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DISCLAIMER

All the work done in this thesis report belongs to the student alone. With supervision, direction, and support from the university, students were encouraged to take charge of their whole thesis research. Conclusions and recommendations made in this study are not necessarily those of the university or study supervisors.

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ABSTRACT

Telecommunication companies have proven to be the best at providing communication services for over a thousand people simultaneously across the country. These services are only possible with the use of equipment, which includes media converters, routers, switches, etc. These pieces of equipment are housed in server rooms that require uninterrupted power supply to run 24/7, thereby providing their services to clients, which include the internet, local area networks, and wide area networks, among many others. However, with the power outages Zimbabwe is currently facing, it is not possible for the telecommunication companies to meet this goal, thereby resorting to the use of backup fuel generators as a way to minimize losses. Although it has been opted for and proven to be efficient, it requires consistent monitoring to ensure that there is no sudden shutdown. This monitoring requires driving to and from designated server rooms, thereby introducing malicious acts such as theft by the messenger and also wastage of fuel. This research will aim at designing and developing a low-cost IoT (Internet of Things) network that provides a real-time monitoring and security system for fuel generators at server rooms in Zimbabwe. The main objectives of this thesis are to design and develop an embedded wireless network architecture that performs real-time monitoring and security of server rooms with IoT integration. ESP8266 NODE MCU and Thing Speak cloud servers are the main points of the system for data processing and monitoring. Data was recorded from the ultrasonic sensor and transmitted to the ESP8266 NODE MCU for uploading to a cloud server (Think speak) for remotely monitoring fuel levels. Fingerprints of authorized users are registered on the fingerprint sensor, and collected data is stored in the sensor database. These databases are used for access control to the fuel tank and comparing data during refill with already stored data, thereby ensuring the security of the system. In conclusion, a real-time monitoring and security system for fuel generators in server rooms has been successfully designed and developed, and

telecommunication companies in Zimbabwe will be able to use their backup fuel generators safely while providing a smooth flow of service to their designated clients.

Contents

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

In this chapter, the author shares the fundamentals and background that formed the backbone of the work project. A brief summary of the problem's background leads to the problem statement, which comprises the ideal, the realistic, and the solution that brings about the whole project. The justification for the work done in this study is shared thereafter with the aims, objectives, and research questions.

1.2 Background

Over the past twenty years, it has been determined and proven that data centers are more than forty times as energy-intensive as conventional office buildings. Accordingly, there are a couple of best-practice technologies that have been improved for years. These practices include improved air management, isolation of hot and cold air streams, an improved ventilation system, and uninterrupted power supplies.

According to Robert McFarlane et al. [1], an "uninterruptible power supply is defined as the device that allows a system to keep running for at least a short time when incoming power is interrupted. The more energy stored the longer the time before the power supply runs out. There are three groups of uninterruptible power supplies, which include backup, interactive, and double conversion." According to G. Rajani [2], the most used UPS system is the backup generator, which will be the focus of this project. UPS systems are widely used by most company sectors because of their reliability in providing power continuously.

Telecommunication companies across the country have server rooms that house equipment such as media converters, GW/PE routers, switches, servers, etc. These pieces of equipment facilitate the provision of various services, namely the internet, local area networks (LAN), and wide area networks (WAN), among many others. The sudden cutoff of these equipment's results in a loss of data. Millions of clients connected to these centers will face problems, which will result in low customer service provisions, thereby losing clients and resulting in a loss to the company as a whole. The smooth flow of business and reputation of these companies depend largely on quality service and minimal downtime. However, power outages in Zimbabwe have become an impediment to telecommunication companies meeting these goals. According to Steve Greenberg et al. [3], "for an efficient data center, there should be an uninterruptible power supply," companies have resorted to the use of solar energy and fuel generators to develop UPS (uninterruptible power supply) systems. Solar energy is cheaper but less reliable because of its dependence on weather conditions than fuel generators; hence, the use of generators has become more dominant.

