ST. XAVIER'S COLLEGE

(Affiliated to Tribhuvan University)

Maitighar, Kathmandu

Final Year Project Report

On

"Ghar Niyantran: IoT based Home Automation System for Home Safety"

[CSC -404]

A final year project report submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Information Technology awarded by Tribhuvan University

Under the supervision of
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ST. XAVIER'S COLLEGE

Department of Computer Science
Maitighar, Kathmandu,
Nepal
August 6, 2017

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ACKNOWLEDGEMENT

We take this momentous opportunity to express our heartfelt gratitude, and regards to the respected people for the success of the project. It is a great pleasure to express our deep sense of thanks and gratitude to our Project Supervisor/ Lecturer **Mr. Vishnu Kumar Rana**, Head of Department, Department of Computer Science, St. Xavier's College. His dedication and interest above all his overwhelming attitude as well as providing us with all the crucial advices, guidelines and resources has been the main reason of accomplishment of this project.

The success and final outcome of this project required a lot of guidance and assistance from many people. We would like to express our gratitude to **Er. Rajan Karmacharya**, Department of Computer Science, St. Xavier's College. His timely advice with kindness and enthusiasm has helped us to a very great extend for completion of this project.

We would also like to express our gratefulness to **Mr. Jitendra Manandhar**, **Mr. Bal Krishna Subedi**, **Er. Nitin Malla, Er. Sansar Jung Dewan**, **Er. Sanjay Kumar Yadav**, **Er. Anil Kumar Sah**, **Er. Saugat Sigdel, Mr. Ganesh Dhami, Mr. Ramesh Shahi** and **Mr. Ganesh Yogi,** Lecturers, Department of Computer Science, St. Xavier's College, for their guidance and constant supervision as well as for providing necessary information regarding the project. Furthermore, we are thankful to **Mr. Om Nath Shrestha, Mr. Bibek Konda** and **Mr. Sagar Rijal**, Lab Assistants, Department of Computer Science, St. Xavier's College, for their support.

Our thanks and appreciations also go to our senior **Mr. Ajeet Chaulagain** for providing with all the vital information and constant support for the development of project and our colleague and people who have willingly helped us with their abilities.

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ABSTRACT

With the rapidly evolving technologies, human lives have become much more dependent on electronic and embedded devices which uses IoT technologies. Embedded system is a special-purpose system with a dedicated function that is encapsulated within another, usually larger, system often with real time computing constraints. The Internet of things (IoT) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect and exchange data.

"Ghar Niyantran: IoT based Home Automation System for Home Safety" is a home automation system that uses embedded system and IoT for protecting our home from many mishaps emerging from gas leakage. It consists of sensor which can monitor object distributed in three-dimensional space. The sensor is specialized in measuring the amount the LPG present in the atmosphere. This project allows the owner to monitor the gas present in the surrounding, and in case of any leakages, detect and notify the owner.

Once this system is implemented, it will be capable to control and minimize home accidents, mainly including kitchen misfortunes, to great extent. Even though home feels the safest place in the world, carelessness in operating and handling many household appliances might result in life threatening dangers. Ghar Niyantran deals with one of the excessively used household resource and the dangers it beholds if not handle with care. This system is the best way to keep us informed and updated about information of LPG.

Keywords: Ghar Niyantran, ESP8266 Module, MQ-7 Gas Sensor, Arduino, Virtuino, ThingSpeak, Gas Leakage Detection.

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LIST OF SYMBOLS

V	Volt
%	Percentage
^{o}C	degree Celsius
W	Watt
mW	mega Watt
GHz	Giga Hertz
RH	Relative Humidity
K	Kilohm (aka. Kilo Ohm)
Â	Angstrom
mA	milli Ampere
ppm	Parts per million
cm	Centimeter

ABBREVIATIONS

IoT	Internet of Things
LPG	Liquid Petroleum Gas
ICT	Information Communication Technology
NOC	Nepal Oil Cooperation
OS	Operating System
ESP	Electronic Stability Program
HA	Home Automation
RFID	Radio Frequency Identification
AC	Alternating Current
DC	Direct Current
RF	Radio Frequency
IEEE	Institute of Electrical and Electronics Engineers
WPAN	Wireless Personal Area Networks
FPGA	Field Programmable Gate Array
VHDL	VHSIC Hardware Description Language
VHSIC	Very High Speed Integrated Circuit
LCD	Liquid Crystal Display
LED	Light Emitting Diode
IC	Integrated Circuit

SCR	Silicon Controlled Rectifier
GSM	Global System for Mobile Communications
PDA	Personal Digital Assistant
PC	Personal Computer
UI	User Interface
IDE	Integrated Development Environment
ICSP	In-Circuit Serial Programming
EDA	Electronic Design Automation
MDK	Modern Development Kit
PIR	Passive Infrared
J2ME	Java 2 Micro Edition
SMS	Short Message Service
AT	ATtention
USB	Universal Serial Bus
EEPROM	Electronic Erasable Programmable Read Only Memory
API	Application Programming Interface
DTMF	Dual Tone Multi Frequency
OSGI	Open Source Gateway Interface
WLAN	Wireless Local Area Network
M2M	Machine to Machine

P2P	Point to Point
PHY	PHYsical layer of OSI model
CPU	Central Processing Unit
HTTP	Hyper Text Transfer Protocol
DFD	Data Flow Diagram
UAT	User Acceptance Testing
SOC	System On Chip
ISM	Industrial, Scientific and Medical
I/O	Input Output
PWM	Pulse Width Modulation
SDIO	Secure Digital Input Output
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter
MIMO	Multiple Input Multiple Output
MAC	Media Access Control
A-MSDU	Aggregate MAC Service Data Unit
A-MPDU	Aggregate MAC Protocol Data Unit
MAC/BBP	Medium Access Controller/ Base Band Processor
ISP	Internet Service Provider

CHAPTER 1: INTRODUCTION

1.1 Background

With the rapidly evolving technologies, human lives have become much more dependent on electronic and embedded devices which uses IoT technologies. Technology has even reached to home automation systems. A home automation system is a means that allow users to monitor as well as control home appliances of varying kind. In essence intelligent homes offer new ways of monitoring and controlling appliances. Home automation industry has drawn considerable attention of the researchers for more than a decade. The main idea is to automatically control and monitor gas leakage, fire outbreak and electronic home appliances [1][2][3].

Home is the only place one feels safe and emotionally driven to. As more and more appliances are being used, the risk of mishaps are increasing as well. Even though home feels the safest place in the world, carelessness in operating and handling many household appliances might result in life threatening dangers. Accidents involving fires and burns are the third leading cause of home injury deaths, and they claim more than 3,000 lives a year [1]. The project, "**Ghar Niyantran: IoT based Home Automation System for Home Safety**", meaning house monitor and control in Nepali language, is developed to control and monitor gas leakages in our homes using mobile devices via Wi-Fi and thus reduce the risk of house fires and other gas related mishaps to greater extent. If user unknowingly leaves the gas cooker on the leakage of LPG is immediately absorbed and notified to the user through internet in android mobile phones. Leakage may not occur through the left-on gas cooker but may sometimes also occur due to defect gas pipes or cylinders. In this case, users are totally unaware of the dangers crawling to their doors. Hence, the use of Ghar Niyantran allows the user to monitor the real time gas leaks through their smartphones when in access with the internet.

This home automation system is concerned mainly with home safety. It consists of a sensor which can monitor object distributed in three-dimensional space. The sensor is specialized in detecting and measuring the amount of LPG in the surrounding. This project allows the owner to monitor the gas present in the surrounding, and in case of any leakages, detect and notify the owner hence providing safety from gas leakages, fire outbreak and any other misfortunes emerging from the leakage. This can be realized via wireless sensor network and is controlled by android application using mobile device [3][4][5].

1.2 Problem Definition

Consumption of Liquefied Petroleum Gas (LPG) surged 14.12 percent to 207,038 tons in fiscal year 2015-16, according to recent Nepal Oil Corporation (NOC) statistics. However, with growing consumption of LPG, the series of gas explosions has also taken place. LPG leakage, fire break down has taken a growing occurrence and also results into wastage of valuable resource [6][7]. Understanding and knowing how to monitor and control it are key prerequisites for residential energy conservation and prevent the fire outbreak and gas leakage. Research has shown that, in general, when presented with the appropriate information on LPG usage, average homeowners will change their consumption behavior to decrease their monthly LPG consumption [8].

Sometimes the owners may forget to turn the gas switch off or blow out any fire related equipment, which may result into massive fire outbreak especially in Nepal where the houses are connected to each other. Home automation is related here to prevent gas leakage, fire outbreak and reduce unnecessary LPG consumption at homes. It is necessary to notify the owners about such leakage and/or wastage of the non-renewable resource at home so that they are aware of these and can take necessary steps to avoid its consequences. This will not only helps to prevent the house from disaster but also reduce the individual cost, resource wastage and energy load for betterment of the society and the nation [9].

The main problem considered here is house safety and LPG consumption monitoring and control to some extent. It is necessary to focus on an important aspect of our everyday lives, which has reason to concern us even more in the future that is LPG consumption awareness. [9] However, the challenge is to prevent homes from fire hazard and to reduce energy consumption in one's home, making the user aware of his/her impact on the environment by putting onto scale his/her lifestyle's energy and resource consumption. One possible way to do this is to enable some sort of home automation or home monitoring system [8][9].

1.3 Scope and Objectives

1.3.1 Scope

The excessive use of mobile technology in recent time has become an important asset for development of smart home applications. After conducting various research, it can be gathered that there is a huge scope of mobile application development [10]. Following the same notion, some of the scope of the project are listed below:

- The immediate scope of this project is to monitor gas leaks in real time system anywhere at home and in offices.

- The area of use is generally where humans themselves couldn't be physically present or mentally aware.

- A useful research project on status of gas leakages and its consequences due to carelessness of people as well as defective appliances that use or contain gas.

- The application can be used to analyze the status of reduction of LPG wastage as well as fire hazards after implementation of the system [11][12].

1.3.2 Objectives

The primary objective of this project is to develop the system that can assist the stakeholders in their effective execution of appliance by monitoring and controlling them as needed. The system was thoroughly studied and on the basis of requirements the objectives were set [10][12]. The project is designed to fulfill the following objectives.

1. To design and implement a home automation system for monitoring household and office gas-using appliances from anywhere using mobile.

2. To detect and notify about the leakage of gas and fire outbreak in absence of the owner whenever internet is available.

3. To reduce the wastage of non-renewable natural resource i.e. LPG gas, hence reducing home owner's monthly LPG consumption and bill.

1.4 Project Features

The project is based on research on the internet based home automation system. The project mainly focuses on the emerging problem in the country that is LPG leakage. The team members have designed the system using hardware components such as Arduino, MQ-7 Gas Sensor and Wi-Fi shield. The developers used Arduino and Virtuino platform for the application development. The end-product is a fully functional application that provides the facilities for monitoring of gas leakage and amount of gas emitted through internet from anywhere outside. The application is based on android platform so Android devices are required to run the application.

1.5 Feasibility Study

A feasibility study is a study made before committing to a project. A feasibility study leads to a concrete decision whether the proposed project is fit to be initiated and completed [9]. Feasibility study considers various factors that are directly or indirectly concerned with the project. The home automation system both hardware and software aspect which needs delicate attention to value its existence, efficiency and effectiveness. The team members carried out the intensive feasibility study for this project considering the various factors associated with it [14]. The feasibility study included following scope.

1.5.1 Technical Feasibility

The technical feasibility assessment is focused on gaining an understanding of the present technical resources of the organization and their applicability to the expected needs of the proposed system. It is an evaluation of the hardware and software and how it meets the need of the proposed system [14][15]. While developing an application many technical question arises that need to be answer before the project can go to the floors. The current application developed is technically feasible. This application is built using Android platform using Virtuino tools. The hardware used for the project include Arduino (micro controller), Gas Sensor (MQ-7) and Wi-Fi Shield (ESP 8266). The hardware used are pretty minimum and low cost as well.

1.5.2 Economic Feasibility

The purpose of the economic feasibility assessment is to determine the positive economic benefits to the stakeholders that the proposed system will provide. It also includes the quantification and identification of all the benefits expected. This assessment typically involves a cost/benefit analysis [15][16]. In economic terms, the development and deployment of this project has been minimal. Any OS can be preferred to develop the

application and also for the usage android device which is the most common mobile device can be used to access this application. Besides that, the investment on the hardware used were also moderate. The team used low cost and open source microcontroller like Arduino, Gas Sensor (MQ-7) and Wi-Fi Shield (ESP 8266). Also the operational and training cost of this application is minimal since the application comes in an easy to use interface.

1.5.3 Operational Feasibility

Operational feasibility is a measure of how well a proposed system solves the problems, and takes advantage of the opportunities identified during the definition and how it satisfies the requirements identified in the requirements analysis phase of the system development. To ensure success, desired operational outcomes must be imparted during the design and development [16][17]. The team members attempt to ensure that every user can access the system easily and the necessary requirements for using the system is readily available. Since the application is a graphical user interface including digital and analog value display and graph based interfaces, it is very simple to use and requires no additional or special training. The authors develop a menu that users can easily access and show a proper error message when any mistakes are made in the program. It determines the project is acceptable to the users and is enough to run in proposed budget, hence the system is supposed to be feasible regarding all except of operational feasibility.

1.5.4 Legal Feasibility

This application has password protection so only administrative user can modify the tools in the application. The server (ThingSpeak) used in this application also provide the feature of login protection and also an open source which satisfies the legal standards required in application

development. This application will not violate any rules and regulation. Whatever the information and measures were researched and used are noted with references of their paper published and author names. And in regards of codes, they are coded by the team members and the copyright solely goes to the team member only [18].

1.5.5 Schedule Feasibility

Schedule feasibility refers to the implementation of the work within the planned schedule. Tools like Project Time Schedule and Gantt chart are essential in developing feasible schedule [16][18]. The project is feasible in terms of schedule and can be met in defined time frame.

1.6 System Requirements

1.6.1 Software requirements

The software requirements in developer and client perspective is listed below in table:

a. Developer Side:

Requirements	**Software Used**
Computer System	PC with Pentium 4 or any greater processor, 512 MB RAM, Operating System.
Programming Language	Arduino Language
IDE	Virtuino Platform, Arduino IDE

Table 1: Software Requirements (Developer Perspective)[19][20]

b. Client Side

On client perspective, the software requirement is Android Operating System.

1.6.2 Hardware requirements

Hardware Devices	**Description / Roles in Project**
Arduino Microcontroller	Open Source Microcontroller that is responsible to store a program and simulate other associate devices and sensors based on that program code.
ESP 8266 Module	ESP 8266 is Wi-Fi shield that can be used as Access point or station to make a wireless communication over an internet or

	local network. In this project it is used to send and receive HTTP message to and from ESP module.
MQ-7 Gas Sensor	MQ-7 gas sensor has high sensitivity to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam, it is with low cost and suitable for different application.
Relay Module	Used to control the status of appliances.
Power Source Adapters	Adapter with 3.3V, 5V and 12V is used for hardware setup.

Table 2: Hardware Requirements [21][22]

Beside these some other minor hardware's like led, jumper wires, Breadboard are also required.

CHAPTER 2: LITERATURE REVIEW

2.1 Background of Home Automation

The concept of home automation has been around since the late 1970s. But with the advancement of technology and services, people's expectations of what a home should do or how the services should be provided and accessed at home has changed a lot during the course of time, and so has the idea of home automation systems [23][24]. If we look at different home automation systems over time, they have always tried to provide efficient, convenient, and safe ways for home inhabitants to access their homes[25].

Below we present different research papers and project related with home automation done so far in short.

2.2 Arduino Board Uno R3

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Some of its features are as follows:

- ATmega328 microcontroller
- Input voltage - 7-12V
- 14 Digital I/O Pins (6 PWM outputs)
- 6 Analog Inputs

- 32k Flash Memory

- 16MHz Clock Speed [26]

2.3 Advanced Home Automation Using FPGA Controller

In this paper, author introduced a new technology with Field Programmable Gate Array (FPGA) controller, Bluetooth and Android phones. It is wireless technology. VHDL language is used for a Xilinx Spartan-3E. V means VHSIC (Very High Speed Integrated Circuit) [27]. FPGA Controller is based on Basys2 development board. FPGA has a many input and output pins so it can connect number of home equipment's. FPGA is used for controlling home equipment's. Bluetooth is used for monitoring equipment by wireless technique. Android phone is used for speech recognition. DC motor, stepper motor, a LED (Light Emitting Diode) are connected to FPGA. A microcontroller has less number of input and output pins than FPGA Controller. Main aim of this paper is to increases the speed using parallel communication [28][29].

2.4 Android Based Appliances Control System

In this paper, controlling fan speed and light intensity is specialty of the project. This paper hold two parts, hardware part called process unit and software part called monitoring unit. Process unit contain Bluetooth module LM400, LCD (Liquid Crystal Display), dimmer circuit, and microcontroller PIC16F877 (40 pin IC). Monitoring unit contain only smartphone. For better efficiency dimmer circuit is designed using SCR (Silicon Controlled Rectifier). Home appliances can control using android phone which has Bluetooth application. Bluetooth module is used for communication. It is wireless technology. Dimmer circuit is used for controlling the fan speed and intensity of light [30][31].

