used for display Raspberry pi screen on the monitor. Standard USB keyboard and mouse was used. It was connected to the Raspberry Pi and installation of the operating system started after installation. The configurations has been changed like set a new password for default user, enabling SECURE SHELL (SSH) for access the command line of a Raspberry Pi remotely from another computer and enabling VNC server for Remote controlling the Raspberry Pi from PC without any need to monitor.

First, update the system's package list by entering the following command:

```
sudo apt-get update
```

Next step upgrades all installed packages to their latest versions using the command below:

```
sudo apt-get dist-upgrade
```

When installing the Debian operating system deployed, the Apache, MySQL, and Tdtool software was loaded and installed. When installing the operating system, Apache and MySQL, the default settings are used as no special needs exist.

4.2 XBee Configuration

After upgrade installing was finished, XBee module using XBee Explorer adaptor and XCTU SOFTWARE connected to PC [61]. The XBee modules are needed to be configured individually before they can be prepared. The Digi website provides free software X-CTU (XBee Configuration and Testing Utility) which is required for the configuration of the XBee modules. The following Figure 4.1 shows the layout of the X-CTU program. The XBee that is connected to Raspberry Pi installed Firmware version (10ef) as seen in the Figure 4.1 and configured to work as a coordinator.

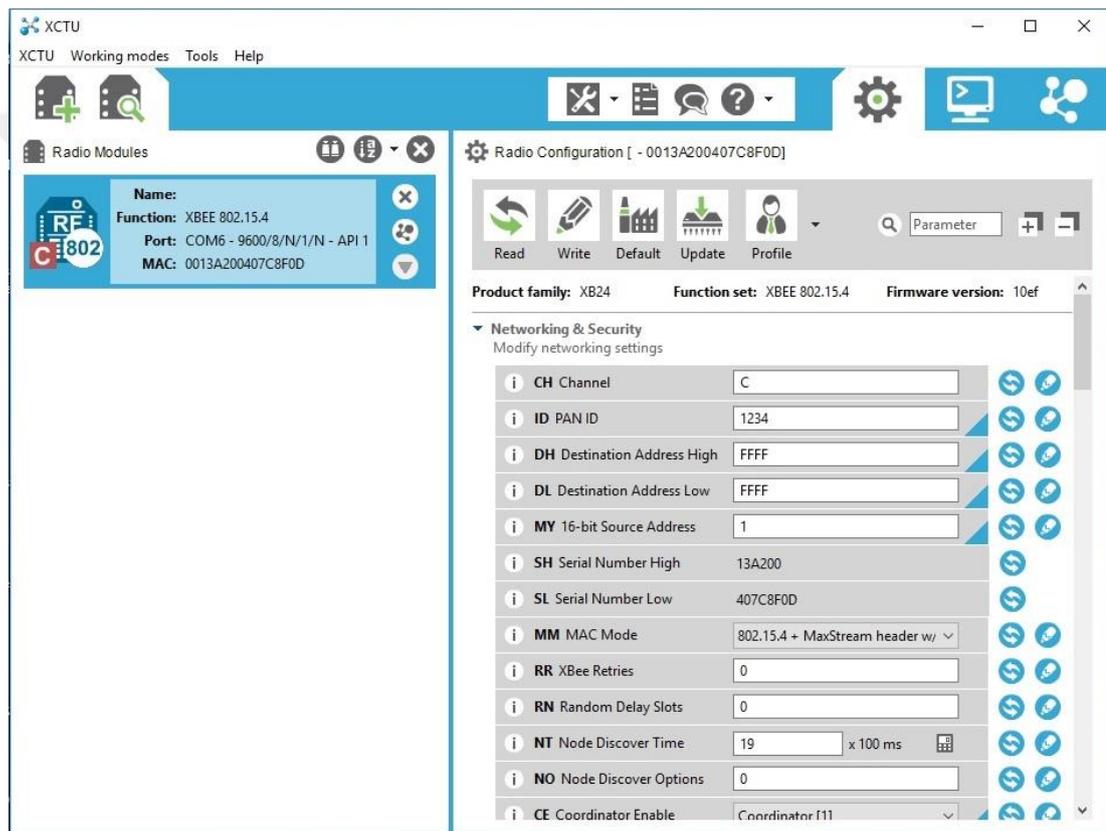


Figure 4.1: XBee Coordinator Configuration.

