DESIGN AND DEVELOPMENT OF AN INTEGRATED PLATFORM FOR GSM, WEB AND IVR BASED DEVICE CONTROLLING SYSTEM WITH REFERENCE TO IOT

A

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CERTIFICATE

This is to certify that the thesis entitled " **DESIGN AND DEVELOPMENT OF AN INTEGRATED PLATFORM FOR GSM, WEB AND IVR BASED DEVICE CONTROLLING SYSTEM WITH REFRENCE TO IOT** " Submitted by **HIRAKJYOTI SARMA (REG. NO. : FINAL/05/COM003 of 2013-2014)**, a research Scholar in the department of Computer Science & Technology, Bodoland University, Kokrajhar for the award of the **Degree of Philosophy** is a record of an original research work carried out by him under my supervision and guidance. The thesis has fulfilled all requirements as per the regulation of the institute and in my opinion has reached the standard for submission. The results embodied in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

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DECLARATION BY THE CANDIDATE

This PhD thesis entitled "**DESIGN AND DEVELOPMENT OF AN INTEGRATED PLATFORM FOR GSM, WEB AND IVR BASED DEVICE CONTROLLING SYSTEM WITH REFRENCE TO IOT**" *Submitted by me* for the award of the **Degree of Philosophy** is an original work carried out by me and has not been submitted so far in part or in full, for any other degree or diploma to any other University or Institution.

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ABSTRACT

In the present day of modern era, automation technique for home appliances has become a crucial and important area in the contemporary research of present Technology as information science and technology is growing up very fast from the computing to communication. In this present work, research has been emphasized to design and develop a common platform for providing the accessibility of people over the household electrical devices not only locally, but also remotely in a secured, reliable and efficient way. The present designed system contains two main working modules. The first module is the server module that includes the core part of the system which manages controlling and monitoring of the household electrical devices available in the entire system. Another part is hardware interface module that provides an electronic circuit with a microcontroller which is responsible for triggering the proper actions to the relay drivers connected with the devices of the entire home automation system. In the server side, an integrated database is created for storing the command actions along with the time, date and the user's information for controlling different electrical devices. Then the command actions will be sent to the second module i.e. hardware interface module for firing. Hence, it can be claimed that the present work is providing the accessibility for the remote user to send their request through four different communication mechanism like SMS, Web, speech, Wi-Fi in the reference of Internet of Things and then it will stored in the common database followed by the command actions to be applied in the home electrical appliances. GSM communication is designed with the help of AT command while the web communication need internet with a web server. The Speech communication is designed with the help of an Interactive Voice Response system where the sample voice data is recognized and tested with help of two different recognizing tools like HTK and Sphinx. Both of the recognizing tools use Hidden Markov Model for recognising voice commands. A comparison study between the two tools in terms of efficiency is done also here. The final addition to this integrated system is Wi-Fi based with reference to IoT through a Wi-Fi enabled mobile using a static IP address. However, it will be better to expose the need of database server that some learning techniques can be applied based on the previous actions performed by individual user. The most emerging facility over the other home automation system is scalability such way that if one of the four communication mechanisms fails, then the another one remains operational.

Through the integrated common database, the all users can control the remote devices using all communication mechanisms. Besides, the design of the present system is emphasized on the security of the system so that the unauthorized user cannot handle it.

Keywords: Home Automation System, Interactive Voice Response, HTK, GSM, Internet of Things, Hidden Markov Model, Sphinx, AT Command, Web Server, SMS, Integrated database

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LIST OF ABBREVIATION

HAS	HOME AUTOMATION SYSTEM
AT	ATTENTION
GSM	GLOBAL SERVICE FOR MOBILE
IOT	INTERNET OF THINGS
IVR	INTERACTIVE VOICE RESPONSE
ASR	AUTOMATIC SPEECH RECOGNITION
MFCC	MEL FREQUENCY CEPTRAL COEFFICIENT
HMM	HIDDEN MARKOV MODEL
LAN	LOCAL AREA NETWORK
SMS	SHORT MESSAGE SERVICE
HTTP	HYPERTEXT TRANSFER PROTOCOL
HTML	HYPERTEXT MARKUP LANGUAGE
FTP	FILE TRANSFER PROTOCOL
GUI	GRAPHICAL USER INTERFACE
PHP	HYPERTEXT PREPROCESSOR
IP	INTERNET PROTOCOL
USB	UNIVERSAL SERIAL BUS
LCD	LIQUID CRYSTAL DISPLAY
WER	WORD ERROR RATE
GMM	GAUSSIAN MIXTURE MODEL
DNS	DOMAIN NAME SPACE

1

INTRODUCTION

CONTENT

CHAPTER 1

INTRODUCTION

1.1 Introduction

The idea of “automation” has been conceptualized since several years ago in the evolution of Home Automation Systems. It was started by a student who connected two electric wires with the help of an alarm clock for closing of a circuit having a battery and electrical light bulb. In the passage of time, a few automated systems were developed to control alarms, sensors, actuators, video cameras etc. In fact, the aim of developing these systems is to make automated buildings termed as “intelligent home”. According to the developers and researchers, to make such type of “intelligent home”, one or more automated systems should be required termed as “home automation system”. So, some developers introduce a few home automation systems which are becoming popular among the researchers as well as common people also because it represent a great opportunity for research in generating some new areas in engineering, architecture, computing and make the common people life more easy and comfortable. However, though these new technologies are still in their early stages, but people take it as an essential fundamental requirement in their day to day life [1]. As the integrated circuits and microprocessors become more and more accessible and the Internet communication is a fact of today with the improved availability of cellular networks, these advancements naturally should find use in modern home automation systems. These systems provide the consumers increased security and safety, economic benefits and convenience by giving them control over all the appliances in the house. Designing a home automation system for monitoring and controlling various devices in remote locations can be done through a variety of communication options such as wireless LAN technologies, dial-up modems, private radio networks, satellite communication, Internet, cellular network and so on. Several studies on home automation have been done using different types of control methods [2].

1.2 Motivation

In recent years, modern life style becomes so busy and full of task schedule that people often forget to do some simple duties. Such as forget to switch of their household appliances. People don't bother about their types of carelessness every time, but this can give

them real trouble sometime. Unnecessarily energy is consumed. For too much consumption of energy, the generated heat can damage the device. As a result, it makes a severe interruption in their job schedule, besides some loss of money and time also. Therefore, they want to manage home appliances from a remote location through an automated system. In general, every people use voice, internet, GSM and Wi-Fi service to communicate with each other. But, this system has to communicate between human and any electrical or electronic device by using lots of communication mechanism. As a result, people can access too many devices within a building or home at any time, from anywhere, resolves many of the problems that users often face when they return home, saving a significant amount of time. In fact, for above primary need of human day to day life, many companies and developers are motivated to the field of home automation which is still in an early stage [2]. In this work also an integrated system for device controlling is designed and implemented by motivating the willingness of people to access their home appliances through different way from a remote place at anytime.

1.3 Objective

The system would be designed such that the users can communicate with their household appliances remotely and locally through GSM, Web, Speech and IoT based communication mechanism. The system is controlled by the users' instruction that is frequently occurred in a particular manner and time. An integrated database is also designed for storing the all instructions of users that are sent via GSM, web, speech and IoT based communication mechanism. A switching circuit is designed and developed that is connected with the server through USB port. So, the entire system is a Home Automation System that can be handled by different four communication mechanism so that if one fails, then another can manage it. The real objective of this research focuses on developing a hybrid home automation system in an efficient manner with less limitation rather than the existing HAS with single communication mechanism [3].

1.4 Problem Definition

In Modern era, Information technology is becoming an essential part of human day to day life. When Time passes Human wants everything to be operational automatically with the help of computers. Internet makes it easier and people often becomes crazy to communicate with their electrical devices by using Internet, their mobile, own voice/speech

and Wi-Fi module etc. rather than communicate with the other people. Therefore, this type of expectation of any human being puts some queries into the Researchers every time.

i) Could we somehow control our household electrical devices automatically and remotely using a computer Interface with a human like performance?
ii) After having a few home automation systems to control Household appliances, why an another integrated one is needed?

The solution of the first expectation is Home Automation System. Home automation refers to the use of computer and information technology installed in a simple house in order to achieve automation of housework or household activity through automatic controlling of various home appliances and devices such as light, fan, AC, TV etc. There are a few Home Automation Systems that can range from simple remote control based lighting system through to complex computer/micro-controller based networks with varying degrees of intelligence and automation. Here four methods have different challenges individually. At first, SMS is used for the communication between a human being and machine rather than among the peoples. But, Challenges is that when the SMS is received by the server, only action command available in the text message is not only received, some other fields are also received by the server and from that only action command should be stored in the database. Secondly, the web page is designed in PhP and it is not too simple to integrate the web page with the microcontroller directly. So, the commands should be stored first in the database and microcontroller will be operated by triggered command from the server [4].

Here, it is the time for solution of second query. Although, a lots of design leading to a home automation system having home appliances over wired or wireless communication already developed, but in the present work a special impact has been focused to introduce an integrated platform combining different device controlling mechanism to make the life of the inhabitant simple and easier and it can be claimed that if any communication mechanism goes wrong, still the system will become operational through other communication options.

The module for speech communication is cost effective, efficient and easy to implement than the other system so that using this platform we can make the life of the inhabitant simple and easier and it can be claimed that unlike the other communication mechanism this system will response within a second according to our voice [3]. Actually, this system has to face some challenges during its development and implementation phase

like Noise, Speaker Variability because noise reduces the strength of a speech signal i.e. incorporate the speech signal. During of implementation period, accuracy of our speech recognition system may be degraded as every speaker has their special and unique voice. That is why it should be also maintained for a better speech based device controlling system.

Data capturing majorly occurs through various sensors, PLCs, etc., which are connected to IoT gateways to collect & transmit data to the cloud**.**

1.5 Contribution of the thesis

The major contributions of the present study can be highlighted as follows.

a) An effort is made to design an integrated platform for the four different types of communication mechanism based device controlling system through a common database. The four types of communication mechanisms are GSM, Web, Speech and Wi-Fi (IoT based).

b) A brief experimental study is made where the general SMS service through GSM network is used for the communication between the users and the Household appliances.

c) An additional effort was made establish communication between the users and electrical devices by using web services through Internet.

d) One of the major contributions of the present study is to design of Speaker Independent speech recognition system is designed to recognize the voice commands spoken by the users.

e) Generation of an Interactive Voice Response system for communicating with the web server where the devices are connected through a Telephony data acquisition setup.

f) A brief reflection on the experimental work which was made to design an ASR engine. The ASR engine is a Sub-word Hidden Markov Model (HMM) based ASR engines that is used for recognition of device names, responses (yes/no) and the action command (on/off).

g) An IoT based interface is designed in terms of a web page through the IP address of a Wi-Fi module to control the appliances from the range of Wi-Fi locally.

1.6 Organization of the Thesis

In First Chapter, a basic overview of automation system is described briefly. It is declared that this present study is also an automation system for controlling household appliance. The object of this present work is also mentioned in this chapter i.e. from where the motivation had come, why it is needed and how it is fulfilled in practical purpose. It covers the problem definition of this designed system i.e. after the availability of lots of home automation system why an integrated system is needed.

In Second Chapter, the literary survey is presented in a nutshell which had been done during the development time of entire system. This chapter covers a vast study of different hardware instruments or components, software packages, software tools and the environments where the system is brought up. Another addition to the chapter is related study where a brief discussion of some journal papers and a few books related to this work are made.

In Third Chapter, the present framework of the entire system is described in a diagrammatic block representation. The block diagram of this system layout contains mainly three modules, a user module, a server module and hardware interface. The Diagram of present system framework for three communications and the three modules are described in this chapter.

In Fourth Chapter, the implementation of the whole system is explained in various sections. This chapter covers overview of each and every communication mechanisms, database design and microcontroller programming design in details. The implementation of the software package and the whole system mechanism is also illustrated in this chapter. This chapter contains how the user command can be sent to the server through different Communications. The techniques, procedures, programming logics for the implementation of the system like SMS reading, Speech Training and Testing are explained here.

In Fifth chapter, the result is shown and discussed using some representation of the software interface. The accuracy of the system is analysed also with the help of some

parameter and mathematical formula. It is claimed that anyone can visualize and control the proposed system easily with the help of this chapter. This chapter analyzes the efficiency of the mechanisms in term of values and graphs. It gives a little bit comparison also between the different mechanisms for speech recognition. This chapter discussed also the challenges regarding for creating the common platform for every users so that the system will become an integrated one in true manner.

In Sixth Chapter, points out some important features of this system that can be implemented in future so that the system will be an efficient home automation system with precision accuracy. Besides, this chapter also concludes the different aspects regarding the present system.

2

LITERATURE SURVEY

CONTENT

CHAPTER 2

LITERATURE SERVEY

2.1 Overview

Automation system has been a feature of science fiction writing for many years, but has only become practical since the early 20th Century following the widespread introduction of electricity into the home, and the rapid advancement of information technology. In 1889, Nikola Tesla patented an idea for the remote control of vessels and vehicles. In between 1915 and 1920, the emergence of electrical home appliances began. This leads to the decline of domestic servants and their gradual replacements by cheap and mechanical household devices. Ideas similar to modern home automation systems originated during the World's Fairs of the 1930s. Fairs in Chicago (1934) and New York (1939) depicted electrified and automated homes. In 1966, Jim Sutherland, an engineer developed a home automation system called "ECHO IV"; this was a private project and never commercialized. The first "wired homes" were built by American hobbyists during the 1960s, but were limited by the technology of the times. In 1984, the term "smart house" was first coined by the American Association of House builders [5].

2.2 Basics of PC Based Device Controlling

While the fundamental purposes and functions of instrumentation systems have remained the same from its inception there is a paradigm shift over the years in methodology of measurement and interpretation and control due to continuous technological innovations. The introduction of fast and digital technology and components such as analog to digital convertors, microprocessors associated with revolutionary advancement in communication technology has replaced natural scale-up versions of manual monitoring and control to highly advanced automated process monitoring and control systems[6].

The industrial revolution has contributed largely in the development of machine based control where machines in process industries were took over the work done by the human physical power. The early production processes were natural scale-up versions of the traditional manual practices. These are designed as batch process which later was expanded to continuous processes resulting in economical and technological benefits. Industrial PCs

(IPCs) become more and more important in the field of automation technology. Due to their scaling options and various combinations of visualisation and control on one device, Industrial PCs provide clear advantages for many applications.

PCs are available with the following software equipment-

- PC as component, on request with operating system, without further software
- Industrial PC as visualisation system
- Industrial PC as control and visualisation system

2.2.1 Wired Based Communication from Source to PC

The concept of home automation technology emerged in 1975, when a company in Scotland developed X10. X10 allows various devices and appliances in the house to communicate with each other over the already existing electrical wires. All the appliances and devices (such as lights, fans, air-conditioners, TV etc) are equipped with receivers, and the means of controlling the system, such as remote controls or keypads, are equipped with transmitters. These receivers detect a certain signal initiated by the transmitter so that the user can operate them via a remote command. To turn off a lamp in another room, the transmitter will issue a message signal in numerical code which will be transmitted through power-line cable to the specific lamp and commands the lamp to turn off.

X10 is the father of power line home automation protocols. It facilitates control of household devices over the existing home wiring system. X10-compatible devices are still popular in home automation products because of their low cost and ease of installation. But communication over electrical lines using X10 is not always reliable because the lines may get "noisy" from powering other devices. An X10 device could interpret a false electronic interference as a command and react, or it might not receive the command at all. So, noise filters and phase couplers will be required to implement X10 which makes it very expensive.

Lon work is an important type of bus-line home automation protocols. It uses Home and commercial control network. A Lon Works control network is any group of devices working together to sense, monitor, communicate, and control. A Lon Work smart homes use a separate 12-volt cable (twisted pair) to transmit data to devices, which runs in parallel to the traditional mains cable. The use of this cable means that devices are independent of conventional mains borne power supplies [7].

Ce-Bus is another type of bus-line home automation protocols. The Consumer Electronic Bus (Ce-Bus) Standard is a protocol specification developed by the Electronic Industries Association for electronic devices to transmit commands and data.

The RS-232 is a cable communication protocol that connects the computer with the device directly. It is a standard protocol used in asynchronous serial communication. It is the primary protocol used over modem lines. It is the protocol used by the MicroStamp11 when it communicates with a host PC. The communication is achieved via a computer serial port and the serial port of the device. In order to connect to a PC or laptop that doesn't have a serial port, it is possible to convert the serial port to a USB using a USB-to-Serial converter. On the other hand, the RS- 485 is a cable which allows many devices to be connected to a computer. Through a single RS-485 cable multiple devices can communicate with a computer. The communication is achieved via a computer serial port and the serial port of the devices.

2.2.2 Wireless Based Communication from Source To PC

In 1895, Guglielmo Marconi opened the way for modern wireless communications by transmitting the three-dot Morse code for the letter 'S' over a distance of three kilometers using electromagnetic waves. From this beginning, wireless communications has developed into a key element of modern society. From satellite transmission, radio and television broadcasting to the now ubiquitous mobile telephone, wireless communications has revolutionized the way societies function. In the early 1900s, voice and then music was transmitted and modern radio was born. Early radio systems transmitted analog signals. Today most radio systems transmit digital signals composed of binary bits, where the bits are obtained directly from a data signal or by digitizing an analog signal. A digital radio can transmit a continuous bit stream or it can 8group the bits into packets. The introduction of wired Ethernet technology in the 1970's steered people from radio-based networking. In 1985, the federal Communications Commission (FCC) enabled the commercial development of wireless LAN [8].

In Wireless Communication, one can transmit/receive voice and data using electromagnetic waves in open space. The information from sender to receiver is carrier over a well-defined frequency band (channel).Each channel has a fixed frequency bandwidth and Capacity (bit-rate). Different channels can be used to transmit information in parallel and independently.

2.2.2.1 Infrared Based Mechanism

An infrared based home automation system will employ a remote control that sends infrared signals to the receivers attached with each home appliance. These infrared signals carry a command that specifies the activation of the device. Infrared technology is very cheap and is easily affordable but infrared requires line of sight to transmit signals from transmitter to receiver. Infrared remote controls use invisible light pulses below the visible wavelength spectrum (approx. 950nm). In terms of its radiation behaviour it is like any other visible source of light: There must be a line of sight between the transmitter (light source) and the receiver (light detector). Any obstacles between transmitter and receiver will prevent from correct reception. Under good conditions scattered light or light reflected from walls may keep the system working. Having walls between the remote controller and the receiving device will definitely disable the remote control. This obvious disadvantage of IR remote controls simplifies the protocol at the same time [9].

2.2.2.2 Bluetooth Based Mechanism

Bluetooth is a promising technology for short-range, low-power wireless communications. Operating in the 2.4GHz license-free ISM (Industrial, Scientific-Medical) band, Bluetooth adopts a 79-channel Frequency Hopping Spread Spectrum (FHSS)1 technology with a hopping rate of 1600 hops per second. In Bluetooth, before any two devices can communicate with each other, they must go through a device discovery procedure which consists of two steps, inquiry and paging. The former is for devices to find each other, while the latter is to establish actual connections. According to the specification, the inquiring procedure may take 10.24 seconds or longer, and the paging, 7.68 seconds or longer. This long connection setup time is fine for static applications, but is intolerable for mobile applications demanding quick and short connections, such as multi-media name card exchange and pedestrian surroundings information retrieval. Consequently, many approaches have been proposed to speed up the Bluetooth device discovery procedure.

One major component in the discovery delay is the long frequency-matching time. Bluetooth adopts master-slave architecture. To establish a connection between two devices, a potential master should be in the inquiry state to periodically send consecutive ID packets on some predefined 32 channels (or frequencies2), and a potential slave should be in the inquiry scan state trying to catch an ID packet from the right channel at the right time. Only

when a frequency-matching occurs, i.e., the slave correctly receives an ID packet, can the inquiry-paging procedure be started [10].

2.2.2.3 Zigbee Based Mechanism

Nowadays the most prominent network used in home automation is ZigBee. ZigBee is a high level communication protocol that uses small, low-power radio waves based on an IEEE 802 standard for personal area networks. ZigBee technology employs mesh networks, meaning there's more than one way for the message to get to its destination. A ZigBee mesh provides multiple pathways from device to device (like the Internet) and uses Routing Algorithm to determine the fastest route for messages to reach the device receivers. ZigBee eliminates a single point of failure because if nodes go down or are removed, ZigBee devices can "zig" and "zag" through the network to their destination like a bumblebee. ZigBee is similar in concept to other WPAN such as the well known “Bluetooth”. However, it is designed to provide connectivity between small packet devices (battery powered active nodes), while Bluetooth concerns connectivity between large packet user devices such as mobile phones and laptop computers. Thus, ZigBee devices are much less complex as well as less expensive than comparable Bluetooth devices. ZigBee provides long range signal transmission among nodes in a mesh network where each node of the network requires power source (batteries). Although ZigBee is suitable in case of large buildings and wide campus, in case of a Home or office rooms it leads to huge power consumption and expensive installation. Besides, home automation networks don't need all the complexity of a ZigBee mesh network or WPAN because activation commands are short messages and can be communicated within short range [11].

2.2.2.4 Web Based Mechanism

Internet is a reliable and feasible option for achieving the interaction with the home automation network from the remote place. To accomplish this achievement, a web server should be needed to receive requests and responses from remote clients. The clients can send requests to the home appliances. The home appliances can send their statuses to be displayed for the remote client through the server. A web page is constructed as an interactive interface where commands can be submitted by the client to change and also monitor the status of the devices. Using a web page through the internet we can access the database directly. The status changes that are reflected to the database are transferred to the device through first the

master and then to the slave nodes, which will be described in the next section. In addition a login/password based access is setup to prevent unauthorized accesses. With the internet page, authorized users can login to their home environment, monitor and change the status of the devices of their choice.

A user interface is built to bridge the database with the hardware attached. Along being a user interface this program with certain intervals synchronizes the status of the devices to match their status with the database value. If there is any change in status of a device in the database, this change is synchronized with the device. Similarly the statuses of the devices are updated on the database as the conditions on devices change [12].

2.2.2.5 GSM Based Mechanism

The GSM is an excellent choice in establishing a communication from remote locations where Internet may not be available. The communication between the user and the home is established by the SMS (Short Message Service) protocol. A GSM modem is connected to the home automation server. The communication between the home automation server and the GSM modem is carried out by the AT (Attention) commands. Sending and receiving SMS messages are all performed in the PDU (Protocol Description Unit) mode since the text mode may not be available on all GSM modules. The Global System for Mobile Communications (GSM) is a digital standard wireless technology GSM is the most widely used wireless technology in the world with one billion customers globally, which represents 72% of all wireless customers. GSM has a high presence among users (almost everybody has a mobile) raising the probability of the remote controlled HAS to be accessible, furthermore by programming the GSM modem using AT/AT+ commands it provides another security layer (modem will respond only to specific mobiles) and certain robustness. At this backup level, the interaction with the user is very simple; the bilateral communication is reduced to the minimum, only representing emergency processes. Eventually, the remote-controlled HAS will send alerts to the user´s mobile informing about unusual state changes in the sensors within the building, afterwards user is able to activate/deactivate some automated devices required to solve the issue either by dials or messaging or, in the usual case, using a web interface, in any case the user will have always two possible accesses in case that one fails. Normally the probability of accessing the GSM network will be higher than accessing the Internet [13].

2.2.2.6 Speech Based Mechanism

An automated home is also called as a smart home. As we know, the speech is a special kind of communicator among all human beings for their communication; Human voice commands are used for speech based home automation system to operate the electrical home appliances. This idea is most beneficial for human society, especially for old age and physically handicapped people. Basically, speech based home automation system has two schemes for controlling and automating devices. When users are at home, Bluetooth technology is used as one of the schemes for controlling of electrical appliances. It uses a kind of Bluetooth module and a Bluetooth controller mobile application to switch on or switch off the devices. When users are at outside home, the GSM/GPRS technology is used as another scheme for controlling the electrical devices. The total system also alarms the users about any disturbance or interruption into the house when users are stayed outside. This system is designed and developed on microcontroller board. A programming language integrated development environment (IDE) is used for developing the necessary software. Relays and bulbs are used as load to demonstrate the working of the prototype system. Speech based Home automation system provides accessibility, comfort and energy efficiency along with security surveillance [14].

2.2.2.7 IOT Based Mechanism

Home automation is the process of controlling or operating various equipment, electrical devices automatically with the help of lots of control and communication techniques or mechanisms. The electrical devices present at home like fan, lights, water pump, fire alarm, refrigerator etc. can be managed using different controlling mechanisms mentioned already above. The recent emerging technique to control electrical devices is Internet of Things(IoT) over the cloud. There are lots of home automation systems like Wi-Fi based through a static or dynamic IP address from an android mobile phone, Arduino based home automation, remote android application based home automation system, RFID based home automation system and some other home automation based touch screen. [15].
The most effective and innovative application of IOT is nothing but the Wireless home automation through Internet of Things that can be developed to control electrical devices from a remote place over the cloud. The desired components and tools for home automation

system using IoT are mentioned like a Wi-Fi module, TRIAC, Resistors, Capacitors, Opto-coupler, diode, regulators, loads etc.

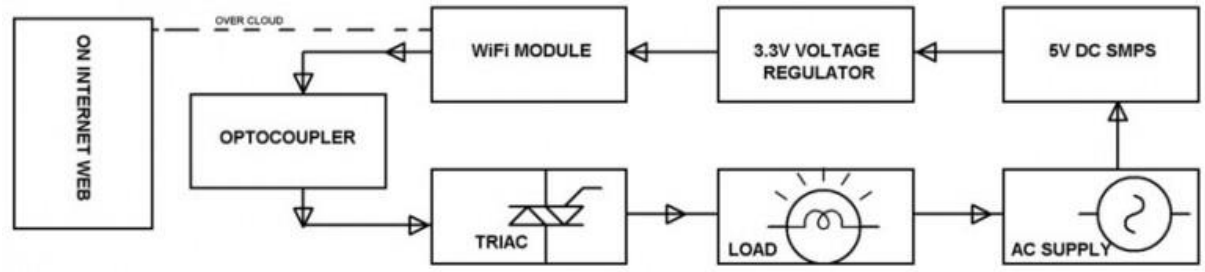

Figure 2.1: Required Blocks for IOT based Home Automation

The entire system framework of home automation using IOT can be divided into various blocks like power supply, Opto-coupler, Wi-Fi module, Switch Mode Power Supply (SMPS), TRIAC, voltage regulator, and loads.

Wi-Fi Module

Wireless Fidelity is one kind of wireless networking technology to interchange the information among more than one device without using any cable or a single wire. Wi-Fi technologies have various standards such as Wi-Fi 802.11a, 802.11b, 802.11g and 802.11n. Wi-Fi module is used to receive the requests and responses in terms of commands from the internet and activate the relay drivers connected to the loads using TRIAC & Opto-coupler by running a program within the Wi-Fi module [16].

Voltage Regulator

Voltage regulator is electronic equipment. Usually, in the power system, it is used for regulating voltage. There are different models of voltage regulators. First one is variable voltage & another one is fixed voltage regulators. Fixed voltage regulators are again subdivided into various types such as electro-mechanical, automatic voltage, linear, hybrid regulators, etc.. In fact, for a Wi-Fi module, 3.3V voltage regulator is required to provide sufficient power supply from 5V SMPS power supply.

Figure 2.2: voltage Regulator

Opto-coupler

Opto-coupler is the package of light emitting device and light sensitive device where electrical connections are not existed. Opto-coupler is called as also Opto-isolator. The connection between the light emitting & light sensitive devices is established by using a beam of light. The light emitting device is simply a LED and light sensitive device is a TRIAC. Therefore, system used to drive loads depending on the signal that can be received from a Wi-Fi module. [17].

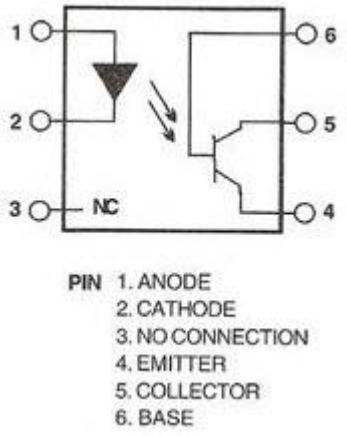

Figure 2.3: Opto - Coupler

User can control and monitor the loads using a web page with self designed interface. The user can send action request through the static IP and these actions are fed to Wi-Fi module. Any reachable wireless modem is used to configure the Wi-Fi module to access internet. The action requests received by a Wi-Fi module are executed by a software package programmed in a Wi-Fi module. The Wi-Fi module is configured to TRIAC & Opto-coupler using the loads are turned ON & OFF and status based on action requests. The web page is used to display the load status (ON or OFF or STATUS).

2.3 Global System for Mobile Communication

Global System for Mobile communications (GSM) is an open sourced digital cellular technology based communication technique that is used to transmit human voice and data services through a mobile. GSM differs from first generation wireless systems in that it uses digital technology and Time Division Multiple Access (TDMA) transmission methods. GSM is a circuit-switched system that divides each 200 kHz channel into eight 25 kHz time-slots.