2.5 Bluetooth Based Home Automation and Security System Using ARM 9

In this paper, the two microcontroller development boards via ARM 7 and ARM 9 were used. ARM 9 (S3C2440A) is in transmitter side and ARM 7 (LPC2148) is in receiver side. Operating system Wince6.0 is used for designing the application on ARM 9. In hardware parts ARM7, ARM 9, ULN2003, Relays, Bluetooth module are used. VB.NET is used for designing apps. Graphical User Interface module and Serial Port Profile modules are used in software part. Bulb, fan is controlled using Bluetooth, ARM – MDK kits acts as a processor. It is cost effective project [32].

2.6 IoT based Home Alert System using Wi-Fi and Cloud Technologies

This system is composed of Intel Edison Board as a base and various sensors to fulfil the people's requirements. The system monitors some unexpected parameters like gas leakage, high temperature, fire and intrusions in the absence of the family members and intimates the user about the abnormal behavior of the environment of house with the help of an auto generated email with the risk of high, moderate or low. The components used in this paper are Intel Edison Board, LM35sensor, MQ2 sensor, PIR sensor, 16x2 LCD, Breadboard, Buzzer, LEDs, IoT Analytics Cloud Platform and Wi-Fi module. . It monitors various home affecting environmental parameters like intrusions, fire, leakage of LPG and other smokes and sends a real time information via email to the owner in case of any threat. This system is composed of Intel Edison Board as a base and various sensors to fulfil the people's requirements [33][34].

2.7 Architecture of Home Alert System

The microcontroller unit plays a central role, where All the sensors are connected to it like PIR sensor which detects the motion about 6meters of distance, MQ2 and LM35 sensors are to detect its atmospheric conditions and notifies the user about

the intrusions and other abnormal environmental parameters by sending an auto-generated email using WI-FI module and same copy of data will be stored on cloud so that it can be used for further investigations. The user can access this data from anywhere remotely and can have track of his home safety [35][36].

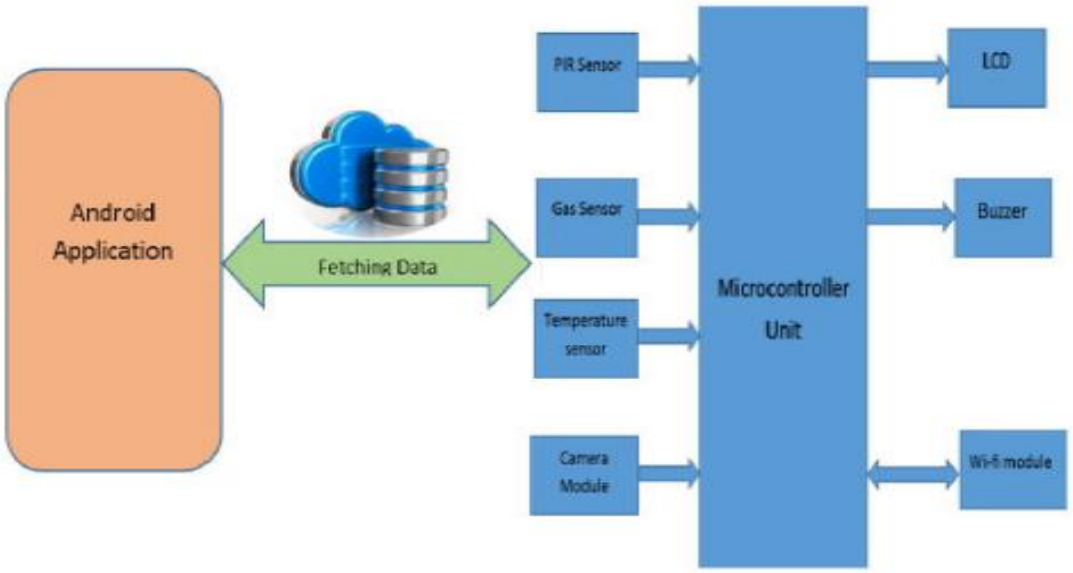

Figure 1: Architecture of Home Alert System [36]

2.8 GSM Based Home Automation System

This paper is based on the system that controls a home using GSM network, the internet and through speech. As a change in the status of the devices occurs, the user is informed in real time. The user commands are transferred to a server which is usually done by a PC. The server processes the user commands and sends them to the relevant units [30]. GSM is used as a communication medium to help establish connection in places where there may not be proper internet connectivity. The server uses AT commands to communicate with the GSM modem. The mobile interface is developed using J2ME. The server has 4 engines running – the web server, database, main control program and speech recognition program. The system can be controlled using SMS. It can send confirmation messages [36].

Speech processing is done with a dynamic time wrapping algorithm. Each application node has four parts – the transmitter, receiver, I/O device and a microcontroller. The main control program in the server takes status information from the devices' transceiver in real time. The system makes use of a PIC16F887 microcontroller for home appliances control. The hardware components include an Atmel microcontroller, which is connected with a RS232 serial port. It also has EEPROM memory to ensure that the relevant details are stored. An Arduino board is the controller used to interface the appliances. The client is a PC that is connected via USB to the Bluetooth module, sensor circuit and a pulse width modulation circuit. Sensors and actuators are used to control the circuit. Bluetooth devices can scan and detect other devices easily and to check whether devices are working properly or not. The system also has an illumination sensor that can turn on lights when external light is dull and a temperature sensor [30][37].

2.9 Phone Based Home Automation

It provides a system for a smart home that includes facilities such as a system controller, house wide wiring and a common interface. A hardware based remote controller for power point control has been described in this paper. The function of this remote controller is to control the power supplied to devices at a remote location. This system uses the telephone line for transmitting the commands. The controller is a logic system built entirely of hardware. It uses a DTMF transceiver which is interfaced with a solid state relay to control the power supply [36]. It could be implemented experimentally with infra-red signals and AC power line carrier technology as well. There are three components in the system. The first is the DTMF receiver and ring detector. The second part is the IO interface unit. The third part is the PC which does the online operations. The PC detects the ringing of the line and then authenticates the user. The user are then allowed to use the keypad tones to control the devices as required. The major drawback is that the number of appliances is limited by the number of keys in the keypad. An ordinary phone usually has 12 keys only [38].

2.10 Bluetooth Based Home Automation System

Bluetooth technology makes use of an Arduino Bluetooth board and is secured and cost effective. An interactive python program is used in the cell phone to provide the user interface. The I/O ports of the Bluetooth board and relays are used for interfacing with the devices which are to be controlled. The Bluetooth is password protected to ensure that the system is secure and not misused by any intruders [31]. The Bluetooth has a range of 10 to 100 meters, 2.4 GHz bandwidth and 3Mbps speed. A feedback system will report status of devices after every signal toggle. The main drawback with respect to Bluetooth is that it takes a long time to discover and access devices in its vicinity. It does not provide energy conservation tips. Real time access cannot be achieved. Anywhere access to the devices cannot be achieved. Access is limited to within the Bluetooth range [32][37].

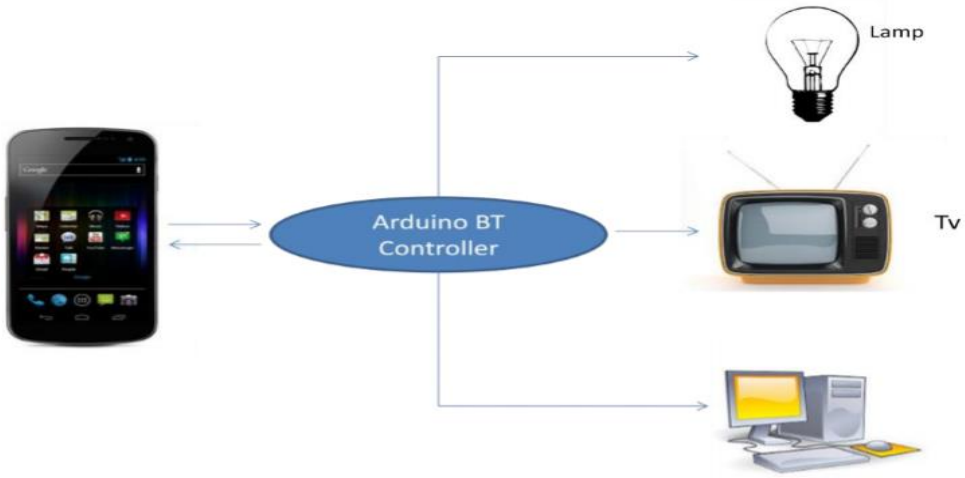

Figure 2: Block Diagram of Bluetooth Based Home Automation [37]

2.11 ZigBee Based Home Automation

ZigBee is a wireless communication based home automation system. The system uses PIC microcontroller and voice recognition for this purpose. The voice commands are taken from a mike [39][40]. They are compared with a voice store and processed. The PIC microcontroller then transmits the commands through ZigBee to the receiver. The receiver unit has another PIC microcontroller that can

process the command. It uses relays to control the respective appliances. This system has the drawback that ZigBee is a low range communication medium. So remote access is hindered from faraway locations. This system has added feature of smoke detection. When smoke is sensed, it sends a message to the user's built-in mobile number [41][42].

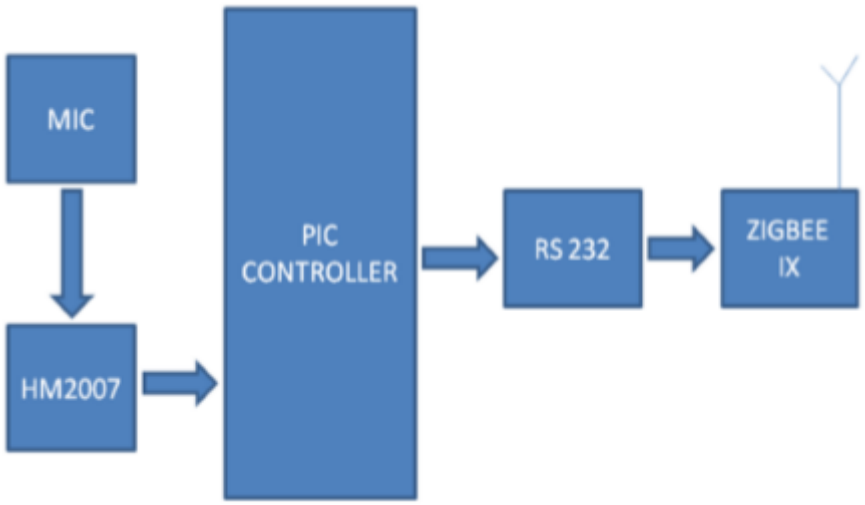

Figure 3: Block Diagram of Transmission Unit [41]

2.12 Wireless Control System

This system uses wireless communication made by linking up stand-alone appliances that are present at home or in office and integrating to form a c-operating network. A combination of various technologies like Wi-Fi and Bluetooth are used to integrate the system. The universal Plug and play capability is used to provide a transparent network of devices to the user. This system makes use of the Open Service Gateway Interface (OSGI) [43][44]. The appliances are connected via different networking technologies. The user application layer makes use of web browsers, pocket PC application and a central console. Speech based commands can also be used for controlling the appliances. Advanced features are provided such as device discovery and device connection. The entire system is implemented in a Linux platform. The system also has the ability to add intelligent

control modules. These control modules are capable of knowledge capturing and pattern recognition. The universal plug and play system uses many standard protocols for interoperability. The main advantage of the system is its interoperability. Another advantage is the dynamic discovery of the service. It also has the ability for sharing of service [45][46].

2.13 Gas Detection Using MQ7 Gas Sensor

MQ7, in this project, is used for CO-collection detection in houses, factories and underground operations. The size of MQ7 is 3.5cm X 2.2cm (1.4inch x 0.9inch).This sensor can detect leak within the range of 10 to 1000 ppmm zone. 100ppmm co is the characteristic gas of MQ7. Its sensitive resistance is from 2K to 20K in 100ppm co. Its sensitivity from below 3% up to exactly 3%. The response time it requires is less than or equals to 1s. Similarly, its recovery time is less than or equals to 30s. Its heating resistance is 31Â±3, heating current is less than or equals to 180mA, heating voltage is 5.0VÂ±0.2V /1.5Â±0.1V and heating power is about 350mW. The conditions this sensor requires are as follows:

- Conditions: Ambient Temperature:-20C~+50C
- Humidity: <=95%RH
- Oxygen Content: 21% [12][48]

2.14 Wireless Connection Through Wi-Fi Module 802.11

This modules' pre-certified design, small footprint, and rich features make them perfect for network applications such as smart energy, home monitoring, sensor networks, and home control. This stand-alone WLAN (IEEE 802.11 b/g/n) module is used to provide a powerful solution for a simple and fast way to embed Wi-Fi for cloud-connectivity in this project. S1 WLAN Module is designed to operate in 2.4GHz ISM frequency band, it applies a highly integrated MAC/BBP and RF

single chip RT3070 with 150Mbps PHY rate supporting. It fully complies with IEEE802.11n draft 3.0 and IEEE802.11b/g feature. S1 is low power consumption and low-cost compact WLAN module. This module can be built-in other embedded applications due to which it can easily be entrenched within our project [47]. Following are the environment that this module requires to operate effortlessly:

- Operating temperature: 0^{o} C to $+50^{o}$ C
- Storage temperature: -20^{o} C to $+85^{o}$ C
- Operating humidity condition ranges from 20% to 80% (non-condensing)
- Non-operating humidity condition including warehouse ranges from 20% to 80% [48]

2.15 ESP 8266 Wi-Fi Module

This Wi-Fi module uses 802.11 b/g/n protocol and Wi-Fi Direct (P2P) as well as soft-AP. It has integrated TCP/IP protocol stack as well as integrated TR switch, balun, LNA, power amplifier and matching network [47]. It has integrated PLL, regulators, and power management units. This module produces +19.5dBm output power in 802.11b mode. It has an integrated temperature sensor. It also supports antenna diversity. Power down leakage current of ESP8266 Wi-Fi module is less than 10uA. Integrated low power 32-bit CPU could be used as application processor. It has SDIO 2.0, SPI, UART and STBC, 1×1 MIMO, 2×1 MIMO with A-MPDU & A-MSDU aggregation & 0.4μs guard interval. The module wakes up and transmits packets in less than 2ms. Its standby power consumption is less than 1.0mW (DTIM3) [49].

2.16 Virtuino

Virtuino is a free software application from the System Maintenance subcategory, part of the System Utilities category. The app is currently available in English and it was last updated on 2016-10-25. The program can be installed on Android. Virtuino app is used to control Arduino over BLUETOOTH, control Arduino over INTERNET (Ethernet shield or ESP8266), control Arduino over WIFI (ESP8266), control Arduino with SMS, control internet of things server - ThingSpeak data monitor. It can control at the same time more than one Arduino boards, this can visualize your Arduino project. Virtuino provides visual interfaces with widgets like LEDs, buttons, switches, value displays, instruments, regulators etc. It is easy to use. You need to add only two or three lines to your Arduino code [21][50].

2.17 ThingSpeak Server

ThingSpeak is an Internet of Things (IoT) platform that lets you collect and store sensor data in the cloud and develop IoT applications. The ThingSpeak IoT platform provides apps that let you analyze and visualize your data in MATLAB, and then act on the data. Sensor data can be sent to ThingSpeak from Arduino, Raspberry Pi, BeagleBone Black, and other hardware. Many IoT projects collect data from a sensor and send the data to ThingSpeak at the same time over and over [22]. To continuously collect and send data to the cloud requires the device to be powered and connected all of the time. A battery-powered IoT device like a Particle Photon or Onion Omega2 would run out of power quickly. There are many IoT applications where you want your IoT device to collect the data offline over a long period of time, then send the data all at once to ThingSpeak for analysis. The ThingSpeak team at MathWorks is excited to announce Bulk-Update! This new ThingSpeak feature is targeted at IoT devices trying to optimize battery use by allowing the device to update a lot of data at once. To help you get started with bulk-update, we have written examples for Arduino, ESP8266, Particle Photon, and the Raspberry Pi 3 [51].