In one case study for a particular service provider, employees have to manually monitor fuel levels in generators by driving to and fro on scheduled days. This exercise on its own increases fuel consumption, while cost reduction is of essence to service providers. In addition, this system is hazy in terms of fuel consumption rates in order to monitor progress and trends. At Telone ("a parastal telecommunication company owned by the Zimbabwe government headquarters"), several incidents have occurred where fuel budgets could not balance. This continuously raised suspicions about fuel theft by employees, but they could not be concluded since there was no evidence. A real-time monitoring system for fuel generators can introduce a new operation for fuel top-ups and keeping track of the messengers. This real-time data can be directly monitored by the management and accounts departments to prevent any possibility of malicious acts.

1.3 Problem Statement

Telecommunication companies use fuel generators as the backup uninterruptible power supply (UPS) to provide a smooth flow of service to their clients. Malicious acts and physical monitoring that are involved with the use of this UPS imposed by the messengers in maintaining fuel levels can cause drastic financial losses to the companies. A real-time monitoring and security system will make this UPS backup method more adaptable with minimum losses. It reduces the need for the messengers to drive to and from the server centers, thereby minimizing fuel wastage.

1.4 Research Questions

i. What is the capacity of the fuel tanks used in server rooms?

ii. How much fuel is required to pump up a server room?

iii. How long does it take for the fuel to runoff?

1.5 Aim and Objectives

1.5.1 Aim

Develop a real-time, remotely controlled automated monitoring and security system that records fuel level and registers the fingerprint of the messenger topping up the fuel.

1.5.2 Objectives

1. To design a level monitoring and link it database in real-time
2. To design security system to capture messenger details and fuel added
3. To link the system to Thing Speak server for management and management of your time monitoring

1.6 Justification of Study

The increase of malicious acts on generator fuel in companies has resulted in increased loss and more expenses. A fuel generator monitoring and security system brings about solving this problem, both tangible and non-tangible, with less human intervention. It cuts down the expense of physical monitoring of the fuel which would have resulted from driving to and from the server room centres. It also brings about securing the fuel by the use of fingerprint thereby showing in the database, persons who had access to the generator.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

According to Justin Paul and Alex Rialp Criado [4], a literature review article gives a thorough assessment of the literature on a subject, theory, or methodology and synthesizes earlier research to increase the body of knowledge.

In this chapter, the author gives an overview of the current implemented fuel generator monitoring and security system, as well as previously related work on the project components.

2.2 OVERVIEW

Over a century, backup ups fuel generators have been physically monitored, but as technology advances, more and more advanced technologies are being implemented to reduce time-consuming and malicious acts. Internet of things (IoT) technology is changing the way people interact with their devices. Smart fuel generator monitoring is one of the few IoT solutions for businesses that turns fuel generators into smart machines with end-to-end automation. Fuel generators are critical for supplying electrical power during an outage and preventing business operations from being disrupted. These generators are an asset to any organization and provide years of dependable service. As a result, maintaining these generators becomes a pressing task in order to ensure that assigned work is completed without difficulty. To ensure smooth operations, many organizations are turning to an Internet of Things -enabled generator monitoring solution.

2.3 EXISTING SYSTEM

2.3.1 Micro-controller-based measurements system

The system was proposed by S. Reza et al. [5]. The proposed system is depicted in Figure 1 below. The method was proposed to prevent fuel theft from tanks. When reloading the fuel in the tank, the generator and an official present at the server room location remove a quantity of fuel in such a way that the sensor is unable to detect the error.

The technology operates by monitoring the amount of fuel and saving the data on a regular basis according to the current time scale. By reviewing the data in the data collection system, control system owners may readily discover fuel reloaded, how much was used, and the missing rate of fuel from the generator site.