2.3.1 GSM Module

GSM module is used to establish communication between a computer and a GSM system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. GSM module consists of a GSM modem assembled together with power supply circuit, AT command set and RS232 communication interface on CMOS level. [18]

Figure 2.4: GSM/GPRS Modem

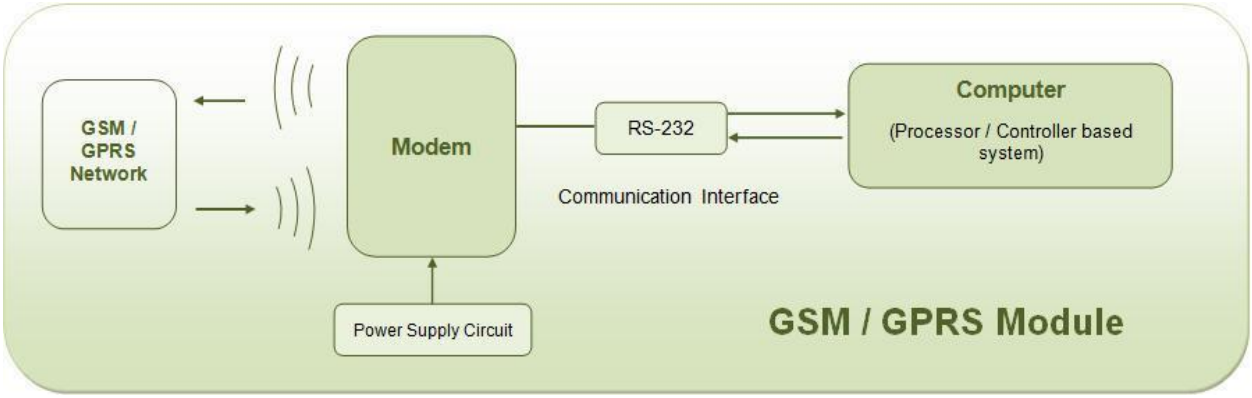

Figure 2.5: Communication module GSM/GPRS Modem

GSM MODEM is a wireless device that generates, transmit or decode data from a cellular network, for establishing communication between the cellular network and the computer. These are manufactured for specific cellular network (GSM/UMTS/CDMA) or specific cellular data standard (GSM/UMTS/GPRS/EDGE/HSDPA) or technology (GPS/SIM). Wireless MODEMs like other MODEM devices use serial communication to interface with and need Hayes compatible AT commands for communication with the computer (any microprocessor or microcontroller system).

A GSM modem requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. Also they have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification. A GSM MODEM can perform the following operations:

1. Receive, send or delete SMS messages in a SIM.
2. Read, add, search phonebook entries of the SIM.
3. Make, Receive, or reject a voice call.

The MODEM needs AT commands, for interacting with processor or controller, which are communicated through serial communication. These commands are sent by the controller/processor. The MODEM sends back a result after it receives a command. Different AT commands supported by the MODEM can be sent by the processor/controller/computer to interact with the GSM cellular network.

2.3.2 SMS Technology

SMS Technology i.e. short message service technology is a mechanism of delivery of short messages over the mobile networks. It is a store and forward way of transmitting messages to and from mobiles. The message (text only) from the sending mobile is stored in a central short message center (SMS) which then forwards it to the destination mobile. This means that in the case that the recipient is not available; the short message is stored and can be sent later. Each short message can be no longer than 160 characters. These characters can be text (alphanumeric) or binary Non-Text Short messages. An interesting feature of SMS is return receipts. This means that the sender, if wishes, can get a small message notifying if

the short message was delivered to the intended recipient. One user can send short messages to any other GSM mobile user around the world. So SMS is more or less a universal mobile data service [17].

Two services given by SMS Technology –

1. Short message Mobile Terminated (SMS-MT): the ability of a network to transmit a Short Message to a mobile phone. The message can be sent by phone or by a software application.
2. Short message Mobile Originated (SMS-MO): the ability of a network to transmit a Short Message sent by a mobile phone. The message can be sent to a phone or to a software application.

How does SMS work –

The figure below shows a typical organization of network elements in a GSM network supporting SMS.

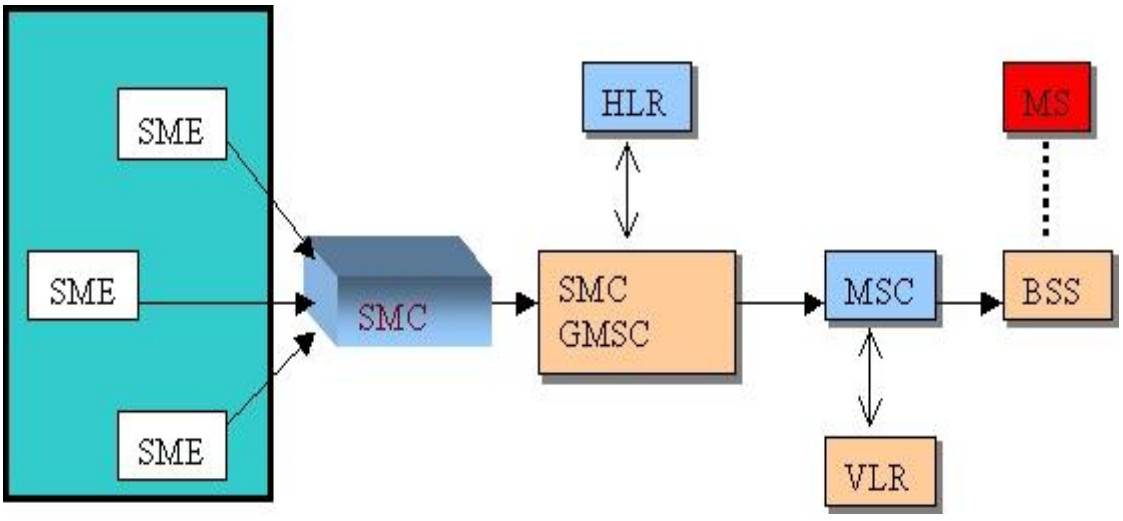

Figure 2.6: Organization of SMS module

The SMC (Short Message Centre) is the entity which does the job of store and forward of messages to and from the mobile station.

The SME (Short Message Entity) which can be located in the fixed network or a mobile station, receives and sends short messages. [18]

The SMS GMSC (SMS gateway MSC) is a gateway MSC that can also receive short messages. The gateway MSC is a mobile network's point of contact with other networks. On receiving the short message from the short message centre, GMSC uses the SS7 network to interrogate the current position of the mobile station form the HLR, the home location register.

HLR is the main database in a mobile network. It holds information of the subscription profile of the mobile and also about the routing information for the subscriber, i.e. the area (covered by a MSC) where the mobile is currently situated. The GMSC is thus able to pass on the message to the correct MSC.

MSC (Mobile Switching Centre) is the entity in a GSM network which does the job of switching connections between mobile stations or between mobile stations and the fixed network.

A VLR (Visitor Location Register) corresponds to each MSC and contains temporary information about the mobile, information like mobile identification and the cell (or a group of cells) where the mobile is currently situated. Using information from the VLR the MSC is able to switch the information (short message) to the corresponding BSS (Base Station System) which transmits the short message to the mobile. The BSS consists of transceivers, which send and receive information over the air interface, to and from the mobile station. This information is passed over the signalling channels so the mobile can receive messages even if a voice or data call is going on. In our proposed system, SMS sending and receiving Technology is implemented with the reference to AT command.

2.3.3 AT Commands

AT commands are sets of commands used for communication with the cellular modem. **AT** commands are comprised of assemblies of ASCII characters which start with the **"AT"** prefix and finish with a suffix<CR> character. The **AT** prefix is derived from the

word **AT**tention, which asks the modem to pay attention to the current request (command) [19].

There are four types of AT commands classified as-

a) Test commands - used to check whether a command is supported or not.

b) Read command - used to get mobile phone or modem settings for an operation.

c) Set commands - used to modify mobile phone or modem settings for an operation.

d) Execution commands - used to carry out an operation.

AT commands are used to request services from the cellular modem.

Such as:

- **Call services**: dial, answer and hang up.
- **Cellular utilities:** send/receive SMS.
- **Modem profiles:** Auto Answer.
- **Cellular Network queries:** GSM signal quality

2.3.3.1 General Syntax Definition Used In AT Command

Table 2.1: General Syntax Definition of AT Command [19]

Syntax	Definition
<CR>	Carriage return character
<LF>	Line-feed character
<...>	Name enclosed in angle brackets is a syntax element. The brac themselves do not appear in the command line.
[...]	Optional sub-parameter of a command or an optional part terminal information response, enclosed in square brackets. brackets themselves do not appear in the command line.
//	Denotes a comment, and should not be included in the comman

2.3.3.2 AT Commands Protocol

The **AT** commands interface is basically a Modem Services upon Request. Communication always begins from the terminal side. This means that any service should be requested from the terminal. Thus a request is called a "command". Each command must be answered by a "results code" from the cellular modem. The results code reports command status to the terminal. Some commands may include several "Response" requests to the terminal.

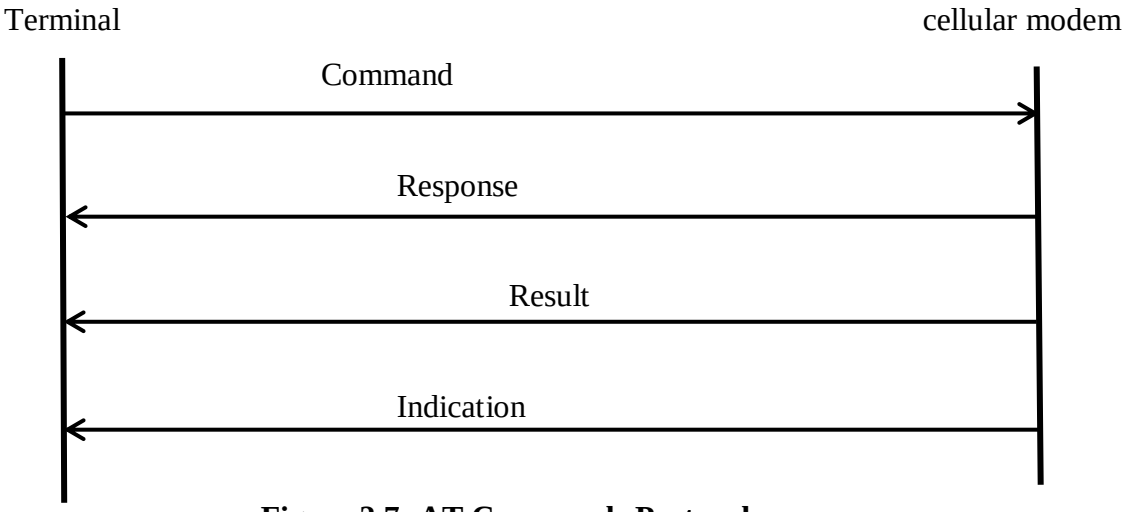

Figure 2.7: AT Commands Protocol

The figure 2.7 shows a general messaging sequence of AT commands protocol between the terminal and the cellular modem.

2.3.3.3 AT Commands Structure

An AT command line may contain one or more commands. Delimiters are used to separate the commands from each other, according to the following structure:

Table 2.2: General Syntax Definition Used In AT Command

Prefix	Command1	Delimiter	Command2	Delimiter	……	Command N	suffix

- Each AT command has the "AT" prefix string.
- Each AT command has the suffix <CR>.

- The delimiter is either a semicolon ";" or none, meaning space.

The Different basic structure of an AT command line:

Table 2.3: Syntax Definition of ATD

Command line prefix Extended commands delimited with semicolon AT(CMD1) (CMD2); Basic command(no + prefix)	As Example, ATD 9706733484 ; This is used to dial this certain Number.

Table 2.4: Syntax Definition of CMGF

Command line prefix sub-parameter AT + (CMD1) = 1 Basic Extended command(prefixed with +)	As Example, AT + CMGF =1 This is used to make the message format as text

Table 2.5: Syntax Definition of CPIN

Command line prefix Test command for checking possible sub parameter values AT + (CMD1) ? Basic Extended command(prefixed with +)	As Example, AT + CPIN? This is used to know The SIM PIN state is ready or not.

2.3.3.4 Results Code Structure

When a command is issued, the cellular modem responds with a message, called a "Result Code", which tells the terminal the result of the command that was requested.

The result code has the following structure:

Prefix	Code	Suffix

2.3.3.5 Response and Indications Structure

The following is the information response and indications structure:

Token	Separator	Arguments

Where,

The separator is ":".

In this proposed system, basically three of AT command are used. They are given below-

2.3.3.6 Call Control AT Commands

- Dial command D

Description: The ATD command sets a voice, data or fax call. As per GSM 02.30, the dial command also controls supplementary services. For a voice call, the application sends the following ASCII string to the product.

Syntax: **ATD< nb >;** Where, <nb> is the destination phone numbe

Here,

Semicolon (;) : When given after <number string>, a voice call is originated to the given address, otherwise a data call is originated.

- Hang-Up command H

Description: The ATH (or ATH0) command disconnects the remote user. In the case of

multiple calls, all calls are released (active, on-hold and waiting calls). The specific Wave com ATH1 command has been appended to disconnect the current outgoing call, only in dialling or alerting state (i.e. ATH1can be used only after the ATD command, and before its terminal response (OK, NO CARRIER,...). It can be useful in the case of multiple calls.

Syntax: ATH;

2.3.3.7 Short Messages Commands

- New Message Indications to Terminal +CNMI

Description: This command handles enabling of unsolicited notifications to the terminal when an SMS is received by the GSM modem. After sending an unsolicited response to the TE, the G24 will expect a +CNMA (new message acknowledgement) from the TE within a predefined timeout of 60 seconds. The GSM modem will not send another unsolicited response to the TE before the previous one is acknowledged. If acknowledged within the timeout, the new SM is not saved in the message storage. If not, the new SM is saved in the message storage and +CNMI parameters are set to 0.

Syntax: AT+CNMI= [<mode> [,<mt>[,<bm> [,<ds>[,<bfr>]]]]]

Defined values:

<mode>: controls the processing of unsolicited result code

<mt>: sets the result code indication routing for SMS-DELIVERs. Default is 0.

<bm>: set the rules for storing received CBMs (Cell Broadcast Message) types depend on its coding scheme, the setting of Select CBM Types (+CSCB command) and Default is 0

<ds> : for SMS-STATUS-REPORTs. Default is 0.

<bfr>: Default is 0

- Preferred Message Format + CMGF

Description: The message formats supported are *text mode* and *PDU mode*. In PDU mode, a complete SMS Message including all header information is given as a binary string (in hexadecimal format).Therefore, only the following set of characters is allowed:

{‘0’,’1’,’2’,’3’,’4’,’5’,’6’,’7’,’8’,’9’, ‘A’,‘B’,’C’,’D’,’E’,’F’}. Each pair or characters are converted to a byte (e.g.: ‘41’ is converted to the ASCII character ‘A’, whose ASCII code is 0x41 or 65). In Text mode, all commands and responses are in ASCII characters. The format selected is stored in EEPROM by the +CSAS command.

Syntax: AT+CMGF=<index>

As example, AT + CMGF=1 for text mode

AT + CMGF=0 for PDU mode

- Read message +CMGR

Description: This command allows the application to read stored messages. The messages are read from the memory selected by +CPMS command.

Syntax: AT+CMGR=<index>

- Send message +CMGS

Description: The <address> field is the address of the terminal to which the message is sent. To send the message, simply type, <ctrl-Z> character (ASCII 26). The text can contain all existing characters except <ctrl-Z> and <ESC> (ASCII 27). This command can be aborted using the<ESC> character when entering text. In PDU mode, only hexadecimal characters are used (‘0’…’9’,’A’…’F’).

Syntax: Command syntax in text mode:
AT+CMGS= <da>[,<toda>] <CR>
text is entered <ctrl-Z / ESC >

Command syntax in PDU mode:
AT+CMGS= <length><CR>
PDU is entered <ctrl-Z / ESC >

Parameters used in the syntex are given below-

<da>: Destination address in quoted string. This field contains a single MIN number.

<toda>: Type of DA. Value between 128-255 (according to GSM 03.40.9.1.2.5). If this field is not given and first character of <da> is '+', <toda> will be 145, otherwise 129.

<length>: Size of message in PDU mode format, in octets, excluding SMSC data.
<mr>: Sent message reference number.

2.4 World Wide Web Communication

The World Wide Web communication is a system of interlinked hypertext documents accessed via the Internet. With a web browser, one can view web pages that may contain text, images, videos, and other multimedia, and navigate between them via hyperlinks.

2.4.1 WAMP Server

WAMP Server is a web development platform on Windows environment allowing anyone to create dynamic web applications with Apache2, Php and MySQL. WAMP is an acronym formed from the initials of the operating system Microsoft Windows and the principal components of the package: Apache, MySQL and one of Php, Perl or Python. Apache is a web server. MySQL is an open-source database. Php, Perl and Python are scripting languages that can manipulate information held in a database and generate web pages dynamically each time content is requested by a browser. Other programs may also be included in a package, such as phpMyAdmin which provides a graphical user interface for the MySQL database manager. [20]

2.4.1.1 Apache web server

Apache is basically a most widely used Web server based on HTTP in the world. Originally, apache is introduced for open source environments like UNIX. But later on, the Apache Web server has been designed and developed for Windows and other environment also. It is playing a key role in the initial growth of the World Wide Web. Apache was

originally based on NCSA HTTP code. The NCSA code has since been removed from Apache, due to a rewrite. [21]

Apache supports some common language interfaces like Perl, Python, Tcl, and Php. Apache features configurable error messages, DBMS-based authentication databases, and content negotiation. It is also supported by several graphical user interfaces (GUIs). It supports password authentication and digital certificate authentication. Apache has a built in search engine and an HTML authorizing tool and supports FTP. Because the source code is freely available, anyone can adapt the server for specific needs, and there is a large public library of Apache add-ons.

Apache has a few salient features like Stability, Efficiency, Portability and Open-source.

2.4.1.2 Php

Php (Php: Hypertext Preprocessor) was created by Rasmus Lerdorf in 1994. It was initially developed for HTTP usage logging and server-side form generation in UNIX. Php is a server scripting language, and is a powerful tool for making dynamic and interactive Web pages. Php code is interpreted by a web server with a Php processor module which generates the resulting web page: Php commands can be embedded directly into an HTML source document rather than calling an external file to process data. It has also evolved to include a command-line interface capability and can be used in standalone graphical applications. [22]

The main functional activities of Php regarding this present work are -

- ✓ generate dynamic page content
- ✓ create, open, read, write, and close files on the server
- ✓ collect form, data from the server
- ✓ send and receive cookies
- ✓ add, delete, modify data in the common database.
- ✓ restrict users to access some pages on the website
- ✓ encrypt data

Php is used in this present work because -

- ✓ Easy to use: Code is embedded into HTML.
- ✓ Cross Platform : Runs on almost any Web server on open source OS also.
- ✓ Cost Benefits : php is free.
- ✓ Huge databases : support for a wide range of databases.

2.4.1.3 MySQL

MySQL is a database system used on the web and runs on a server. MySQL is developed, distributed, and supported by Oracle Corporation. It is a Multi-user and multi-threaded RDBMS server. MySQL is ideal system for both small and large databases. It uses SQL to interact with and manipulate data. It supports various programming languages. MySQL is very fast, reliable, and easy to use. MySQL can Access tables from different databases. MySQL is a relational database management system (RDBMS), and ships with no GUI tools to administer MySQL databases or manage data contained within the databases [23].

2.5 Speech Recognition Tools for Communication

The Speech is one of the most essential & primary mode of Communication among peoples. Human beings are always motivated to create computer system that can understand and talk like humans. So, Speech Recognition becomes one of the important research areas. In this context, automatic speech recognition (ASR) becomes most essential which can be built using HTK and Sphinx toolkit based on Hidden Markov Model. In the matter of our system, both toolkits were tried to use for speech recognition. But, Finally HTK was preferred for our system.

Speech recognition is a process of converting speech signal to a sequence of word. Various approaches have been used for speech recognition which includes Dynamic programming and Neural Network.

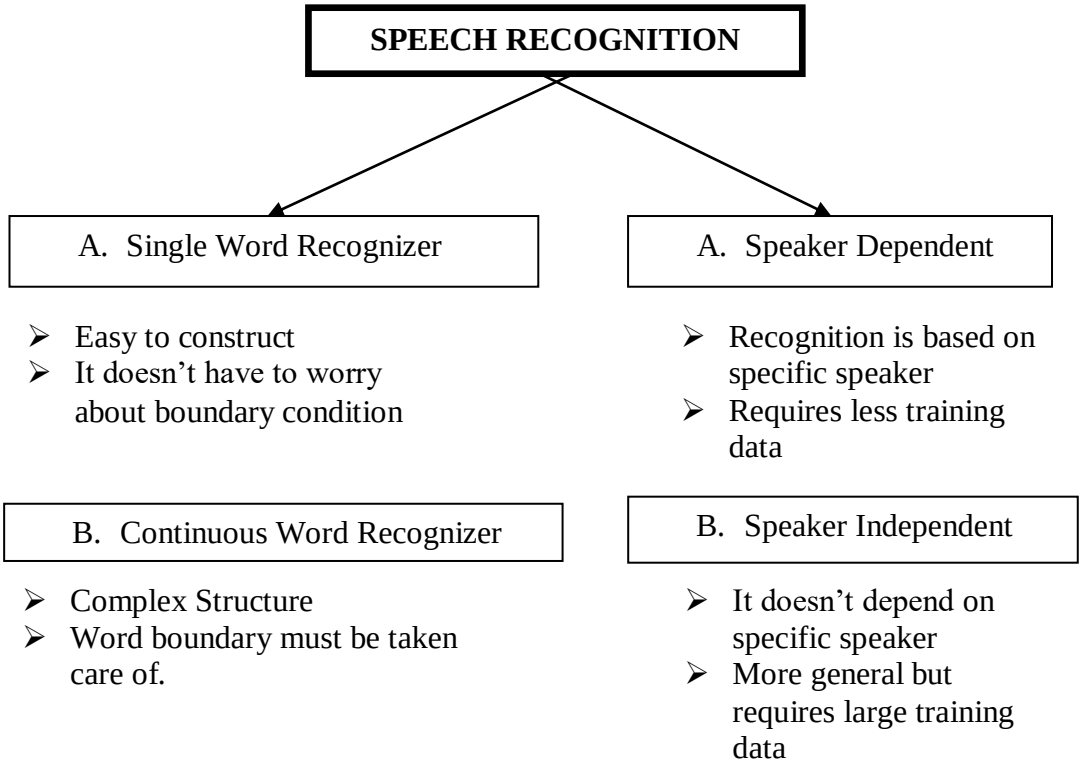

Figure 2.8: Speech Recognition Process Module

2.5.1 Speech Recognition and HMM

Speech recognition consists of two main modules, feature extraction and feature matching. The purpose of feature extraction module is to convert speech waveform to some type of representation for further analysis and processing, this extracted information is known as feature vector. The process of converting voice signal to feature vector is done by signal-processing front end module. As shown in below block diagram input to front-end is noise free voice sample and output of it is feature vector. In feature matching, the extracted feature vector from unknown voice sample is scored against acoustic model, the model with max score wins, and its output is considered as recognized word. There are a few methods for implementing front-end (for extracting feature factor) [24].

- MFCC (Mel-Frequency Cepstrum Coefficient)
- LPC (Linear Predictive Coding)

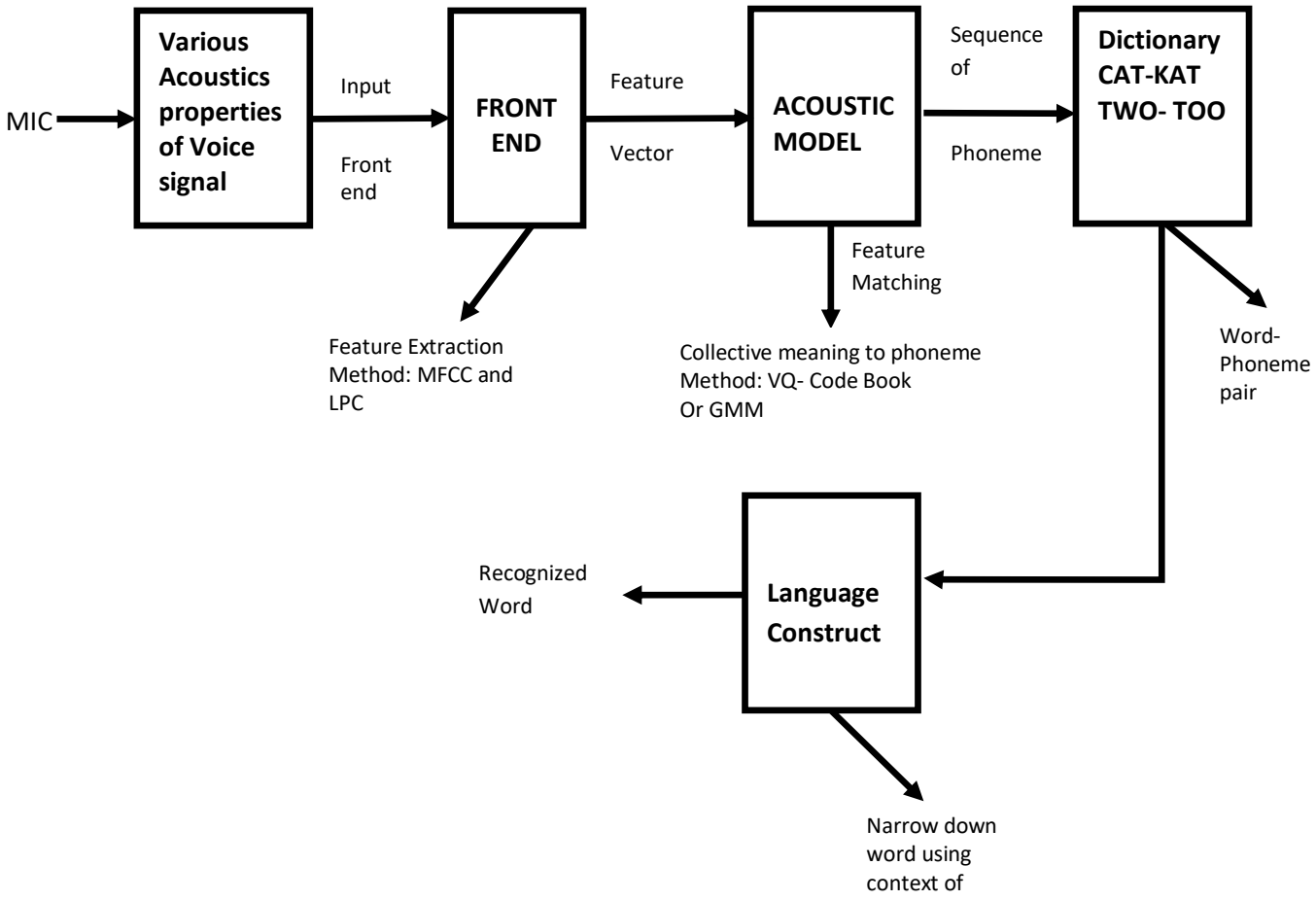

Figure 2.9: Speech Recognition model using HMM

2.5.2 Recognizing Toolkit – HTK

The HTK tools are best introduced by going through the processing steps involved in building a sub-word based continuous speech recognizer.

There are 4 main phases:

- Data preparation
- Training
- Testing
- Analysis.