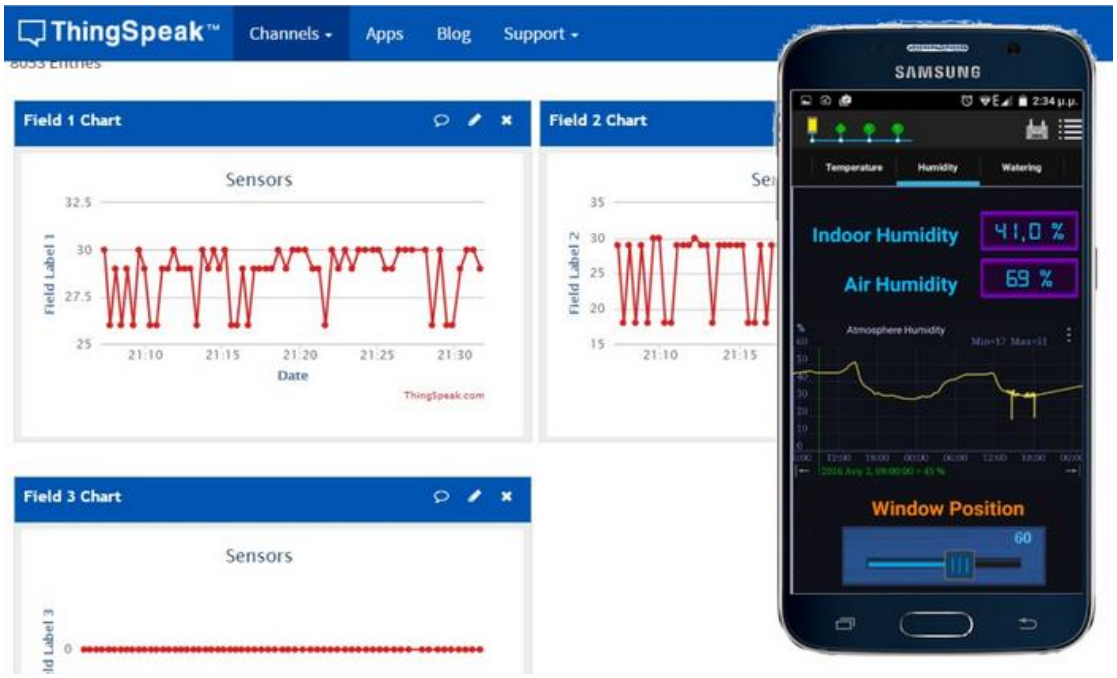

Figure 4: ThingSpeak IoT Virtuino Monitor (Arduino +Ethernet Shield) [52]

Different techniques for home automation system have been surveyed. Different author gives various techniques with block diagram, flowchart and their explanation with proper layout of successful execution with adequate strengths and weaknesses.

There are various major strengths and weaknesses drawn from the conclusions laid by various researchers [18].

Major strengths:

1. Exhaustive research has been carried out on Internet based Monitoring scheme with various protocols and systems providing detailed description of remote process states to the authorized users.

2. Many remote monitoring systems have been designed and experimented by using GSM/SMS which normally involved the use of GSM (Global System for

Mobile Communication) modem for carrying sensing and control of devices in the system by users having cellular coverage. It is popular because of its unparalleled availability and modest security at the affordable price.

3. Numerous systems have been developed using Wireless Sensor Networks which consists of several sensor nodes in proximity and having data transmission and reception capability between nodes and central base station for wide range of applications. Though initial deployment cost may be high, the operational cost of data communication within the system is negligible [20] [21].

Major Weakness:

1. Most of systems based on Internet monitoring require higher operational cost based on bandwidth / data speed requirements and hence is justified only in industrial or biomedical applications in developing countries. These systems generally do not have alert facilities against occurrence of abnormal conditions. User needs to have PC / smart phone / PDA with suitable software support. Security vulnerability is the most striking alert point of Internet. No malicious party should ever gain control of system. Web usage requires resources like flawless Internet connections and hosting servers, which may not always fit to the concept of remote controlling.

2. The development and deployment cost of wireless sensor networks is very high due to need of motes, sensors, radio transceivers, etc. spread over a large area.

3. It is difficult to upgrade existing conventional control systems with remote control capabilities.

4. The GSM modem used in cellular based remote monitoring system increases the cost of the system.

5. The long term operational cost of Internet and cellular monitoring systems is relatively high due to usage charges incurred in each message transaction [20] [21] [22].

CHAPTER 3: SYSTEM DEVELOPMENT

3.1 Project Management Strategy

Project management is related with aligning the right resources to deliver the right projects at the right time. A project management is the appropriate application of knowledge, tools, skills, technology, time, budget and human resource to produce specific result [53]. Project management starts from the project initiation where the team members need to identify the tools, techniques and resources required to develop the project [17]. The authors allocate the project team and divided the roles and responsibilities among the team members for the smooth functioning of the project.

3.1.1 Project Workflow and Schedule

- Team Size: 2
- Total effective project duration (in weeks): 11

3.1.2 Project Team

Resource	Role
Mr. Vishnu Kumar Rana	Project Supervisor
Abhishek Tamrakar	Designer/ Developer
Dikita Tuladhar	Designer/ Developer

Table 3: Project Team

3.1.3 Roles and Responsibilities

The different roles and responsibilities were divided among the team members depending upon their knowledge and skills. The supervisor initiated the project's various aspects and enhanced project quality through effective mobilization and encouragement of the team members as well as controlling overall project [53]. The team members have the responsibility to do the research and find out the solutions to meet the predefined objectives.

Roles	**Responsibilities**
Supervisor	• Help understand performance and goal • Provide essential information • Track the progress of the project • Provide real-time feedback • Share the information and experience • Assist in resolving emergencies • Motivate and encourage the team members
Team Members	• Understanding the purpose and objective of the project

	• Working to timescales and within cost constraints • Conduct extensive research and analysis • Identifying issues and risks • Design • Development • Test • Implementation • Documentation

Table 4: Project Roles and Responsibilities

3.2 System Analysis

Successful implementation of the system depends on the well-executed system analysis and design effort. System analysis is the procedure of studying the system and its components to build the better system to avoid the failure [54].

The stakeholders in this system are the users or the house owners and the application developers. The user of the application is the responsible for controlling the home appliances using the android application from anywhere using the internet. The main user of the application are the house owners who can control and

operate the system. The administrator of the application is responsible for maintaining the system.

3.2.1 Functional Requirements

- The system should have user friendly UI.
- The user should be able to monitor the home appliances.
- The user should be notified properly.

3.2.2 Non-Functional Requirements

- System should not carry any ambiguity regarding the operational features.
- System should run smoothly.
- System should not crash.
- System must work with existing resources and achieve the objectives.

3.3 System Design

System design is to bring down the knowledge of requirements and analysis to design the software product. Design is the phase to set up the hardware and build the UI for the application .The design of the application must address the requirements set in the initial stage of the application development. Various diagrams such as system architecture, system flow chart, context diagram, data flow diagrams, use case diagram and sequential diagram were created in the design phase to make the development process much easier [18][53]. The graphical representation of the project makes us able to have the overview of the system and its various structural and functional aspects. The development phase is hugely assisted by the design of various components that form the crucial part of the

application. The design part however excludes any association with the code that builds the application. The design of the application is done with the help of various tools and hardware available in the market. An application designed with considering all the aspects of the system development results in structurally and functionally proper application [54].

3.3.1 Conceptual Idea

The idea behind the project, "**Ghar Niyantran: IoT based Home Automation System for Home Safety**" is to develop a home automation system that allows to monitor the LPG leakage remotely through the help of Virtuino Platform. It is also responsible to provide a notification to the user about the gas leakages at home or office or anywhere this application is embedded to. An ESP module acts as the middleware that make a communication between user at remote position through Android Phone and Hardware system setup at home.

3.3.2 Basic Architecture of a System

The basic and overall architecture of the system is shown in Figure 3.

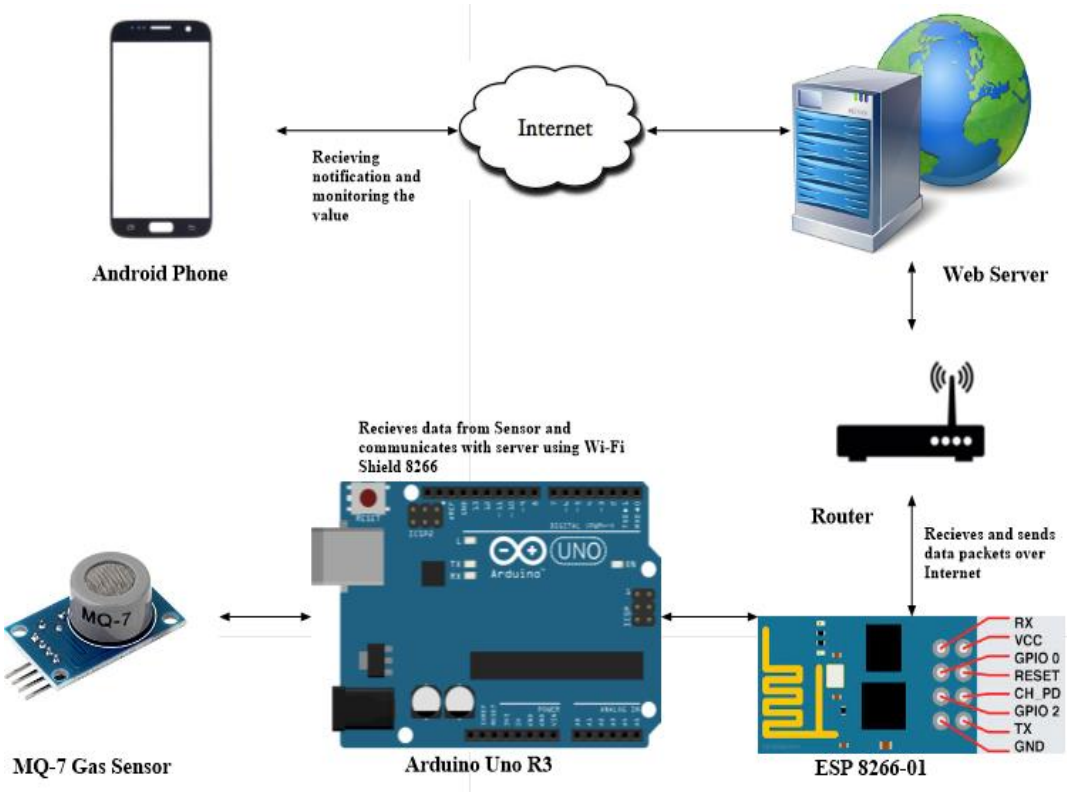

Figure 5: Architecture of the System

The diagram in Figure 5 represents the components and working flow of Internet based Gas Monitoring System. The MQ-7 Gas Sensor is connected to Arduino. Arduino processes the input signal and determines the level of gas in terms of Voltage (V). Using ESP module, Arduino establishes connection with ThingSpeak Web Server to send the level of gas in the atmosphere to the server. By using API of server, the Virtuino android application can retrieve the server channel data and display using various tools.

3.3.3 Design and Development Tools

Various design and development tools were used for the successful completion of the project. Different simulating software and hardware tools are used in the project. Table below presents short information about different design and development tools and their roles in the project.

Design/Development Tools	**Description / Roles in Project**
Arduino IDE	The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code that needs to be uploaded to Arduino Microcontroller [19]
Arduino Microcontroller	Open Source Microcontroller that is responsible to store a program and simulate other associate devices and sensors based on that program code [26]
MQ-7 Gas Sensor	To detect the LPG leakage and send the sensor data to Arduino IDE through Microcontroller [12]
ESP 8266 Modules	Wi-Fi shield that can be used as Access point or station to make a wireless communication over an internet or local network. In this project it is used to send and receive HTTP message to and from the Arduino and send HTTP GET request to server [49]
ThingSpeak Server	ThingSpeak, an Internet of Things (IoT) platform, that lets you collect and store sensor data in the cloud and develop IoT

	applications as well as allows analyzing and visualizing of data in MATLAB, and then act on the data [22]
Virtuino Platform	To develop an android application that communicates with server (ThingSpeak) [21]
Android Platform	To run the android application [46]

Table 5: Design and Development tool for the project

3.3.4 Flowchart

3.3.4.1 From Users Perspective

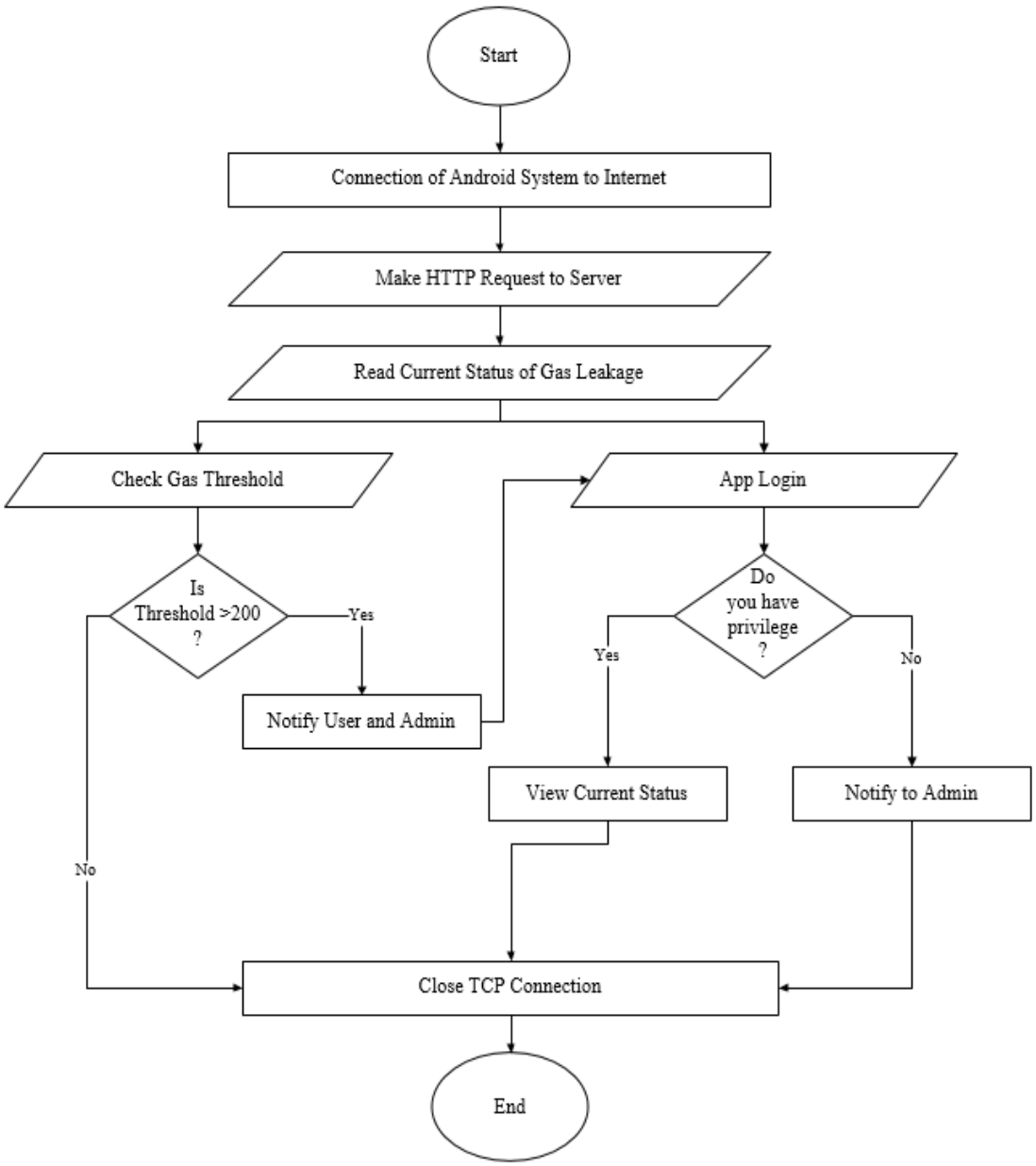

Figure 6: Flow Chart (From User's Perspective)

The diagram in Figure 6 represents the flowchart that shows the working of Home automation system from user's perspective. To monitor LPG leakage remotely, firstly user through Virtuino Platform connects to the internet. HTTP request is made to the ThingSpeak server through Android Application to know the status (i.e. level of gas leakage in the atmosphere) of the LPG-based appliances running at home. Arduino on the other end, receives the status from the ESP Module with the help of Wi-Fi module (ESP8266). The received status is then compared with the specified threshold which when crossed is notified to the user through the app [55].

3.3.4.2 From Hardware Perspective

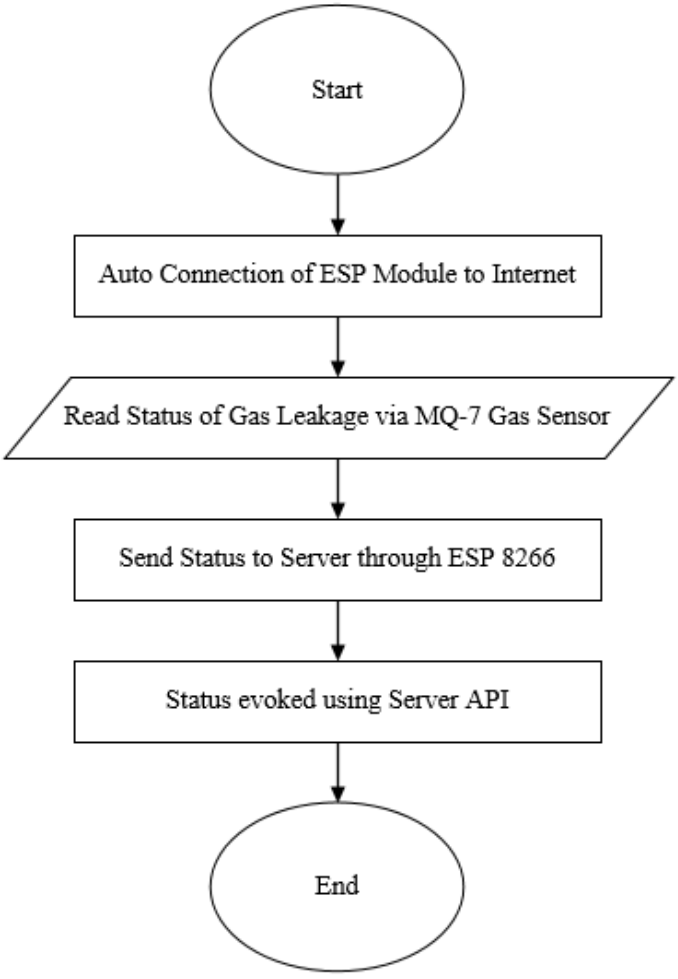

Figure 7: Flow Chart (From Hardware Perspective)

The diagram in Figure 7 represents the flowchart that shows the working of Home automation system from Hardware's perspective. Wi-Fi shield attached to the Arduino is setup to auto connect with the internet. Arduino then reads the status of gas leakage through MQ-7 gas sensor. The status is then send to ThingSpeak server though ESP 8266 by making a HTTP request through Wi-Fi Shield. The status from the ESP Module is then invoked by server API to be able to monitor remotely [55].