XBee S1 Coordinator configuration shown in the table 4.1:

Table 4.1: XBee S1 Coordinator configuration.

CH Channel:	C
ID PAN:	1234
DH Destination address high:	FFFF
DL Destination address low:	FFFF
My 16-bit Source address:	1
CE Coordinator Enable:	Coordinator [1]
AP API Enable:	API Enabled [1]

XBee S1 End device configuration show in the table 4.2:

Table 4.2: XBee S1 End device configuration.

CH Channel:	C
ID PAN:	1234
DH Destination address high:	0
DL Destination address low:	1
My 16-bit Source address:	0
CE Coordinator Enable:	End device [0]
AP API Enable:	API Enabled [1]
D0 DIO0 configuration:	DO low [4]
D1 DIO1 configuration:	ADC [2]
IR Sample Rate:	3E8

4.3 Install MySQL Database

Before we get started, we need to install MySQL server and the Python bindings for MySQL:

```
sudo apt-get install mysql-server python-mysqldb
```

During the installation of MySQL server, you will be prompted to enter a password for the MySQL root account.

And then the php5-mysql install adds the MySQL libraries to allow PHP to access the MySQL database.

```
sudo apt-get install mysql-server  
sudo apt-get install php5-mysql
```

MySQL comes with a shell that can be used for configuration. We can use the MySQL shell to create a database:

```
$ mysql -u root -p  
Enter password:  
mysql> CREATE DATABASE current  
mysql> USE current
```

And we will create database table named (current) consist of five columns:

```
CREATE TABLE current2 (id INT AUTO_INCREMENT NOT NULL,  
cdate INT, current DOUBLE(6,3), status DECIMAL(10,0),  
power INT, primary key (id));
```

For showing and controlling MySQL database and changing configuration without working the command terminal, we made and installed (Phpmyadmin package). Phpmyadmin is a free tool designed to easily allow for administration of MySQL. It is big popular and used in several web server environments inside the world. It is very important that Debian's package repositories can have a Phpmyadmin package, on the other hand, be careful to the configuration file is saved in. it may be various in some aspects of the official phpmyadmin documentation. We can enter the following to be easier:

```
sudo apt-get install phpmyadmin
```

After all installing process completing, we should be able to access the Phpmyadmin from a browser. To test, go to the follow address in your browser. (IP address of the Raspberry Pi/phpmyadmin) or (raspberrypi.local/phpmyadmin). Then, we should enter a user name and a password (by Default username: root and password will be the same password that had entered while installing OS in the Raspberry Pi) then, the home page of Phpmyadmin will appear and we can begin to change the configuration of our database as shown the Figure 4.2 below.



Server: localhost » Database: current » Table: current

[Browse](#)
[Structure](#)
[SQL](#)
[Search](#)
[Insert](#)
[Export](#)
[Import](#)
[Privileges](#)
[Operations](#)
[Tracking](#)
[Triggers](#)

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
<input type="checkbox"/>	1	id	int(11)	No	None	AUTO_INCREMENT		Change Drop Primary Unique Index Spatial Fulltext Distinct values
<input type="checkbox"/>	2	cdate	int(11)	Yes	NULL			Change Drop Primary Unique Index Spatial Fulltext Distinct values
<input type="checkbox"/>	3	current	double(6,3)	Yes	NULL			Change Drop Primary Unique Index Spatial Fulltext Distinct values
<input type="checkbox"/>	4	status	decimal(10,0)	Yes	NULL			Change Drop Primary Unique Index Spatial Fulltext Distinct values
<input type="checkbox"/>	5	status1	decimal(10,0)	Yes	NULL			Change Drop Primary Unique Index Spatial Fulltext Distinct values
<input type="checkbox"/>	6	power	int(11)	Yes	NULL			Change Drop Primary Unique Index Spatial Fulltext Distinct values