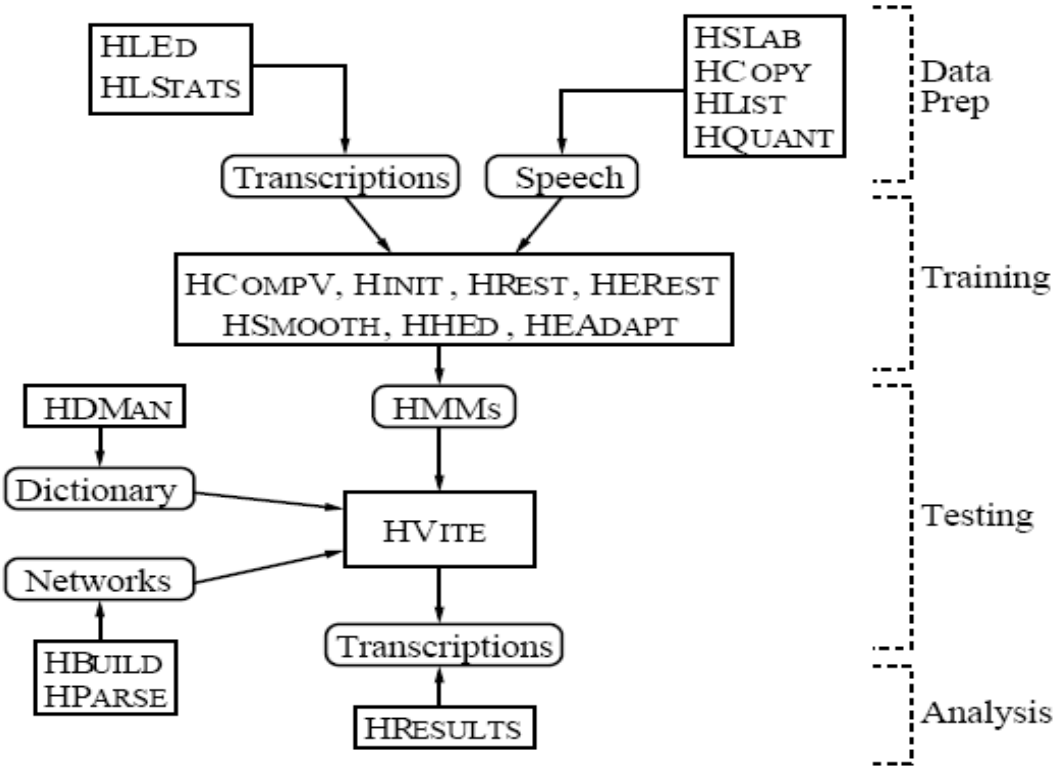

Figure 2.10: HTK Processing Stages

2.5.2.1 Data Preparation Tools

For building a set of HMMs, a set of speech data files and their associated transcriptions are required. Very often speech data will be obtained from database archives. Before it can be used in training, it must be converted into the appropriate parametric form and any associated transcriptions must be converted to have the correct format and use the required phone or word labels.

Although all HTK tools can parameterise waveforms *on-the-fly*, in practice it is usually better to parameterise the data just once. The tool HCopy is used for this. HCopy is used to copy one or more source files to an output file. Normally, HCopy copies the whole file, but a variety of mechanisms are provided for extracting segments of files and concatenating files. By setting the appropriate configuration variables, all input files can be converted to parametric form as they are read-in. Thus, simply copying each file in this manner performs the required encoding [25].

Transcriptions will also need preparing. Typically the labels used in the original source transcriptions will not be exactly as required, for example, because of differences in the phone sets used. Also, HMM training might require the labels to be context-dependent. The tool HLEd is a script-driven label editor which is designed to make the required transformations to label files. HLEd can also output files to a single *Master Label File* MLF which is usually more convenient for subsequent processing. Finally on data preparation, HLStats can gather and display statistics on label files in preparation for building discrete probability HMM system.

2.5.2.2 Training Tools

The second step of system building is to define the topology required for each HMM by writing a prototype definition. HTK allows HMMs to be built with any desired topology. HMM definitions can be stored externally as simple text files and hence it is possible to edit them with any convenient text editor. Alternatively, the standard HTK distribution includes a number of example HMM prototypes and a script to generate the most common topologies automatically. With the exception of the transition probabilities, all of the HMM parameters given in the prototype definition are ignored. The purpose of the prototype definition is only to specify the overall characteristics and topology of the HMM. The actual parameters will be computed later by the training tools. Sensible values for the transition probabilities must be given but the training process is very insensitive to these. An acceptable and simple strategy for choosing these probabilities is to make all of the transitions out of any state equally likely [26]

Firstly, an initial set of models must be created. If there is some speech data available for which the location of the sub-word (i.e. phone) boundaries has been marked, then this can be used as *bootstrap data*. In this case, the tools HInit and HRest provide *isolated word* style training using the fully labeled bootstrap data. Each of the required HMMs is generated individually. HInit reads in all of the bootstrap training data and *cuts out* all of the examples of the required phone. It then iteratively computes an initial set of parameter values using a *segmental k-means* procedure.

On the first cycle, the training data is uniformly segmented, each model state is matched with the corresponding data segments and then means and variances are estimated.

If mixture Gaussian models are being trained, then a modified form of k-means clustering is used. On the second and successive cycles, the uniform segmentation is replaced by Viterbi alignment. The initial parameter values computed by HInit are then further re-estimated by HRest. Again, the fully labelled bootstrap data is used but this time the segmental k-means procedure is replaced by the Baum-Welch re-estimation procedure. When no bootstrap data is available, a so-called *flat start* can be used. In this case all of the phone models are initialized to be identical and have state means and variances equal to the global speech mean and variance. The tool HCompV can be used for this.

Once an initial set of models has been created, the tool HERest is used to perform *embedded training* using the entire training set. HERest performs a single Baum-Welch re-estimation of the whole set of HMM phone models simultaneously. For each training utterance, the corresponding phone models are concatenated and then the forward-backward algorithm is used to accumulate the statistics of state occupation, means, variances, etc., for each HMM in the sequence. When all of the training data has been processed, the accumulated statistics are used to compute re-estimates of the HMM parameters. HERest is the core HTK training tool. It is designed to process large databases, it has facilities for pruning to reduce computation and it can be run in parallel across a network of machines [26]

The philosophy of system construction in HTK is that HMMs should be refined incrementally. Thus, a typical progression is to start with a simple set of single Gaussian context-independent phone models and then iteratively refine them by expanding them to include context-dependency and use multiple mixture component Gaussian distributions. The tool HHEd is a HMM definition editor which will clone models into context-dependent sets, apply a variety of parameter typing and increment the number of mixture components in specified distributions. The usual process is to modify a set of HMMs in stages using HHEd and then re-estimate the parameters of the modified set using HERest after each stage. To improve performance for specific speakers the tools HERest and HVite can be used to adapt HMMs to better model the characteristics of particular speakers using a small amount of training or adaptation data. The end result of which is a speaker adapted system.
The single biggest problem in building context-dependent HMM a system is always data insufficiency.

The more complex the model set, the more data is needed to make robust estimates of its parameters, and since data is usually limited, a balance must be struck between complexity and the available data. For continuous density systems, this balance is achieved by tying parameters together as mentioned above. Parameter tying allows data to be pooled so that the shared parameters can be robustly estimated. In addition to continuous density systems, HTK also supports fully tied mixture systems and discrete probability systems. In these cases, the data insufficiency problem is usually addressed by smoothing the distributions and the tool HSmooth is used for this.

2.5.2.3 Recognition Tools

HTK provides a recognition tool called HVite that allows recognition using language models and lattices. HLRecsore is a tool that allows lattices generated using HVite (or HDecode) to be manipulated for example to apply a more complex language model. An additional recogniser is also available as an extension to HTK HDecode. Note: HDecode is distributed under a more restrictive licence agreement.

HVite

HTK provides a recognition tool called HVite which uses the token passing algorithm described in the previous chapter to perform Viterbi-based speech recognition. HVite takes as input a network describing the allowable word sequences, a dictionary defining how each word is pronounced and a set of HMMs. It operates by converting the word network to a phone network and then attaching the appropriate HMM definition to each phone instance. Recognition can then be performed on either a list of stored speech files or on direct audio input. As noted at the end of the last chapter, HVite can support cross-word triphones and it can run with multiple tokens to generate lattices containing multiple hypotheses. It can also be configured to rescore lattices and perform forced alignments [26].

The word networks needed to drive HVite are usually either simple word loops in which any word can follow any other word or they are directed graphs representing a finite-state task grammar. In the former case, bigram probabilities are normally attached to the word transitions. Word networks are stored using the HTK standard lattice format. This is a text-based format and hence word networks can be created directly using a text-editor.

However, this is rather tedious and henceHTK provides two tools to assist in creating word networks. Firstly, HBuild allows sub-networks to be created and used within higher level networks. Hence, although the same low level notation is used, much duplication is avoided. Also, HBuild can be used to generate word loops and it can also read in a backed-off bigram language model and modify the word loop transitions to incorporate the bigram probabilities. It should be noticed that the label statistics tool HLStats mentioned earlier can be used to generate a backed-off bigram language model. As an alternative to specifying a word network directly, a higher level grammar notation can be used. This notation is based on the Extended Backus Naur Form (EBNF) used in compiler specification and it is compatible with the grammar specification language used in earlier versions of HTK. The tool HParse is supplied to convert this notation into the equivalent word network. Whichever method is chosen to generate a word network, it is useful to be able to see examples of the *language* that it defines. The tool HSGen is provided to do this. It takes as input a network and then randomly traverses the network outputting word strings. These strings can then be inspected to ensure that they correspond to what is required. HSGen can also compute the empirical perplexity of the task. Finally, the construction of large dictionaries can involve merging several sources and performing a variety of transformations on each sources. The dictionary management tool HDMan is supplied to assist with this process.

2.5.2.4 Analysis Tool

Once the HMM-based recogniser has been built, it is necessary to evaluate its performance. This is usually done by using it to transcribe some pre-recorded test sentences and match the recognizer output with the correct reference transcriptions. This comparison is performed by a tool called HResults which uses dynamic programming to align the two transcriptions and then count substitution, deletion and insertion errors. Options are provided to ensure that the algorithms and output formats used by HResults are compatible with those used by the US National Institute of Standards and Technology (NIST). As well as global performance measures, HResults can also provide speaker-by-speaker breakdowns, confusion matrices and time-aligned transcriptions. For word spotting applications, it can also compute *Figure of Merit* (FOM) scores and *Receiver Operating Curve* (ROC) information.

2.5.3 Recognizing Toolkit – Sphinx

Sphinx is an open source toolkit for automatic speech recognition. Sphinx is a large vocabulary speech recognizer with high accuracy and speed performance. It is also a collection of tools and resources that enables developers or researchers to build successful speech recognizers [27]

There are three stages for Sphinx recognizer

a) Data Training
b) Data Testing
c) Performance Evaluation

Stages of training

- ✓ Training context Independent phone HMMs
- ✓ Training context Dependent phone HMMs
- ✓ Decision tree building
- ✓ Training context Dependent tied phone HMMs
- ✓ Recursive Gaussian splitting

2.5.4. Asterisk

Asterisk is a software platform, runs on the numbers of operating systems like NetBSD, OpenBSD, FreeBSD, Mac OS X and Solaris; although initially designed for Linux using a GNU General Public licence (GPL) as a free software licence. It was first introduced in the year 1999 by Mark Spencer to have an implementation of telephone PBX. PBX stands for Private Branch Exchange that allows connected phones to make calls to each other, as well as capable of connecting VoIP and PSTN services. Asterisk starts with loading the dynamic module loader and initializing the drivers associated with channels, and linking them with appropriate internal APIs. The PBX of Asterisk accepts calls from the interfaces and handles them accordingly based on the dial plan. Asterisk dial plan is the kernel of all Asterisk based system, which talks about handling of inbound and outbound calls, based on

a configuration file named extensions.conf. The dial plan works based on four important components- namely contexts, extensions, priorities and applications [28].

- **Contexts** - This is the subsection of the dial plan, which is defined by giving the name (name can be made up of numbers, letters, hyphen and underscore) of the context in the square bracket.
- **Extensions** - For accepting a call by the Asterisk, series of steps are to be performed and those steps are uniquely defined through the extensions.
- **Priorities** - As extensions are having numbers of steps, those steps are known as priorities and each step executes one application.
- **Applications** - It is for performing a specific action on the current channel. Some of the inbuilt applications are Answer ( ), Hangup ( ) are already available.

2.6 IOT BASED WI-FI COMMUNICATION

IoT (Internet of Things) is an advanced automation and analytics system which exploits networking, sensing, big data, and artificial intelligence technology to deliver complete systems for a product or service. These systems allow greater transparency, control, and performance when applied to any industry or system. They enhance data collection, automation, operations, and much more through smart devices and powerful enabling technology.

IoT systems allow users to achieve deeper automation, analysis, and integration within a system. They improve the reach of these areas and their accuracy [29].

2.6.1 IoT − Key Features

The most important features of IoT include artificial intelligence, connectivity, sensors, active engagement, and small device use. A brief review of these features is given below:

AI – IoT makes virtually anything ‘smart’ essentially i.e. it enhances every aspect of life with the power of data collection, artificial intelligence algorithms, and networks. This can mean something as simple as enhancing your freeze and cabinets to detect when milk and your favourite cereal run low, and to then place an order with your preferred grocer.

Connectivity – It enables technologies for networking, and specifically IoT networking, mean networks are no longer exclusively tied to major providers. Networks can exist on a much smaller and cheaper scale while still being practical. IoT creates these small networks between its system devices.

Sensors – IoT loses its distinction without sensors. They act as defining instruments which transform IoT from a standard passive network of devices into an active system capable of real-world integration.

Active Engagement – Much of today's interaction with connected technology happens through passive engagement. IoT introduces a new paradigm for active content, product, or service engagement.

Small Devices – Devices, as predicted, have become smaller, cheaper, and more powerful over time. IoT exploits purpose-built small devices to deliver its precision, scalability, and versatility.

2.6.2 Programming Language –Lua

Lua is a lightweight multi-paradigm programming language designed primarily for embedded systems and clients. Lua is cross-platform, since it is written in ANSI C, and has a relatively simple C API. In the context of this system, Lua has been used to write script for ESP8266 module to support remote control of device. The features of Lua are described in brief below-

- simple
- efficient
- portable
- extensible
- adaptable to a broad range of applications
- Lua is an extension programming language
- Suitable for use as an embedded language within a host application
- Cross Platform Support
- Implemented in ANSI C
- Lightweight core occupies just 60k and executable footprint of just 140k

2.6.3 Embedded Web Server

Embedded systems have traditionally been isolated, self-contained systems; at most, they might have communicated with other systems within a limited range on a local network. This is no longer the case as embedded systems, especially small, very deeply-embedded devices, increasingly use the Internet as a way to communicate with each other and with the people managing them. The use of embedded devices to communicate to other devices using internet is called embedded web technology.

An embedded system that includes integrated web connectivity so that it can respond to browser requests and respond accordingly is known as an embedded web server. Such Internet functionality can be acquired in a variety of forms from a variety of sources, both open-source and commercial. These generally fall into one of two categories: small, simple web servers and application servers having greater functionality.

A web server has one role: to implement the HTTP protocol. This protocol allows a browser to issue a request to which a server will respond. Today's web is highly sophisticated, featuring elaborate graphics and streaming media, yet surprisingly, HTTP is a very simple protocol. All it does is transport requests and responses. Because HTTP is a stateless protocol, there is no intelligence in the operation, there is no decision-making or context, and there are no scripts or code to execute. There is also no concept of dynamic page creation; if a page is going to be created dynamically, some other program has to do that work and put the result where the web server expects it to be.

HTTP understands only nine operations (typically called "methods" or "verbs"), of which the most important are GET and POST. GET is used to download a "resource" (typically a file) located at a specified location (the "uniform resource locator", or URL). The response to a GET request contains the resource, accompanied by HTTP header information. When someone clicks a link in a web browser to go to a new page, they are sending a GET request to the server asking for the HTML page located at the URL they clicked.

POST is used to submit data from the web browser back to the server. This is the request that is generated when someone hits the "Submit" button on a filled-out form. A basic web server cannot process a POST request, since it will have no idea what to do with

the data in the request. It must rely on some other program or utility to process the data. On older standard websites, that utility might be a Common Gateway Interface (CGI) plug-in as the web server would simply hand any POST requests over to be handled by CGI. While CGI isn't appropriate for most embedded applications due to its size, performance, and inability to exist in a monolithic architecture, the fact remains that the web server needs something else to handle data returned by a web browser.

Unlike desktop-based web applications which typically provide information or entertainment, embedded web applications can actually cause something to happen on the device. For example, we might change the direction of an antenna; we might control the power supply of devices or we might open or close a valve. The hard buttons that would normally be built into the system are effectively replaced by, or duplicated by, virtual buttons in a browser-based form. Using the Internet to control an embedded system has a direct impact on the cost of building and maintaining the system. Physical controls like buttons mean additional components and cost as well as a design that must accommodate access to the controls. Even more importantly, embedded systems are increasingly being deployed in remote locations. In those applications, the cost isn't dominated by components, but rather by the people that must go out to maintain and operate the system. This makes remote access critical to the cost-effectiveness of the system. The Internet is the most straightforward way of getting to the target system because worldwide infrastructure already exists [30].

2.6.4 ESP8266 Wi-Fi Module

The ESP8266 Wi-Fi Module is an essential module for Wi-Fi communication which has basic useful features as mentioned below-

- 32-bit RISC CPU
- 64 KB of instruction RAM, 96 KB of data RAM
- External QSPI flash: 512 KB to 4 MB* (up to 16 MB is supported)
- IEEE 802.11 b/g/n Wi-Fi
- WEP or WPA/WPA2 authentication, or open networks
- 16 GPIO pins
- SPI
- I^2C

- I²S interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 10-bit ADC

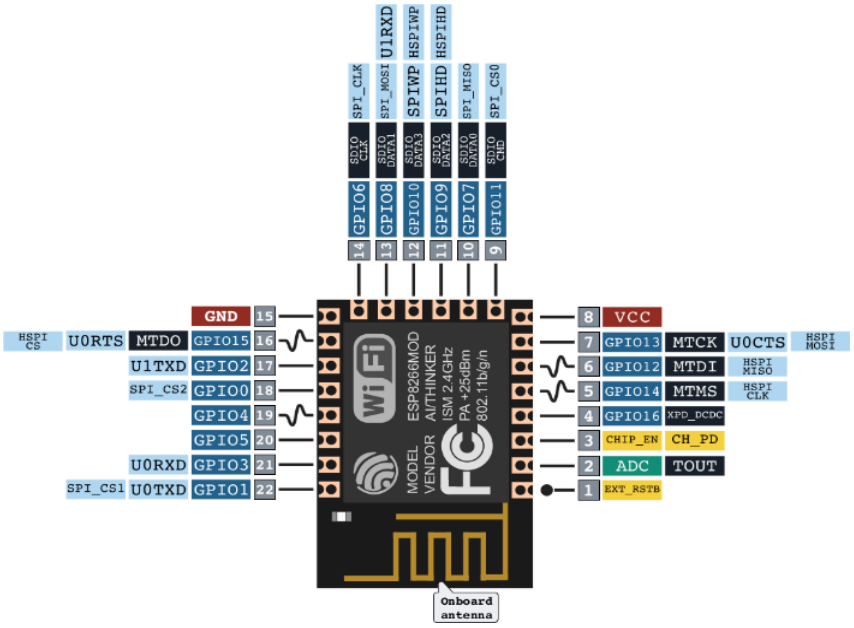

Figure 2.11: Pinout of ESP8266

2.7 OVERVIEW OF AT89S52 Microcontroller

AT89S52 is a popular 8051 chip designed and developed by ATMEL. It is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software

selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM con-tents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset [31].

2.7.1 Architecture of AT89S52

Detailed Pin diagram and block diagram of AT89S52 Microcontroller is shown in the fig. 2.4 and fig 2.5 respectively

VCC*:* Supply voltage.

GND: Ground.

a) Port 0

Port 0 is an 8-bit open drain bi-directional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high impedance inputs. Port 0 can also be configured to be the multiplexed low-order, address/data bus during accesses to external program and data memory. In this mode, P0 has internal pull-ups. Port 0 also receives the code bytes during Flash programming and outputs the code bytes during program verification. External pull-ups are required during program verification.

b) Port 1

Port 1 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. In addition, P1.0 and P1.1 can be configured to be the timer/counter 2 external count input (P1.0/T2) and the timer/counter 2 trigger input (P1.1/T2EX), respectively, as shown in the below figure.

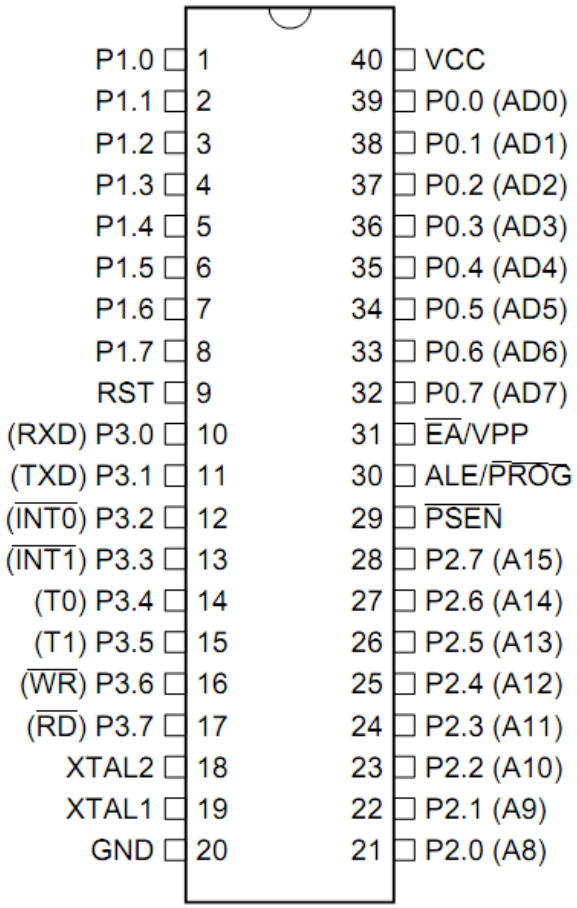

Figure 2.12: Pin out diagram of AT89S52

c) Port 2

Port 2 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @ DPTR). In this application, Port 2 uses strong internal pull-ups when emitting 1s. During accesses to external data memory that use 8-bit addresses (MOVX @ RI), Port 2 emits the contents of the P2 Special Function Register. Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.

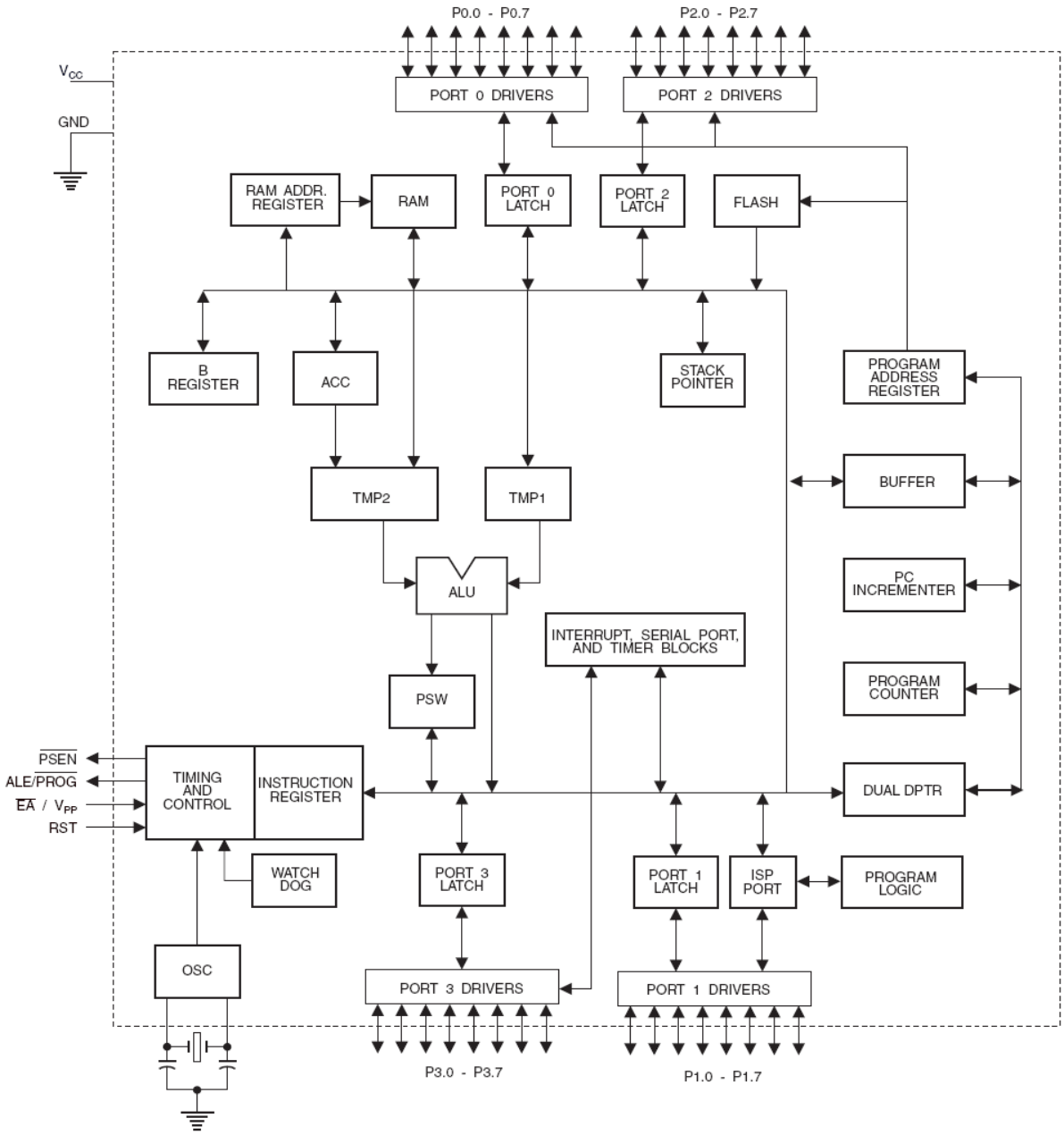

Figure 2.12: Block Diagram of microcontroller

d) Port 3

Port 3 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins, they are pulled high by the internal pull-ups and can be used an inputs. As inputs, Port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups. Port 3 also serves the functions of various special features of the AT89S52.

e) RST

Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.

f) ALE/PROG

Address Latch Enable is an output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming. In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external data memory. If desired, ALE operation can be disabled by setting bit 0 of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode**.**

g) PSEN

Program Store Enable is the read strobe to external program memory. When the AT89C52 is executing code from external program memory, PSEN is activated twice each machine cycle, except that two PSEN activations are skipped during each access to external data memory.

h) EA/VPP

External Access Enabled. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed, EA will be internally latched on reset. EA should be strapped to VCC for internal program executions.

This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming when 12- volt programming is selected.

i) XTAL1

Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

j) XTAL2

Output from the inverting oscillator amplifier.

2.7.2 Instruction Set Architecture Of AT89C51

There are lots of Function registers present in the AT89S52 microcontroller.

a) SBUF Register: For a byte of data to be transferred via the TxD line, it must be placed in the SBUF. SBUF holds the byte of data when it is received by the 8051's RxD line.

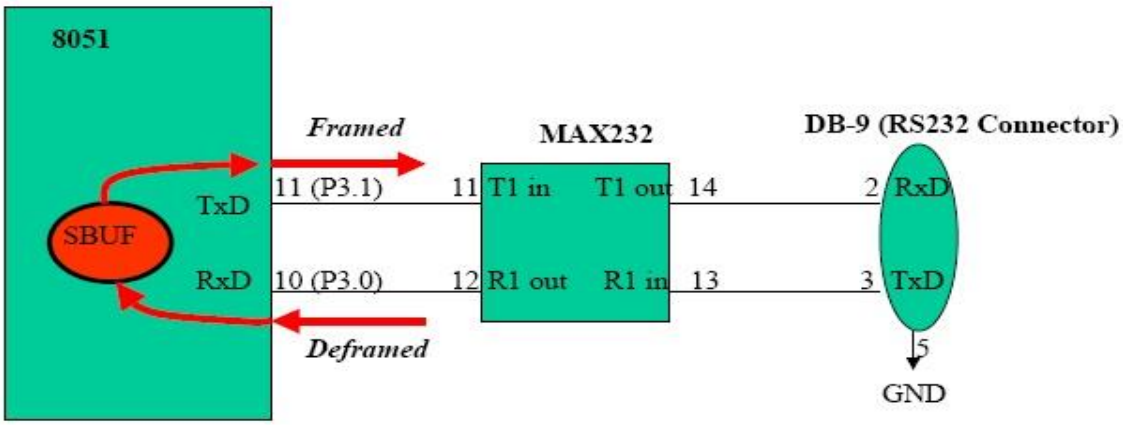

Figure 2.14: Block Diagram of SBUF register with MAX232

Here,

MAX232 : TTL to Serial Connector, DB9 : 9-pin D-type connector

b) SCON Register: This is the serial port control register. It should be set to hexadecimal 0x50 for 8-bit data mode.

SM0	SM1	SM2	REN	TB8	RB8	TI	RI

i) SM2 enables the multiprocessing capability of the 8051.

ii) REN (Receive Enable): It allows the 8051 to receive data on the RxD pin. If user wants 8051 to both transfer and receive data, REN must be set to '1'.

iii) TB8 (Transfer bit 8): It is used for serial modes 2 and 3, so here we make TB8=0.

iv) RB8 (Receive bit 8) :It is used for serial modes 2 and 3, so here we make RB8=0.

v) TI (Transmit Interrupt) :This is a flag bit. When 8051 finish the transfer of the 8-bit

character, it raises the TI flag to indicate that it is ready to transfer another byte.

vi) RI (Receive Interrupt) : When 8051 receive data via RxD, it get rid of the start and stop bits (deframed procedure) and places the byte in the SBUF. Then it raises the RI flag to indicate that a byte has been received and should be picked up before it is lost.

c) TMOD: This register controls the timers for baud rate generation and it should be set to hexadecimal 0x20 to enable timer 1 to operate in 8-bit auto-reload mode.

d) TH1: This register should be loaded with a constant so that the required baud rate can be generated. Table 6.3 shows the values to be loaded into TH1 and the corresponding baud rates for two different clock rates.

e) TR1: This register starts/stops the timer and it should be set to 1 to start timer 1.

f) TI: This register should be set to1 to indicate ready to transmit.