3.3.5 Context Diagram

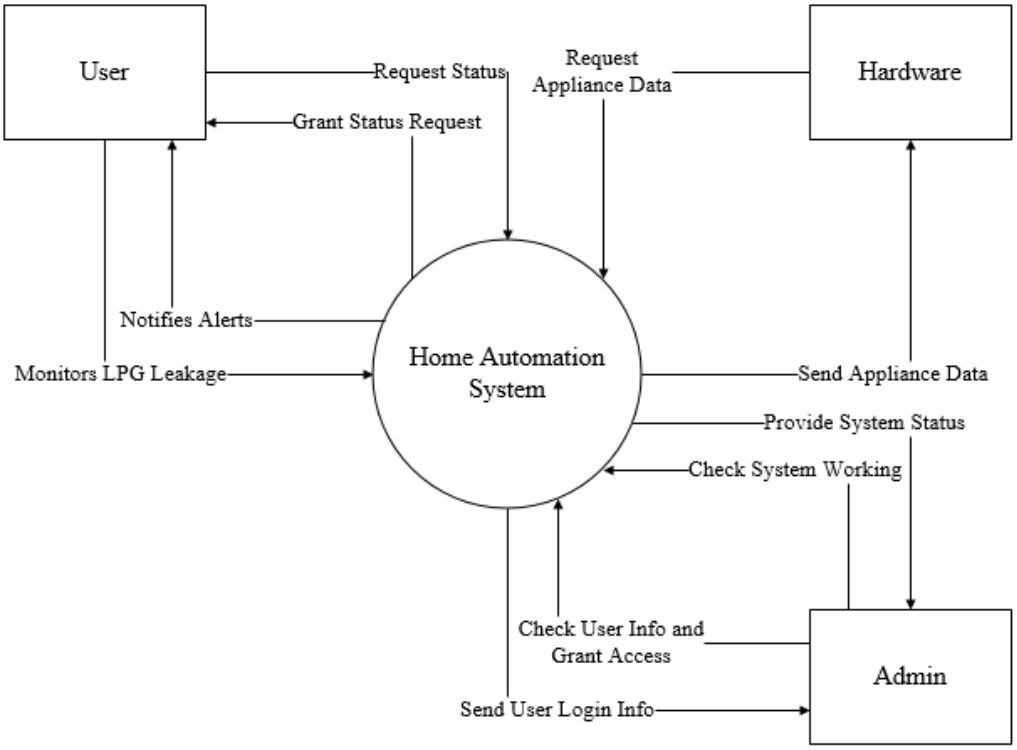

Figure 8: Context Diagram

A System Context Diagram (SCD) in system engineering is the diagrammatic representation that defines the boundary between the system, or part of a system, and its environment, showing the entities that interact with it. This diagram is a high level view of a system. It is similar to a block diagram [56].

The diagram in Figure 8 shows the context diagram of the system. According to the Figure, the system shows the relationships of three entities- User, Hardware and Admin with the Home automation system. User request status data from the System and system grants the request to the user. Once the request is granted, user can monitor the LPG level and gets notification if there happen to be any leakage [57].

Appliance data are requested by the hardware to the system and in return, system provides data to the hardware.

The home automation system provides the admin with user login information and system status. Admin is responsible to check user information and maintain the overall working of the system.

3.3.6 DFD Level 0

DFD is a graphical representation of conveying how information data flows through systems and how that data is transformed in the process. DFDs, are important particularly when one require a clear understanding of the boundary between existing systems and postulated systems [58].

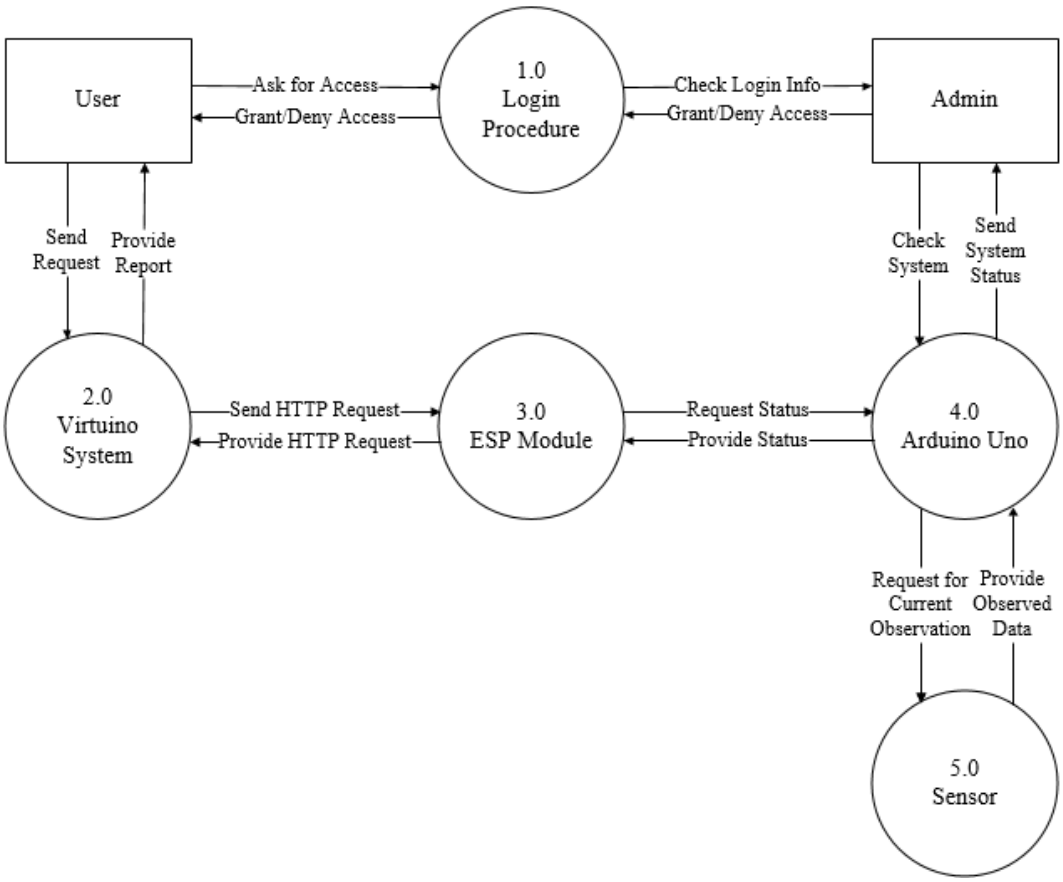

Figure 9: DFD Level 0

The diagram in Figure 9 represents the Data Flow Diagram (DFD) decomposed to level 0. Once the access is granted, the user sends and receives request through Virtuino System. Virtuino system is responsible to send HTTP request to ESP Module and get HTTP request back from it. Then, ESP receives the signal from the Arduino Uno. Admin, on the other end, can also receive system status from Arduino Uno. It also check and maintain the system. Arduino Uno provides all the information through sensor.

3.3.7 DFD Level 1

3.3.7.1 DFD Level 1 of Process 2.0

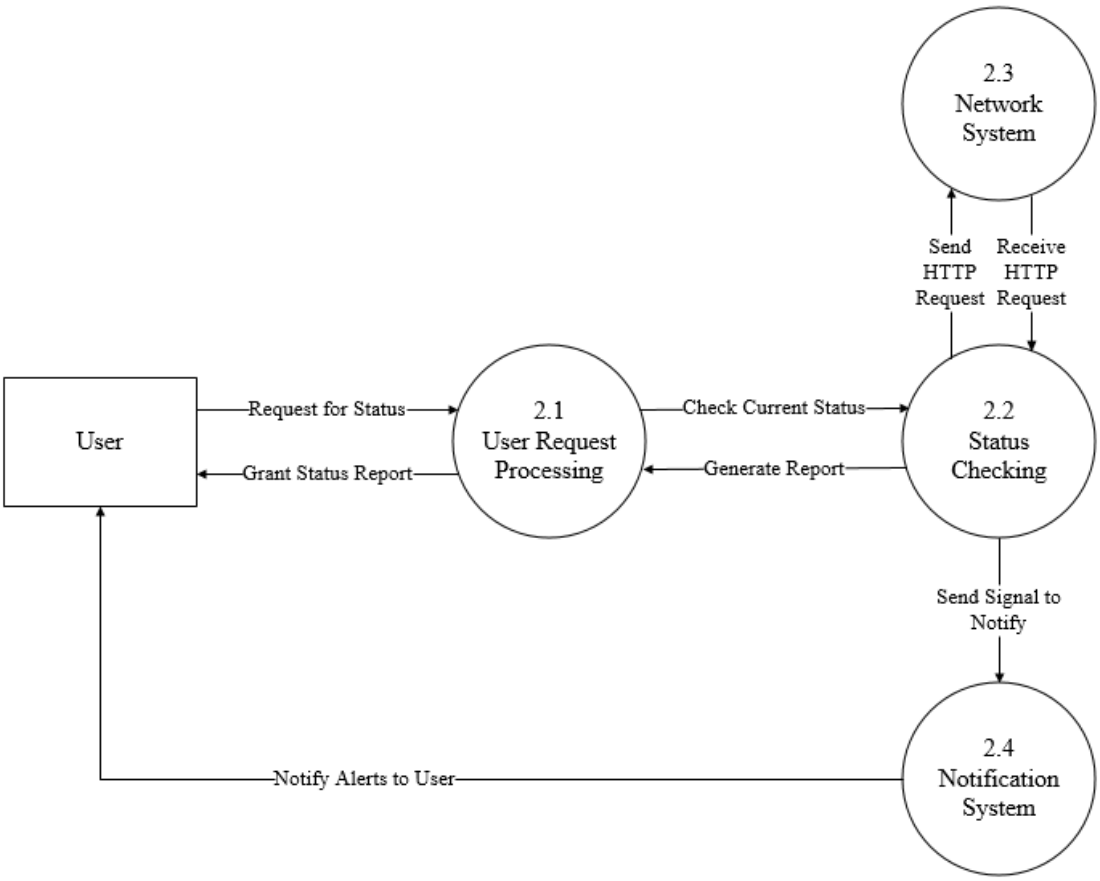

Figure 10: DFD Level 1 of Process 2.0

The diagram in Figure 10 shows the DFD Level 1 of Process 2.0 to illustrate the working of Virtuino System where a user interacts with several sub system of overall system. User Interacts with User Request Processing system, which in turn, receives the system status from Status Checking and Notification System for accurate notification about the leakage. Similarly, Status Checking interacts with Network System to send and receive HTTP Requests and signals the Notification System to notify.

3.3.7.2 DFD Level 1 of Process 4.0

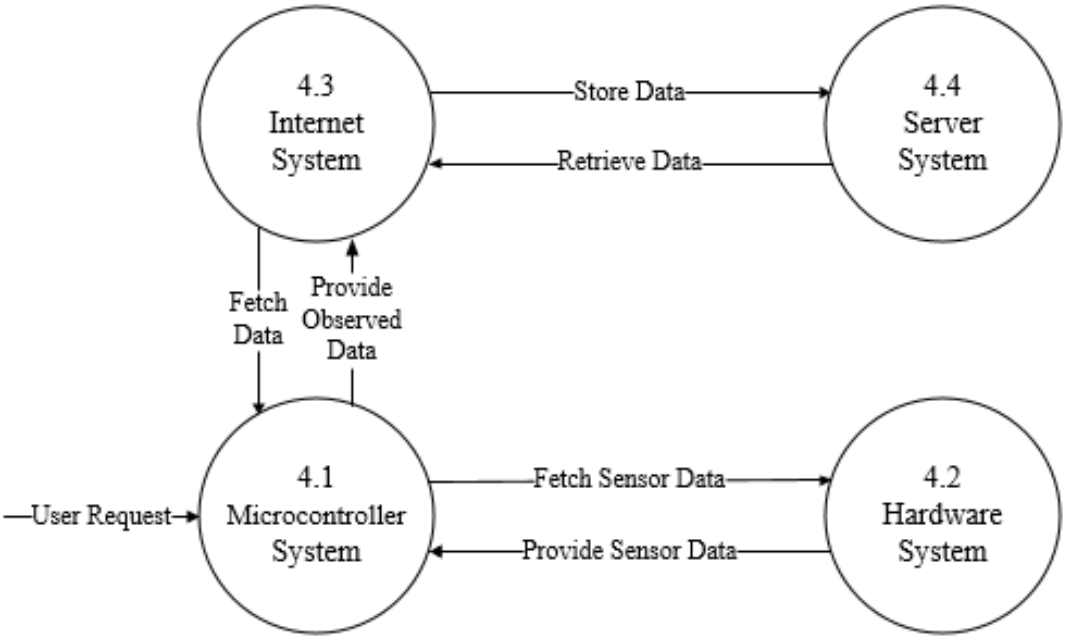

Figure 11: DFD Level 1 of Process 4.0

The diagram in Figure 11 represents DFD Level 1 of Process 4.0 to illustrate the internal working of Arduino Uno. The user's request is processed through various sub-systems. The Microcontroller System interacts with Hardware System and Internet System to fetch for sensor data and observed data, respectively. Internet System stores and receives data through server (ThingSpeak).

3.3.8 Use Case Diagram

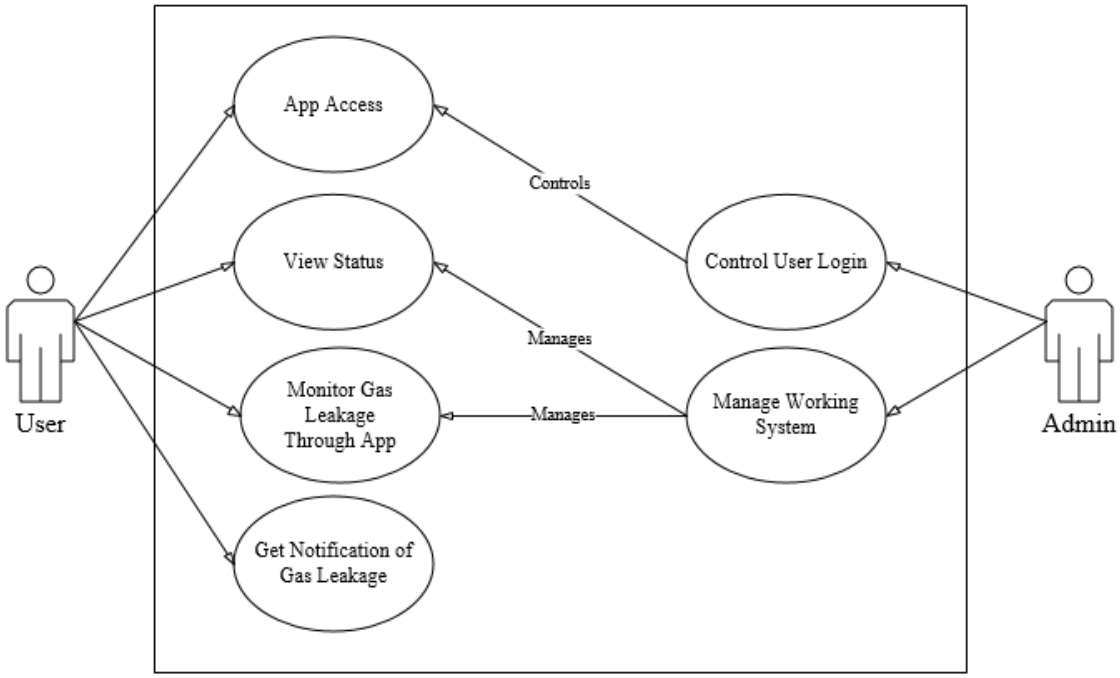

Figure 12: Use Case Diagram

The diagram in Figure 12 represents the Use Case Diagram of the system. It simply shows a graphical depiction of the interactions among the elements of a system i.e. User and Admin. Use case is helpful to identify, clarify, and organize system requirements. Above diagram shows that user can access the application, view and monitor the gas leakage and get notification of the leakage. On the other hand, Admin can manage and maintain the system as well as control user login.