Check All With selected: Browse Change Drop Primary Unique Index

[Print view](#) [Relation view](#) [Propose table structure](#) [Track table](#) [Move columns](#)

Add column(s) At End of Table At Beginning of Table After

+ Indexes

Information

Space usage		Row statistics	
Data	352 KIB	Format	Compact
Index	0 B	Collation	latin1_swedish_ci
Total	352 KIB	Next autoindex	6,090
		Creation	Mar 19, 2017 at 05:51 PM

Figure 4.2 : Phpmyadmin Platform

- 1- Id: AUTO_INCREMENT attribute can be used to generate a unique identity for new rows.
- 2- cdate: (Current date) date and time at the sensing moment.
- 3- current: (Current data) sensing value after making mathematical processing to get Electric current.
- 4- Power: (Power data) Electric power in Watt.
- 5- Status: There are four status cases, status column It contain one of these values (0,1,2,3) as below:
 - Status = 0: ZigBee Not connected.
 - Status = 1: No data or Power strip if off.
 - Status = 2: Error data received.
 - Status = 3: Power strip is ON.

4.4 Python Script

A. The first code that had been written is turn on Dio0 the node's ZigBee. The python program is to be typed in the leaf pad. Leaf pad is created by file manager->right click->create->blank file->enter a file TurnOn.py- > click ok.

It is the first step to write the scripts as shown below.

```
import time
import serial
```

import time and pyserial library which will be used.

```
ser = serial.Serial('/dev/ttyUSB0', 9600)
```

We will try to establish a communication between the Raspberry pi and ZigBee via serial port. We used the serial ttyUSB0.

```
on = "7E 00 10 17 AB 00 13 A2 00 40 82 07 18 FF FE 02
44 30 05 2F"
```

API format for Remote AT Command Request as it shown in the table 4.3 [62].

Table 4.3: API format for Remote AT Command Request.

Byte	Value	Description
0	7E	Start byte – Indicates beginning of data frame
1	00	Length – Number of bytes (ChecksumByte# – 1 – 2)
2	10	
3	17	Frame type - 0x17 means this is a AT command Request
4	AB	Frame ID – Command sequence number
5	00	64-bit Destination Address (MAC address of Destination)
6	13	
7	A2	
8	00	
9	40	
10	82	
11	07	
12	18	
13	FF	Destination Network Address (Set to 0xFFFFE to send a broadcast)
14	FE	
15	02	Remote command options (0x02 to apply changes)
16	44	Select DIO0
17	30	
18	05	Set DIO0 as output (DIO0 = 1)
19	2F	Checksum

```
msgon = "".join(on.split())
msgon = msgon.decode("hex")
ser.write(msgon)
```

The function of upper line's code deletes spaces between bytes and converting the hexadecimal form of a string into the corresponding Unicode.

Now, it is ready to send the AT comment to node's ZigBee using a written code.

B. In the same way for Turning off Dio0, we had created a new file named TurnOff.

By using a text editor and written the code:

```
#!/usr/bin/env python
```

```
import time
import serial

ser = serial.Serial('/dev/ttyUSB0', 9600)

off = "7E 00 10 17 AB 00 13 A2 00 40 82 07 18 FF FE 02
44 30 04 30"

msgoff = "".join(off.split())

msgoff = msgoff.decode("hex")

ser.write(msgoff)
```

In this case, we have just changed the byte number 18 from (05) to (04) for reset DIO0.

- C. This script has been written to store the received data from ZigBee to MySQL database. The algorithm is shown below in the Figure 4.3.