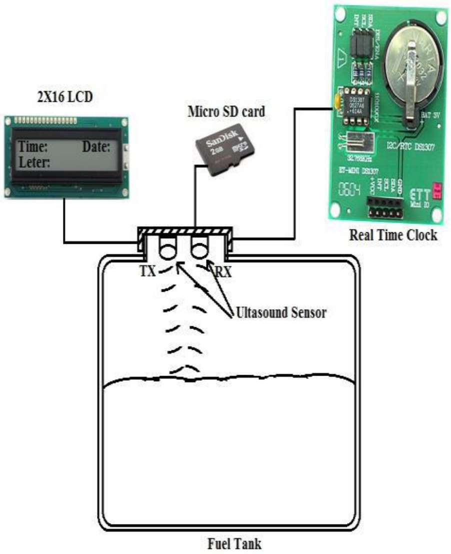

Figure 1: Microcontroller Based System

The system includes an ultrasound sensor module, a liquid crystal display (LCD) to show updates, a micro SD card for data storage, and a real-time clock (RTC) to provide precise time and date. The complete system is controlled by two PIC microcontrollers (18F4520).

2.3.2 GSM Technology system

Generator monitoring system (GMS) is based on the global system for mobile communication technology (GSM), which was proposed by S. Boopathi et al., [6]. GMS can monitor various parameters remotely, such as the external power supply, battery voltage, and fuel level, with the use of a GSM modem. It sends notifications to the operators remotely through text. The proposed block diagram of the system is shown in Figure 2 below.

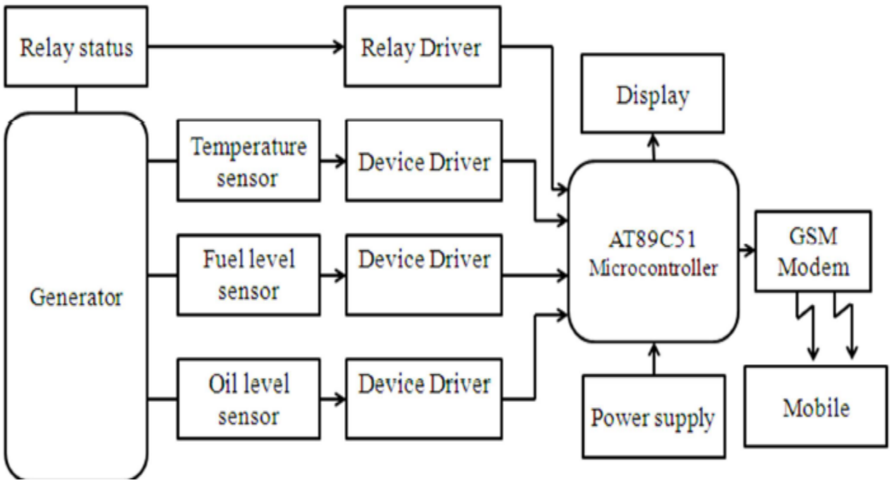

Figure 2:Gsm Technology System

The system is comprised of both hardware and software. The hardware architecture is made up of a stand-alone embedded system based on a microcontroller, a GSM modem, and a driver circuit. The GSM modem allows communication by way of SMS messages. The SMS message contains directives that must be executed. The SMS message is transmitted to the GSM modem as a text message with a preset format over the GSM public networks. When the GSM modem receives a negative signal from the EB supply, it sends an SMS to the user informing them of the power supply's non-availability, fuel level, and coolant temperature.

2.4 CONCLUSION

Throughout the century, technology has evolved to accommodate theft and other nefarious acts. The microcontroller-based **measures system** presented by S. Reza et al. [5] was intended to reduce these actions; however, it had a number of fallbacks. SD cards have certain downsides for data storage, including the fact that they can only hold a limited amount of data and must be updated or formatted after a specific length of time. It is susceptible to corruption, resulting in data loss. The system developed to accommodate these fallbacks, resulting in a superior system. S.Boopathi et al., [6], introduced the **generator monitoring system (GMS),** which is based on the worldwide system for mobile communication technology (GSM). The method bridged the gap by utilizing SD cards with limited storage and a GSM modem. The system effectively remotely monitors the fuel level by sending alarms, but it has the disadvantage of not remotely exhibiting the use of fuel over time.