3.3.9 Sequence Diagram

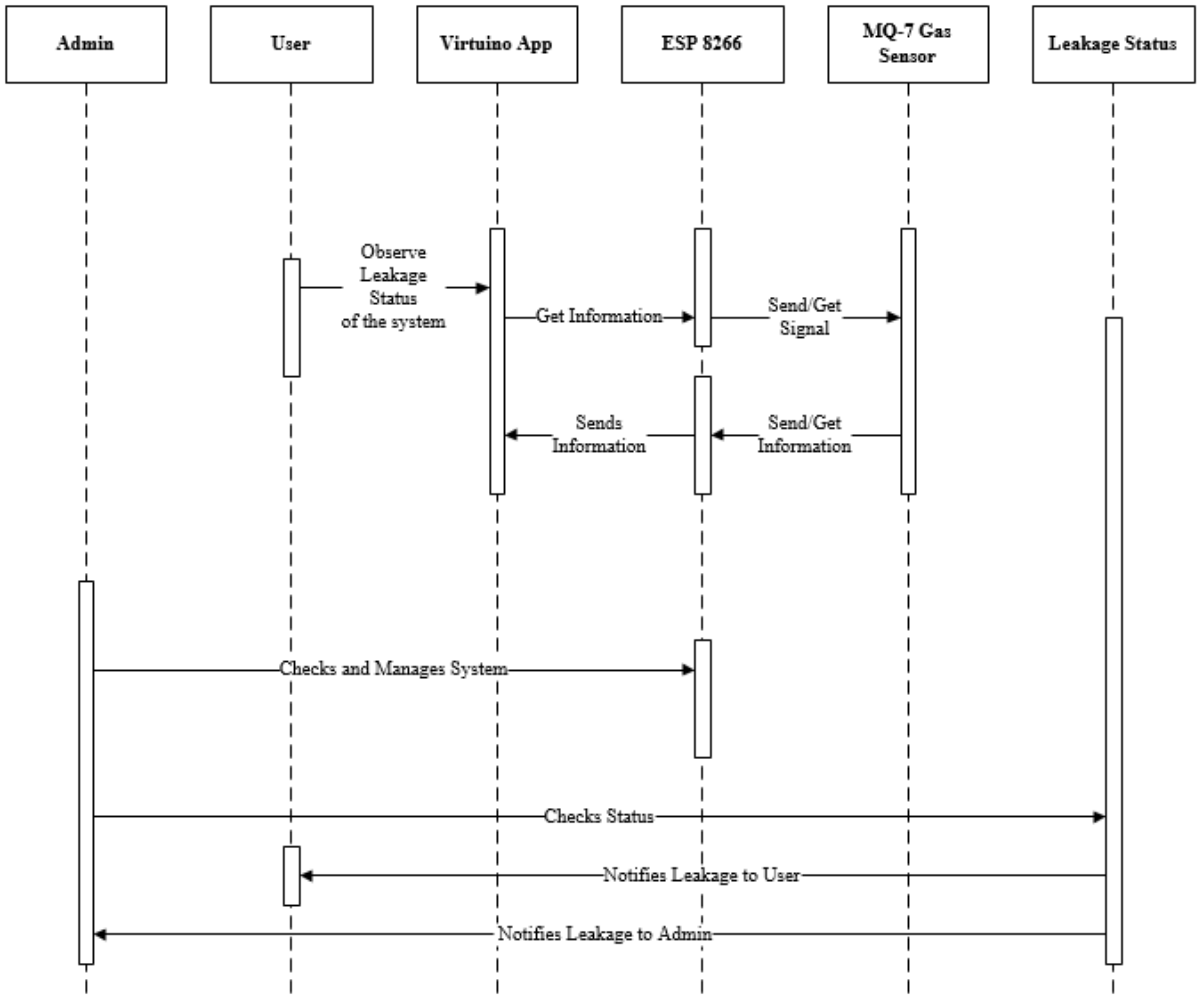

Figure 13: Sequence Diagram

The diagram in Figure 13 represents the sequence diagram of the system. According to above Figure, user observes the status of leakage through Virtuino Application. Virtuino Application gets the status information through ESP 8266 which reads the value from MQ-7 Gas Sensor. Sensor also reads the status information from the ESP. Similarly, Admin checks and manager the overall system. Leakage is notified to Admin and the User.

3.4 Time Schedule and Gantt Chart

3.4.1 Time Schedule

TIME SCHEDULE				
Task No	Task Name	Planned		Duration(in Days)
		Start Date	End Date	
1	Preliminary work	05/05/17	08/06/17	
1.1	Planning for the Project	05/05/17	05/07/17	3
1.2	Analysis of the topic	05/08/17	05/10/17	3
1.3	Discussion with supervisor	05/11/17	05/12/17	2
1.4	Background reading	05/13/17	05/16/17	4
1.5	Preparation of Project Proposal	05/17/17	05/21/17	5
1.6	Preparing Gantt chart and Project schedule	05/05/17	08/06/17	93
1.7	ToR Approval from supervisor	05/22/17	05/22/17	1
1.8	First Review (Milestone 1)	05/23/17	05/23/17	1
2	Research work	05/15/17	06/02/17	
2.1	Research on embedded system and ICT	05/15/17	05/20/17	6
2.2	Research on micro-controller Arduino	05/21/17	05/25/17	5
2.3	Research on Arduino with sensors	05/26/17	05/28/17	3
2.4	Research on Android connection to Arduino	05/29/17	05/30/17	2
2.5	Hardware Design Research	05/31/17	06/01/17	2
2.6	Second Review (Milestone 2)	06/02/17	06/02/17	1
3	Hardware and Software Analysis	06/03/17	06/10/17	
3.1	List and Cost estimation of hardware device	06/03/17	06/04/17	2
3.2	Planning devices and tools needed for design	06/05/17	06/06/17	2
3.3	Planning for software development tools	06/07/17	06/09/17	3
3.4	Third Review (Milestone 3)	06/10/17	06/10/17	1
4	Design	06/11/17	06/27/17	
4.1	Application Design	06/11/17	06/13/17	3
4.1.1	Data Flow Diagram	06/14/17	06/14/17	1
4.1.2	Use Case Diagram	06/15/17	06/15/17	1
4.1.3	Flow Chart Diagram	06/16/17	06/17/17	2
4.1.4	Design User Interface	06/18/17	06/19/17	2
4.2	Database Design	06/20/17	06/21/17	2
4.3	Hardware Design	06/22/17	06/26/17	5
4.4	Fourth Review (Milestone 4)	06/27/17	06/27/17	1
5	Implementation	06/30/17	07/17/17	
5.1	Program Coding in Arduino	06/30/17	07/16/17	18
5.2	Installation of Hardware devices	06/27/17	07/16/17	21
5.3	Fifth Review (Milestone 5)	07/17/17	07/17/17	1
6	Testing	07/18/17	07/24/17	
6.1	Validating system output	07/18/17	07/20/17	3
6.2	Purposed Design and Cost Analysis	07/21/17	07/21/17	1
6.3	Critical Analysis	07/22/17	07/23/17	2
6.4	Sixth Review	07/24/17	07/24/17	1
7	Dissertation	07/17/17	08/01/17	
7.1	Draft Report Writing	07/17/17	07/19/17	3
7.2	Final Report Writing	07/20/17	07/24/17	5
7.3	Report Evaluation and Conclusion	07/25/17	07/29/17	5
7.4	Submission of Final Draft copy Report	07/30/17	07/30/17	1
7.5	Correction of Final Draft copy Report	08/01/17	08/01/17	1
8	Final Phase	08/02/17	08/06/17	5
8.1	Final Documentation Printing and Binding	08/02/17	08/03/17	2
8.2	Approval of Final Draft	08/04/17	08/05/17	2
8.3	Final Documentation Submission to college	08/06/17	08/06/17	1

Table 6: Time Schedule of the project

3.4.2 Gantt Chart

Figure 14: Gantt Chart for the project

3.5 Testing

Software testing is a process of executing application with the intent of finding software bugs. It can also be stated as the process of validating and verifying that a software application meets the specified requirements that guided its design and development [59]. Hence, it is also known as the process of evaluating a software item to detect differences between given input and expected output. Testing assesses the quality of the product. Software testing is a process that should be done during the development process. [60][62].

3.5.1 Unit Testing

Unit testing is a software development process in which the smallest testable parts of an application, called units, are individually and independently scrutinized for proper operation. It is testing of an individual unit or group of related units. Each and every functional module is tested and analyzed separately to ensure that the information flows in and out as expected [63].

3.5.2 Integration Testing

Integration testing is the phase in software testing in which individual software modules are combined and tested as a group. It is a testing in which a group of components are combined to produce output. Also, the interaction between software and hardware is tested in integration testing if software and hardware components have any relation [64]. The errors were detected and analyzed by integrating all separate modules as one.

3.5.3 System Testing

System testing is the testing to ensure that by putting the software in different environments it still works. The purpose of this test is to evaluate

the system's compliance with the specified requirements. System testing is done with full system implementation and environment [61]. System testing is conducted for the project to evaluate the system with its specified requirements. In this testing whole hardware system as well as android application was tested to check the errors. The errors that arose during testing were checked and resolves accordingly [65].

3.5.4 User Acceptance Testing

User Acceptance testing is done in order to ensure whether the application and hardware system meets the user requirements or not [61]. During UAT, actual software users test the software to make sure it can handle required tasks in real-world scenarios, according to specifications. The user friendliness of app was checked through feedback of friends and colleagues. Also hardware system were tested in User acceptance testing mode.

3.6 Test Case

Following Testing process were carried out to verify the proper working Ghar Niyantran.

3.6.1 Test Case 1

Firstly hardware connection is shown where Arduino and ESP module are connected.

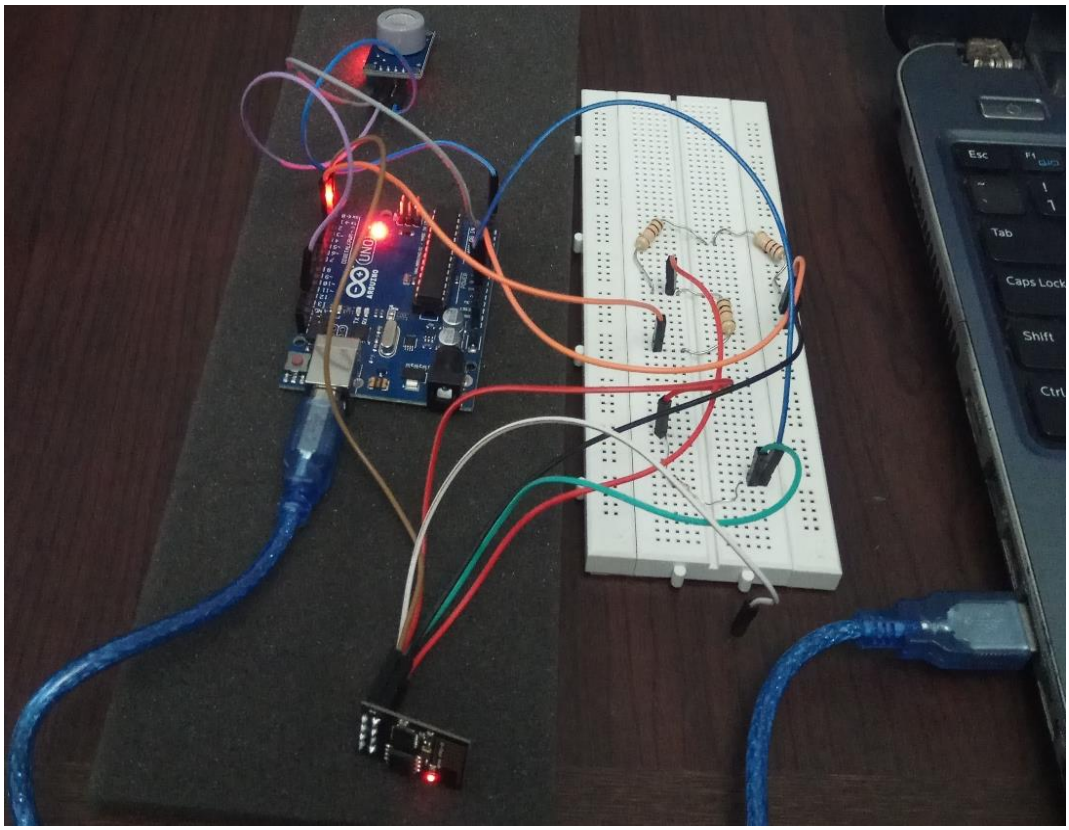

Figure 15: Test Case 1 (Image 1)

The image in Figure 15 shows the hardware setup where the Arduino is connected to ESP8266 module. The Arduino is powered by USB cable connected to laptop which in turn provides power to gas sensor and ESP8266 module.

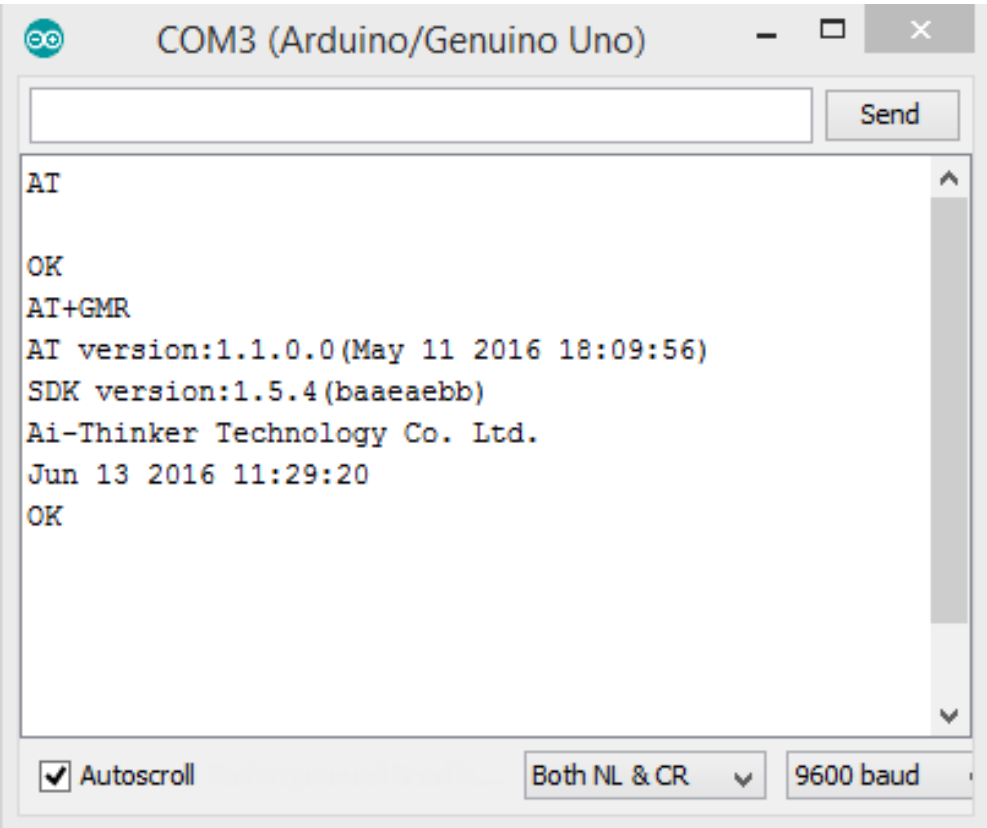

Figure 16: Test Case (Image 2)

The diagram in Figure 16 shows test connection between ESP module and Arduino through Arduino IDE Serial Monitor.

3.6.2 Test Case 2

For correct functioning of the system hardware system must be connected. After successful connection of hardware, then only android application will able to send the HTTP request to Arduino and receive back HTTP response from the Arduino through ESP.

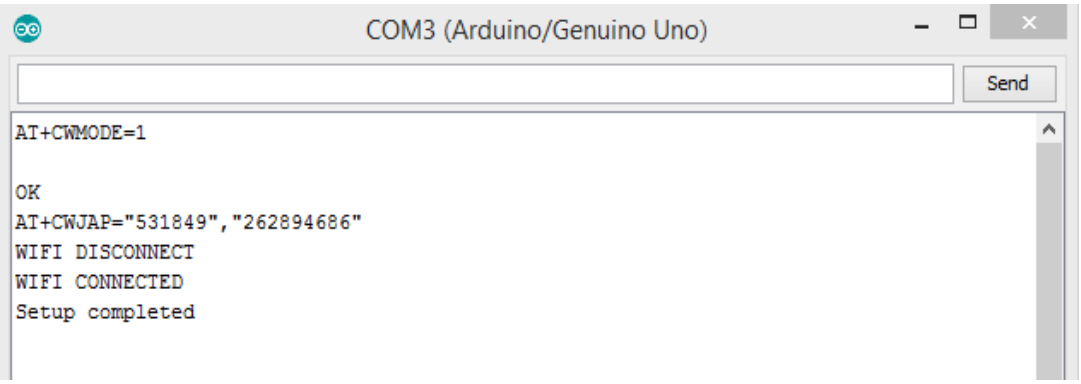

Figure 17: Test Case 2 (Image 1)

The image in Figure 17 shows the connection of ESP8266 module with Wi-Fi by invoking AT+CWJAP command with Wi-Fi SSID and Password.