2.7.3. MAX 232: TTL to Serial Convertor

RS232 is bi-polar and a voltage of 3 to 12 V indicates an ON state while a voltage of 3 to 12 V indicates an OFF state. Standard TTL logic devices, including the AT89S52 microcontroller, operate with TTL logic levels between the voltages of 0 and 5 V. Voltage level converter ICs are used to convert between the TTL and RS232 voltage levels. One such popular IC is the MAX232, manufactured by MAXIM, and operators with 5 V supply. The MAX232 is a 16-pin DIL chip incorporating two receivers and two transmitters and the device requires four external capacitors for proper operation. The microcontroller can be connected to external RS232 compatible equipment via a MAX232 type voltage converter IC [32].

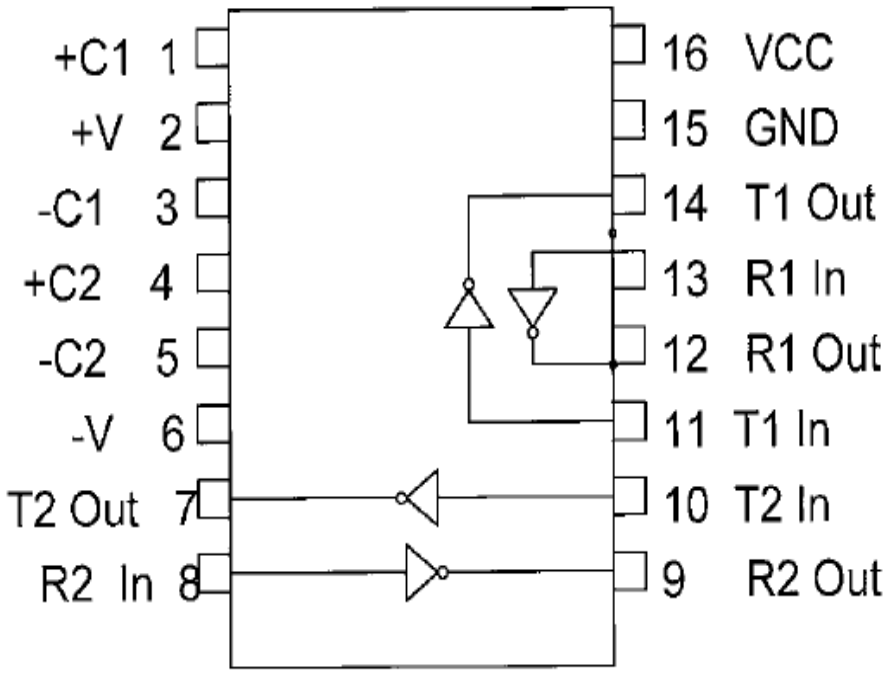

Figure 2.15: Pin Diagram of MAX232

Since RS232 standard is not TTL compatible, so a MAX232 line driver is needed.

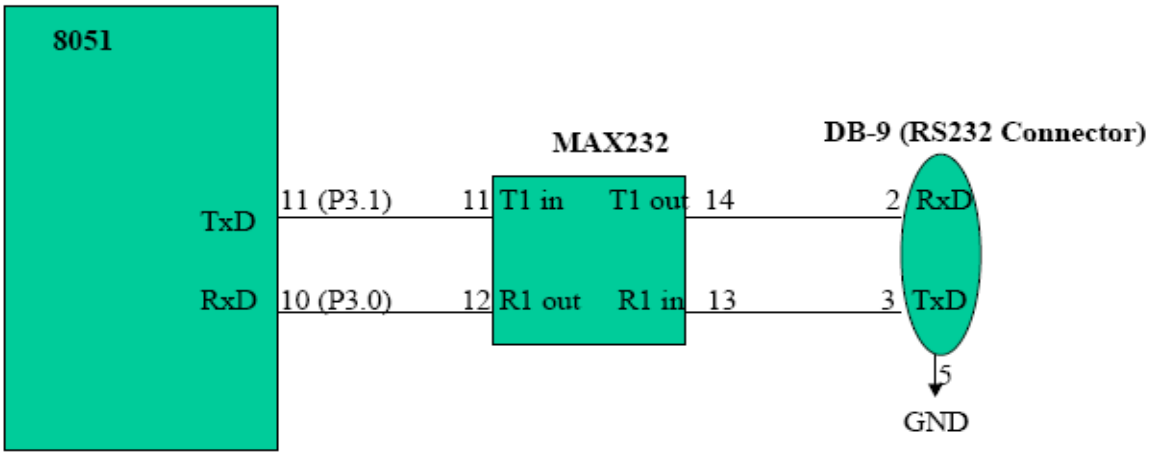

Figure 2.16: Communication of RS232 with MAX232

2.7.4 Keil

The Keil 8051 Development Tools are designed and developed by ARM to solve the complex problems facing embedded software developers. Keil development tools for the 8051 Microcontroller Architecture support every level of software developer from the

professional applications engineer to the student just learning about embedded software development.

The industry-standard Keil C Compilers, Macro Assemblers, Debuggers, Real-time Kernels, Single-board Computers, and Emulators support all 8051 derivatives. The Keil µVision3 is a Windows-based software development platform that combines Project Management, Source Code Editing, Program Debugging, and Flash Programming in a single, powerful environment [33].

2.7.5 Universal Burner

A universal microcontroller programmer or microcontroller burner is a hardware device accompanied with software which is used to transfer the machine language code to the microcontroller/EEPROM from the PC. The compiler converts the code written in languages like assembly, C, java etc to machine language code (which is understandable by the machines/microcontrollers) and stores it in a hex file. A universal burner acts as an interface between the PC and the target controller. The API/software of the programmer reads data from the hex file stored on the PC and feeds it into the controller's memory. The target controller on which the program needs to be burned is placed on the programmer using a ZIP socket. The software transfers the data from the PC to the hardware using serial, parallel or USB port.

Depending on the way it interacts with PC, there are three types of microcontroller programmers:

a) Parallel Programmer uses the parallel port of the PC. They are low cost programmer but not widely used.

b) Serial Programmers uses the serial port to interact with PC via RS232 protocols. They are more popular among hobbyist working on PC. However both the serial and parallel programmers will become obsolete in near future. The major reason is being unavailability of parallel and serial ports in the PCs & Laptops in the coming years.

c) USB Programmer uses the USB interface to transfer the data from PC. The main advantage of the USB burner is that they are powered from the PC itself and there is no need of any additional supply. The USB programmers have already become popular and will soon replace the serial and parallel programmer [34].

2.6 RELATED WORKS

Since 20th century, lots of work has been done by the researcher in all over the world to develop a better, efficient and cost effective home automation system. Some of them are pointed out.

Armando Roy Delgado, Rich Picking and Vic Grout [1] describe an investigation into the different aspects and potentiality for remote controlled operation of home automation systems. The concept of "intelligent home" is also illustrated in terms of automated systems in this paper. The research persons said that the future home network will have ubiquitous embedded computation with an increasing number of appliances having wireless communication. In fact, there are many recent tendencies to integrate various kinds of embedded devices and consumer appliances into software systems. The journal explains possible actual benefits for Home Automation Systems discuss several issues that may affect a remote-controlled Home Automation System and Proposes a standardized remote-controlled Home Automation System architecture. So, it is concluded that one access to many devices within a building at any time, from anywhere saving a significant amount of time.

Prof. Mamata Bhamare, Tejashree Malshikare, Renuka Salunke, Priyanka Waghmare [2] describes a system to control, manage and monitor the network from our wireless handheld device i.e. mobile phone from any remote place irrespective of distance. In this journal, it is considered that the basic setup of LAN with the server PC connected to GSM service provider through a GSM modem. The interaction between the clients and the wireless media happens through this server. A small text file from any of the client or server machine can be opened in user mobile phone. In the block diagram of the proposed system explained in the paper, it is seen that from mobile, message is sent to server through GSM modem. In the message, there is mobile number of the user, client name and operations to be performed on system. That message is sent to server then server recognizes the authorized

client among all clients. Then, client sends the response to the server after completion of that requested operation on the client. After that, server sends feedback to the administrator through GSM modem. Again message parsing is used to send SMS to the administrator that specifies that operations on the client are performed. So, it is concluded that SMS remains the most efficient communication system for pushing the content on to the mobile devices. The software is developed on a server based software application that provides ability to send and receive messages through GSM network and communicates through standard TCP/IP protocol.

Avigyan Datta Gupta, Sayan Samanta, Avishek Acharjee [3] have presented a circuit that one can operate home appliances like light, freeze, fan and water pump from office or any other remote place. So if one forgets to switch off light or other electrical appliances while going out, it helps to turn off them from a remote place with your mobile phone. The mobile phone works as the remote control from any area covered by GSM network for home appliances. One can control the desired appliance by pressing the corresponding key. In this paper work, a device controller is introduced that can represent a safe & secured wireless communication with proper authentication and less data loss. The circuit of the proposed project explained in the journal has two parts. One is the hardware part and other is software part. The hardware part contains of microcontroller AT89C51 and the software part consists of a program for the microcontroller is written using microcontroller programming software. In this paper, AT89C51 Specification is described very clearly using the pin out diagram of AT89C51. Here, Detailed Pin Description of Microcontroller AT89C51 that is used in this paper work is explained which gives a vast knowledge in the time of literature review about the particular microcontroller. So, it is concluded that project has shown a system using a simple extra mobile phone; user can control their electrical home appliances.

Soumya Sunny P, Roopa .M [5] explain an embedded web server that enables a situation where it is possible to monitor and control electrical devices using any one of standard web browser. According to this paper, a web server in the system facilitates the accessibility to the user interface functions for the electrical appliances using a web page. A web server can be attached into any electrical devices and communicated to the Internet so that the devices can be monitored and controlled remotely using the web browser in a computer. This paper mentions a solution for embedded system which has the accessibility to the Internet using which one can get the access, monitor and maintain conveniently. In the

literature review of this journal, it gives a extensive knowledge about embedded web server and its benefits with web browser. Now-a-days, in different places, designed embedded web server can be used with the equipments and instruments of industrial and medical science field. An admin can observe and operate the tools simply. Administrator can design more powerful user interface without extra hardware requirements. So, it is summarized that users located at a remote place can only require a simple internet web browser to run the experiments on real hardware configuration.

M.Can Filibeli,Oznur Ozkasap,M.Reha Civanlar [4] describes that Powerful microcontrollers are used as parts of most home and office appliances of today. Integrating web servers to these intelligent devices will aid in controlling them over the Internet and also in creating effective user interfaces in the form of web pages. This paper presents a novel approach to control devices with embedded web servers over the Internet and to form device networks such that their components can make use of one another's services and functions while improving the user interfaces. The main benefits of this approach include its lightweight design, automatic configuration, and, utilization of widely available and tested network protocols of TCP/IP. The system explained in this paper provides for easy control of house appliances through the Internet. The journal describes also that based on the use of well-known and stable protocols such as TCP/IP, HTTP, and PPP; the system is robust and easy to develop. It offers user-friendly, low-cost interfaces to the household devices instead of expensive and complex ones. So, it is concluded that the Internet has been mostly used to connect personal computers so far, but shortly all kinds of home appliances with embedded computers will exchange information over the Internet.

Inderpreet Kaur [35] described that an automatic systems are being preferred over manual system. The journal describes that the automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. This paper explains the concept and need of home automation very extensively. An automated home can be a very simple grouping of controls, or it can be heavily automated where any appliance that is plugged into electrical power is remotely controlled. Costs mainly include equipment, components, furniture, and custom installation. Control system security may be difficult and costly to maintain, especially if the control system extends beyond the home, for instance by wireless or by connection to the internet or other networks. So, from this paper it is concluded that Each and every product will be smart devices that are

used daily and that will be controlled through a smart chip called microcontrollers. Each and Every home appliances will be controlled either by PC or hand held devices like PDA or mobile handsets. Some examples of it are when anybody want he/she can switch on/off Fan of your home by mobile handset or PC.

Ali Ziya Alkar [36] presents the design and implementation of a low cost but yet flexible and safe and secure internet based home automation system. According to the author aim of home automation is to control home devices from a central control point. The communication between the devices is wireless. The protocol between the units in the design is enhanced to be suitable for most of the appliances. The system is designed to be low cost and flexible with the increasing variety of devices to be controlled. An embedded version of this system with a network capable PC processor embedded in a single package with the master node is also in progress.

Mr. Abhishek Vichare, Ms. Shilpa Verma [37] explains the connection of a micro-controller with Local Area Network and how it can be used as a web server. This paper offers a new method for users with an option from a local server, using the Internet to control household devices from a remote location. This system is developed by personal computers, interface cards, microcontroller, along with window-type software and microcontroller control software. The present system is configured to control household appliances (on/off/yes/no) to regulate their output power. In this project work, researchers use Philips P89C51RD2BN microcontroller.

L. R. Rabiner, B.H. Juang, C.H. Lee [38] analysed some of the key point in several areas of automatic speech recognition. Authors also briefly discuss the requirements in designing successful real-time applications and address technical challenges that need to be faced in order to reach the ultimate goal of providing an easy, natural and flexible voice interface between people and system. They also described that Speech recognition systems have been developed for a wide variety of applications, ranging from small vocabulary keyword recognition over dial-up telephone lines, to medium size vocabulary voice interactive command and control systems on personal computers, to large vocabulary speech dictionary, automatic speech understanding, and limited-domain speech translation.

Faisal Baig, Saira Beg, Muhammad Fahad Khan [39] discussed that the advancement in technology has made their scope much larger then before by taking these technologies from industry to home and daily usage appliances. This paper presents the system frameworks of universal remote based on mobile phone. The proposed system provides facility to users in order to control their home appliances using voice command. System has ability to recognize speaker and speech by using the recognition engine which limits the access to only authorized persons that can interact and control the home appliances. The main purpose of this method is to merge both mechanisms bring them on a single platform to facilitate severely disabled, low vision and old person. The focus of this research is to provide a universal remote which can easily control remote control appliances using voice command in secured manner.

D. Pavithra, Ranjith Balakrishnan [40] proposes an efficient implementation for IoT (Internet of Things) used for monitoring and controlling the home appliances through Internet. Home automation system uses the computer as a user interface. They can communicate with home automation network through an Internet gateway, i.e. low power communication protocols like Zigbee, Wi-Fi etc. This project aims at controlling home appliances via mobile phone using Wi-Fi as communication protocol and raspberry-pi as server system. The user here will move directly with the system through a web-based interface over the Internet, whereas home appliances like lights, fan are remotely controlled through a easy designed web page. An extra feature that enhances here is to protect from fireplace accidents is its capability of removing smoke in order that within the event of any fireplace, associates an alarming message and an image is sent to Smartphone. The server will be interfaced with relay hardware circuits that control the appliances running at home. The communication with server allows the user to select the appropriate device. The communication with server permits the user to pick out the acceptable device. The server communicates with the corresponding relays. If the web affiliation is down or the server isn't up, the embedded system board still will manage and operate the appliances locally. By this the system provides a climbable and price effective Home Automation system.

Wang, D., Lo, D., Bhimani, J., & Sugiura, K. [41] describes technologies for Internet of Things (IoT) such as sensor, network and data processing which are flying rapidly. According to the evolution, many potential applications have been developed in the fields of

home automation system. In this paper, a platform was designed to connect sensor data with user daily life. As an application of it, a home appliances monitoring and controlling system was implemented that can be operated and controlled by any authorized user. Although home appliances are becoming more intelligent day by day, not only the manufacturers are promoting new smart appliances, there are also many web enabled mobile oriented remote controller products. Anyways, current products always have platform compatibility problems, additionally, user interaction in such systems is becoming more and more complex. This work proposes an approach to enhance traditional appliances and the controlling experience using an IoT based electrical Appliances Controlling System. With sensors the appliances can be controlled environment condition like temperature, light etc. The sensor data are processed by single-board computer and delivered to mobile applications through wireless communication. The results of implementation and experimentation have shown in the proposed system and platform can provide more IoT application possibilities in day to day life.

Ravi Kishore Kodali, Vishal Jain, Suvadeep Bose and Lakshmi Boppane [42] explained that Internet of Things (IoT) represents the idea of remotely connecting and monitoring real world objects (things) through the Internet. When it comes to our house, this concept can be applied incorporated to make it smarter, secured and automated. This IoT project focuses on building a smart wireless home security system which sends alarms to the owner by using Internet in case of any trespass and raises an alarm optionally. Besides, the same can also be utilized for home automation by making use of the same set of different sensors. The exertion obtained by preferring this system over the similar kinds of already existing systems is that the alarms and the status sent by the Wi-Fi connected microcontroller managed system can be received by the user on his phone from any distance irrespective of whether his mobile phone is connected to the internet.

Md. Saidur Rahman, Saqif Masud, Shahida Sultana [43], proposed an efficient and cost-effective IoT-based smart home automation system where electrical appliances can be controlled and monitored. The proposed system is an integration of the traditional electrical appliance controls and web and Internet of Things based control system. With the proposed system, user gets both the option to control or monitor the electrical appliances remotely over internet using a static IP addresses and also through switch circuit and electrical board available at home. The system is developed fulfilling three specific objectives like user-

comfort, cost-effectiveness and real-life implementation. The system is designed for mass usage with the possible commercial service operation. A miniature prototype has been developed with the proposed system to prove the possibilities and show its feasibility.

3

METHODOLOGY

CONTENT

CHAPTER 3

3. METHODOLOGY

3.1 System Framework

The present system is an integrated Home Automation System that can be used to operate, control and manage various electrical home appliances. The entire module of the system contains two sub modules as the server and the hardware interface. User can transfer their commands to the home automation server through different four communication mechanisms like GSM, Web, Speech, IoT and can get back the responses also. The requested commands are first checked for authentication, then processed and digitized and finally sent to the relevant sub-module i.e switching circuit to be processed.

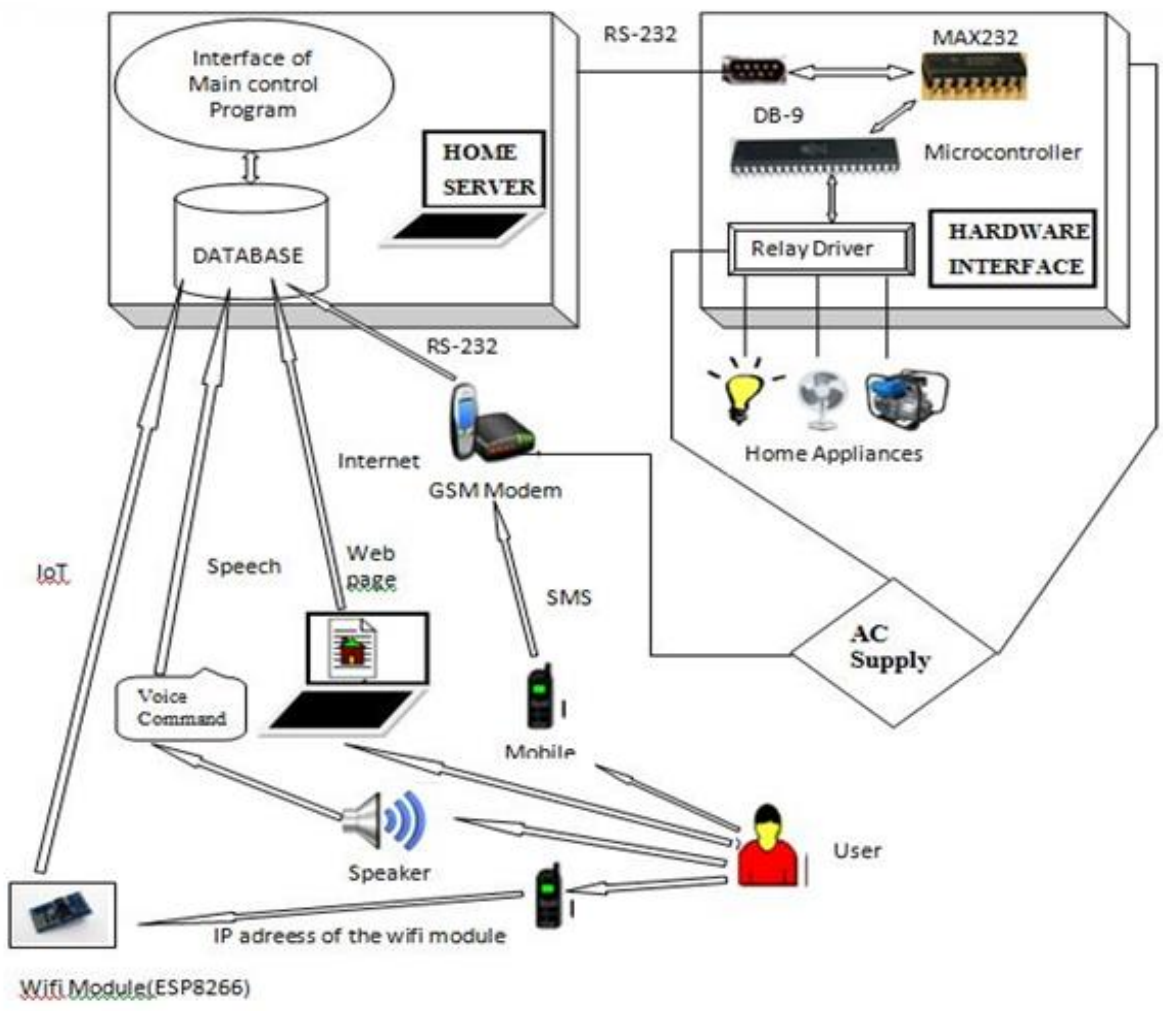

Figure 3.1: System Architecture of Entire System [44]

The software package burned into the microcontroller present in the electronic circuit has also the ability to response the status of the devices by sending back to the users of the system so that everything can be monitored in real time. After receiving the responses from the appliance nodes, the server explained them and performs the needful and necessary actions.

3.2 Communication Mechanism

In the entire Home Automation System, four communication mechanisms (GSM, Web, Speech, IoT) have been implemented to handle electrical appliances. All mechanisms are atomic and independent to each other, but connecting through only a common database. With the help of this kind of mechanisms, people can interact with the Devices as like as with the other people.

3.2.1 GSM Communication

Usually, GSM is used for the communication among peoples to each other from a remote place. But here, GSM modem or a mobile is used for the communication between human and electrical devices located in a remote place. There are two GSM modems where one is available in User's hand that is used to send the human commands or message and another is connected with the server that is used to receive that particular message through SMS service and store the commands in the database. Finally the system will forward the commands to the microcontroller by using the serial port communication and the devices will be operated accordingly over the actuators. The SMS will be sent by the user and received by the Server through AT command. Before that already the valid action commands are pre-stored in the database using server side programming. The connection of the GSM modem is easily made with the server by using a USB to serial communication cable. RS-232 is used for serial port communication between the GSM modem and Server PC [45].

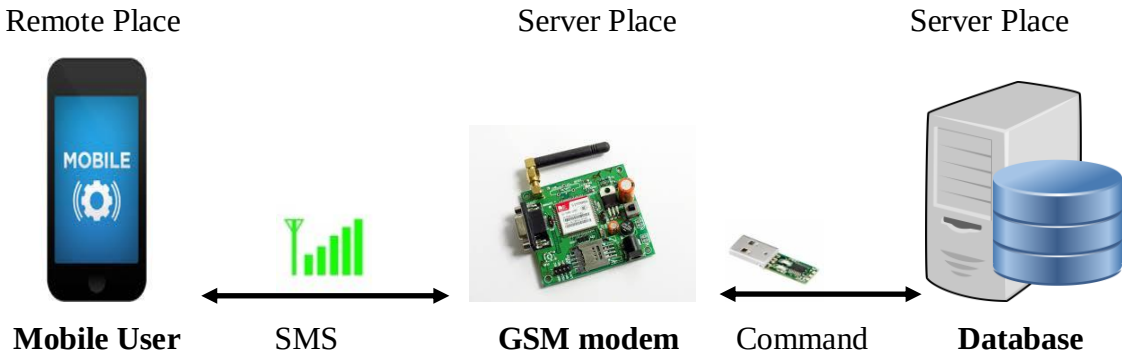

Figure 3.2 : Block diagram for GSM Communication

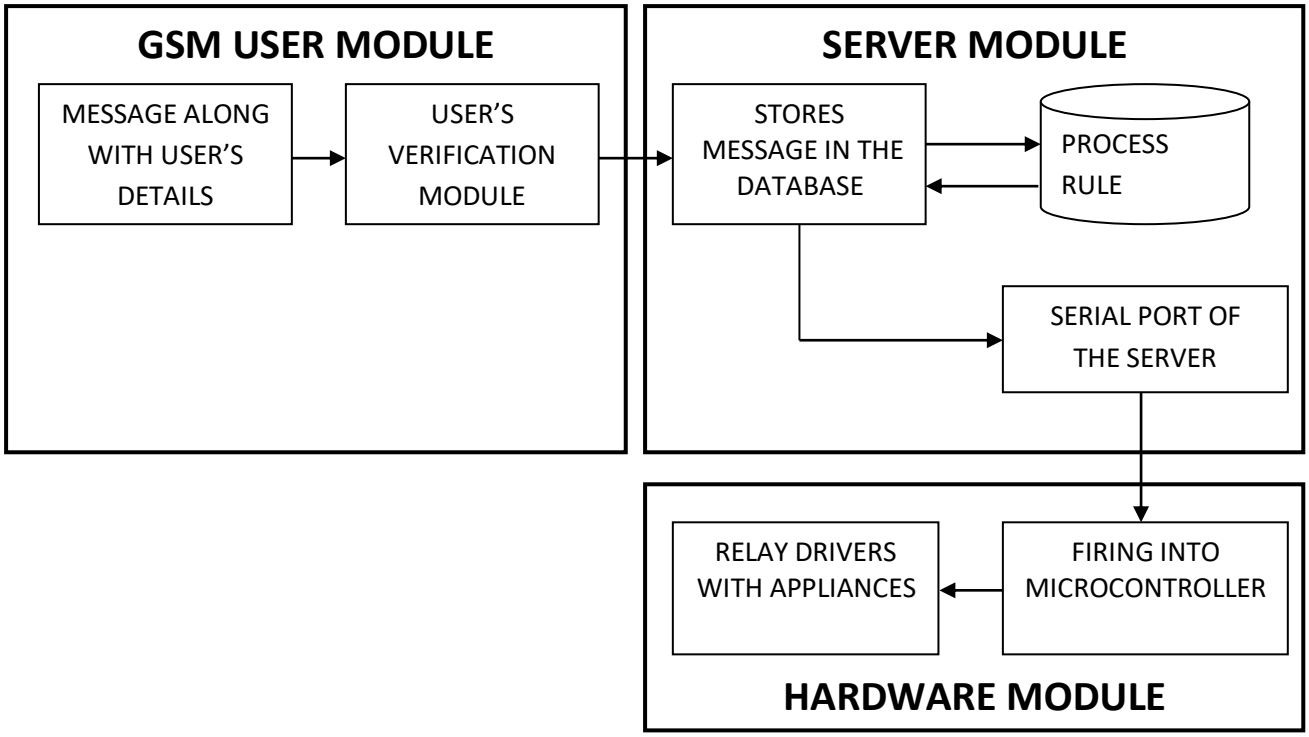

Figure 3.3: Frame work for GSM Communication

3.2.2 Web Communication

In our day to day life, we frequently use the web page and Internet to send some queries and access or get some information regarding those queries globally. But here, web page designed in PhP is used to send some commands that will be stored in the database connected with the Server and some electrical devices. As a result, Devices are controlled according to the commands. For this communication, the remote users have to open the

webpage where different buttons are available for different appliances. In the web page, the current statuses of devices are also available so the user can choose the correct action for operation. A web server is responsible for creating a platform for dynamic web application.