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This project bridges the current gap by using a Wi-Fi based microcontroller esp8266 in conjunction with a cloud server instead of a GSM modem. It offers infinite data storage, allowing for the continuous monitoring of fuel levels and protecting the fuel tank with the use of a fingerprint sensor. It lowers both the time spent manually checking the fuel levels and the theft rate.

2.5 What are the existing notable features of IoT-based Fuel generator monitoring and security system?

2.5.1 Real-time alerting

This feature sends real-time maintenance alerts as well as important notifications via email and text message. These alerts can be triggered whenever an anomaly is detected by the sensors installed in the fuel generator. Low fuel, leakage, overheating, increased engine temperature, noise-level variations, and unexpected breakdowns are just a few of the anomalies that can be detected in generators, which helps to drastically reduce resolution time.

2.5.2 Fuel monitoring and tracking

Since most incidents take place while operations are in progress, it is crucial to monitor fuel consumption flow. IoT-powered monitoring helps generators operate efficiently by keeping track of fuel usage patterns, refuelling needs, fuel leaks, and other factors. Additionally, it can track fuel consumption at predetermined intervals like hourly, daily, weekly, and so forth for the best fuel management. It can also help assess how long the engine can operate on refilled fuel and whether fuel top-ups are necessary. The supply chain can function more efficiently with such meticulous fuel monitoring and real-time reports on its present utilization.

2.5.3 Remote management

This function sends essential notifications and real-time maintenance alerts by email and text message. The fuel generator's IoT sensors can set out these alerts anytime an anomaly is discovered. Anomalies that can be identified in generators include low fuel, leakage, overheating, increased engine temperature, noise-level changes, and unexpected breakdowns, which significantly cut down on resolution time.

2.5.4 Security and surveillance

Security is vital when it comes to asset management. Regardless of where the generator is located, asset surveillance is made possible with the use of IoT-based fuel generator monitoring. This makes it possible to get camera feeds for keeping an eye on any activity going on the property. The implanted sensors will keep an eye on activity inside the building and door access, delivering notifications if an unwanted entry is made.

2.5.5 Mobility

Gaining remote tracking and information access is the whole aim of employing a fuel monitoring device. Automate access to the schedule for mobile management. In urgent situations, it is possible to immediately raise maintenance tickets and start maintenance procedures for the operations staff.

2.6 HARDWARE

2.6.1 ESP8266

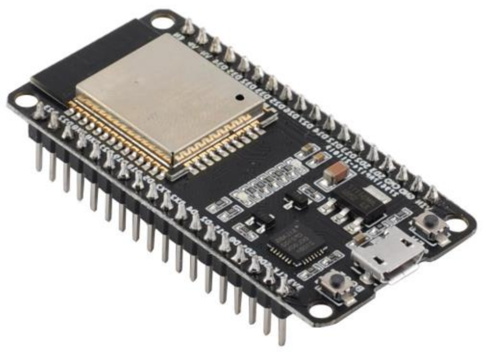

Figure 3:ESP8266

2.6.1.1 What is ESP8266?

The ESP8266 is a low-cost, low-power system-on-chip microcontroller developed by Espressif Systems. It features integrated Wi-Fi and Bluetooth connectivity, making it ideal for IoT applications. It has a dual-core processor and plenty of GPIO pins, making it versatile for a wide range of projects. The ESP8266 is a microcontroller that combines a processor, memory, Wi-Fi, Bluetooth, and other peripheral interfaces into a single chip. It's commonly used in IoT projects due to its affordability, low power consumption, and built-in wireless capabilities. [7].

2.6.1.2 Why ESP8266?

ESP8266 is suitable for IoT generator fuel monitoring systems due to its low power consumption, integrated Wi-Fi connectivity for data transmission, and GPIO pins for interfacing with sensors measuring fuel levels, temperature, and other parameters. Its ability to communicate wirelessly allows for remote monitoring and control of the generator's fuel status, making it a practical choice for such applications.