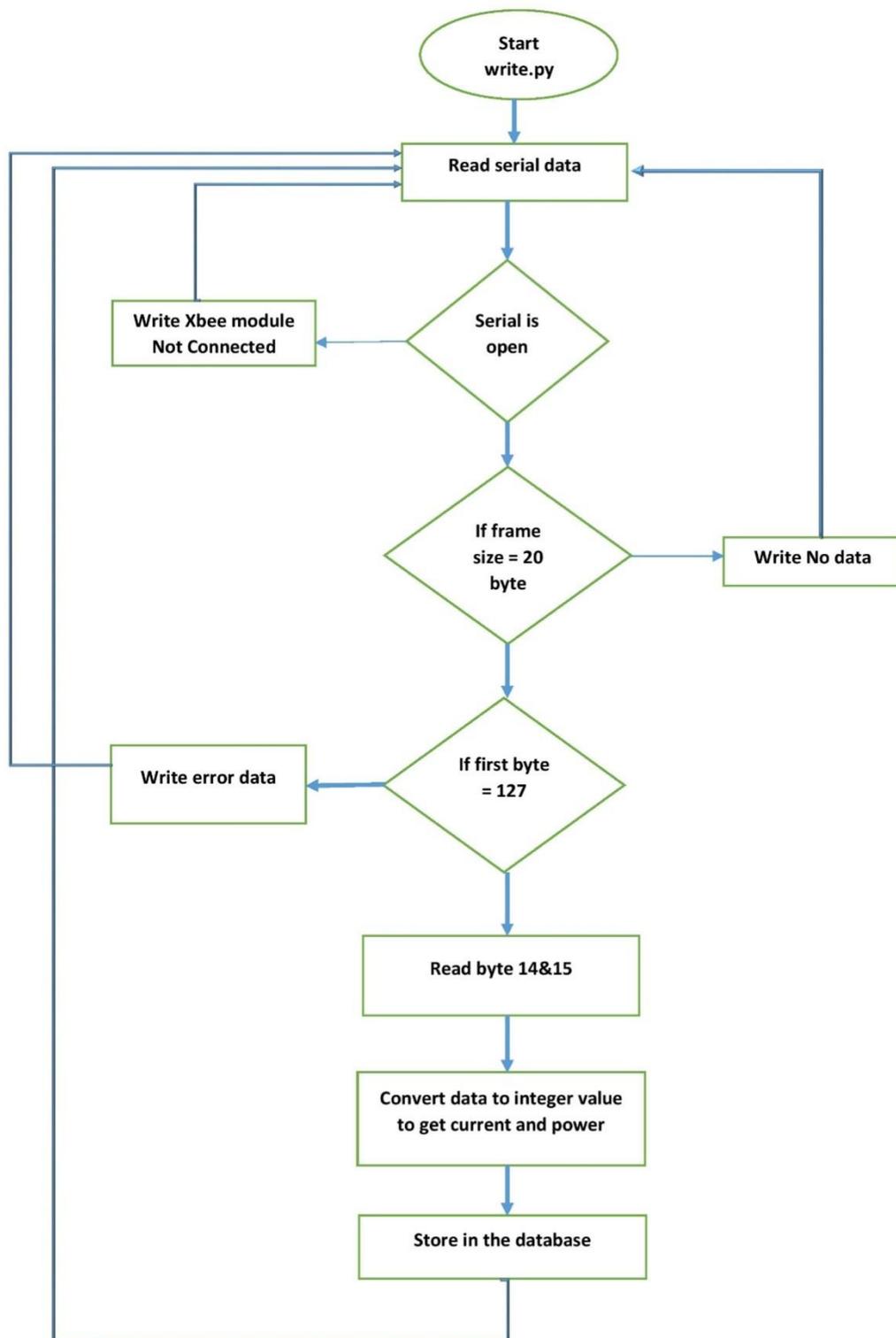


Figure 4.3: Flow chart of python script to store data in the database

```

#!/usr/bin/env python
import MySQLdb
import random
import datetime

import serial
import time

db = MySQLdb.connect("localhost", "monitor", "123",
"current")
curs=db.cursor()

while True:
try:
ser=serial.Serial("/dev/ttyUSB0", 9600, timeout=1)

ser.flushInput()
ser.flushOutput()

while True:
    time_sensor = time.time()
    size = ser.inWaiting()
    if size:
        data = ser.read(size)

        s = data
        s1 = "".join("{:02x}".format(ord(c)) for c
in s)

        i2 = int(str(s1[0:2]), 16)
        if i2 == 126:

            c1 = int(str(s1[26:30]), 16)
            Cdata1 = ((3.3 / 1024) *
(c1))/(0.185*2))
            c2 = Cdata1 * 220