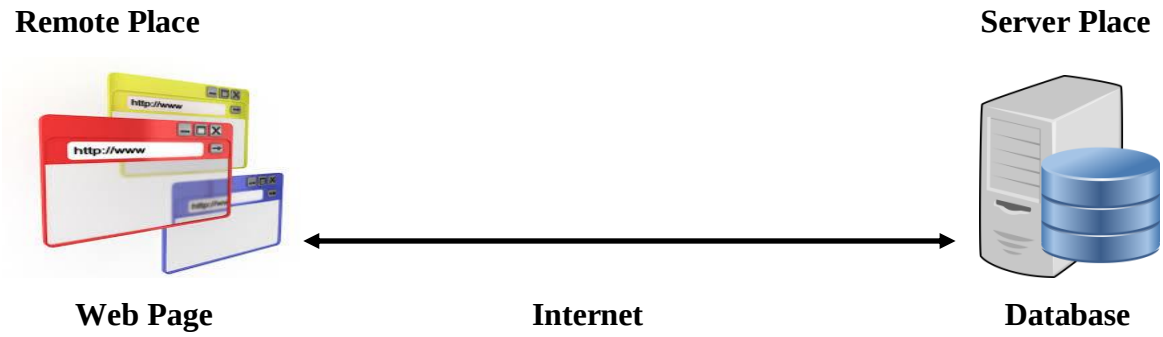

Figure 3.4: Block Diagram for Web Communication

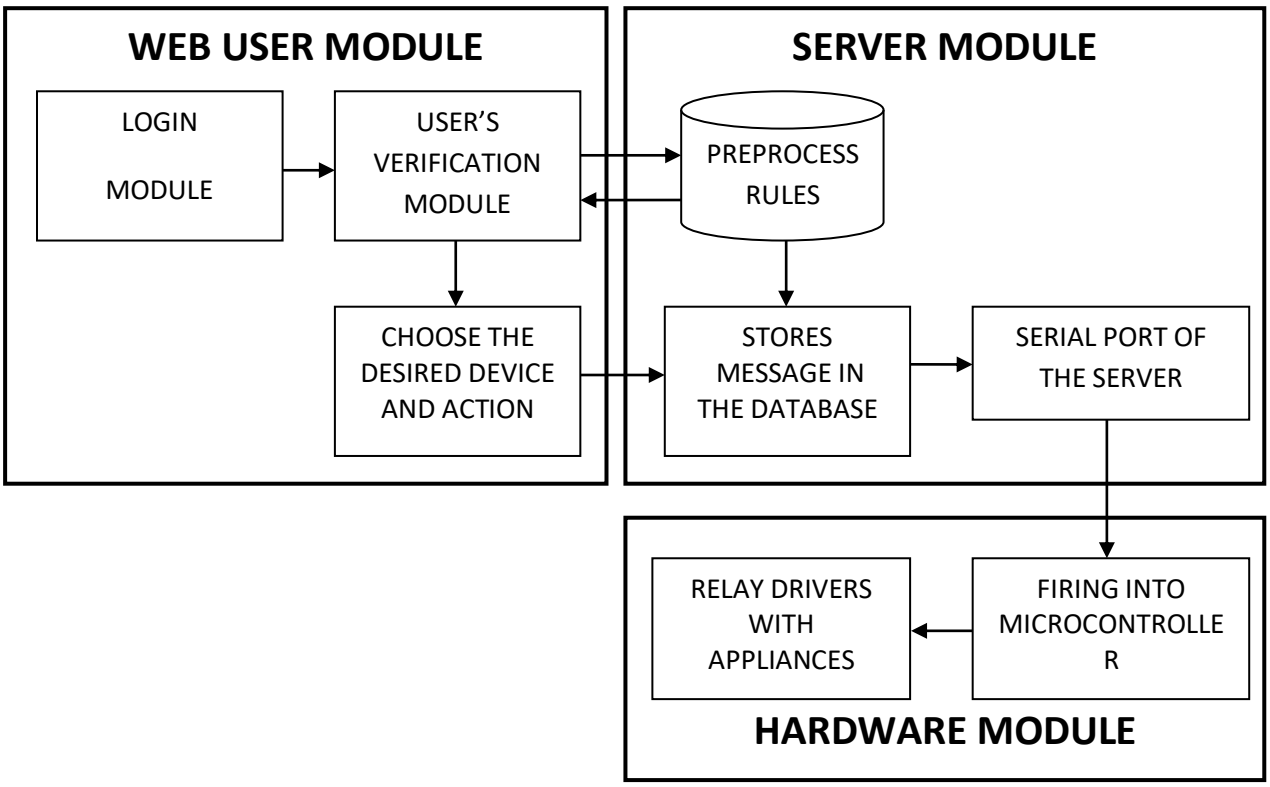

Figure 3.5: Frame work for WEB Communication

3.2.3 Speech Communication

This Communication is to design and development of an Asterisk based Interactive Voice Response (IVR) platform that allows the users to access and control the status of their home appliances remotely. In this IVR based platform, a mobile phone is connected to the system through Bluetooth or a PRI line. A computer system is considered as the Asterisk PBX server. Hence, users are able to make a call to the Bluetooth enabled mobile phone and then the users will be redirected to the server to offer the IVR based platform, through which the users will be able to give their choices of actions to be performed over the electrical devices [46]. A database is also maintained in the server to store the user's registered phone number and training set of voice samples or speech commands so that only authorized users can access the system. Once an authorized user inputs the action commands over the IVR platform, the voice commands will be tested with the trained voice samples stored in the database and the system will forward the commands to the microcontroller by using the serial port communication and the devices will be operated accordingly over the actuators.

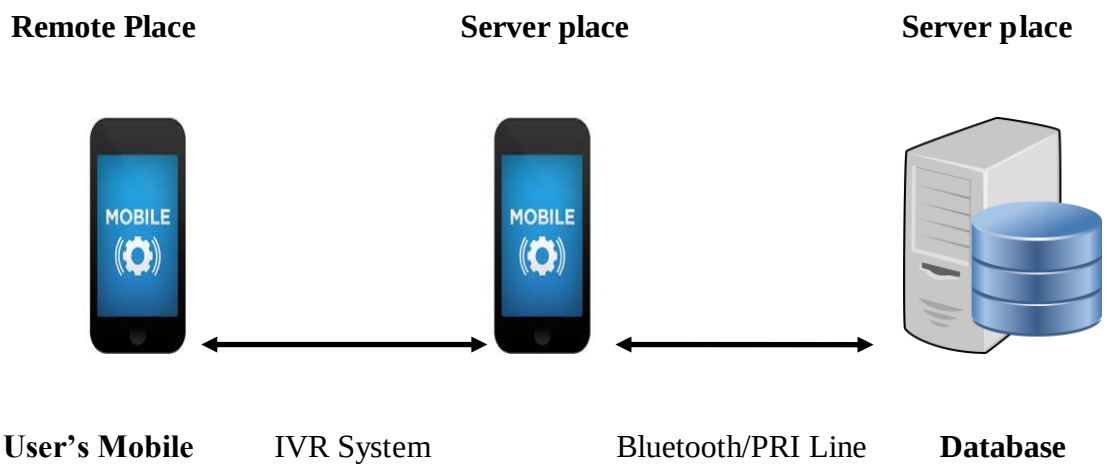

Figure 3.6: Block Diagram for Speech Communication

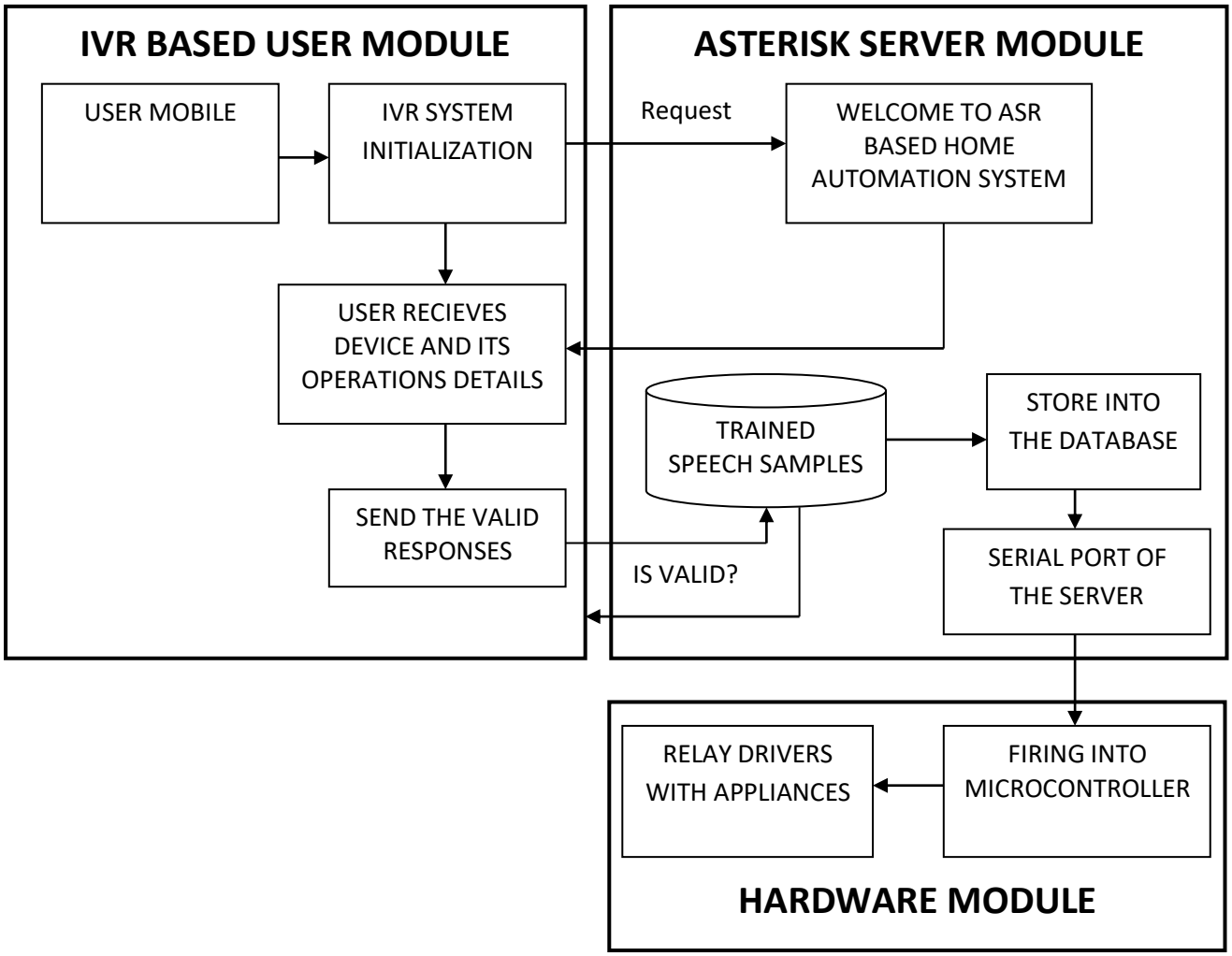

Figure 3.7: Frame work for SPEECH Communication

2.2.4 IoT Communication

There are lots of Wi-Fi modules for the connectivity between two terminals (Client & Server). But here, ESP8266 Wi-Fi module is connected with the user's Mobile using the particular IP address of ESP8266. The ESP module is an integrated chip which offers an inbuilt strong and high range Wi-Fi connectivity. For operating the devices on cloud or over the internet the data is transferred wirelessly to database. Therefore this module provides the most efficient service in its quality. It is a low cost Wi-Fi chip. The programming for ESP8266 is designed by using an extensible and light weight programming language, "Lua" [47]. The Wi-Fi module is connected with the server with the integrated Database. At the very beginning, the user's mobile should be connected with the system through ESP8266

module. Then users have to put the IP address in the URL of the user's mobile. Users can see a page designed by 'Lua' programming Language in his/her mobile where the different action commands are available to be operated.

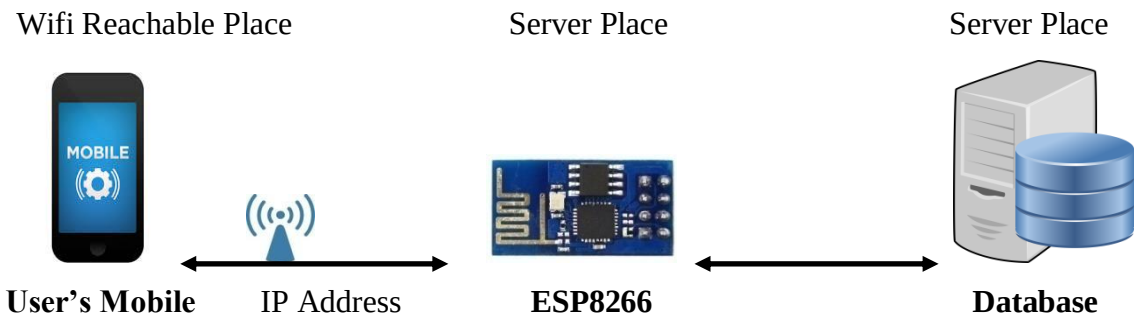

Figure 3.8: Block Diagram for Wi-Fi Communication

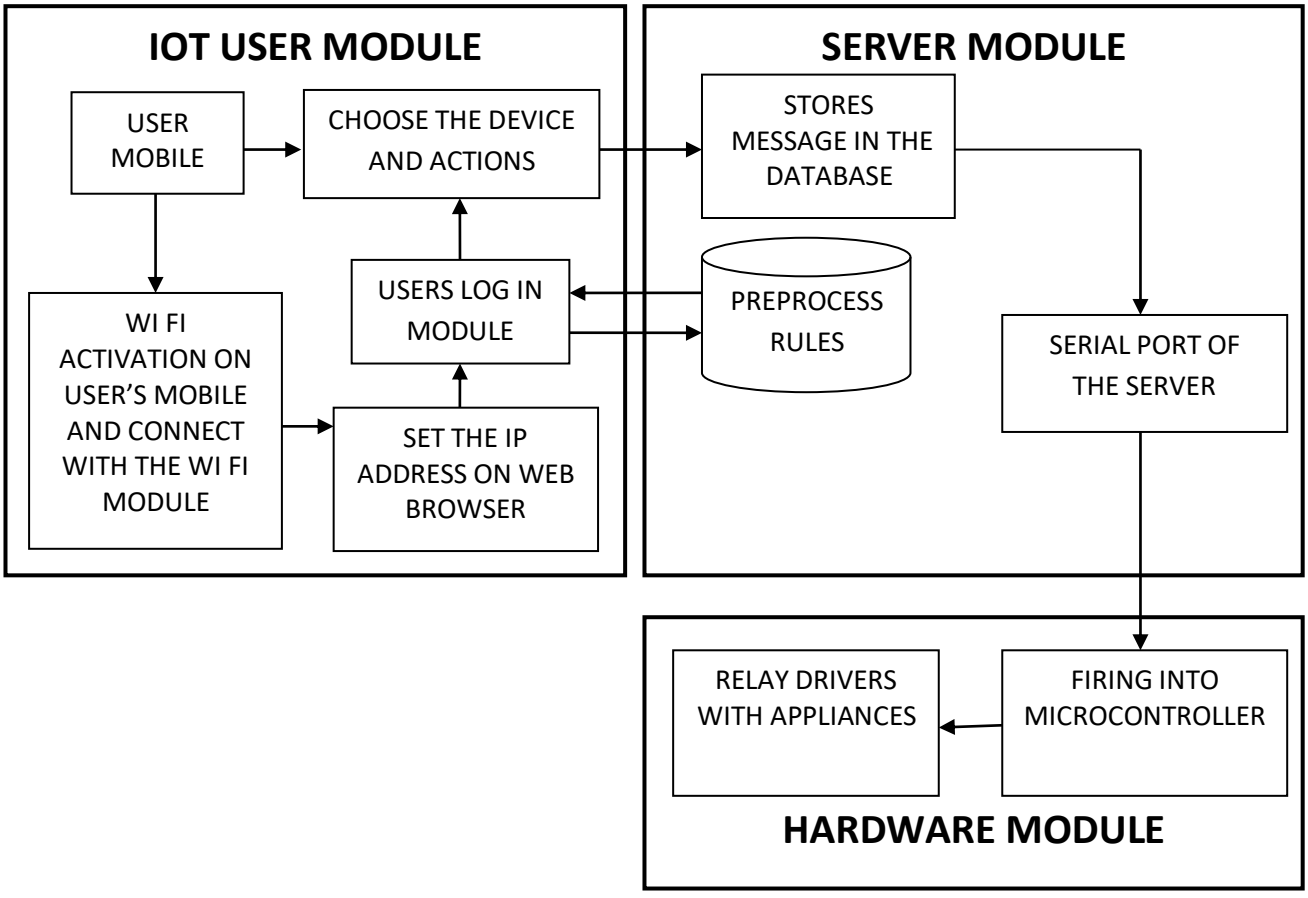

Figure 3.9: Frame work for Wi-Fi Communication

In the below figure, an idea about the operation of home automation system can be gained. The four different appliances such as fan, light, freeze and TV are operated remotely using Wi-Fi and through an application installed on mobile. These appliances are connected through the microcontroller with its digital input/output pins. These devices are connected with local Wi-Fi using a communicating module called esp8266. This hardware implementation contains 4 different parts. (i)A 16X2 LCD display for displaying status of the system and IP address of the local Wi-Fi network (ii) Relay for switching the load automatically, (iii) AT89S52 Microcontroller for decision maker and (iv) esp8266 version 12 for connecting to local Wi-Fi.

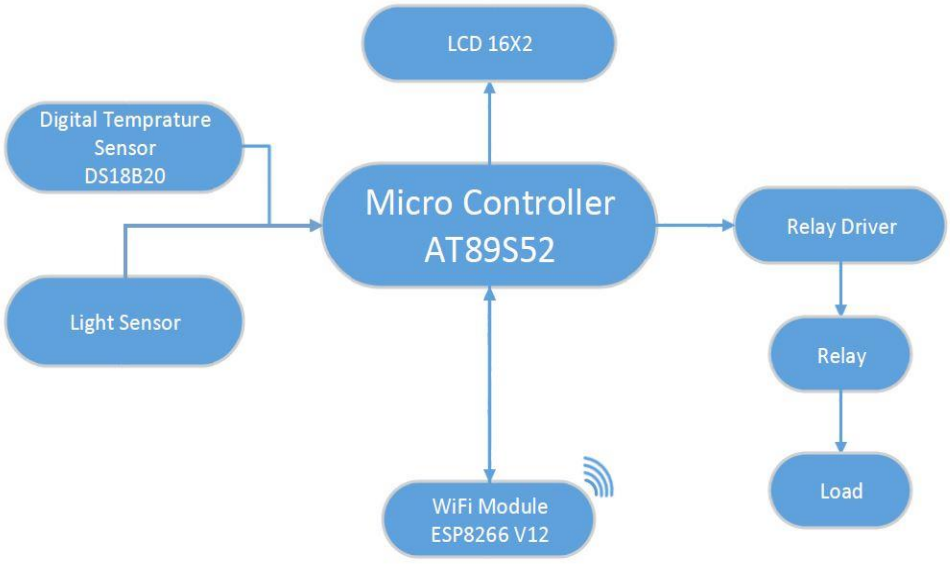

Figure 3.10: Components for IoT Communication[46]

3.2 FUNCTIONAL DETAILS OF DIFFERENT MODULES

3.2.1 SERVER MODULE

The server module contains a common database and the software package, the two sub-modules of the systems. The database is the core part of the home server because it is only responsible for storing all the information details regarding the electrical devices and its controlling for the users as well as the administrator. The integrated database is always ready for the incoming information (command/action) to the server that can be delivered through

four communication mechanisms like SMS, Web Page, Speech and Wi-Fi. Basically, server has the accessibility for accessing web page which is present in the user's PC through internet and also can access messages from the mobile phone through GSM network. In Speech Communication, the voice commands given by the user are stored into the same database through an IVR system. In IOT mechanism, user can send their action command through and interface present in their mobile through an IP address of a Wi-Fi Modem. In this system, we have used Lua, lightweight multi-paradigm programming language designed primarily for embedded systems and clients to write script for ESP8266 module to support remote control of device.

Similarly, on the other hand, users can know the status of the electrical devices. At a particular time, Users can visualize the status at a moment when he/she wants either in the web page or in their cell phone from a remote place. The remote communication between the server and the internet connected user's computer can be established by a static IP address (Internet IP). The GSM modem is simply connected to server by a USB to serial communication cable [44].

The server module also can be easily configured to handle one hardware interface module. Server machine is nothing but a normal PC containing software package. The server software is developed using Python, so server should support python application for open source Linux based operating System. The software package can access the database containing by the home server. The hardware module can be controlled by the server locally as well as remotely. RS232 communication protocol is selected to be the network infrastructure that connects server and hardware interface modules. The main functions of the server is to manage, control, and monitor distrusted system components, that enables hardware interface modules to execute their assigned tasks and to report server with triggered events.

3.2.2 Hardware Interface Module

The hardware interface module contains two sub modules as microcontroller and the connecting the electrical devices. The AT89S52 microcontroller is the core part of the hardware interface and electronic circuit board is the intermediate between microcontroller and the household appliances. Besides, a software package is developed in embedded C

programming using the compiler named as Keil for controlling the 8051 microcontroller. The source code for the ARM microcontroller was written in programming language C. The IDE used was KeilμVision.TheμVision IDE from Keil combines project management, make facilities, source code editing, program debugging, and complete simulation in one powerful environment. The μVision development platform is easy-to-use and helps us quickly create embedded programs that work. The μVision editor and debugger are integrated in a single application that provides a seamless embedded project development environment. The serial port present in the hardware module is responsible for receiving the instruction given by the server machine. The server's instructions are transmitted into microcontroller via a TTL to serial convertor MAX 232. On the other hand, for implementing IoT based communication, ESP8266 Flasher is used for flashing the firmware into the ESP8266 Wi-Fi module. Then ESPlorer is used which is an IDE for ESP developers. SciTE is used because is an IDE for Lua development [47]. The microcontroller is connected with the electronic circuit board by simply a wired connection and board is also directly connected to the electrical appliances using direct wired connections. Hardware interface module provides the controlling of electronic devices like lights, water pump, freeze and fans etc. Actually, the hardware interface is none other than an electronic circuit with a relay driver board. An adapter will supply 12 V to the whole electronic circuit and relay driver board.

Administrator or User can see the status and all the information regarding the device control in a LCD display locally. The LCD display is also controlled by the software package present in the microcontroller. In other hand, the hardware interface has the ability to send the status of the device or reply of the user's command.

4

IMPLEMENTATION

CONTENT

CHAPTER 4

IMPLEMENTATION

4.1 Overview

As mentioned the proposed framework, the implementation of designed automation system is depend on the different modules. They are the server software design, database design and the hardware interface design. In a general view, the whole proposed framework needs some implementation requirements [48].

1) **User friendly interface**: All the users of the present system can easily handle the home automation system locally or remotely through an easy and user friendly graphical user interface.
2) **Security and authentication**: Only valid authorized user can manage, control and monitor the system (locally or remotely) as users have to log in with their user-id and password.
3) **Low cost per node / High node count:** More than hundred nodes may be needed to provide automation in case of building automation. Anyway, society needs competitive performance to be delivered at a low system cost. Along with this, also protocols need to measure to high node count e.g., ensuring message delivery
4) **Large area coverage**: As there is no limitation of area of locations, users can manage the home automation system from a remote place of anywhere. So, the implementation part of the system should have the availability of large area coverage.
5) **System Scalability**: Scalability is the ability of a system, network, or process, to handle growing amount of working a capable manner or its ability to be enlarged to accommodate that growth. For example, system upgrade/downgrade by adding/removing hardware interface module should be easy and systematic task.

The implementation of complete proposed system is based on some systematic way of-

a) Home Server Set Up

b) The user module Initialization

c) Receiving the user's delivered command or instruction by the server.

d) Designing the database.

e) Maintaining the common platform for all four communication mechanisms.

f) Firing the commands to microcontroller

g) Microcontroller programming design

h) Electrical circuit design

i) Providing security features

4.2 Home Server Set Up

Since Home Server is nothing but a PC, So Administrator has to open the channel for the communication with the user through all mechanisms on the server so that users can control the appliances connected with the server from a remote place. In the server interface, users have to activate GSM modem that is connected with the server for the Communications.

4.3 Receiving Command through SMS

At the time of activating the server, the administrator has to open the channel for GSM communication. In the server interface, when user press the "Connect GSM modem" button then two AT commands will generate automatically as per as the programming part. At the beginning, AT+CMGF=1 i.e. the message is appeared in text format as the messages stored in SIM are in binary format i.e. AT+CMGF=0 by default. Then, AT+CNMI=1,2,0,0,0 i.e when GSM modem receives the SMS [58]. It enables the notifications or information about whether the message is reached to the node or not where the GSM modem is connected. After that, the command, AT+CMGR reads the SMS from the particular selected port by using +CPMS command. But, the message has not only the action command, it has also different parameters like source number of the message, status of the message (read/unread), users' name and password etc. The message is usually arrived as mentioned below-

"*message_status,address,*[*address_text*]*,service_center_time_stamp*[*,address_type,TPDU_first_octet,protocol_identifier,data_coding_scheme,service_center_address,service_center_address_type,sms_message_body_length*]*<CR><LF>sms_message_body"*.

So, from those, the predefined programming package present in the PC in the server side extracts the proper command sent by the users and if it is valid, dumps it into the database .

The all commands used for the GSM communication is described briefly as follows [49].

- **New Message Indications to Terminal +CNMI**

Description: This command handles enabling of unsolicited notifications to the terminal when an SMS is received by the GSM modem. After sending an unsolicited response to the TE, the G24 will expect a +CNMA (new message acknowledgement) from the TE within a predefined timeout of 60 seconds [59]. The GSM modem will not send another unsolicited response to the TE before the previous one is acknowledged. If acknowledged within the timeout, the new SM is not saved in the message storage. If not, the new SM is saved in the message storage and +CNMI parameters are set to 0.

Syntax: AT+CNMI= [<mode> [,<mt>[,<bm> [,<ds>[,<bfr>]]]]]
Defined values:

<mode>: controls the processing of unsolicited result code

<mt>: sets the result code indication routing for SMS-DELIVERs. Default is 0.

<bm>: set the rules for storing received CBMs (Cell Broadcast Message) types depend on its coding scheme, the setting of Select CBM Types (+CSCB command) and Default is 0

<ds> : for SMS-STATUS-REPORTs. Default is 0.

<bfr>: Default is 0

- **Preferred Message Format + CMGF**

Description: The message formats supported are *text mode* and *PDU mode*. In PDU mode, a complete SMS Message including all header information is given as a binary string (in

hexadecimal format).Therefore, only the following set of characters is allowed: {‘0’,’1’,’2’,’3’,’4’,’5’,’6’,’7’,’8’,’9’, ‘A’,‘B’,’C’,’D’,’E’,’F’}. Each pair or characters are converted to a byte (e.g.: ‘41’ is converted to the ASCII character ‘A’, whose ASCII code is 0x41 or 65). In Text mode, all commands and responses are in ASCII characters. The format selected is stored in EEPROM by the +CSAS command.

Syntax: AT+CMGF=<index>

As example, AT + CMGF=1 for text mode

AT + CMGF=0 for PDU mode

- **Read message +CMGR**

Description: This command allows the application to read stored messages. The messages are read from the memory selected by +CPMS command.

Syntax: AT+CMGR=<index>

- **Send message +CMGS**

Description: The <address> field is the address of the terminal to which the message is sent. To send the message, simply type, <ctrl-Z> character (ASCII 26). The text can contain all existing characters except <ctrl-Z> and <ESC> (ASCII 27). This command can be aborted using the<ESC> character when entering text. In PDU mode, only hexadecimal characters are used(‘0’…’9’,’A’…’F’).

Syntax:Command syntax in text mode*:*

AT+CMGS= <da>[,<toda>] <CR>

text is entered <ctrl-Z / ESC >

Command syntax in PDU mode*:*

AT+CMGS= <length><CR>

PDU is entered <ctrl-Z / ESC >

Parameters used in the syntax are given below-

<da>: Destination address in quoted string. This field contains a single MIN number.

<toda>: Type of DA. Value between 128-255 (according to GSM 03.40.9.1.2.5). If this field is not given and first character of <da> is '+', <toda> will be 145, otherwise 129.

<length>: Size of message in PDU mode format, in octets, excluding SMSC data.
<mr>: Sent message reference number.

4.3 Receiving Command through Web

In order to achieve interaction with the home automation network from the outside, the other option is to use the Internet. To accomplish this, a web server is built to take requests from remote clients. The system is modelled with three different units. The first unit is the PC side which is formed of a user interface component, the database and the web server components. The user interface and the internet front end are connected to a backend database server. The clients/users can send requests to the server machine through a web page. A web page is constructed as an interactive interface where commands can be submitted by the client to change and also monitor the status of the devices. The web page is designed by the high level scripting language PHP. When user gives the command in the web page by pressing the respective button present in the web page, then the command line with receiving system, system date and action is received by the server database designed by MySql. The two machine, user's PC and home server communicate each other through internet using a real IP address (Internet IP). The LAMP server has the main responsibility for communication among the server database and user's web page.