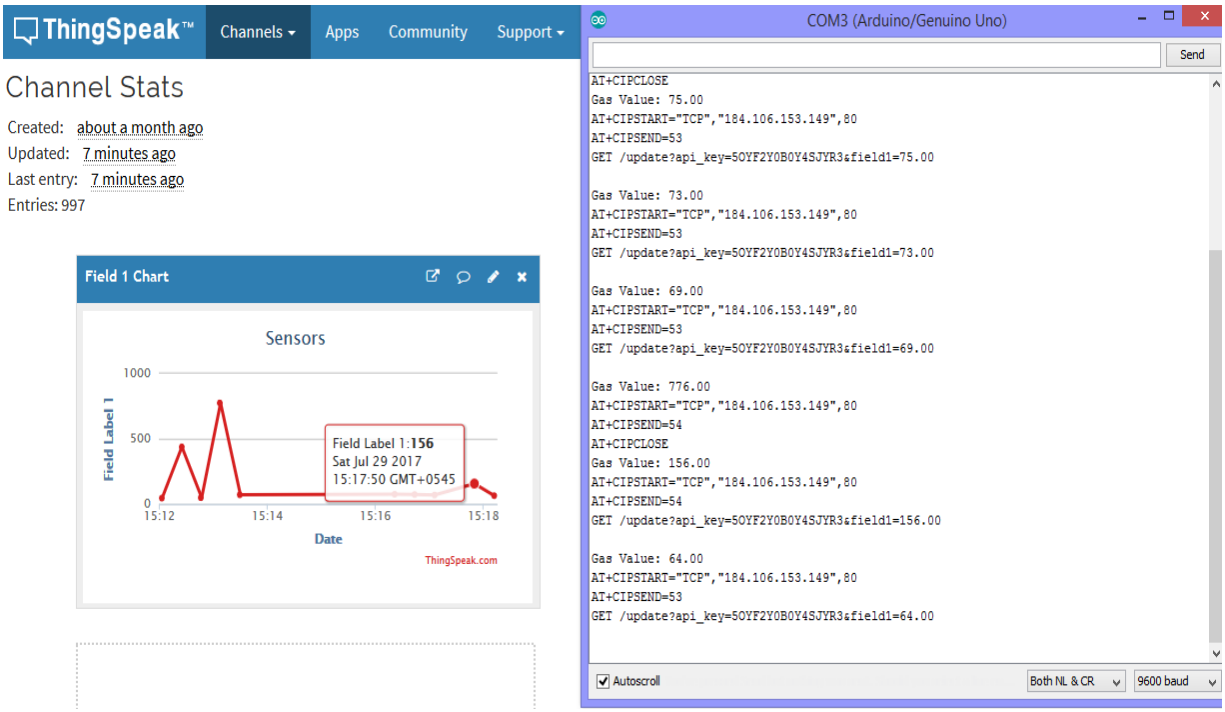

Figure 18: Test Case 2 (Image 2)

The diagram in Figure 13 Shows the gas being sent to the ThingSpeak server. ThingSpeak then successfully generates graph showing the representation of LPG value denoting the date and time of when the gas value was sent.

3.6.3 Test Case 3

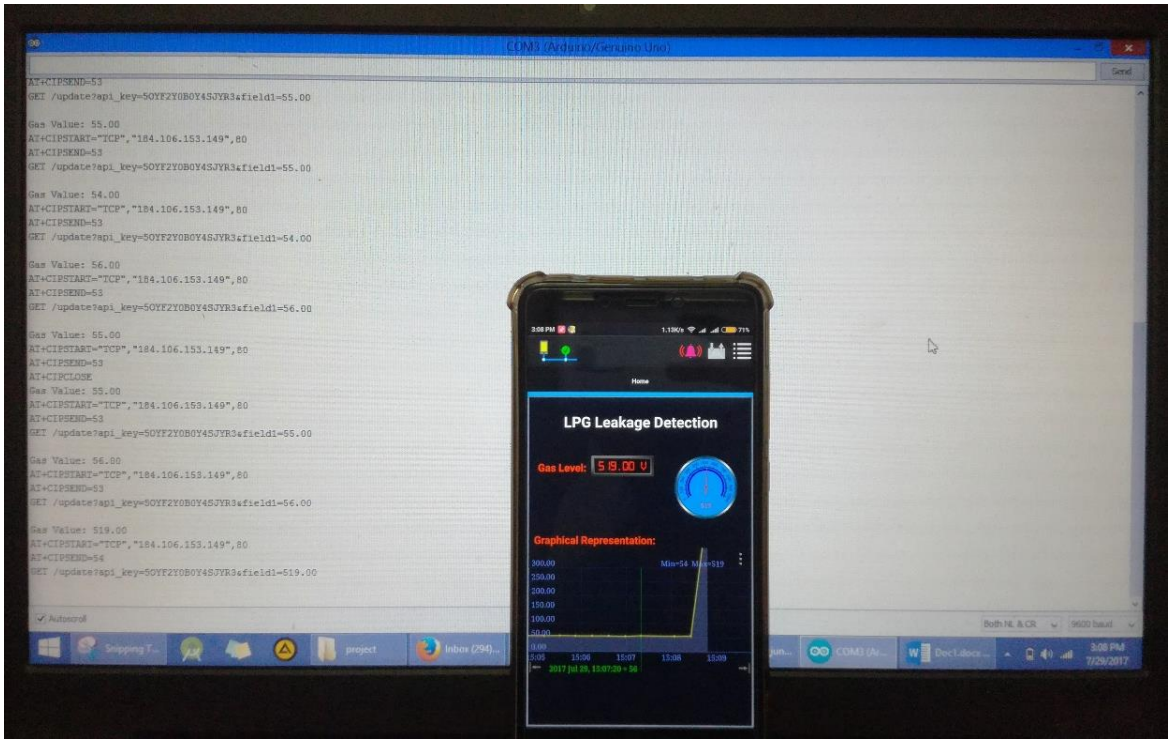

Figure 19: Test Case 3

The image in Figure 19 shows the gas value successfully being received by the Virtuino App Interface. Virtuino App displays the value in graphical representation, digital as well as analog display. The value is received through ThingSpeak server.

3.6.4 Test Case 4

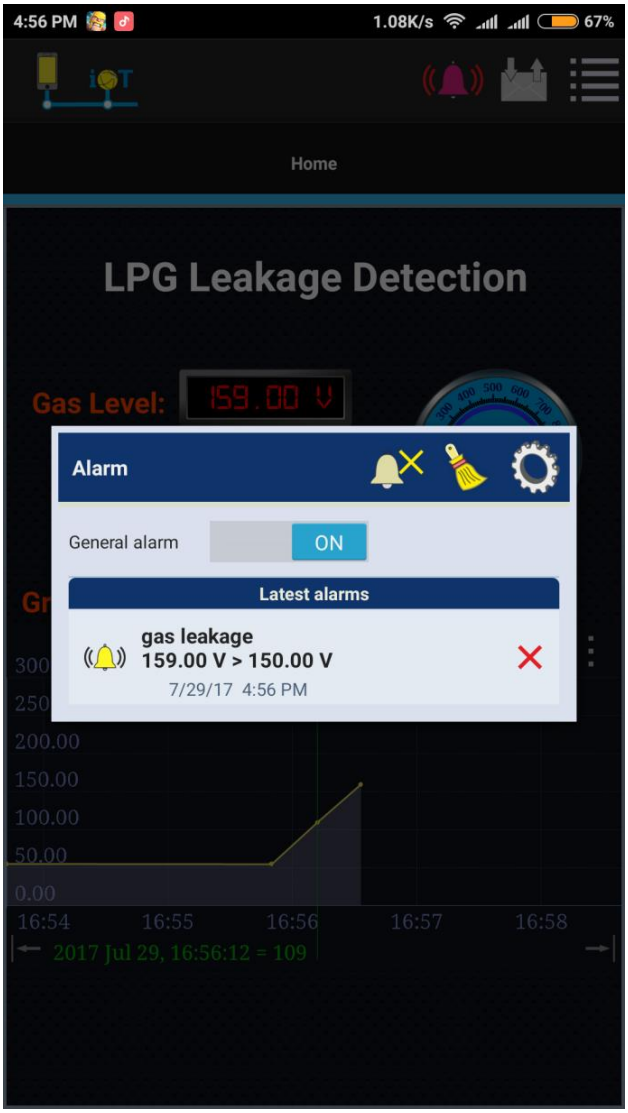

Figure 20: Test Case 4

The screenshot in Figure 20 shows the alarm being successfully notified to the user with a buzzing sound once the gas level reaches above the gas threshold.

3.7 Implementation Methods

The implementation of home automation in a particular home needs technical manpower. The project here is done focusing on main functionality of the system. While considering operational features during development, the system is not prepared to that level like a readymade product where non-technical person can setup the system [67].

Here are the steps that need to be followed to implement the home automation system in a particular organization, businesses or home.

3.7.1 Setup Hardware Connection

Arduino with ESP 8266 module along with MQ-7 gas sensors needs to be secured in the house. Arduino Pin configuration with Wi-Fi modules and Gas Sensor should be done as indicated in Arduino code.

3.7.2 Join Home Access Point

To make HTTP request and response, ESP 8266 module needs to be connected to the home Wi-Fi network. Arduino code needs to be recompiled with available home Access name and password.

3.7.3 Implement Remote Server

Remote Server that is ThinkSpeak Server is used, that serves as the gas sensor data storage which can be then invoked by the android application. The Arduino sets up TCP connection with ThinkSpeak server using ESP8266 module and sends gas sensor data to ThinkSpeak channel using ThinkSpeak Channel API key.

3.7.4 Android Application

To control the devices remotely and within the routers periphery, user needs to install android application. After installation of application user needs to connect to ThinkSpeak server for HTTP request and response. Android application is provided with digital value monitor and Graph to represent the leakage data.

CHAPTER 4: RESULT ANALYSIS

4.1 Results

The project, “Ghar Niyantran: IoT based Home Automation System for Home Safety” is able to monitor the LPG leakage remotely. In the project Virtuino platform is used to monitor the level of LPG at real- time and has the ability to notify the users in case of gas leakage through the application.

4.2 Screenshots and Function Prototype

4.2.1 Application Screenshots

4.2.1.1 Splash Screen

Figure 21: Splash Screen of application

The screenshot in Figure 21 represents the splash screen of the Virtuino android application. The splash screen takes about 3 seconds time duration to load before showing the monitoring screen.

4.2.1.2 Login Screen

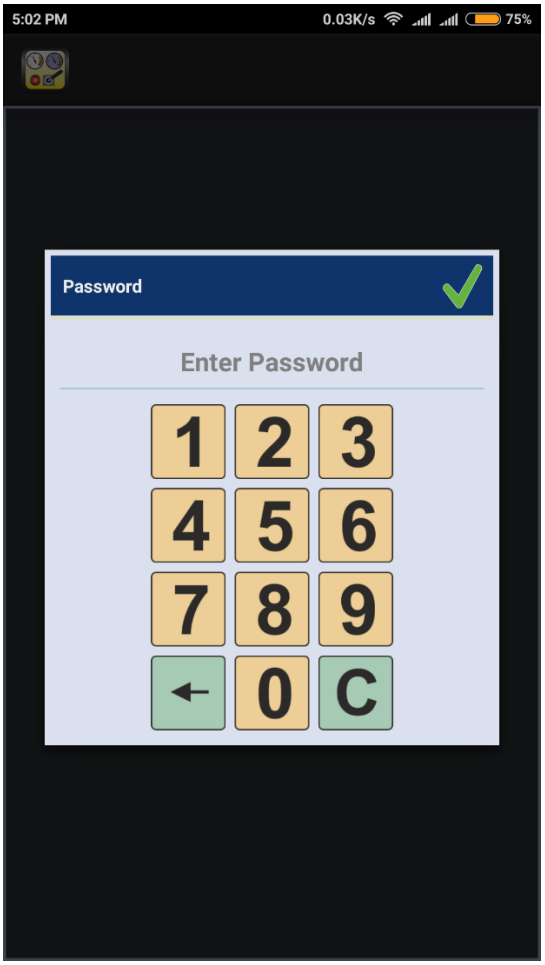

Figure 22: Android Screen displaying Password Protected Login

The screenshot in Figure 22 represents the Virtuino android screen that shows the Login screen consisting of a dialog box with a text field and a set of numbers including a backspace button and a clear button. This protects the monitoring screen from being accessed by unauthorized personnel.

4.2.1.3 Home Screen

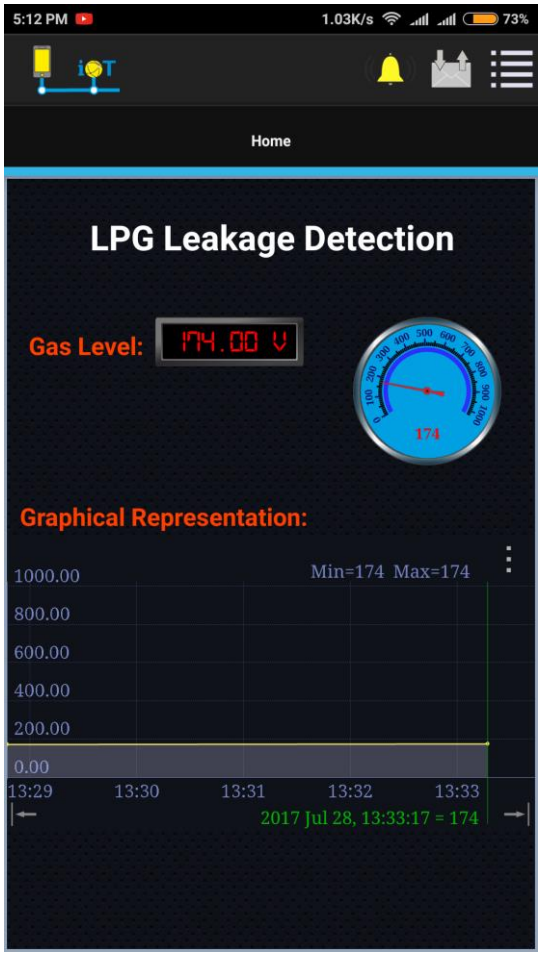

Figure 23: Home Screen displaying Gas Leakage Monitor

The screenshot in figure 23 represents the Virtuino android application screen that displays the real-time gas leakage level extracted from ThingSpeak server. The level of gas sensed by the MQ-7 Gas Sensor is recorded in ThingSpeak server via Arduino Uno. Virtuino establishes TCP connection with server through HTTP request. Virtuino app uses the API of ThingSpeak channel to receive the sensor data.

Virtuino Tool Configuration for Value Representation in Digital and Graphical Display

Figure 24: Virtuino Tool Configuration

The image in Figure 24 shows configuration of Virtuino App Tools such as digital and graphical display.

4.2.2 Server Screenshots

4.2.2.1 Server Channel

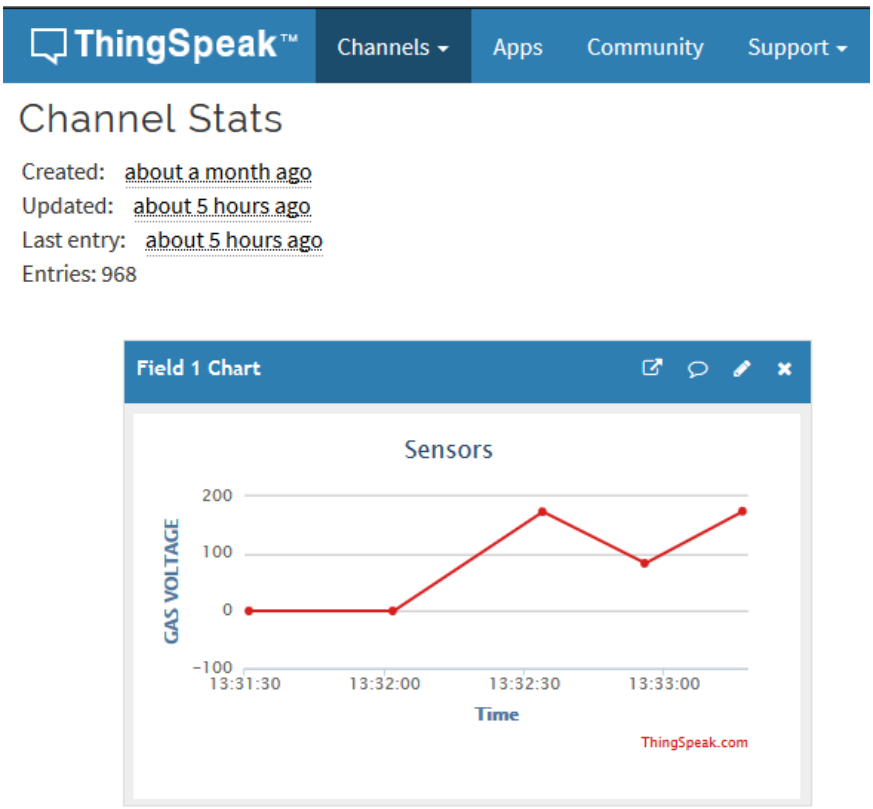

Figure 25: ThingSpeak Channel

The screen shown in Figure 25 represents the interface of ThingSpeak Channel. Arduino establishes TCP connection with ThingSpeak server through HTTP request. Once the connection is established, Arduino uses Write API Key of ThingSpeak Channel to send sensor data to ThingSpeak Channel to display values.