```

```

        Cdata = Cdata1
Pdata = c2
        print c2

        Dstatus = 3

    else:
    print 'error data'
        Cdata = 0
        Pdata = 0
        Dstatus = 2

else:
print 'no data'
        Cdata = 0
        Pdata = 0
        Dstatus = 1

curs.execute ("""INSERT INTO current
                values(id, %s, %s, %s,%s)""", (str(time_sensor)
, str(Cdata) , str(Dstatus) , str(Pdata)))
db.commit()

time.sleep(1)

except serial.SerialUtil.SerialException:
print 'ZigBee not connected'
time_sensor = time.time()
    var1 = 0
    var2 = 0
    var3 = 0
curs.execute ("""INSERT INTO current
                values(id, %s, %s, %s, %s)""",
(str(time_sensor) , str(var1) , str(var2) , str(var3)))
db.commit()

time.sleep(1)

```

4.4 Web-Server configuration and web-page building

Here the Apache, which is essential, can help a lot HTML files above HTTP, and with further modules which can help dynamic web pages by utilizing scripting

languages "PHP", for arranging Apache web server upon Raspberry Pi, at the beginning, try to install the apache2 package by writing the following orders in to the Terminal.

```
sudo apt-get install apache2 -y
```

By default, Apache puts a test HTML file in the web folder. This default web page is served when you browse to <http://raspberrypi.local/> or <http://192.168.1.XX> (Whatever the Pi's IP address is) from another computer on the network.

Default web page is just a HTML file on the file system. It is located at:

```
/var/www/html/index.html
```

To allow Apache server to process PHP files, we'll need to install PHP5 and the PHP5 module for Apache. Type the following command to install these:

```
sudo apt-get install php5 libapache2-mod-php5 -y
```

Then, we will change index.html to index.php and write the Php, html, java and CSS scripts.

Web page consists of three main components: The first one is buttons for turn ON/OFF that programmed using JavaScript that call PHP code for calling python script that has been explained in section 1.4.A/B for sending digital signals over ZigBee technology to the node.

The second component is label text. It is also developed based on Java-PHP which is able to get data stream without any reload page from the database. The Chart is the third component the in web page. Dynamic charts are useful in displaying data that changes with time like stock price, temperature and etc. Dynamic updates are supported by all chart types including line, area, column, bar, pie and etc. Below are some examples of HTML5 & JavaScript based dynamic charts. Dynamic charts are also referred to as live charts or real-time charts. Interactive JavaScript charts (highcharts) provides many types of charts and has many advantages [63], dynamic chart (Spline updating each second) has been used fetching sensor data that stored in the database with date and time at the moment of reading. The function for display the Spline chart is:

```

<script>
var chart; // global

/**
 * Request data from the server, add it to
the graph and set a timeout to request again
 */
function requestData() {
    $.ajax({
        url: 'lastrow.php',
        success: function(point) {
            var series =
chart.series[0],
                                shift =
series.data.length > 50; // shift if the series is
longer than 20

                                // add the point

            chart.series[0].addPoint(eval(point), true,
shift);

                                // call it again after
one second
                                setTimeout(requestData,
2000);

                                },
                                cache: false
                            });
    }

$(document).ready(function() {
    chart = new Highcharts.Chart({
        chart: {
            renderTo: 'container',
            defaultSeriesType:
'spline',

                                events: {

                                    load: requestData

```

```
Charts'
    },
    title: {
        text: 'Live POWER'
    },
    xAxis: {
        type: 'datetime',
        tickPixelInterval: 150,
        maxZoom: 20 * 1000
    },
    yAxis: {
        minPadding: 0.2,
        maxPadding: 0.2,
        title: {
            text: 'Power',
            margin: 80
        }
    },
    series: [{
        name: 'Power and Time',
        data: []
    }]
});
});

</script>
```

Raspberry Pi is connected to the internet through the Router, and Router is configured to forward port 80 to Raspberry Pi as shown in the Figure 4.4 to work as web server.