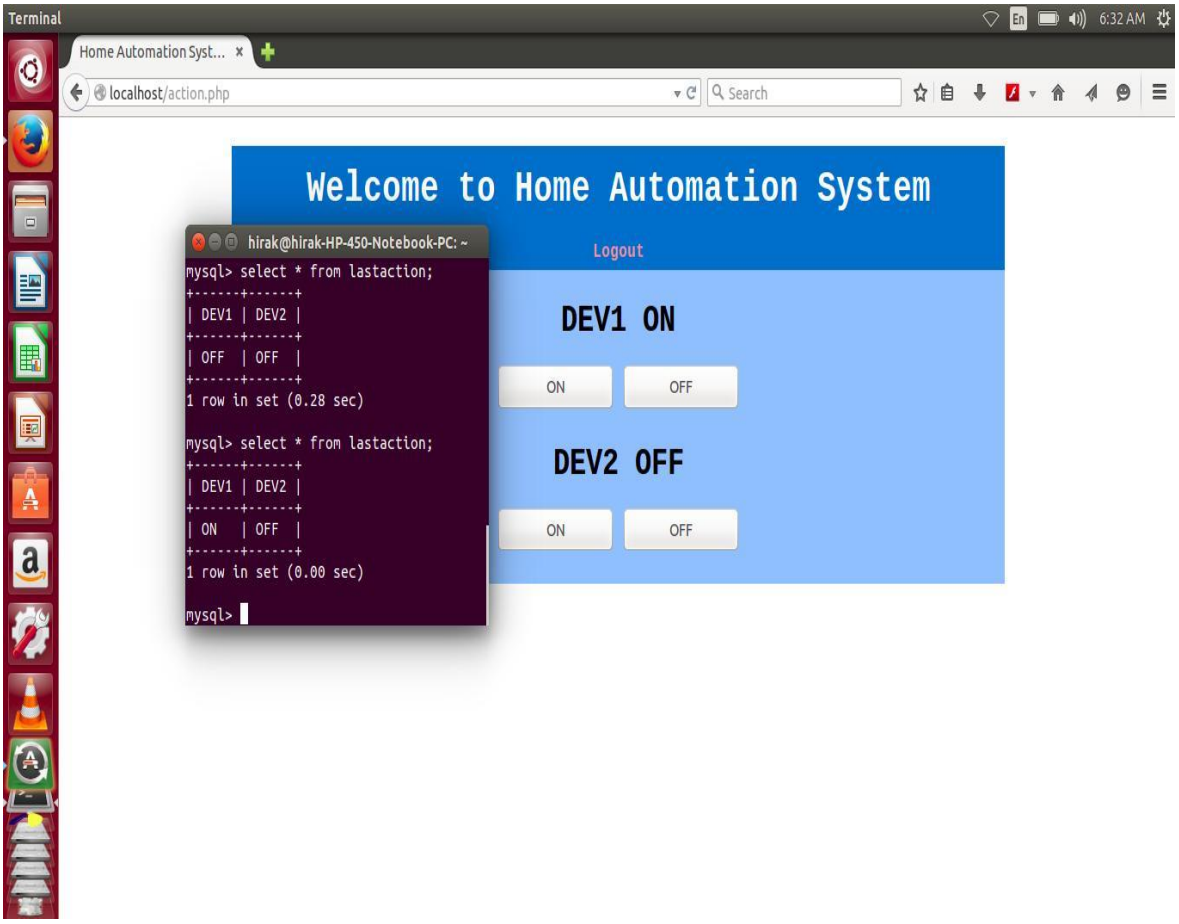

Figure 4.1 Screenshot of Web Interface

4.5 Receiving Command through Speech

As mentioned the proposed framework, the implementation of designed system is depend on mainly two modules. The first one is speech recognition and another one is hardware interface for controlling Devices. The speech Recognition module consists of different sub-modules such as data collection, data preparation, data training, data testing, execution etc. The hardware module provides an interface to get the recognized command that are to be used for device controlling by using a microcontroller, heart of the switching circuit. The main task is to develop interface using relevant speech technologies so that the most noise of users is able to get the relevant information with minimum human intervention. The speech-interface will also be designed to take into speaker independent voice responses as well as errors of the ASR system. The Automatic Speech Recognition engines containing sub-word Hidden Markov Model (HMM) based ASR engines for recognition of appliances name to be controlled [50]. The Speech recognition toolkit HTK is used for generation.

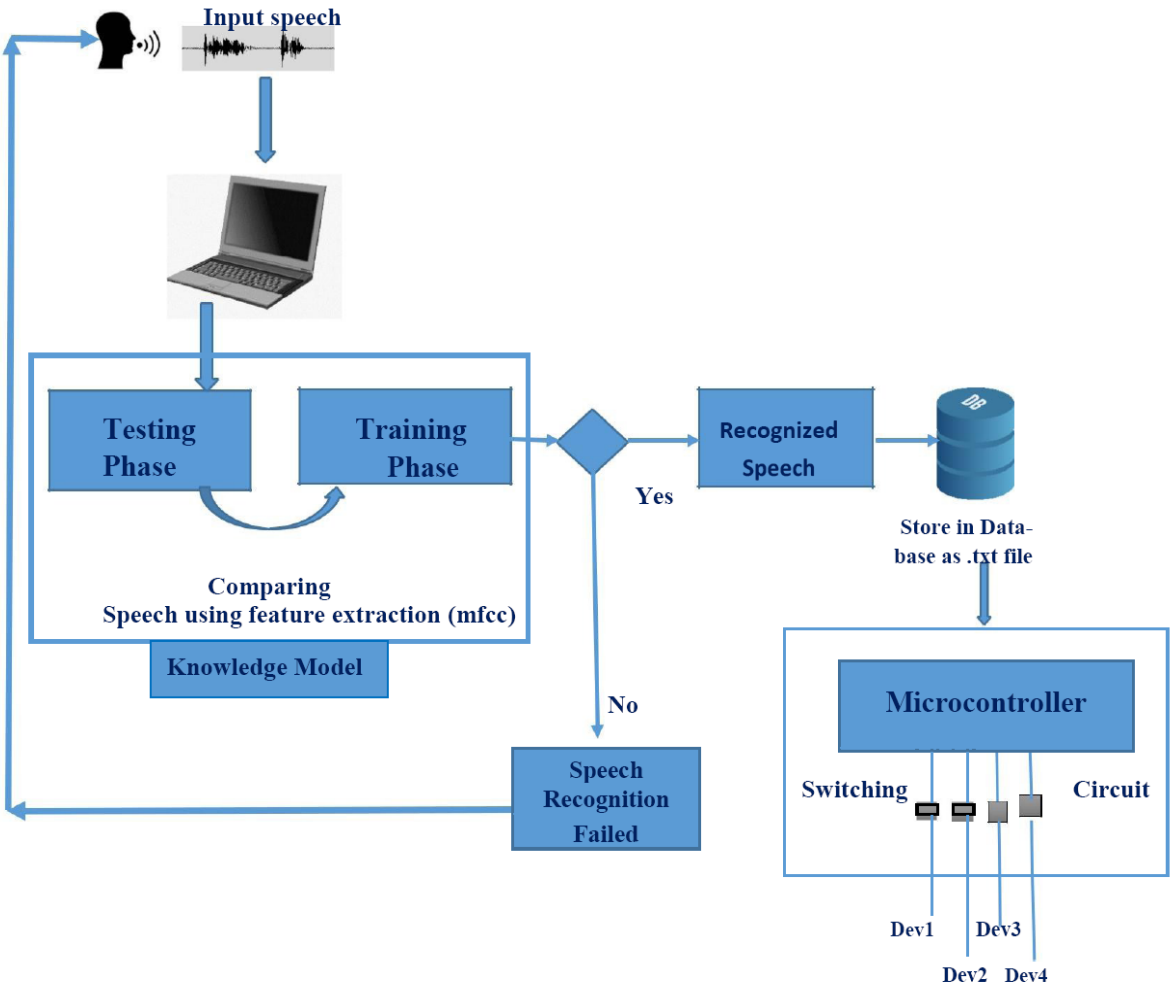

Figure 4.2: Design of Speech Implementation [46]

4.5.1 Input Speech

In our proposed system we use speech as command for controlling electronic device. Therefore we have collected our required voice data from different people in different environment. For collection our required data, we have used microphone and wave surfer as a voice recording toolkit. We have tried to avoid the noise in our recording environment. Still in our collected data, we found some noisy samples. Depending on noisy utterance, we have ignored such samples for further processing. We have saved all voice data in .wav file extension with 16000 bit rate. Collection of voice data for speech recognition is very challenging because the accuracy of recognition depends on this collected input speech as well as collecting training data.

Table 4.1: Data Collection Parameter with its values

Parameter	Value
Sampling Rate	16 kHz,16 bits
Wave Format	Mono, Wav
Speakers	200(140 M +60 F)

Development of Interactive Voice Response System for controlling Devices

For designing an interactive voice response system the developer must design a call flow chart for his program. The authorized users interact with the server system with a predefined call flow. As the Home Automation system mainly deals with some isolated words only hence system seeks isolated word from the user. Otherwise the performance of the system will be decreased. As the IVR system is designed to give the name of the devices that should be controlled and actions to be applied for the devices [51]. The user has to prompt yes/no for increasing the confidence of the reorganization engine. The user will get the information of the status for the current appliances connected with the hardware interface if the name of the devices name provided the recognition of the queries success. If the recognition of the device name or the action (ON/OFF) is failed then the system will be terminated. The following figure 4.2 shows flow of the system is the actual frame work for the IVR system.

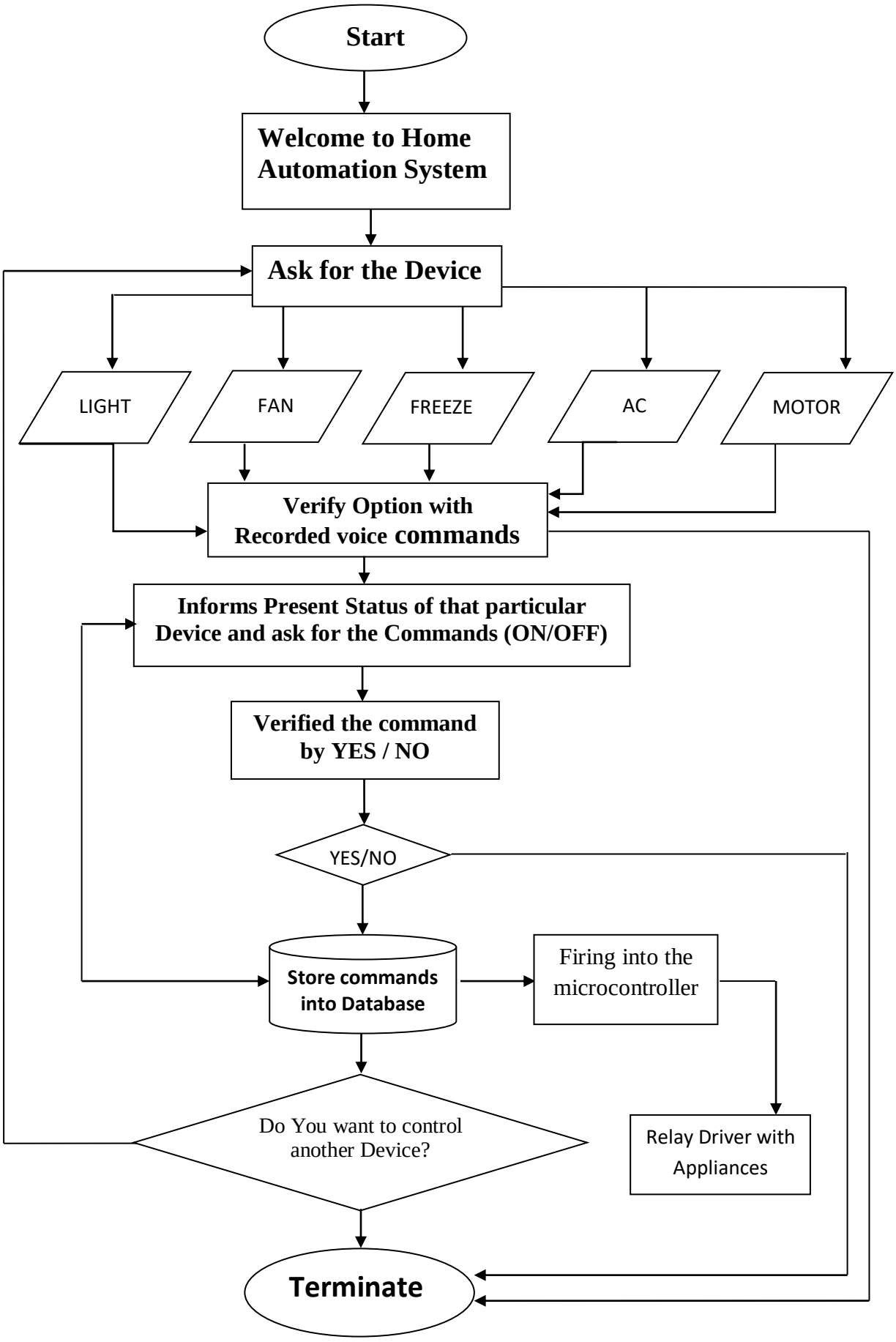

Figure 4.3: Call Flow Diagram for IVR System

4.5.2 IVR design

An IVR system containing a spoken dialog manager is a computer agent that interacts with users by understanding their speech spoken in different languages. The input in spoken dialog systems consist of small set of spoken words like action commands (ON/OFF), appliances name ,yes and no. In this work, a focus is mainly concentrated on building of dialog manger and evaluating the performance of speech recognizer engine. In this designed system user can take the input by making a call, recognize to word with the predefined HTK based recognizer and then language model generate the word based on our recognizer output. Dialog manger takes the output from the language analyzer module and passes it to the language generator. It also controls the structure of the dialogue [52].

The entire server side system consists of Bluetooth enabled mobile phone, Asterisk server, speech interface, dialog manager and Mysql database. Asterisk is open source (Unix/Linux based platform) communication toolkit that enables the computer to be used as a telephone network server. It consists of computer telephone interface (CTI) card and IVR module. This designed system has used Bluetooth connectivity in place of CTI card. The developed system mainly transmits the pre-recorded voice responses and records and processes the voice query from the user. In this proposed framework, user first call to a mobile number which is connected to our asterisk server. After that server mobile get the call then its blue tooth adaptor connect the asterisk server, with the help of Chan mobile module. Chan mobile is asterisk module which helps to connect asterisk server with Bluetooth enabled mobile and it will help to transfer the communication. Chan mobile transfer the call to Dahdi, It is a collection of open source drivers, for Linux, which are used to interface with a variety of telephony related hardware [51]. Here dahdi will identify the channel API and finally land the call to dialplan. The configuration file named as extension.conf is stored in dialplan. Asterisk gateway interface (AGI) program, shell script is used to integrate Asterisk server with speech recognizer module.

To convert the call flow into dialog manger we have used PHP-AGI script which is integrated with extention.config file. Once the call landed to extention.config file the script will activate and start working according to flow.

4.5.3 ASR design

Since a speaker Independent home automation system has been designing and developing, so as per requirement of the designed system users need mainly three types of data, Device name, action command and yes/no. The speech corpus consist of 9 (5+2+2) English words, out of which 5 device names, 2 action commands (ON/OFF) and Yes/No word. We take 70 males speaker and 30 female speaker of different age group for data recording purpose. A total of 7908 words in speech data were collected digitized at 16 bits/sample at a sampling rate of 16 kHz. In this section, the experimental work on word recognition from a connected word speech corpus will be presented. Wave surfer is used for data recording, praat is used for data analysis, Hidden Markov Toolkit (HTK) is used for feature extraction, training and recognition steps [53].

4.5.4 Recognizing Toolkit – HTK

The HTK tools are best introduced by going through the processing steps involved in building a sub-word based continuous speech recogniser.

There are 4 main phases:

- Data preparation
- Training
- Testing
- Analysis.

4.5.4.1 Data preparation

For building a set of HMMs, a set of speech data files and their associated transcriptions are required. Very often speech data will be obtained from database archives. Before it can be used in training, it must be converted into the appropriate parametric form and any associated transcriptions must be converted to have the correct format and use the required phone or word labels. For data preparation, we have collected nine commands as word (“ON”, “OFF”, “YES”, “NO”, “LIGHT”,”FAN”,”FREEZE”,”MOTOR”,”AC”) from 200 people out of which approximately 140 recordings are of male and approximately 60 recordings are of female speakers. The data is recorded with the help of unidirectional microphone using a recording tool wave surfer in .wav extension. The .wav files recorded are saved as HTK transcription. The sampling rate used for recording is 16 KHz. A labeling

tool wave surfer is used to label the speech waveforms. The label files are used in acoustic model generation phase of the system. Following are the command words that we have collection.

The raw speech data is in the form of wave files. This needs to be converted to MFCC speech vectors. This is a form of spectral analysis of the raw waveform, and can be performed by using the tool HCopy. HCopy is used to copy one or more source files to an output file. Normally, HCopy copies the whole file, but a variety of mechanisms are provided for extracting segments of files and concatenating files. The MFC file can be viewed by using the HTK tool HList [66]. A transcript is needed. This needs to be converted to Unicode, and then to label files. Label files are of the format

<Start> <end> <label>

Where start and end correspond to the beginning and end of the part of the waveform to which this label is being assigned. In case of word level it will be the whole file and thus 0 and -1.

In case of phone level recognition, a phonetic dictionary will be needed to convert the words into phones. Then the start and end values will be that of the various component phones.

4.5.4.2 Data Preparation Tools

Although all HTK tools can parameterise waveforms *on-the-fly*, in practice it is usually better to parameterise the data just once. The tool HCopy is used for this. HCopy is used to copy one or more source files to an output file. Normally, HCopy copies the whole file, but a variety of mechanisms are provided for extracting segments of files and concatenating files. By setting the appropriate configuration variables, all input files can be converted to parametric form as they are read-in. Thus, simply copying each file in this manner performs the required encoding.

Transcriptions will also need preparing. Typically the labels used in the original source transcriptions will not be exactly as required, for example, because of differences in the phone sets used. Also, HMM training might require the labels to be context-dependent. The tool HLEd is a script-driven label editor which is designed to make the required transformations to label files. HLEd can also output files to a single *Master Label File* MLF which is usually more convenient for subsequent processing. Finally on data preparation,

HLStats can gather and display statistics on label files in preparation for building discrete probability HMM system.

4.5.4.3 Training and Testing

Firstly, during training, an initial set of models must be created. If there is some speech data available for which the location of the sub-word (i.e. phone) boundaries has been marked.

In training phase HTK system verify the speeches in different phases.

Phase I: It checks dictionary and filler dictionary with phone list file.

A dictionary is explained to the pronunciations of the words as linear sequence of phonemes in such a way that each line in the dictionary contains exactly one pronunciation specification. The dictionary file is save as .dic extension. In the dictionary file have spacing are regular in each line and there are not extra blank lines in the end .The pronunciation is completely case-insensitive, that is, it is not possible to have two different pronunciations ON and on in the dictionary.

- We create a dictionary of all the words that are there in the vocabulary of the recognizer and save it as .dic extension file. Here the entries of the dictionary will be

ON

OFF

LIGHT

FAN

FREEZE

MOTOR

AC

YES

NO

We make sure that the spacing are regular in each line and there are not extra blank lines in the end.

In this file create a filler dictionary with all non-speech sounds with the name .filler extension file. In our case silence is the only non-speech sound. This filler dictionary

includes the special beginning-of-sentence and the end-of-sentence tokens <s> and </s> respectively as well as the silence word <sil>. However, all of them have the same SIL (silence-phone) as their pronunciation.

Example:-

<s> SIL

</s> SIL

<sil> SIL

It is important to make sure that there are no blank spaces after any line in the dictionary.

Phase II: It checks to make sure that there is not any duplicate entry in the dictionary.

Phase III: It checks the general format and utterance length of the training file. Utterance length must be positive.

This file included the word (or utterances), consisting of the spoken text to the corresponding audio files in the transcription file format. We create list of transcription file and save them as a .transcription extension file. We maintain equal spacing between all the words of the lines.

A list of transcription of all the wave files is created. For example if the contents of the wav files are on, off and status respectively then the transcription will have

<s> on </s> (on202)

<s> off </s> (off121)

It should maintained equal spacing between all the words in

Phase IV: The matching of total number of lines between the transcript file and the control file is done

Phase V: It checks the amount of training data and verifies that the number of n_tied_states is reasonable for those training data or not.

Phase VI: It verifies that all the transcript words are present in the dictionary or not.

Phase VII: It verifies all the phone present in the transcript file is appear in the phone list or not. Phoneme is the basic or the smallest unit of sound in any language. In the phone set that we have used to develop the speech recognition system, the phone set consists of 4 phonemes.

4.5.4.4 Recognition and Analysis

HTK provides a recognition tool called HVite that allows recognition using language models and lattices.HTK provides a recognition tool called HVite which uses the token passing algorithm described in the previous chapter to perform Viterbi-based speech recognition. HVite takes as input a network describing the allowable word sequences, a dictionary defining how each word is pronounced and a set of HMMs. It operates by converting the word network to a phone network and then attaching the appropriate HMM definition to each phone instance. Recognition can then be performed on either a list of stored speech files or on direct audio input. As noted at the end of the last chapter, HVite can support cross-word triphones and it can run with multiple tokens to generate lattices containing multiple hypotheses. It can also be configured to rescore lattices and perform forced alignments.

Once the HMM-based recognizer has been built, it is necessary to evaluate its performance. This is usually done by using it to transcribe some pre-recorded test sentences and match the recognizer output with the correct reference transcriptions. This comparison is performed by a tool called HResults which uses dynamic programming to align the two transcriptions and then count substitution, deletion and insertion errors.

For evaluating performance of speech system we have used the following equations [54]

$PC = (N - D - S)/N \times 100$ where PC gives word correction rate.

$PA = (N - D - S - I)/N \times 100$ where PA gives word accuracy rate.

Word Error Rate (WER) = 100% − Percentage Accuracy (PA)

Where, N = the number of words in test set.

D = the number of deletions.

S = the number of substitutions.

I = the number of insertions.

4.6 Receiving Command through Wi-Fi

The design of the whole system is implemented by following the modular approach for programming. Modules for distinct functionalities that the system must possess were builtstep by step before being put together. Coding was accompanied by regular debugging

and circuit stimulation so as to eliminate errors and to ensure smooth functioning of the system.

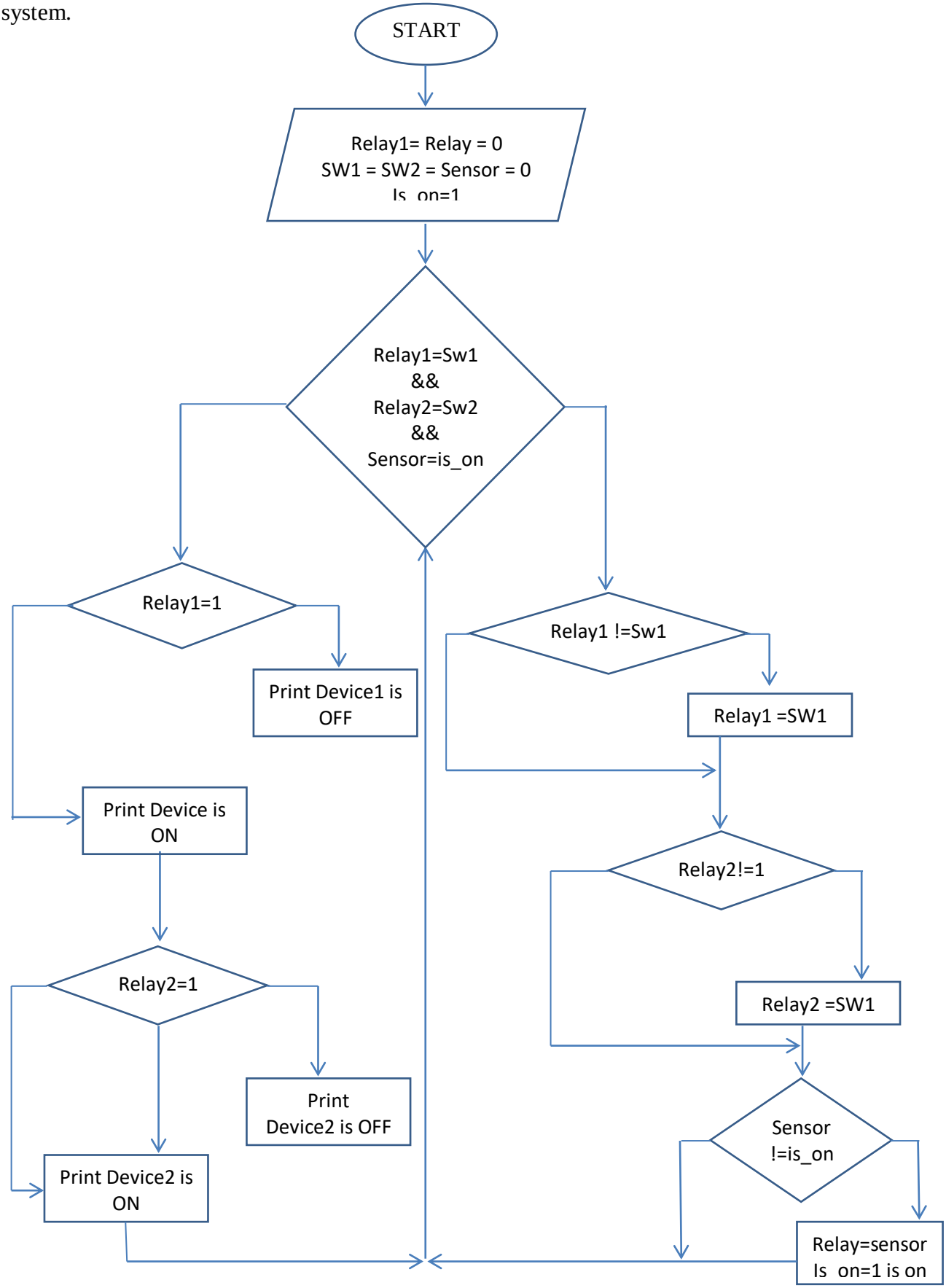

Figure 4.4: Flow Diagram of the designed System [47]

4.6.1 Observation

This IoT based system is very useful in automation as it provides the option of introducing different sensors based on the requirements of the user and automating the control of power supply of the load accordingly with respect to the sensory data. This system also provides some facilities as follows

- Remotely control the power supply of the load.
- Introduce automation on the basis of the parameters that are sensed by the sensor.
- Introduce other sensors in the system which automates the control of the power supply of the load depending upon the value of the sensory data, thereby making the device support modularity and generality.

It also leaves the control to override the flow of automation to the user and remotely control the device according to his or her will.

4.7 Database Design

The database is the main back end of the home server. In this system work, a special focus is given for designing the database as a common integrated platform to store the instructions sent by the user through web page as well as SMS. The database is designed using MySql. The name of the database is LABDA and it is connected to MySql server by using a data source name (DSN). There are basically three tables present in the LABDA database as DEVICE, USERS and a relational table ACTION by which the two table are connected in a many to many relationship.