2.6.1.3 Comparison among ESP8266, Arduino and Raspberry PI

- ESP8266: Low-cost microcontroller with integrated Wi-Fi, suitable for IoT projects. It offers low power consumption and adequate processing power for many applications.
- Arduino: Widely used microcontroller platform known for its simplicity and ease of use. It's suitable for prototyping and DIY projects but may require additional shields/modules for connectivity.
- Raspberry Pi: Full-fledged computer with an operating system (usually Linux), offering more processing power and advanced capabilities compared to microcontrollers like ESP8266 and Arduino. It's suitable for projects requiring a higher level of computing power, such as media centers or web servers.

2.6.1.4 Related Work

ESP8266 is extensively used in various IoT applications, including home automation, environmental monitoring, smart agriculture, and industrial automation.

It's used for developing wireless communication systems such as Wi-Fi mesh networks, Bluetooth beacons, and IoT gateways.

ESP8266 is employed in data logging and analytics projects, where it collects sensor data and sends it to cloud platforms for storage and analysis.

It's also utilized in embedded systems applications such as robotics, smart appliances, and wearable devices due to its small form factor and connectivity features.[4]

2.6.2 Buzzer

Figure 4:Buzzer

2.6.2.1 What is a buzzer?

It is defined as a simple audio device that produces sounds in responses to an incoming electrical signal

2.6.2.2 Related Work

Buzzer was used as an alarming sound device by M. Ali, B.Ali and M. Shan (2020) in the GSM-Based Generator Fuel and Temperature Monitoring System project. The project was focused on detecting theft of fuel generators by raising an alarm with the help of a GSM modem. A GSM modem is used to send a text message to the server operators.[4]

2.6.3 Ultrasonic Sensor

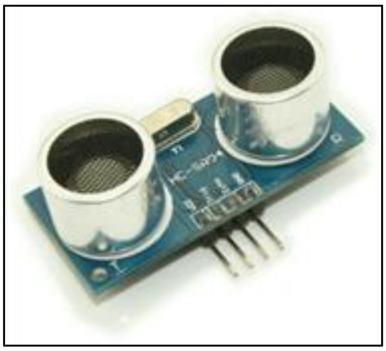

Figure 5: Ultrasonic Sensor

2.6.3.1 What is ultrasonic sensor?

It is defined as a piece of electronic equipment that measures the distance between two objects by emitting ultrasonic sound waves and converting the reflected waves.

2.6.3.2 Related Work

An ultrasonic sensor was used as a reader of the fuel level by A. Ahmed, S.Mohammed and M. Satte (2017) in the fuel management system project. The system was built on the Raspberry PI and takes information about fuel level in real time through its ultrasonic sensor and uploads it to the internet, where it can be remotely monitored.[5]

2.6.3.3 Comparison between capacitive level sensor and ultrasonic sensor?

Capacitive Level Sensor:

- Measures level based on changes in capacitance.
- Suitable for measuring various types of liquids and materials.
- Non-contact measurement.
- Resistant to harsh environments.

Ultrasonic Sensor:

- Measures level based on the time it takes for ultrasonic waves to reflect off the surface of the substance being measured.
- Suitable for measuring liquid levels, as well as solids and powders.
- Can be contact or non-contact depending on the application.
- Performance may be affected by environmental factors such as temperature and humidity.

2.6.4 Fingerprint Sensor

Figure 6:Fingerprint Sensor

2.6.4.1 What is a fingerprint sensor?

A fingerprint sensor is a form of technology that recognizes and verifies a person's fingerprints in order to permit or refuse access to a physical space or computer system.

It is a sort of biometric security system that uses a mix of hardware and software methods to recognize a person's fingerprint scans.

2.6.4.2 Related Work

A fingerprint sensor was used as an access controller by M. Rao and R. Gupta (2022) in a data center security project. Where the project focused on security access to the data center rooms. Once a fingerprint is accepted, the doors are opened, denying entrance to unregistered fingerprints.[6]

Conclusion

This marks the end of Chapter 2, where a literature review was carried out on the monitoring and security systems of fuel generators by other previous authors. The author further looked at each component's related work in similar work done by previous authors.