Advanced Forwarding

This allows for incoming requests on specific port numbers to reach web servers, FTP servers, mail servers, etc. so they can be accessible from the public internet. A table of commonly used port numbers is also provided.

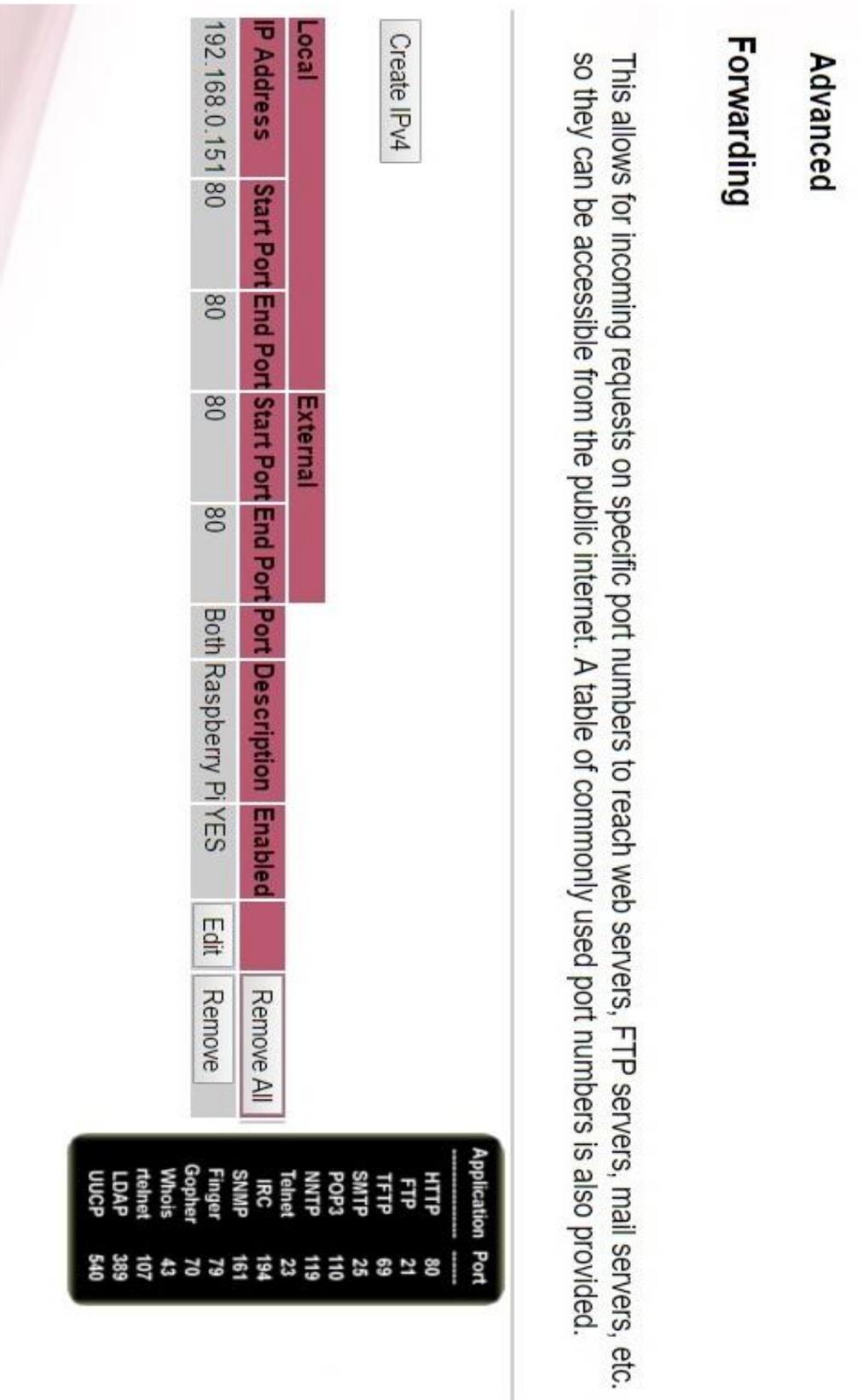


Figure 4.4: Opening port in the Router

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Platform

It is vital in this unit to control and get the status of appliances, and the home environment within Internet as the aim served this model is selected.

In this project, we have developed an electrical outlet controlling household appliances from inside and outside the home based on minicomputer. Web-server setting up in Minicomputer and home page have been designed computable with different web browsers and tested by using various devices like PC, cell phone, and tablet shown in the Figure 5.1.



Figure 5.1: Controlling the bulb by using tablet

Router is configured to forward port number 80 to web-server to be publically and internet accessible. In the Figure 5.2, we see the platform accessed using smart phone connected to the internet through 3G.