4.7.1 E-R Diagram

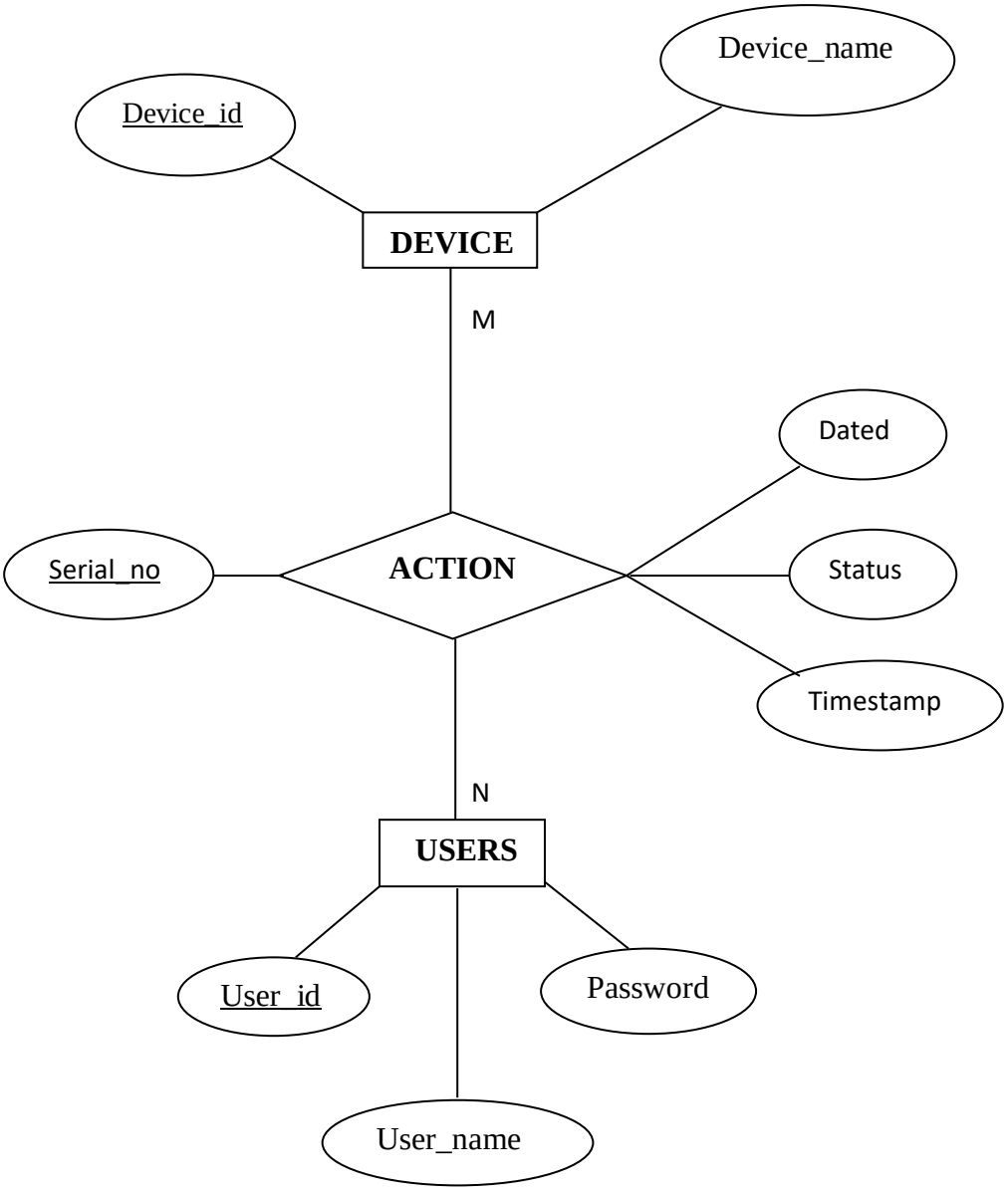

Figure 4.5: Entity- relationship diagram of the database

4.7.2 Relational Schema

The USERS table has three attributes fields – user_id, user_name and password where user_id is a primary key. In users table, user_id, user_name and staus are the attributes where user_id is the primary key. These two table are joined through a relational table action in a many to many relationship. Action table has serial_no,dated,timestamp,devic _id from device, user_id from users table and status attributes. In this table, serial_no, device_id,

user_id are primary key which are act as a composite key. Here, serial_no is auto-incremented because last command (having maximum serial_no) has to be given in the LASTACTION fields. So, LASTACTION table contains only one command at a time because a command is automatically removed when a new command is appeared according to the server programming. But, the LASTACTION table is not included in E-R diagram because it is only used in application level

At first, Database 'labda' is created and used, Then create the Device, Users, Action table. The Device table is shown in tabular form below-

Table 4.2: Device table

Field	Types	Null	Key	Defaults	Extra
Device_id	int (5)	NO	PRI	NULL	
Device_name	varchar(15)	YES		NULL	

Table 4.3: Users table

Field	Types	Null	Key	Defaults	Extra
User_name	varchar(10)	YES		NULL	
User_id	varchar(10)	NO	PRI	NULL	
Password	varchar(10)	YES		NULL	

Table 4.4: Action table

Field	Types	Null	Key	Defaults	Extra
serial_no	int(5)	NO	PRI	NULL	Auto_in
user_id	varchar(20)	NO	PRI		crement
dated	date	YES		NULL	
timestamp	varchar(20)	YES		NULL	
device_id	int(5)	NO	PRI	0	
status	varchar(20)	YES		NULL	

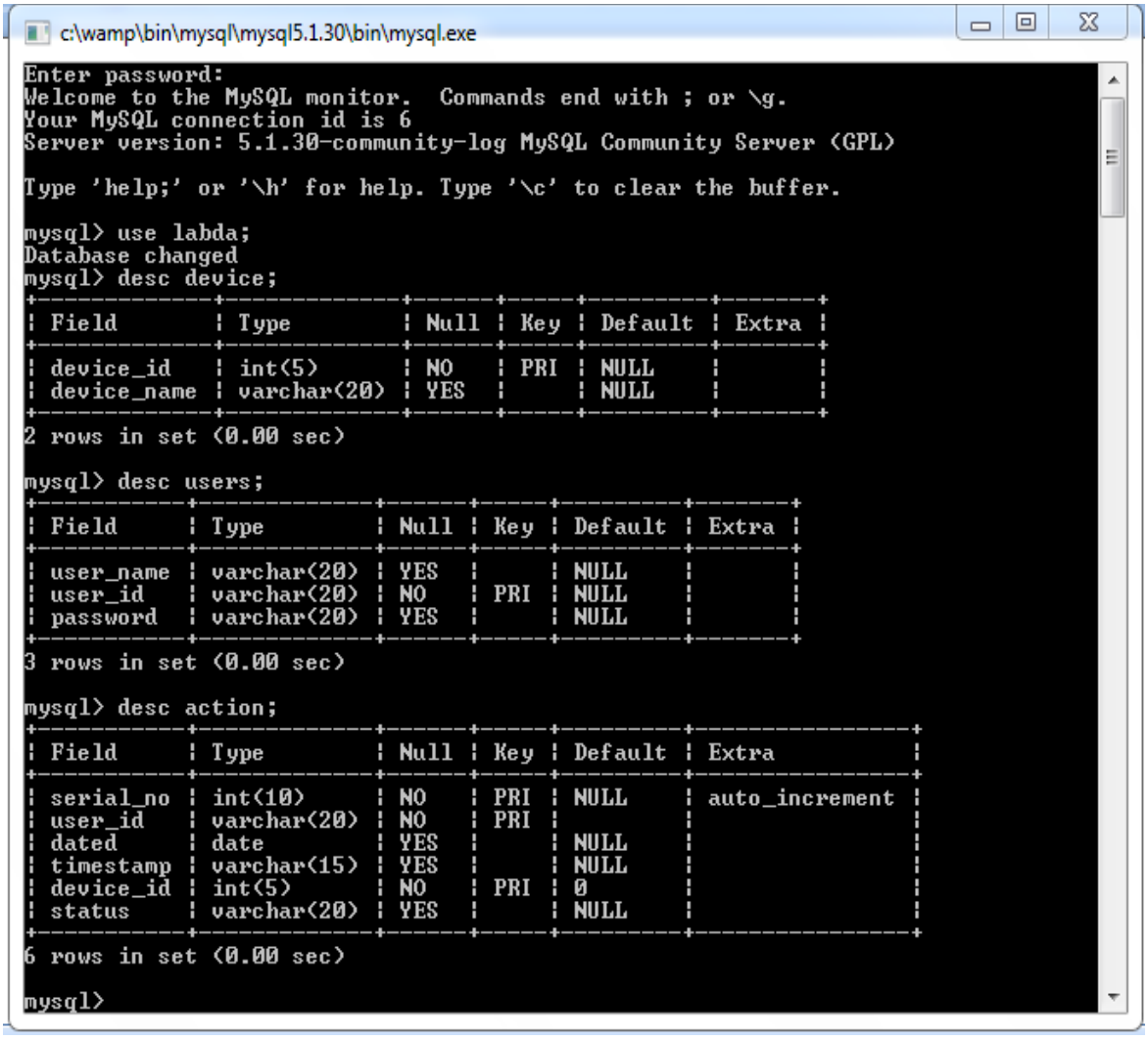

Figure 4.6: Screen shot of MySql having table Description

4.8 Integration of Common Platform

The main aim of this project work is to develop a common platform for both controlling mechanism in terms of an integrated database. At the beginning of the system when the command is arrived from Web page, GSM modem, wi-fi user and speech user in the server, the information details about the commands are stored only in the common database. It first stores in the ACTION table and then stores the command having maximum serial_no in the LASTACTION table as the serial_no of ACTION table is auto- incremented. The feedback or response to the users (Web user, SMS user, wi-fi user and speech user) has always arrived from the same server database. As a result, when the user controls devices via GSM modem, then the same information regarding the device control are available for Web users too. In this way a common integrated platform for the whole systems is maintained by the home server

4.9 Firing Command to AT89S52 from Database

The software package present in the server is mainly responsible for selecting the required command from the ACTION table. The last command stored in the database can be selected easily as the serial_no of ACTION table is auto-incremented. At every time when a message is stored in the ACTION table, then the action having maximum serial_no is stored in the LASTACTION table. The LASTACTION table is the middleware between the database and the microcontroller for firing process. So, the command is arrived at the port of home server from the LASTACTION table. The message is received by the port of the server machine using the port number which is already defined in the server programming. After that, the message is fired by the server program to MAX 232 through the DB-9 serial port using RS232 protocol. The MAX232 convertor fires the signal into the AT89S52 microcontroller and the microcontroller will be programmed in an appropriate way to understand this signal and thus convert it to an electrical signal and transmitted to the switch controlling the relay drivers which will switch the home appliances. The end result will be a simple action like: switching on a light.

4.10 AT89S52 PROGRAMMING DESIGN

The software package present in the hardware interface is responsible for switching the relay driver, controlling the LCD display, sending the switching status from the devices to serial port. The software package is designed by embedded C programming using the Keil compiler. The command/action sent by the user is already stored in a predefined manner such that the microcontroller programming can match it with its own. If it matches with incoming one then a function is called to reset the port as the instruction. As example, 'LIGHTON' is the command and it is matched with predefined command of programming, then, reset the port as 1 where the light is connected and simultaneously same is displayed in the LCD screen. Administrator of the system can see also the latest action done by the remote user over the system locally in the LCD. The Programming code has also designed in such a way that it can send the status of the switching devices when the users want. The embedded C programming is burnt into the microcontroller using the universal burner software.

4.11 HARDWARE INTERFACE DESIGN

The Hardware interface comprises of microcontroller AT89S52, TTL converter MAX232, an oscillator circuit, a voltage regulator circuit and a few discrete components. Microcontroller AT89S52 is at the heart of the circuit. It is a low power, high-performance, 8-bit microcontroller with 4KB of PEROM used as on-chip program memory, 128 bytes of RAM used as internal data memory, 32 individually programmable I/O lines divided into four 8-bit ports, two 16-bit programmable timers/counters, a five-vector two level interrupt architecture, on-chip oscillator and clock circuitry. Capacitor and resistor from the power-on reset circuit, while push-on reset switch is used for manual reset. Pin no. 7 to 14 of LCD is configured to get the result to be displayed from the Port pins P1.0 to P1.7 of the microcontroller respectively. Port pins P3.0 and P3.1 of the microcontroller are configured to get the input from 11 and send reply to12 pin of MAX232 respectively.

The figure 4.7.depicts the whole electronic circuit along with the relay driver board below-

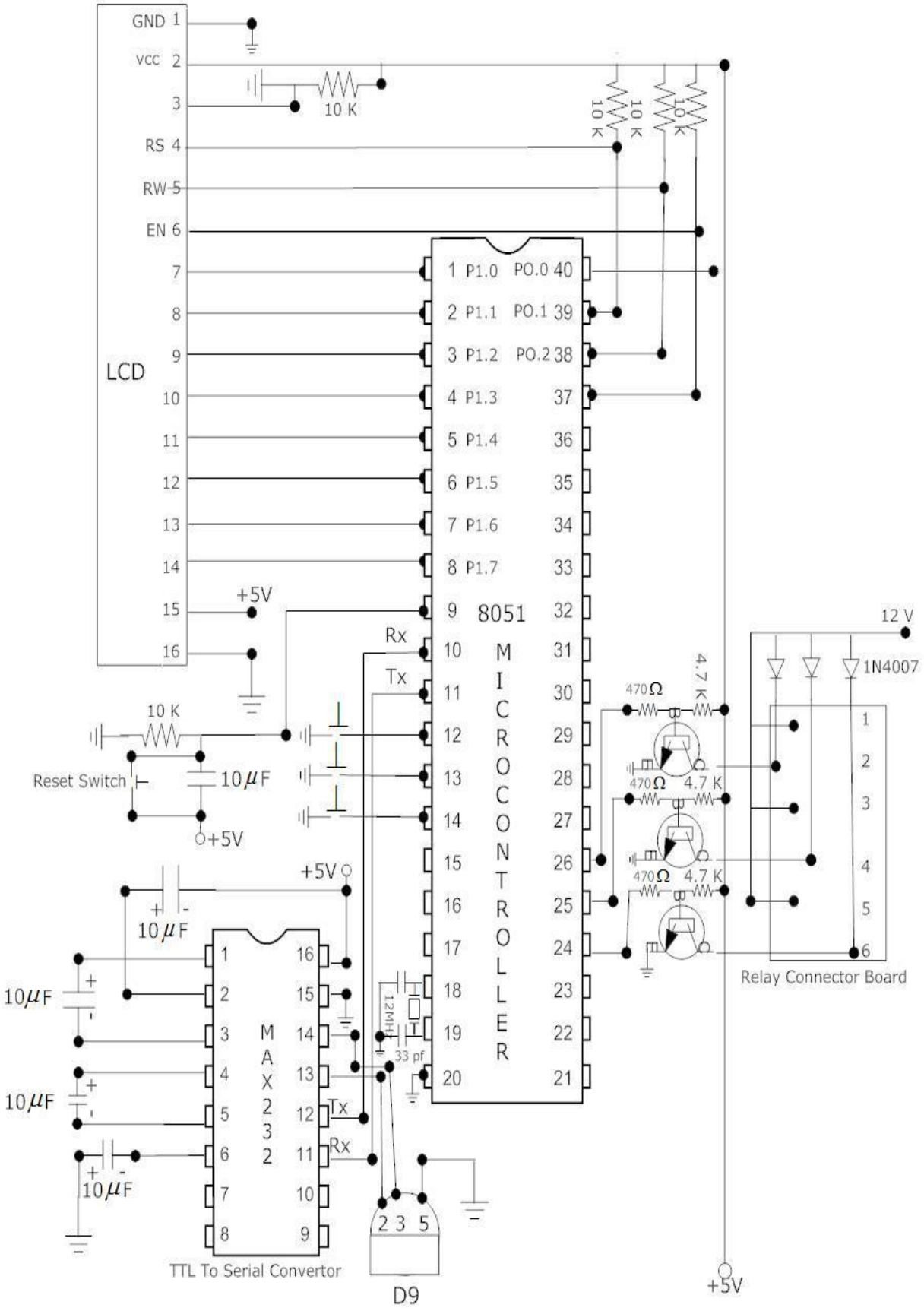

Figure 4.7: Circuit diagram of present hardware Interface

P2.3, P2.4 and P2.5 pins of the microcontroller are connected into the relays of the relay board through 2N2222 switching transistor and 1N4007 for removing the inverse current. Port pin P0.0 is connected to pin 4 of LCD to register selectors, port pin P0.1 is connected to pin 5 of LCD to read and write and port pin P0.2 is connected to pin 6 to enable the communication. The 18 and 19 pin of the microcontroller is connected into an oscillator circuit. The 2 and 3 pin of the DB-9 port is configured with 14 and 13 pin of MAX232 to give the input from the server.

The values and ratings of the component that are used in the implementation of the hardware interface in the table 4.5.

Table 4.5: Component values and ratings [55]

Serial No.	Name of the Components	Values	Ratings
1	AT89S52	8K,flash memory CMOS, 8 bit	0-20 MHz, 5V±15%
2	MAX232	RS232 to TTL Convertor	5V,8ma
3	7805	Three Terminal Positive Voltage Regulator	1A,5V
4	1N4007 diode	Rectifier Diode	Peak reverse voltage:1000v, peak rev current:5uA
5	Resistors	10K,4.7K, 470 ohm	¼ W, ±5% CARBON
6	Capacitors	33pF	Ceramic
7	Capacitors	10uF	16v, electrolytic
8	Crystal oscillator	11.0592 MHz	
9	LCD	Dot-matrix liquid Crystal Display	2.7 to 5.5 V, low power operation
10	2N2222	NPN Switching Transistor	High Current= max. 800mA,Low Voltage= max. 40 V
11	ESP8266	Wi-Fi Module	

4.12 Introducing the Security Features

In the proposed system, the security features should be included as it is a personal switching and controlling device system. Only authorised user can access the system from a remote place at any time. The user can control the system through communication mechanism based web page and SMS technology. So, in the proposed, to control appliances, web user (Internet user) has to log in with his/her user_id and password which are already stored in users table of server database. If it is correct, then only user can access the devices which are connected in the server end. Otherwise, the user machine will display as 'Invalid user_name and password' and not permit the user to access the system. Similarly, the SMS user has to send the user_id and password along with the command at the time of sending the action to the server. The server program extracts the user_id and password from that and performs the same process like the previous one. On the other hand, in case of speech communication, IVR system will work with the registered GSM modem either in server end or in user end. Along with the user has to know the command which is already trained and tested in the speech recognition system. From this point of view, this communication is more secured quite. For IoT communication, User has to operate the home appliances through a web interface designed previously and put their userid and password, otherwise they cannot work with the system. Therefore, only registered users can only work. So, all four communication mechanisms are secured in this way from the unauthorised users.

5

RESULT AND DISCUSSION

CONTENT

CHAPTER 5

RESULT AND DISCUSSION

As mentioned in the objective of the proposed system, the aim of this project work is to control electronic or electrical devices which are controlled through a common platform for four communication mechanisms. So, the outcome of this project should be switch on or off these devices in an efficient manner by using a web page, SMS, Speech and Wi-Fi. The result of this system that is outcome finally can be easily visualized with the help of the screen-shots of graphical user interface of software package and hardware modules.

After connecting and switching the all components required in the system administrator comes to the server machine. So, now operation in the server side will begin.

Step 1: At first, run the server program, once if program is executed, then a login interface is appeared in the server machine.

Step 2: Now administrator has to active the server pressing the Start button in the users interface of the server. Similarly, administrator checks the check box for allowing the system to listen remote control command and presses the Connect to GSM modem to listen the commands sent from the GSM end.

After this, the server system is activated and ready to use i.e. ready operate its functions according to the user's request.

Step 3: Now, this time is for Remote users. There are four types of users communicating four different mechanisms as Webpage users, Mobile SMS users, speech user and Wi-Fi User. The web user uses a web page to send the commands using a standard web browser through a dynamic IP address. Similarly, the mobile user uses message service from a simple cell-phone.

Figure 5.1 Screenshot of one part of present system in server side

5.1 Authentication of the System for Users

In case of the Web and Wifi Communication, remote users have to log in their user_id and password in the user interface as both are interface based in the server end through an IP address.

If user name and password does not match with the database, then the following scenario has been occurred, otherwise can process the system.

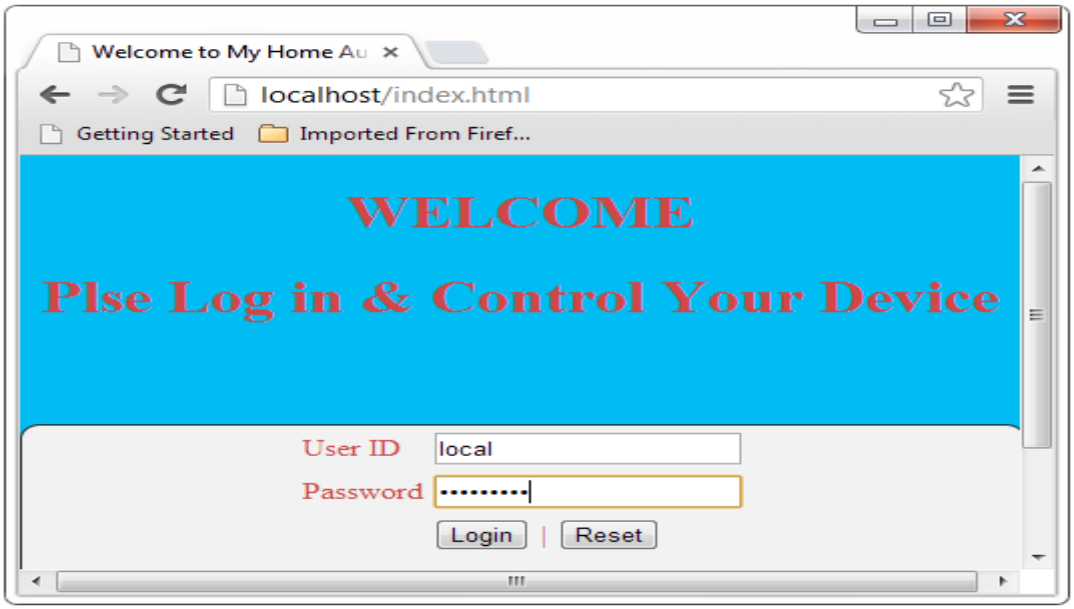

Figure 5.2: User Verification Interface

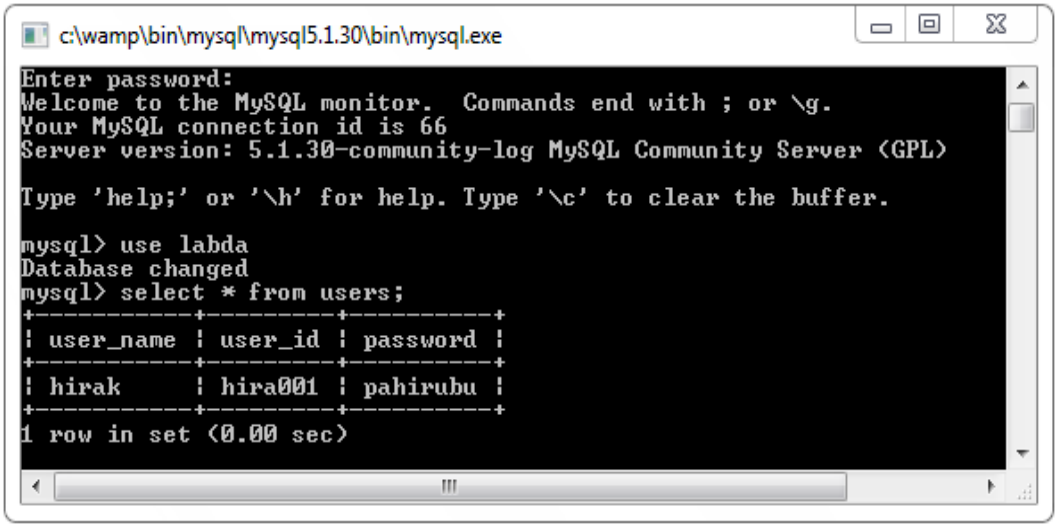

Figure 5.3 : Users Information in MySql

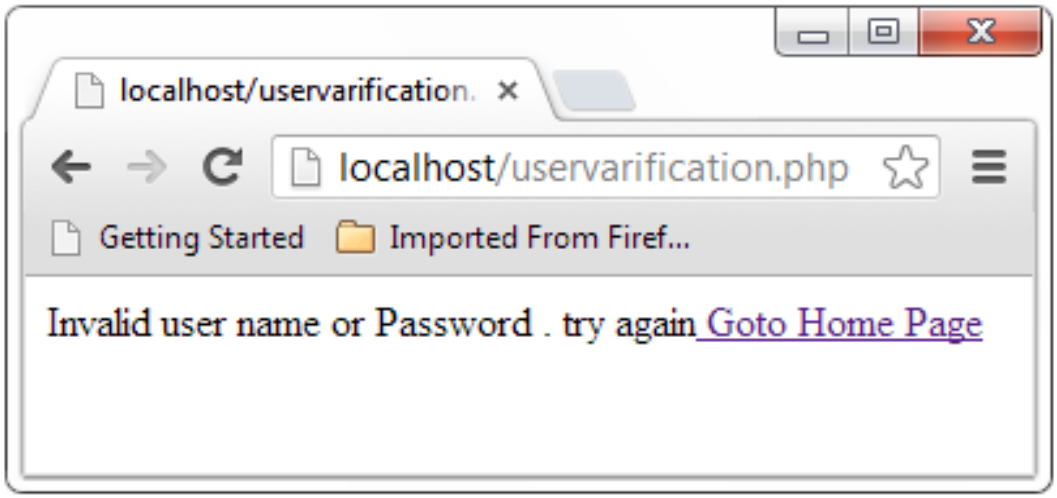

Figure 5.4: Unauthorized Users

If the user name and password is correct, then the following interface is appeared for controlling the devices.

In case of the SMS Communication, remote users have to send their user_id and password along with the SMS that is already predefined. Besides, the SMS should be sent from an authorized mobile number that is also stored in software package available in the server. Otherwise users will be denied to be executed.

In case of Speech Communication, remote users have to call to the server mobile or GSM Modem to deliver their voice commands to control the devices using the authorized mobile number. Otherwise speech cannot be accepted.

5.2 Integrated Database as Common Platform

The integrated database of the system is the heart of the home automation system because every command actions delivered by different communication mechanisms will be stored in a same database to control the household appliances. The database is responsible for storing the various information about the action commands given by different users. The actual command will be triggered to the microcontroller from the same database as database can carry the same status for the devices.

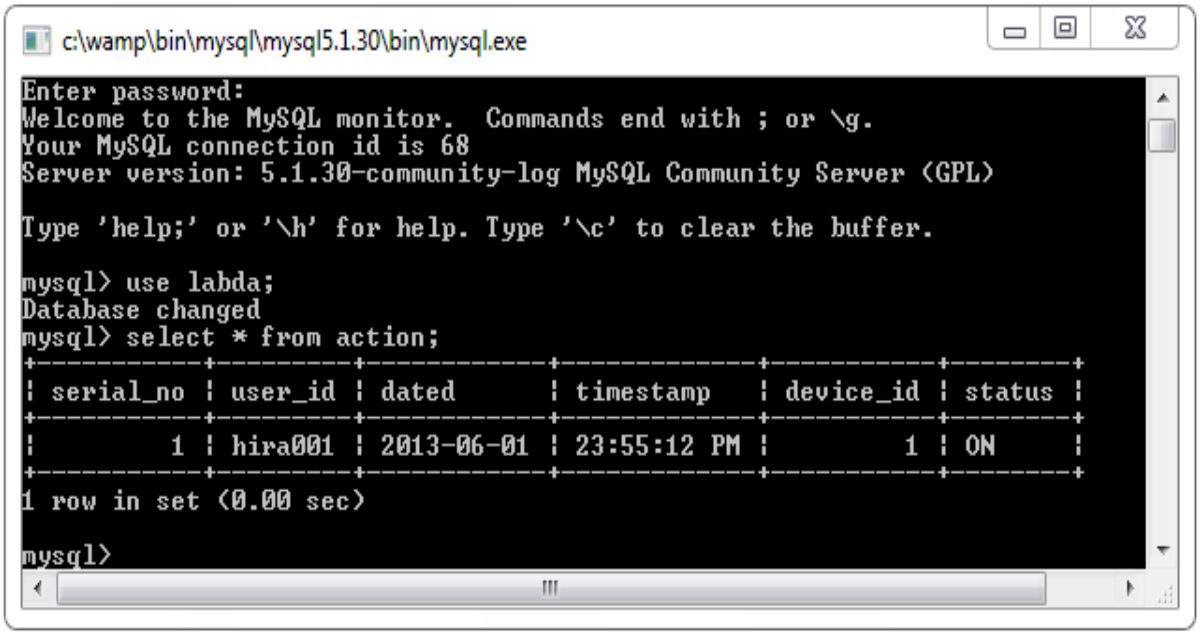

Figure 5.5: action table in MySql database

In the discussion section, it is claimed that the command reached from all four communication mechanism is stored in the same server database and the feedback to both user is delivered from that database. So, it will possible to get the recent status for both users i.e. if device is switched off by the web user, then also that feedback will be delivered into the GSM user and vice-versa. Again, it will possible to get the recent status for both users

i.e. if device is switched off by the speech user, then also that feedback will be delivered into the Wi-Fi users and vice-versa.

5.3 IVR User

In this system, database consists of 8 different words LIGHT, FAN, FREEZE, TV, MOTOR,YES,NO,ON, OFF and STATUS. Our speech recognition systems consist of total 1000 utterance words taken from different speaker. Including these words we have taken 880 utterance words for training, which are spoken by 200 different users and took them as a trainee in training phase by recognition toolkit. After completion of their training we have tested by new utterance words by the new input different speakers. We took 120 new utterance words from new speakers. After testing phase is completed, we have compared the training and testing phase. Then we have recognized different kinds of sounds as mention below:

1. Matching sound: These are the sounds used in the training model which match with the testing sounds.

2. Non matching sound: These are the sounds used in the training model which do not match with the testing sounds.

3. Silence sound: These are the sounds used in the training which do not show any outcome.

5.3.1 Error Analysis and Speech Recognition Accuracy

Word error rate often referred to as WER is a way to measure the performance of an automatic speech recognition (ASR) system. It is tricky to measure because the “ASR result” can have a different length than the “Voice Input”. The calculated results are shown below in the table.

Table 5.1: List of training word, occurrences in training set and % of accuracy

Name of the Word	Total No. of Words	Recognzed Word (N)	Deletions (D)	Substitutins (S)	Insertions (I)	Mis Recognized	Errors	Word Correction Rate(PC)	Word Accuracy Rate(PA)	Word Error Rate
LIGHT	237	232	0	5	3	5	8	97.84	96.55	3.45
FAN	235	227	1	7	2	7	10	96.48	95.59	4.41
FREEZE	238	228	5	5	1	5	11	95.61	95.18	4.82
AC	235	230	3	2	0	2	5	97.83	97.83	2.17
MOTOR	240	233	2	5	2	5	9	96.99	96.14	3.86
ON	242	238	0	4	3	4	7	98.32	97.06	2.94
OFF	242	230	4	8	4	8	16	94.78	93.04	6.96
YES	239	232	3	4	2	4	9	96.98	96.12	3.88
NO	238	232	2	4	0	4	6	97.41	97.41	2.59

The system performances in terms of word recognition accuracies with GMMs of different sizes and fixed number of tied states are given in Table 1.3 Subsequently the number of tied states is also varied for 16 and 32 GMMs/state systems as given in Table 1.4. As the SDS system with 16 and 32 GMMs/state are found to give similar performances and hence we have used 16 GMMs/state in the deployed system.