4.2.2.2 Server API

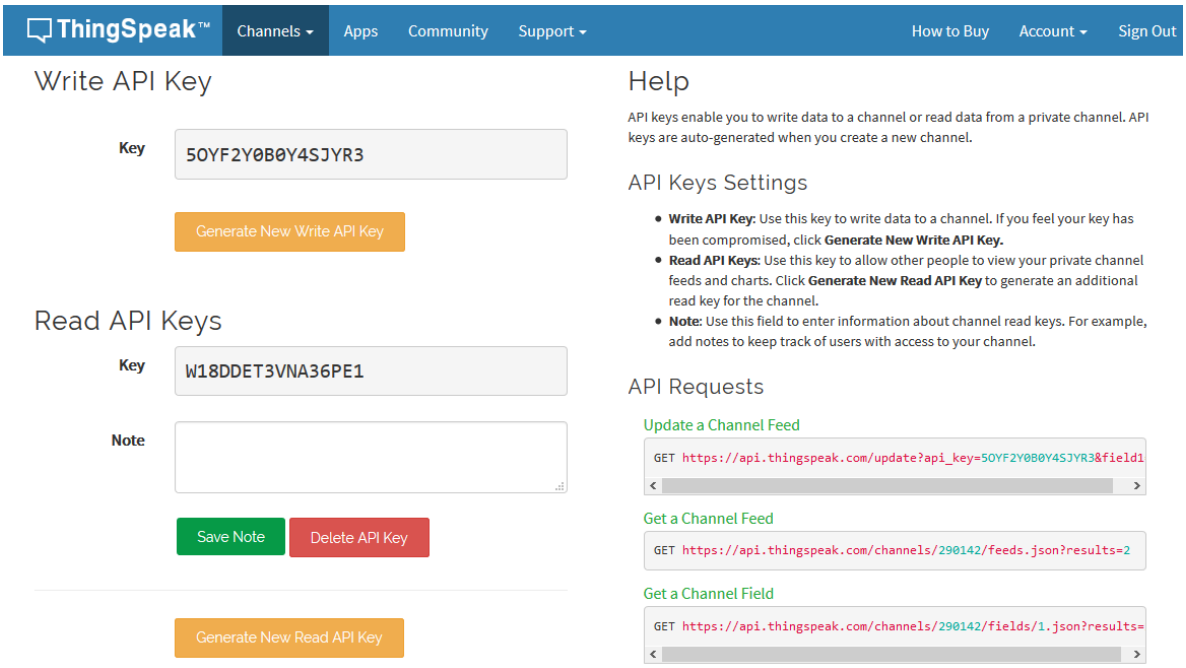

Figure 26: ThingSpeak API

The screen in figure 26 shows the interface of ThingSpeak API Keys. The Write API Key shown in above ThingSpeak Channel is used by Arduino to send sensor data to ThingSpeak Channel.

Adruino API Code

```
String apiKey = "5OYF2Y0B0Y4SJYR3";

String getStr = "GET /update?api_key=";

getStr += apiKey;
```

4.2.3 Function Prototype

4.2.3.1 Hardware Connection

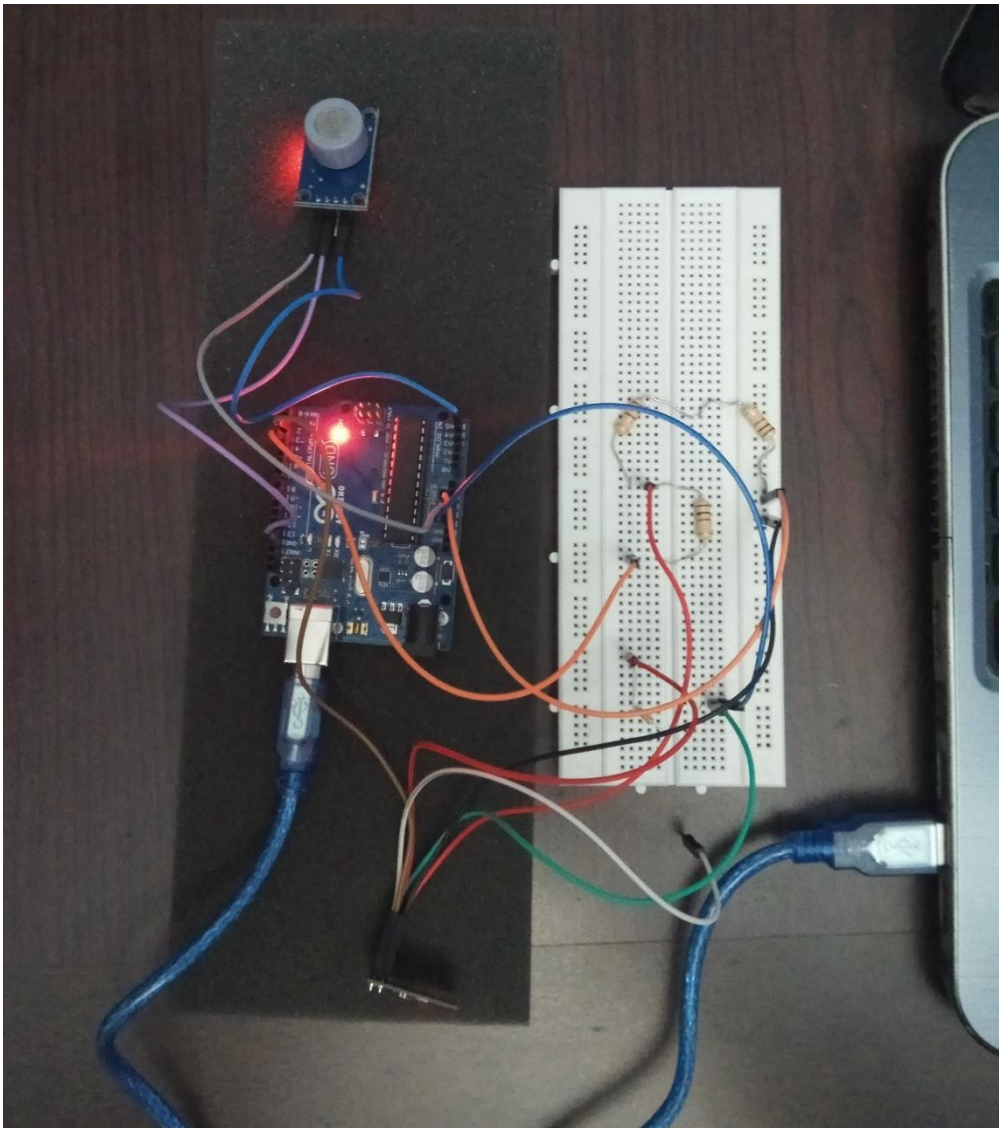

Figure 27: Hardware Connection

The image in Figure 27 represents the connection between Arduino Uno, ESP8266 Module, MQ-7 Gas Sensor, and Breadboard along with some resistors and Jumper Wires. MQ-7 Gas Sensor senses the atmospheric LPG

level. Arduino Uno reads the gas level in terms of voltage and sends it to server using ESP8266 module.

4.2.3.2 Sending Gas Value to the Server

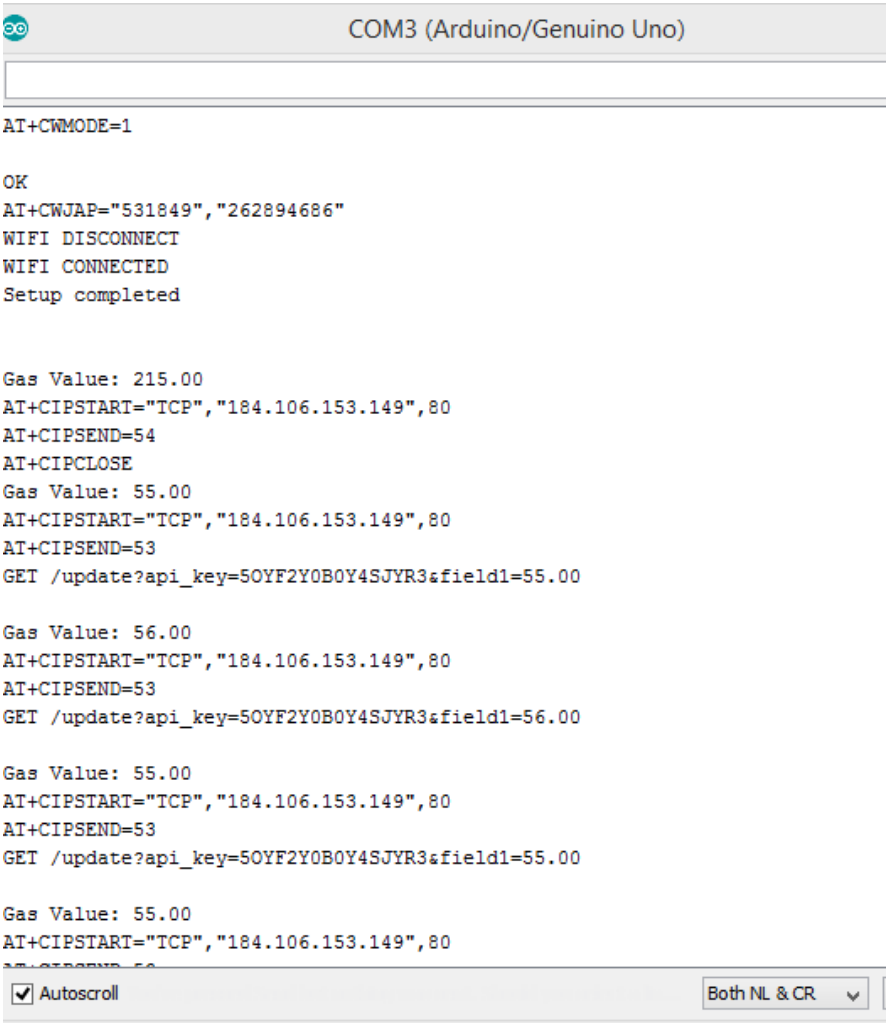

Figure 28: Sending Gas Value to the Server

The screenshot Figure 28 shows connection of ESP8266 Module with Wi-Fi and then the Arduino starts sending gas value to the server using GET request. Each time the value is sent, Arduino establishes TCP connection with the ThingSpeak server. While sending the gas value, Arduino uses Write API Key of the Server Channel.

Arduino Code sending Gas Value to the Server

```
void loop() {

  boolean hasError=false;

  float gasValue=analogRead(A5);    // MQ-7

  Serial.print("Gas Value: ");

  Serial.println(gasValue);

   if (!hasError) thingSpeakWrite(gasValue);

  // thingspeak needs 15 sec delay between updates,

  delay(20000);

}
```

4.2.3.3 Receiving Gas Value by the Server

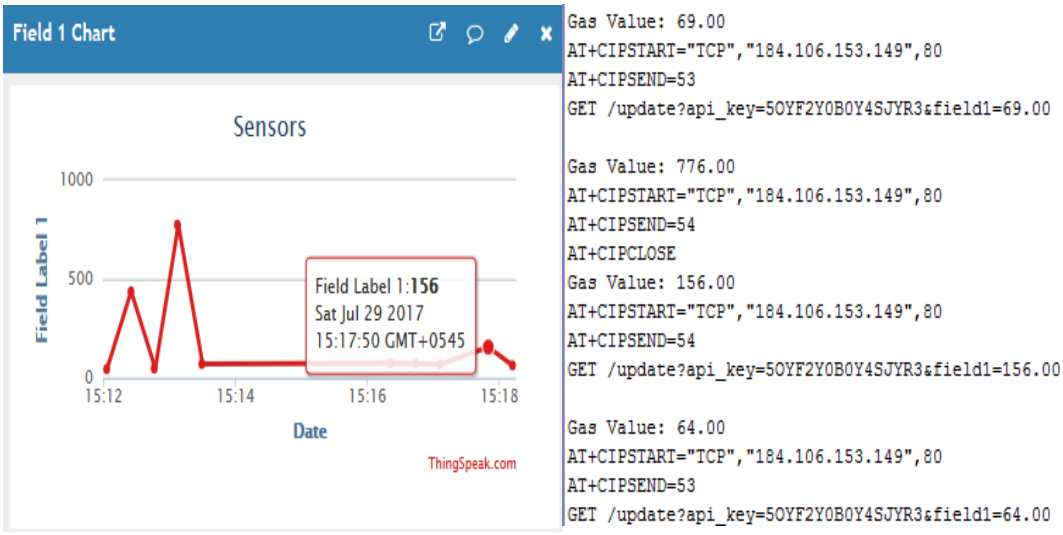

Figure 29: Receiving Gas Value by the Server

The screenshot in Figure 29 represents the gas value being received by the ThingSpeak Server Channel. In the Figure 29, the chart shows the field

level to be 156 which is the gas value received at 15:17:50 GMT+0545. The portion in the right side shows 156.00 V sent to the server channel.

Arduino Code receiving Gas Value by the Server

```
boolean thingSpeakWrite(float value1){

  String cmd = "AT+CIPSTART=\"TCP\",\"";
// TCP connection

  cmd += "184.106.153.149";
// api.thingspeak.com

  cmd += "\",80";

  espSerial.println(cmd);

   String getStr = "GET /update?api_key=";   // prepare GET
   string

  getStr += apiKey;

  getStr +="&field1=";

  getStr += String(value1);

  getStr += "\r\n\r\n";

  // send data length

  cmd = "AT+CIPSEND=";

  cmd += String(getStr.length());

  espSerial.println(cmd);

  if (DEBUG)  Serial.println(cmd);

  delay(1000);

  if(espSerial.find(">")){

    espSerial.print(getStr);
```

```
    if (DEBUG)   Serial.print(getStr);

  }

  return true;

}
```

4.2.3.4 Server Data received by Android Application

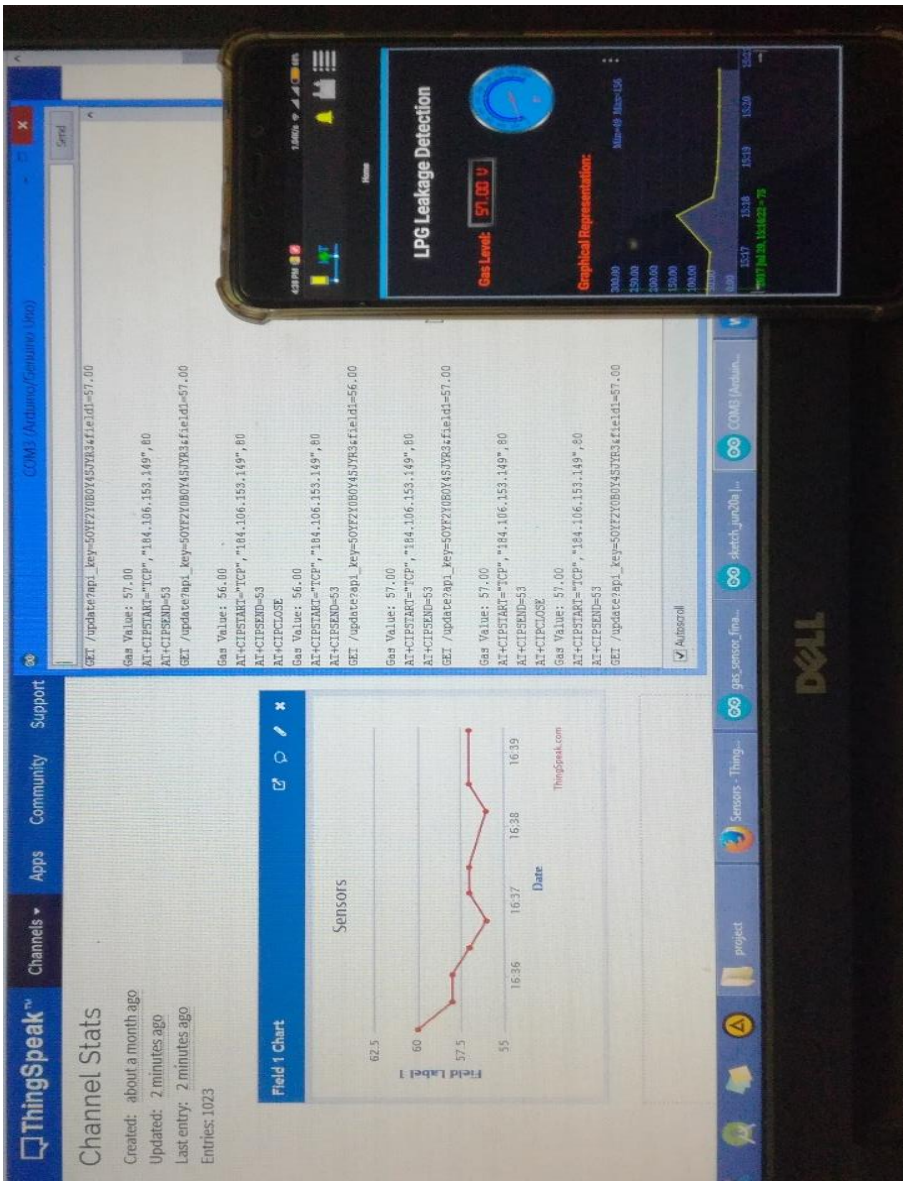

Figure 30: Server Data received by Android Application

The image in Figure 30 shows Virtuino App connecting to ThingSpeak server using Server Channel ID. The latest value in each field chart in the ThingSpeak server is received by Virtuino App and represented using tools such as graph, analog and digital display.