CHAPTER 3 - METHODOLOGY AND DESIGN

3.1 INTRODUCTION

Methodology is defined as a set of guiding concepts and procedures called project management techniques are used to plan, manage, and carry out projects.

This chapter shows the resources, methods, design and work plan the author utilized to simulate the answer to the problem statement are described in this chapter.[8]

3.2 Project Planning

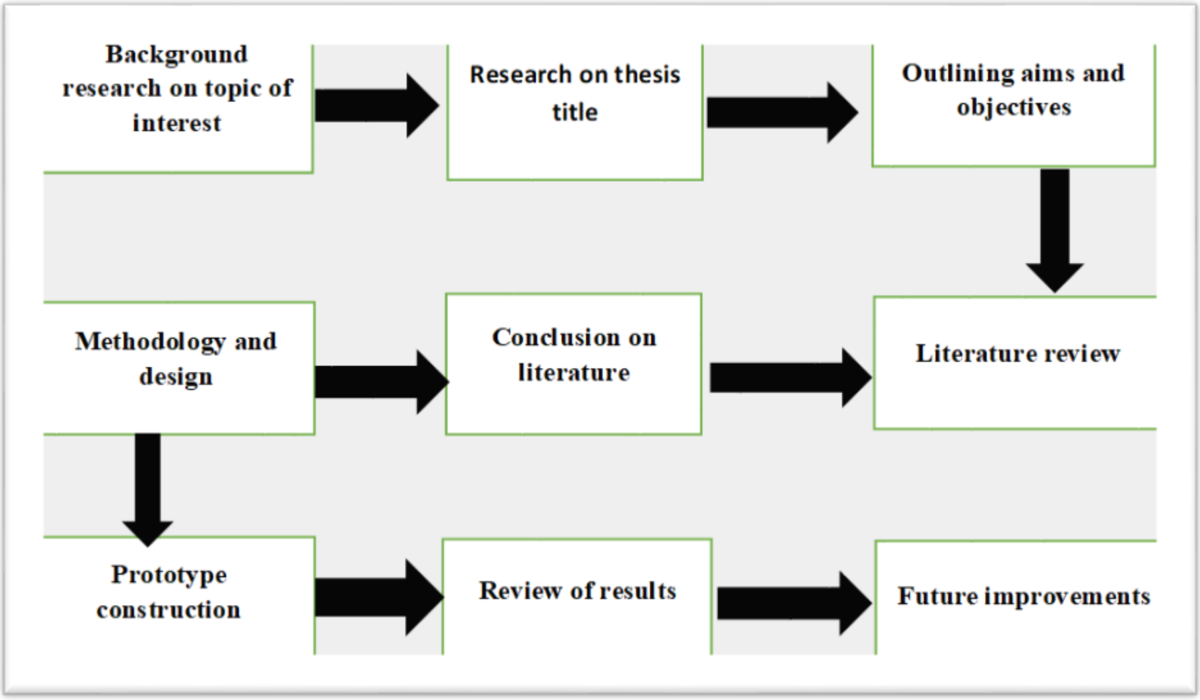

Figure 7: Project Planning

The full project flowchart for the degree project's methodical completion is shown in Fig. 8. Background research begins as soon as the second-year Research Methods course is finished and continues in depth once the title of the final-year thesis has been accepted. After thorough investigation into the project's title, the significance and applicability of the study are identified in order to highlight the major areas of interest and the research's primary goals in order to finish the final thesis. A review and analysis of earlier studies on the topic will provide a comprehensive grasp of the situation as it is today. A thorough assessment of the literature will reveal areas that need new knowledge to be added in order to advance existing understanding in the area of research. An approach based on design, hardware tools, how components are interfaced through programming, and the use of a cloud server to monitor data is proposed after highlighting the problem statement's clarity and relevance to the research.