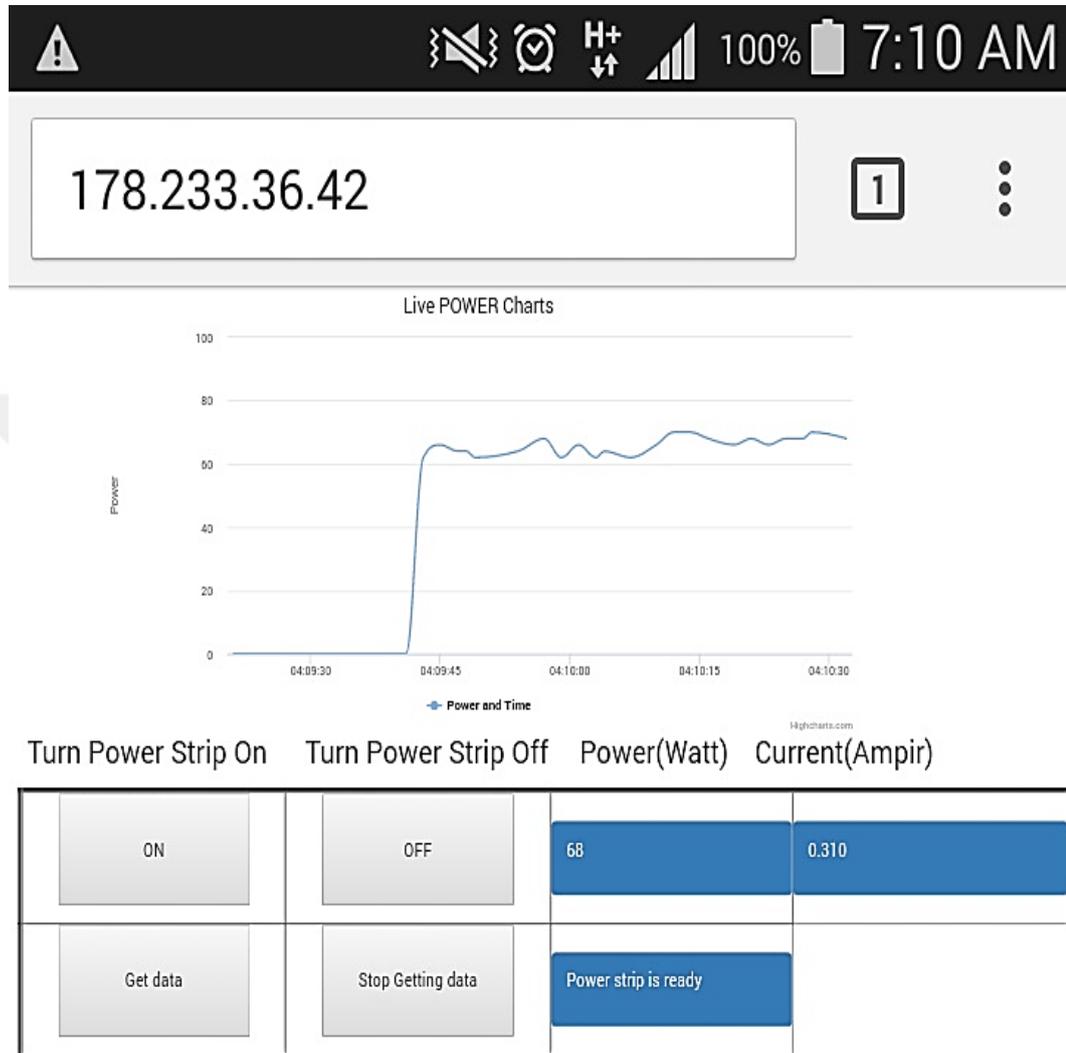


Figure 5.2: power strip web-page

Web page is very light and small size about 6 KB. Therefore, they don't affect too much to data usage. The performance of sending the command is very high. The delay between click the button and the relay to take effect is <1 minute.

The labels in the platform display stream of current sensor readings. Values are changed dynamically every one second without reloading the page, so it saves a lot of data consumption. Chart displays the stream current data. The chart will automatically reflect changes and additions to the source data.

5.2 Current Sensing

ACS712 5 Ampere used for measuring power consumption of electric home appliances. It could be measure up to 1100 W. Therefore, in the experiment, Different loads are plugged to power strip as shown in the Table 5.1. We can extend the range to measure up to 6600 W.

Table 5.1: Current data measurement

Load	Test Current (Amper)	measured using clamp meter 1	measured using clamp meter 1
40 W	0.13	0.11	0.14
70 W	0.34	0.33	0.27
585 W	2.82	2.78	2.86
1000 W	4.21	4.18	4.00

CHAPTER 6

CONCLUSION AND FUTURE APPLICATIONS

6.1 CONCLUSION

It is my belief that an aware consumer is a smart consumer. I feel that if we give the opportunity, most people like to save money whenever it is possible. The Smart Strip will enable the average consumer to take control of their power consumption by providing an easy way to use link between the outlet and their everyday appliances.

In this thesis, we have presented our development for wireless power strip to remote control and current sensing in order to manage home appliances remotely through the Internet using a web interface. Although there is several technologies in the market, but it is still very expensive and may cost up to hundred dollars. Designing our own model help us to save hundreds of dollars as it is cheaper and the cost could be decided by the designer who is the ultimate user of the system. Not only from an economic standpoint, but also the technical side is more flexible. Developer could be able to decide the type and number of sensors to be used and the area to be covered.

The aim of this project is to provide nonphysical control over home appliances. This type of model helps physically disabled and elderly people to control devices because it may be difficult for them to move to switch every time they want to control it. Moreover, the proposed model is cost effective and energy efficient. We developed the power strip along with a cost effective using minicomputer (raspberry pi) and ZigBee communication protocol. The raspberry Pi is configured to work as web-server and different Languages used to design a web-page as a platform for monitoring and controlling. The main advantage of our proposed work is to make the home owners able to manage home appliances remotely anywhere and anytime over the internet. It had been developed to be scalable to add more nodes and can add different sensors as required. The final version of the Smart Power Strip has met most of the original design criteria. The system is able to collect and process the required data and communicate this in a user friendly manner. The system's network communication has been tested on several different devices with great success.

6.2 FUTURE WORK

A part of our future work is to develop a system contains in different sensors to interact with the surrounding environment to be more smarter and fully automated and adapted with different places hospitals, hotels, banks, etc.

In addition to develop program compatible with different operation systems of smart phone such as IOS, Android and Windows Phone to get more interactive by receive the notifications of the changes in the surrounding environment.



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