4.2.3.5 Notification Alert

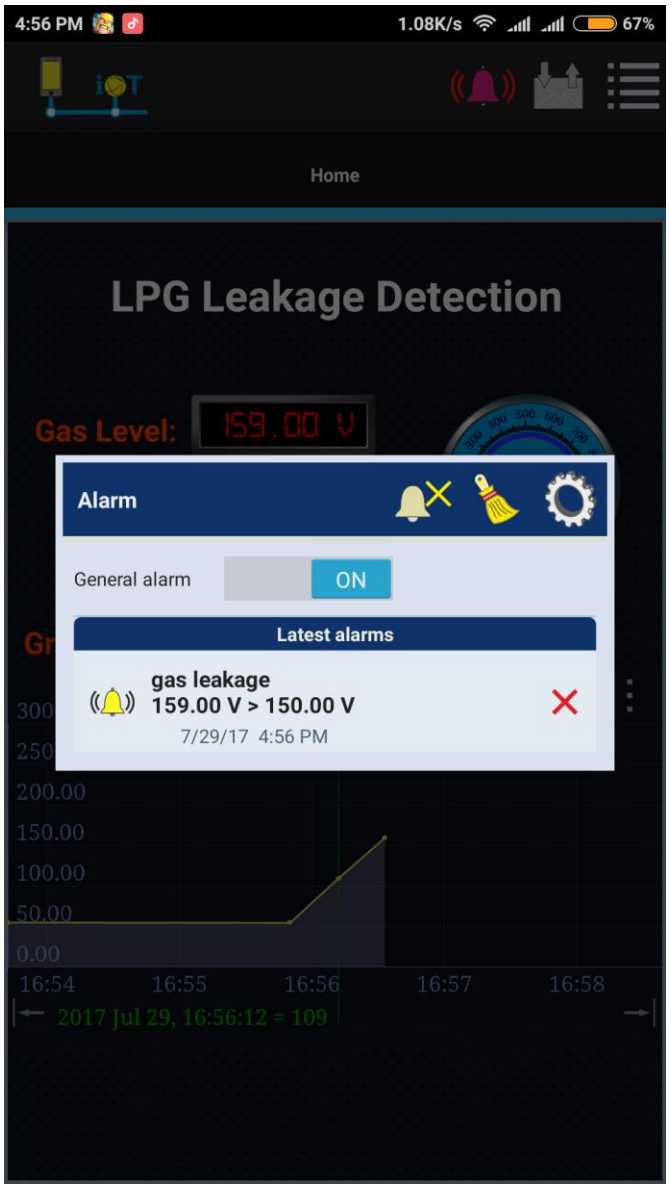

Figure 31: Virtuino App Notifying High Level of LPG

The screenshot in Figure 31 shows the notification alert being sent to the users through Virtuino App. This notification to the users is provided once the detected gas level reaches above the threshold. Figure 31 shows the alarm being triggered when the gas threshold reaches 159 V which is greater than 150 V.

4.3 Critical Analysis

Home Automation is an emerging topic as the technology of today's generation has become more and more self-controlled and automated. Home automation has drawn considerable attention of the researchers because of its multipurpose applications. This topic is gaining global concern due to ability of monitoring of home appliances remotely through smartphones and other internet accessible devices. In the context of Nepal, technology has hit tremendously and with the rapidly increasing busy working schedule, people are finding it very difficult to manage work as well as their houses. Carelessness in the houses can prove to be fatal. From the survey, it has been clear that accidents involving fires and burns are the third leading cause of home injury deaths, and they claim more than 3,000 lives a year.

The most important point of the project was the precise inclusion of the literature review. It resembled the immense research work initiated by the project member during the development and research phases. Various research works were conducted to get an idea on the scope of home automation to monitor gas leakages. Study on web applications, mobile applications and hardware components on the field of home automation was performed. The focus was mainly on how the client monitors the leakage of LPG at home from anywhere distantly. Finally, the mobile application on monitoring gas leakage was found to be a necessity and feasible for the development of the application.

The home automation system developed here is effective and fulfils the objectives defined in the initial stage of the project. The development approach implemented

was the research focused on the quality assessment of the various components being built in the process. The hardware used in this system is relatively cheap yet powerful enough to operate the system. The mobile application on client's end has friendly interface and clearly displays the features and functionality provided by the application. The training about the application can be provided to the users only if necessary as no uncertainty was left in the structure and functional aspect of the application. Despite of the immense effort applied in the development of the project, bug free state of the application can't be guaranteed. The major bug is seen on the hardware aspect due to difficulty in connectivity during the communication between the Arduino Board and the ESP 8266 Module. Moreover, ESP 8266 requires a power supply of 3.3 V and Arduino may not be able to provide adequate power to ESP module. On the other hand, sensor data monitored from MQ-7 Gas Sensor may sometimes fluctuate. A proper analysis of the hardware and the application's various aspects is needed to further improve the quality of the system.

Many problems were faced during the development of the system that lead from the integration of various modules to the deployment for the testing phase. Finally the system can be implemented in the existing resources providing defined functionality. Excluding the possible hardware issues and limitations, there is proper functioning of the application in the designated area. The analysis of the project can be broken down into:

4.3.1 Availability of the Internet

The overall application and hardware is dependent on the internet from receiving and sending the gas value status from the hardware including MQ-7 gas sensor, Arduino and ESP 8266 module to the server and then to the mobile application i.e. Virtuino app. In absence of internet connection, the system fails to deliver its objective to deliver gas value to the server and hence receive it on the mobile application. Yet without the internet connection, user can view the last updated value of the server on the mobile application. User will only be able to view the last updated gas value in the

server through application from anywhere even if internet is not available. The fluctuation of internet also disturbs the system and cannot guarantee the performance, so the reliable internet connection is important to make the system work properly. One of the main problem is the lack of spread of quality internet in the country. In developing country like Nepal, the internet technology is in budding stage. Even in major cities and areas, the problem of network congestion, reliability is big issue. Although there are a number of Internet Service Providers (ISPs), the speed and reliability of the network connection is poor. The issue of power cut also plays main factor in lack of availability of internet.

4.3.2 Hardware and Software

The application is Android based application which means that the user must have android mobile to run the system. The remote server i.e. ThingSpeak server act as gas value holder which is invoked by the android application in mobile device. The hardware used in this system are Arduino Uno R3, Wi-Fi shield (ESP 8266) and MQ-7 gas sensor with breadboard, resistors and jumper wires. Arduino is cheap yet powerful micro controller used for processing whereas Wi-Fi shield is used to transmit and receive data from ESP. The hardware bug of loss of signals from the web is seen frequently. ESP communication with Arduino is not reliable as connection may be lost frequently. Arduino is not able to provide proper power supply to ESP. More powerful devices could be used such as Arduino Mega, NodeMCU Wi-Fi module. However, it results into high cost and the customers might not be able to afford the system.

4.3.2.1 Why Arduino?

The primary reason behind choosing Arduino from other microcontrollers and microprocessor is its great computational power with easiness in setup and configuration and cheapness. Though there are some advance

microprocessors like Raspberry Pi that have robust computational power, the project don't need such microprocessors to meet the system requirements. Also, Arduino is cheap microcontroller with great computational power than other microcontrollers and microprocessors.

4.3.2.2 Why ESP 8266 Wi-Fi Module?

The ESP 8266 provides internet access to Arduino device which sends gas value to server using this module. The ESP 8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. Though there were other Wi-Fi Modules like Huawei Wi-Fi Shield and Node MCU available, the developers had primarily chosen ESP 8266 module due to its simplicity in hooking up with Arduino device. More than that the module is cheap in cost. Availability of different firmware had also made ESP8266 a flexible one. Despite these plus point about ESP8266, it provides low reliable connections than other Wi-Fi module and Shields and requires 3.3V power supply which is difficult to calibrate.

4.3.2.3 Why Android Phone?

Android market is vast and ever growing. Since Android is becoming the popular mobile platform with maximum number of users, the application to monitor the LPG leakage is based on same. Though there are other popular platform like iOS and windows platform, the team members hadn't chosen those in the initial phase due to less coverage of the users in context to Nepal.

4.3.2.4 Why Remote Server?

The team members had chosen to use remote server (ThingSpeak) because of its availability at all times. ThinkSpeak server is itself designed to monitor the sensor values and other IoT related stuffs. It provides API key

to write in its channel with graphical representation and also read value from channel to android application. Even though the hardware components fail to communicate the last updated value is stored in the server. It is available anywhere any time. The android phone and ESP 8266 is not required to connect to same network for the request and response. They can communicate using different network.

4.3.3 System Security

The security of the data and the application is always the matter of concern. Possible measures are taken to ensure the security of the application and the system. However the system doesn't ensure complete security of the data. The application doesn't address the advance challenges in the security. Virtuino app provides means of admin login to add extra elements or tools to platform. The application does provide login feature to the users and the ThingSpeak server also provides login feature for the developers.

4.3.4 Training for the Overall Operation

The system consists of both hardware and software aspect. Even though client uses the mobile application to monitor the gas level, he/she needs to deal with hardware aspect as well. The client needs to check the hardware frequently and also ensure some precautions for hardware safety. So, a training or seminar on the operation of the system before the implementation is a must.

In order to make this application more interactive and efficient, more features can be added. More advance hardware can be used to guarantee proper functioning of the system with less errors and signal loss. In addition to that, if the system can be provided at affordable cost, there is more chance that people use this system for their personal benefit.

4.4 Application of the System

The project, “Ghar Niyantran: IoT based Home Automation System for Safe Home” is related with Home automation that is focused on the observation of leakage and it can be implemented in houses and, although the name refers only to houses, it can also be applied to many different organizations, businesses and places using LPG for monitoring gas leakage remotely. As a prototype the authors had prepared focusing on monitoring the gas leakage in home. But with some enhancement on hardware it can be implemented for more functionality and even on various other fields as well.

4.5 Limitation and Future Enhancements

4.5.1 Limitations

Without a doubt any existing system that researchers have known has some limitations or drawbacks i.e. there are no systems with zero error and 100% accuracy. As the system is developed by using complex and sophisticated sensors and integrated circuits, the system cannot be expected to perform with the accuracy expected in ideal case. The limitations are evident, therefore it is necessary to locate them and presenting them for future enhancement. Some of the limitations of the project is as follows:

- User can get the status of gas value only after a request from android application. There is no mechanism of real time notification to user in android phone.

- The gas leakage value sensed by the sensor may sometimes fluctuate.

- ESP 8266 module is used which is not reliable as compare to other Wi-Fi shield for making a communication over a web.

- ESP 8266 module requires 3.3V from Arduino which it cannot provide adequately and external voltage supply is needed. The voltage of 3.3V from external source is very difficult to calibrate.

- The connection of ESP 8266 module with Wi-Fi is not reliable as it may disconnect with Wi-Fi signal at any time.

- Arduino Uno R3 that is the model of Arduino device used, doesn't provide adequate supply of power to all the devices connected to it. It doesn't support the code if its memory size becomes full.

- System is not ready made, so needs technical manpower to setup and implement the system.

- The HTTP request from android to server and response from server to Arduino is slow.

4.5.2 Future Enhancements

The developed system can be enhanced and improved using some robust and reliable hardware's. Some key future enhancements to the project are listed below:

- This application can extend to home automation functionalities like home appliances controlling.

- Incorporating more Sensors to detect fire, Smoke, Temperature, Humidity etc.

- Implementation of android application that can display data as well as control the home appliances

- Implementation of automatic notification system that shows the status of gas level running at home.

- Using more reliable Wi-Fi shield such as NodeMCU e11 to reduce a request and response time between client and servers.

- Implementing GSM technology so that user without internet connectivity is able to control the appliances/devices.

4.6 Conclusion

Houses have been in prone to many known and unknown risks for a long time. This project will serve all houses a better way to remain safe from fire hazards that are caused through LPG leakages. The completion of this project has almost fulfilled the main objective of our project by developing an embedded system and designing an Internet based home automation system. The whole project demonstrated the idea of developing the system that could monitor and detect the leakage of LPG and notifying the home owners in time. The system has a wide range of application especially now-a-days when people are too busy to keep track of these small yet powerful things. There is no such particular boundary or specialized area for implementation of the project. The system can be implemented in homes, and also in offices or organizations or any other place where LPGs are used. The team members have completed the project with best aptitudes to perform smoothly and also with the further enhancements by which one could definitely upsurge the potential of the system.

Throughout the project a framework has been developed that uses hardware and software in developing a low cost, powerful, accurate and reliable home automation system using different components. . Arduino Uno and Wi-Fi Shield (ESP 8266) are used that provides higher performance with low power consumption. The mobile application was built in Virtuino platform using Arduino IDE. This platform has a user friendly UI and the smooth functionality

that provides the expected output. The system has been tested and found out to be accurate and reliable. Through the process of system analysis to its implementation, different challenges arose and each problem were smoothly handled without losing track of the main objective of the project.

The project has proven to be very beneficial in all aspects. The project has provided the authors with an opportunity of working in different areas of engineering, both hardware and software. The project provides an opportunity to professionally develop an application in the emerging field of home automation. Teamwork between the authors have been the major factor without which this project would not have been possible. The project was successfully developed meeting the objectives of the project and gaining lots of experience of the related field which will contribute to the academic and professional skills.

This project has not only provided the authors with great opportunities but the users as well receives a great help to keep track of the leakages through their smartphones remotely. This will reduce the fire hazards to great extent saving many houses, resources, finances and even lives.

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APPENDIX

Arduino: Source Code:

Test.ino

```
#include <SoftwareSerial.h>

SoftwareSerial espSerial(2,3);   // arduino RX pin=2  arduino TX pin=3    connect the arduino RX pin to esp8266 TX pin   -  connect the arduino TX pin to esp8266 RX pin.

// AT                            Command to display the OK message

// AT+GMR                        Command to display esp8266 version info

// AT+UART_CUR=9600,8,1,0,0      Command to change the ESP8266 serial baud rate  to 9600

// AT+UART_DEF=9600,8,1,0,0      Command to change the default ESP8266 serial baud rate  to 9600

// AT+RST                        Command to reset

void setup() {

 Serial.begin(9600);

 espSerial.begin(9600);         // Change this value to 9600

}

void loop() {

  while (Serial.available()) {

       char ch = Serial.read();

       espSerial.print(ch);

    }

  while (espSerial.available()) {

       char ch = espSerial.read();

       Serial.print(ch);
```

```
    }
}
```

Gas_sensor_final.ino

```
#include <SoftwareSerial.h>

SoftwareSerial espSerial =  SoftwareSerial(2,3);      // arduino RX pin=2  arduino TX pin=3    connect the arduino RX pin to esp8266 module TX pin   -  connect the arduino TX pin to esp8266 module RX pin

String apiKey = "5OYF2Y0B0Y4SJYR3";     // replace with your channel's thingspeak WRITE API key

String ssid="531849";    // Wifi network SSID

String password ="262894686"; // Wifi network password

boolean DEBUG=true;

//=======================================================================
===== showResponce

void showResponse(int waitTime){

    long t=millis();

    char c;

    while (t+waitTime>millis()){

      if (espSerial.available()){

        c=espSerial.read();

        if (DEBUG) Serial.print(c);

      }

    }

}

//=======================================================================
============= setup

void setup() {
```

```
  DEBUG=true;           // enable debug serial
  Serial.begin(9600);
  espSerial.begin(9600);  // enable software serial
                          // Your esp8266 module's speed is probably
                                                          at 115200.
                           // For this reason the first time set the
                  speed to 115200 or to your esp8266 configured speed
                              // and upload. Then change to 9600 and
                                                        upload again
  //espSerial.println("AT+CIOBAUD=9600");
   //showResponse(1000);
  //espSerial.println("AT+RST");         // Enable this line to reset
the module;
  //showResponse(1000);
  //espSerial.println("AT+UART_CUR=9600,8,1,0,0");    // Enable this
line to set esp8266 serial speed to 9600 bps
  //showResponse(1000);
  espSerial.println("AT+CWMODE=1");   // set esp8266 as client
  showResponse(1000);
  espSerial.println("AT+CWJAP=\""+ssid+"\",\""+password+"\"");  //
set your home router SSID and password
  showResponse(5000);
   if (DEBUG)  Serial.println("Setup completed");
   Serial.println("\n");
}
// ============================================================ loop
```

```
void loop() {
  boolean hasError=false;
  float gasValue=analogRead(A5);   // MQ-7
  Serial.print("Gas Value: ");
  Serial.println(gasValue);
   if (!hasError) thingSpeakWrite(gasValue);
  // thingspeak needs 15 sec delay between updates,
  delay(20000);
}
//================================================================
=====
boolean thingSpeakWrite(float value1){
  String cmd = "AT+CIPSTART=\"TCP\",\"";                  // TCP
connection
  cmd += "184.106.153.149";                               //
api.thingspeak.com
  cmd += "\",80";
  espSerial.println(cmd);
  if (DEBUG) Serial.println(cmd);
  if(espSerial.find("Error")){
    if (DEBUG) Serial.println("AT+CIPSTART error");
    return false;
  }
  String getStr = "GET /update?api_key=";   // prepare GET string
  getStr += apiKey;
  getStr +="&field1=";
  getStr += String(value1);
```

```
  //getStr +="&field2=";
 //getStr += String(value2);
  // getStr +="&field3=";
  // getStr += String(value3);
  // ...
  getStr += "\r\n\r\n";
  // send data length
  cmd = "AT+CIPSEND=";
  cmd += String(getStr.length());
  espSerial.println(cmd);
  if (DEBUG)  Serial.println(cmd);
  delay(100);
  if(espSerial.find(">")){
    espSerial.print(getStr);
    if (DEBUG)  Serial.print(getStr);
  }
  else{
    espSerial.println("AT+CIPCLOSE");
    // alert user
    if (DEBUG)   Serial.println("AT+CIPCLOSE");
    return false;
  }
  return true;
}
```