Table 5.2: Word accuracies with different GMM sizes and fixed no. of tied states

Decoder	No. of GMM/state				Total Test files
	4	8	16	32	
Voice Command	66.73	68.45	62.69	62.63	1000

Table 5.3: Word accuracies with different no. of tied states and 16 GMM vs 32 GMM

Decoder	Sennon								Tot. Test files
	1000		1500		2000		2500		
	16 GMM	32 GMM	16 GMM	32 GMM	16 GMM	32 GMM	16 GMM	32 GMM	
Voice Command	70.23	69.5	71.34	62.8	72.38	72.8	72.69	72.6	1000

5.4 Speech Recognition with SPHINX

5.4.1 SPHINX Train

After preparing the environment and data preparation for speech recognition, we have prepared the sample data for training that already collected.

We have followed the following steps [56]:

- In the workspace directory we create the directory hmm using the command mkdir hmm.
- After that we have to go to the hmm directory using the command cd hmm then execute the following command

  $SPHINXTRAIN/scripts_pl/setup SphinxTrain.pl -task calflow1

  The above command sets up all the folders and files required for training. The above script generates the following important directories in hmm directory which contains the configuration files and the required transcript and dictionary files.
- After executing above command, we go to the hmm dir using the command cd hmm
- Then executing the following command

  perl scripts_pl/make_feats.pl -ctletc/calflow1_train.fileids

  The above command extracts the feature in the form of .mfc files and saves them in the feat directory (/workspace/hmm/etc).

- Then we run the command

  $ perl scripts_pl/RunAll.pl

  The whole process may take some time. This creates the trained vectors which will be used while decoding.

5.4.2 SPHINX Decode

After completion training, we have prepared the sample data for decoding that already collected. We have followed the following steps:

- We make the decode directory in the path /home/WordModel/workspace.
- In the path /home/WordModel/workspace/decode

  Then we create the subfolders by name feats, models and wav folders where,

a) feats directory contains all the .mfc (feature extracted files) files

b) wav directory contains all the test wav files

- In the path /home/WordModel/workspace/decode/models create the subfolders hmm and lm

  a) hmm directory has the following files created during training: feat.params, mdef, means, mixture_weights, transition_matrices, variances

  b) lm directory has the following files:

calflow1.dic, calflow1.filler and the calflow1.fsg files

All the above files in hmm and lm are copied from the trained models executing the following commands in the path /home/WordModel/workspace/

cp hmm/model_parameters/taskword.cd_cont_1000_8/* decode/models/hmm/
cp hmm/model_architecture/taskword .1000.mdef decode/models/hmm/mdef
cp hmm/etc/calflow1.dic decode/models/lm
cp hmm/etc/calflow1.filler decode/models/lm
cp hmm/etc/feat.paramsdecode/models/hmm

- We have to make calflow1.jsgf file in the lm directory which has the following format

#JSGF V1.0;

public<topping>

<words> = (on | off | status|fan|light|motor|freeze|ac|yes|no|)

- Now we run the following command to create the calflow1.sfg file

/home/WordModel/workspace/tools/sphinxbase/bin/sphinx_jsgf2fsg

calflow1.jsfg >calflow1.fsg

- The feat.params should have the following enteries–

alpha 0.97

-samprate 8000

-frate 100

-dither yes

-doublebw no

-nfilt 31

-ncep 13

-lowerf 200

-upperf 3500

-nfft 512

-wlen 0.0256

-transform legacy

- We use following Feature Extraction Command for Testing

  /home/WordModel/workspace/tools/sphinxbase-0.6/bin/sphinx_fe-argfile models/hmm/feat.params -c test_files -di wav/ -do feats -ei wav -mswav yes –eomfc

  Where,

  -argfile is specified as models/hmm/feat.params. -mswav specifies the Microsoft Wave file format. test_files contains the list of all the wave files used for testing prepared is a manner similar to that of training.

- The command for decoding is as follows

  /home/WordModel/workspace/tools/sphinx3-0.8/bin/sphinx3_decode -hmm models/hmm -op_mode 2 -fsg models/lm/assamese2.fsg –dict models/lm/calflow1.dic -fdict models/lm/calflow1.filler -ctltest_files -logfn log.txt -hyp /dev/ttyUSB1 -cepdir feats/

Where,

-hmm Directory for specifying Sphinx 3's hmm, the following files are assummed to be present, mdef, mean, var, mixw, tmat. If -mdef, -mean, -var, -mixw or -tmat are specified, they will override this command. -op_mode Operation mode, for internal use only. Since FSG is the mode used so -op_mode has to be set to 2 -fsg Finite state grammar. -ctl Control file listing utterances to be processed (List of file that has to processed) -logfn Log file (log.txt) -hyp Recognition result file, with only words (out.txt) -cepdir Input cepstrum files directory (prefixed to file specs in control file) (Where, feats/ directory contain all the test mfc files.

5.4.3. Result Analysis

Matching Sound

INFO: utt.c(195): Processing: of121
INFO: feat.c(1148): At directory feats/
INFO: feat.c(378): Reading mfc file: 'feats//of121.mfc'[0..-1]
INFO: cmn.c(175): CMN: 4.85 4.07 -2.75 1.21 -0.52 -0.13 0.08 -0.77 0.19 -0.33 0.05 -0.06 -0.19
.....
INFO: fsg_search.c(1080): Utt of121: 134 frames, 679 HMMs evaluated, 1084 history entries

Backtrace(of121)

FV:of121>	WORD	SFrm	EFrm	AScr(UnNorm)	LMScore	AScr+LScr AScale
fv:of121>	<sil>	0	14	28918	-72912	-43994 146759
fv:of121>	off	15	48	260615	-34779	225836 457815
fv:of121>	<sil>	49	133	2995539	-72912	2922627 3338085
FV:of121>	TOTAL			3285072	-180603	

FWDVIT: off (of121)
FWDXCT: of121 S 3922182 T 3104469 A 3285072 L -180603 0 28918 -72912 <sil> 15 260615 -34779 off 49 2995539 -72912 <sil> 134

INFO: stat.c(174): 134 frm; 4 cdsen/fr, 12 cisen/fr, 33 cdgau/fr, 96 cigau/fr, Sen 0.00, CPU 0.00 Clk [Ovrhd 0.00 CPU 0.00 Clk]; Search: 0.00 CPU 0.00 Clk (of121)
INFO: corpus.c(661): of121: 0.0 sec CPU, 0.0 sec Clk; TOT: 0.0 sec CPU, 0.0 sec Clk

Non matching sounds:

INFO: utt.c(195): Processing: o201
INFO: feat.c(1148): At directory feats/

INFO: feat.c(378): Reading mfc file: 'feats//o201.mfc'[0..-1]

INFO: cmn.c(175): CMN: 8.89 0.63 -0.69 0.14 -0.26 -0.29 -0.29 -0.06 -0.17 -0.02 -0.16 -0.12 -0.08

.....

INFO: fsg_search.c(1080): Utt o201: 121 frames, 840 HMMs evaluated, 1275 history entries

Backtrace(o201)

FV:o201>	WORD	SFrm	EFrm	AScr(UnNorm)	LMScore	AScr+LScr	AScale
fv:o201>	<sil>	0	30	710597	-72912	637685	800995
fv:o201>	status	31	65	-253102	-34779	-287881	107181
fv:o201>	<sil>	66	120	2147051	-72912	2074139	2357378
FV:o201>	TOTAL			2604546	-180603		

FWDVIT: status (o201)

FWDXCT: o201 S 3297574 T 2423943 A 2604546 L -180603 0 710597 -72912 <sil> 31 -253102 -34779 status 66 2147051 -72912 <sil> 121

INFO: stat.c(174): 121 frm; 6 cdsen/fr, 12 cisen/fr, 44 cdgau/fr, 96 cigau/fr, Sen 0.00, CPU 0.00 Clk [Ovrhd 0.00 CPU 0.00 Clk]; Search: 0.00 CPU 0.00 Clk (o201)

INFO: corpus.c(661): o201: 0.0 sec CPU, 0.0 sec Clk; TOT: 0.0 sec CPU, 0.0 sec Clk

Silence sounds

INFO: utt.c(195): Processing: o111

INFO: feat.c(1148): At directory feats/

INFO: feat.c(378): Reading mfc file: 'feats//270320.mfc'[0..-1]

INFO: cmn.c(175): CMN: 6.39 0.30 -0.02 -0.29 -0.13 -0.25 -0.24 -0.07 -0.24 0.10 -0.01 -0.02 0.06 .....

INFO: fsg_search.c(1080): Utt 270320: 70 frames, 1781 HMMs evaluated, 348 history entries

WARNING: "fsg_search.c", line 949: No history entry in the final frame 69; using last

entry at frame 57ERROR: "fsg_search.c", line 1001: Final state not reached; backtracing from best scoring entry

Backtrace(270320)

FV:270320> WORD SFrm EFrm AScr(UnNorm) LMScore AScr+LScr AScale

fv:270320> <sil> 0 20 -1096388 -72912 -1169300 -882301

fv:270320> <sil> 21 57 -208573 -72912 -281485 379607

FV:270320> TOTAL -1304961 -145824

FWDVIT: (0111)

FWDXCT: o111 S -191116 T -1450785 A -1304961 L -145824 0 -1096388 -72912 <sil> 21 -208573 -72912 <sil> 70

INFO: stat.c(174): 70 frm; 100 cdsen/fr, 130 cisen/fr, 800 cdgau/fr, 1040 cigau/fr, Sen 0.01, CPU 0.02 Clk [Ovrhd 0.01 CPU 0.01 Clk]; Search: -0.00 CPU 0.00 Clk (270320)

INFO: corpus.c(661): 270320: 0.0 sec CPU, 0.0 sec Clk; TOT: 2.2 sec CPU, 2.2 sec Clk.

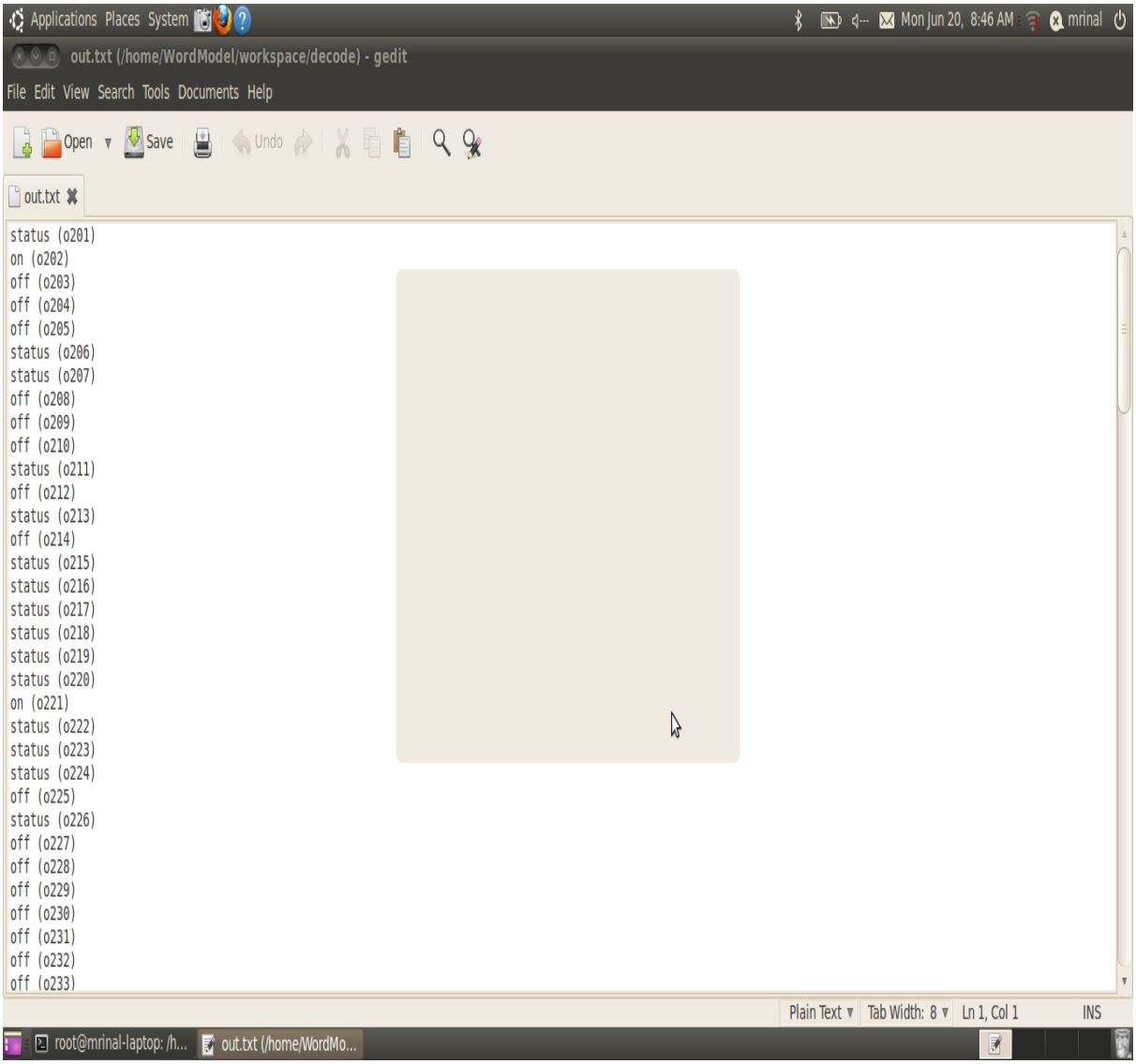

Figure 5.6: Screen shot of output result

Result displayed in manually:

If one wav file is testing then the result will be displayed as-

word recognition(wave file name)

example: on (o221)

Accuracy

From the result of the recognition phase, we have found average 67% accuracy, i.e. our testing voice data has matched with training voice data with overall 67%. This result indicates that the training of our system is completed successfully and shows that the developed system is speaker independent.

5.5 Outcome for Wi-Fi Communication

In this one of the important parts of present work has implemented internet of things with the help of Wi-Fi and established a few points.

Remote Controlling of Load

A device is built up that could control the power supply of the load connected to it, thereby allowing the user to remotely turn the device ON or OFF connected to the load using a web based application through Wi-Fi.

Parameter Based Automation

The present system has given a focus on automation of the power control of the load depending upon certain conditions being met by the parameter which we were collecting from the sensor.

Modular Sensor Based Automation

A system is provided for creating with a sense of generality and thereby decides to include a mechanism to automate the control of the load by introducing some sensors which would be modular in nature. Thus, we could connect any load and automate it on the basis of any parameters just by introducing a suitable sensor to the system.

5.5.1 Wi-Fi enabled Circuit Stimulation

The programming code for this IoT communication is tested first on the circuit stimulator software called Proteus ISIS before actually burning our code into the microcontroller which have helped us save a helped a lot in debugging and testing of code, as a result of which our final working code was possible to be executed successfully and getting the desired result from the system.

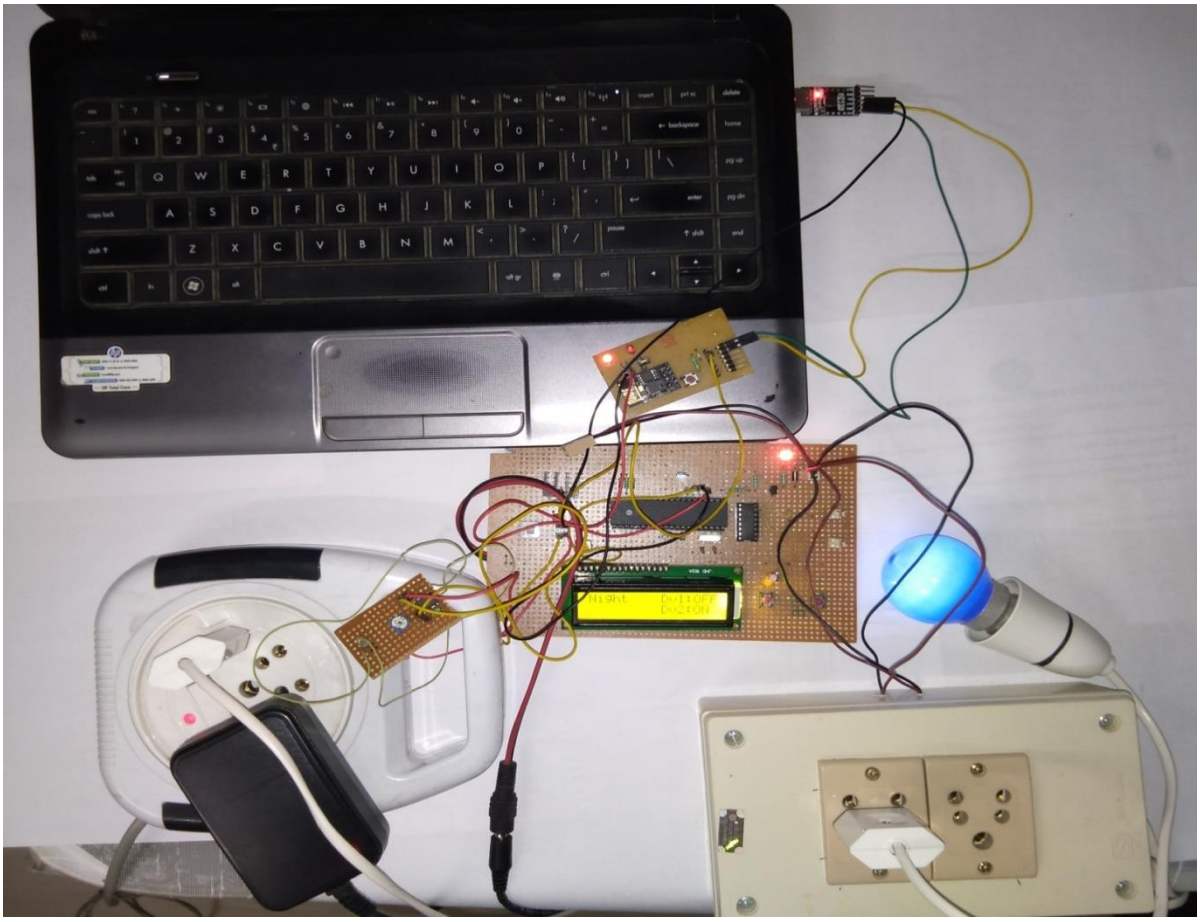

Figure 5.7: Screenshot for the IoT Communication in the server side

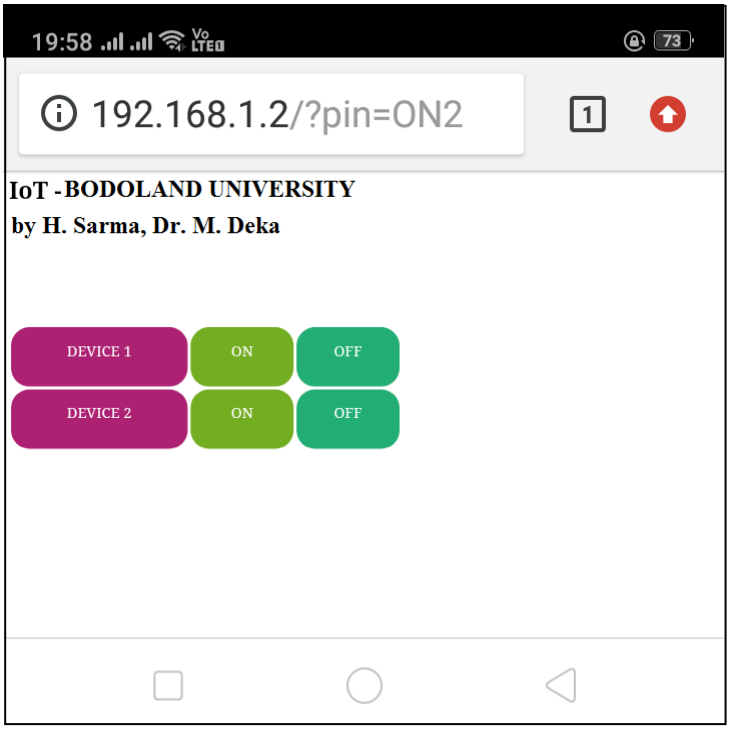

Figure 5.8: Screenshot for Wi-Fi communication at User Side

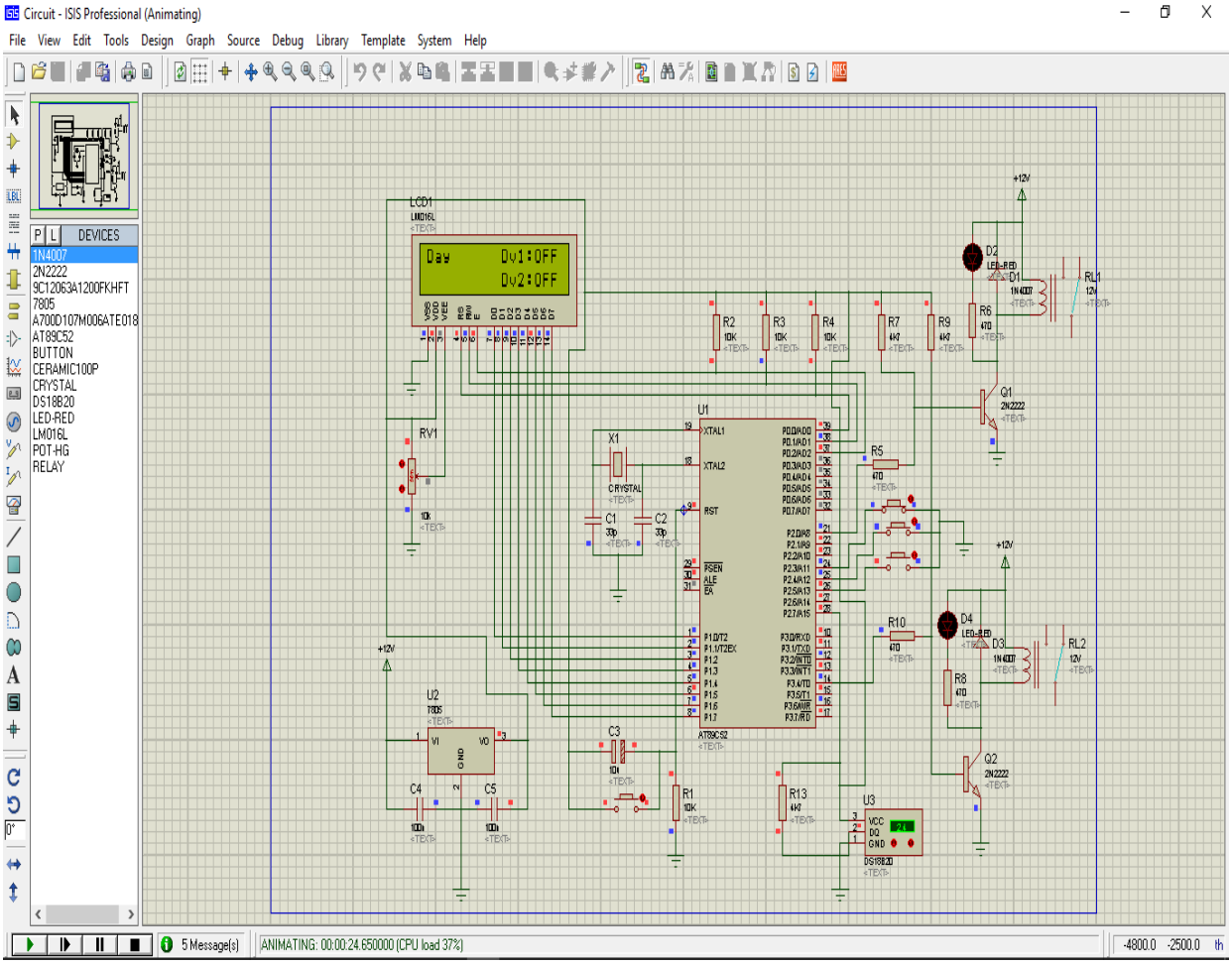

Figure 5.9: Screenshot of circuit simulation in Proteus ISIS

6

FUTURE SCOPE AND CONCLUSION

CONTENT

CHAPTER 6

FUTURE SCOPE AND CONCLUSION

Along with the present features that are be implemented in this work in future, further enhancement can be made to the work so that the whole system will become an ideal one in an easy and efficient manner in the field of home automation. Artificial intelligence is one of the most recent and emerging opportunity that can be implemented in the present system. Using the application of Artificial Intelligence with this system can adopt the behaviour of the home appliances controlled by the user and able to acquire some knowledge regarding the performance of the entire system about their operation. As a result, from that knowledge which is achieved from the previous operations occurred in the present system so that the system can be controlled itself.

The present System describes the design, development and the implementation of an effective home automation system with the GSM, the Internet accessibility. The Internet provides access the full features of the system through an interactive Web interface. As the mobility in the world increases, the need to control home from remote locations also increases. The GSM is an excellent choice for this due to its extensive coverage. Since SMS is a text based protocol, even the most basic GSM systems can have an access to the status of the devices or make changes on these states. The whole system is secured through a login password based authentication. The design is completely wireless and integrated with the software to form a low-cost, robust and easily operable system.

In this work we design and develop a spoken dialog system for controlling household electrical devices from a remote place. The integration of Asterisk server, HTK module using with Bluetooth communication is also described. Finally we evaluate the performance of the system in terms of WER [54]. The development of a speaker independent spoken query system for accessing the household electronic devices is described in detail in this work. In this system, we use speech as the main communicating media between the machine and the human beings. It has been discovered that there are many people who have a computer phobia. The reasons why many people fear to use speech recognition tools have been due to the inadequate user interfaces. The HTK was used for the implementation of the

recognizer. HTKwas used because it is open source, more accruable and has been used by many researchers all over the world. A limited grammar and dictionary were constructed to be used by the recognizer. The Speech data was recorded and labeled from 200 different speakers making the training and the testing corpus. We have also explored a set of data to make the system more speaker independent with a gradual improvement of accuracy from more than 50% of present time.

This IoT based system is very useful in automation as it provides the option of introducing different sensors based on the requirements of the user and automating the control of power supply of the load accordingly with respect to the sensory data. This system also provides some facilities as follows

- Remotely control the power supply of the load.
- Introduce automation on the basis of the parameters that are sensed by the sensor.
- Introduce other sensors in the system which automates the control of the power supply of the load depending upon the value of the sensory data, thereby making the device support modularity and generality.

It also leaves the control to override the flow of automation to the user and remotely control the device according to his or her will. Moving forward, when study is focused on improving the different aspects of the system, it has come to know that the device can be connected to the internet in the following four ways like on the home / business network, connects to a local / remote server, Internet using a Static Public IP Address, Internet using a Dynamic Public IP Address. As of now, this device is used only on the home / business network but it can be also tried to connect the device to the internet by using the rest of the three ways by making uses of Static Public IP Addresses and Dynamic DNS Services [57]. The way for integrating database is more efficient so as to facilitate storing of the value of the parameters and analysis of it. With this implementation finished, there is much to reflect on, in terms of what the hardware was able to achieve, areas that could be improved upon, highlighting the strengths and weaknesses of the presented solution and limitations surrounding the device. One of the first realizations was an appreciation for how much work goes into doing a real, live project in the field. Furthermore, programming embedded microcontrollers in C is an involved task. This project leave with a deeper appreciation for what teams of dozens of computer scientists and hardware and software engineers do when

they work on a single project to bring a product to market, and despite the developments in recent years that make engaging in programming and manufacturing IoT devices/dabbling in the space much easier, why that kind of manpower is required. The key point regarding the entire present work is concluded as follows -

a) An Integrated Platform is designed for the four different types of communication mechanism based device controlling system through a database.
b) The general SMS service through GSM network is used for the communication between the users and the Household appliances. Also used the web services.
c) A Speaker Independent speech recognition system is designed to recognize the voice commands spoken by the users. The main work is to develop interface using relevant speech technologies so that the most noise of users is able to get the relevant information with minimum human intervention.
d) An Interactive Voice Response system is generated for communicating with the server where the devices are connected through a Telephony data acquisition setup.
e) An ASR engines is designed which is a Sub-word Hidden Markov Model (HMM) based ASR engines for recognition of device names, responses(yes/no) and the action command(on/off)
f) The main tasks regarding the speech communication are Integration of speech interface, ASR engine and computer telephony interface: Integration of speech interface, ASR engine, computer telephony interface
g) An IoT based interface is designed in terms of a web page through the IP address of a Wi-Fi module to control the appliances from the range of Wi-Fi locally.
h) This IoT based communication technique is most efficient with respect to time and when the users are locally present, it is very easy to use rather than go through the other communication mechanisms.
i) The performance and efficiency of the integrated system is a task to be measured at execution time as no parameter is used to measure it except the speech communication technique.

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