3.3 GANTT CHART

A Gantt chart is a project management tool that allows you to quickly view time frames for the project. It specifies the project tasks that must be accomplished in the left column and the due dates in the top row. A bar reflects the time of each activity, allowing for knowledge of when each work will begin and conclude at a glance

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3.4 MATERIALS

- ESP8266
- Fingerprint Sensor
- I2C LCD 16 X 2 Module
- Buzzer
- Light Emitting Diodes(LED)
- Ultrasonic sensor

3.5 BLOCK DIAGRAM

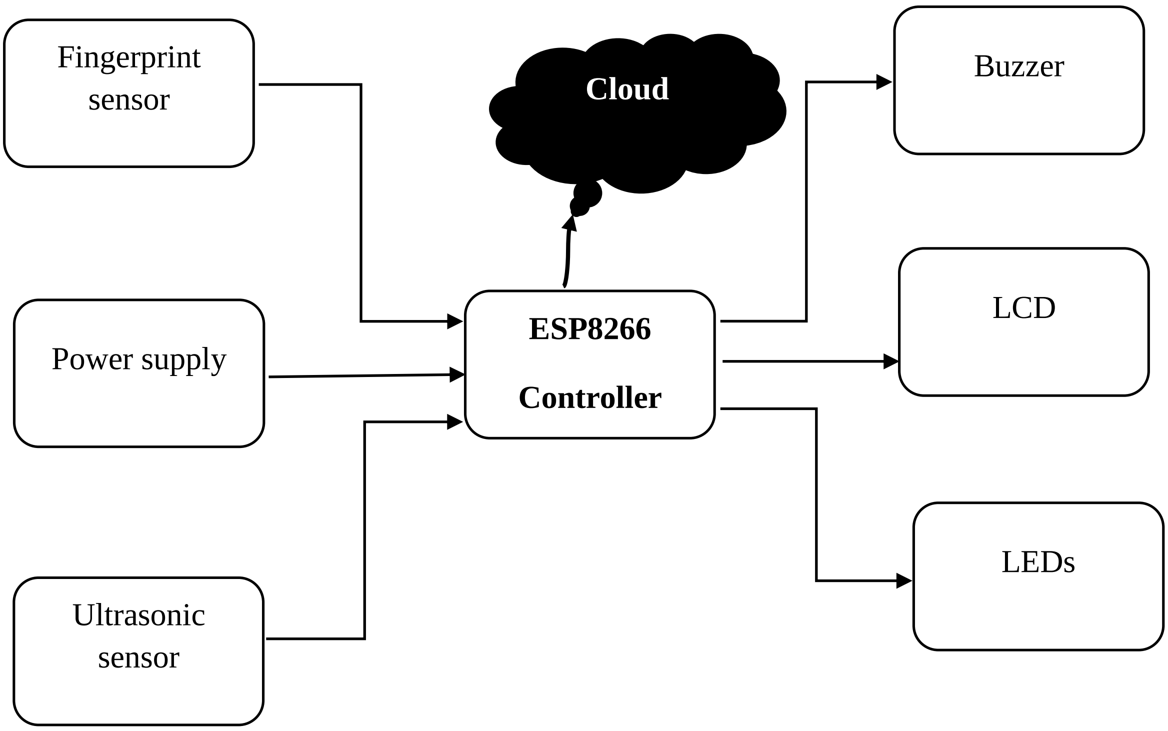


Figure 8:Block Diagram

Two sensors, Ultrasonic sensor and a fingerprint sensor, are the inputs to the system. Ultrasonic sensors are input to the esp8266 Wi-Fi module, and the collected data is then uploaded in real time to the Think speak cloud server, which is an IOT platform that uses graphs for the interpretation of data. Fingerprint sensors act as the access controller to the fuel tank; once access is accepted, a green light-emitting diode (LED) is turned on, and if access is denied, a red light-emitting diode (LED) is turned on. When the tank is full, a buzzer is employed to provide a warning sound.

3.6 CIRCUIT DIAGRAM

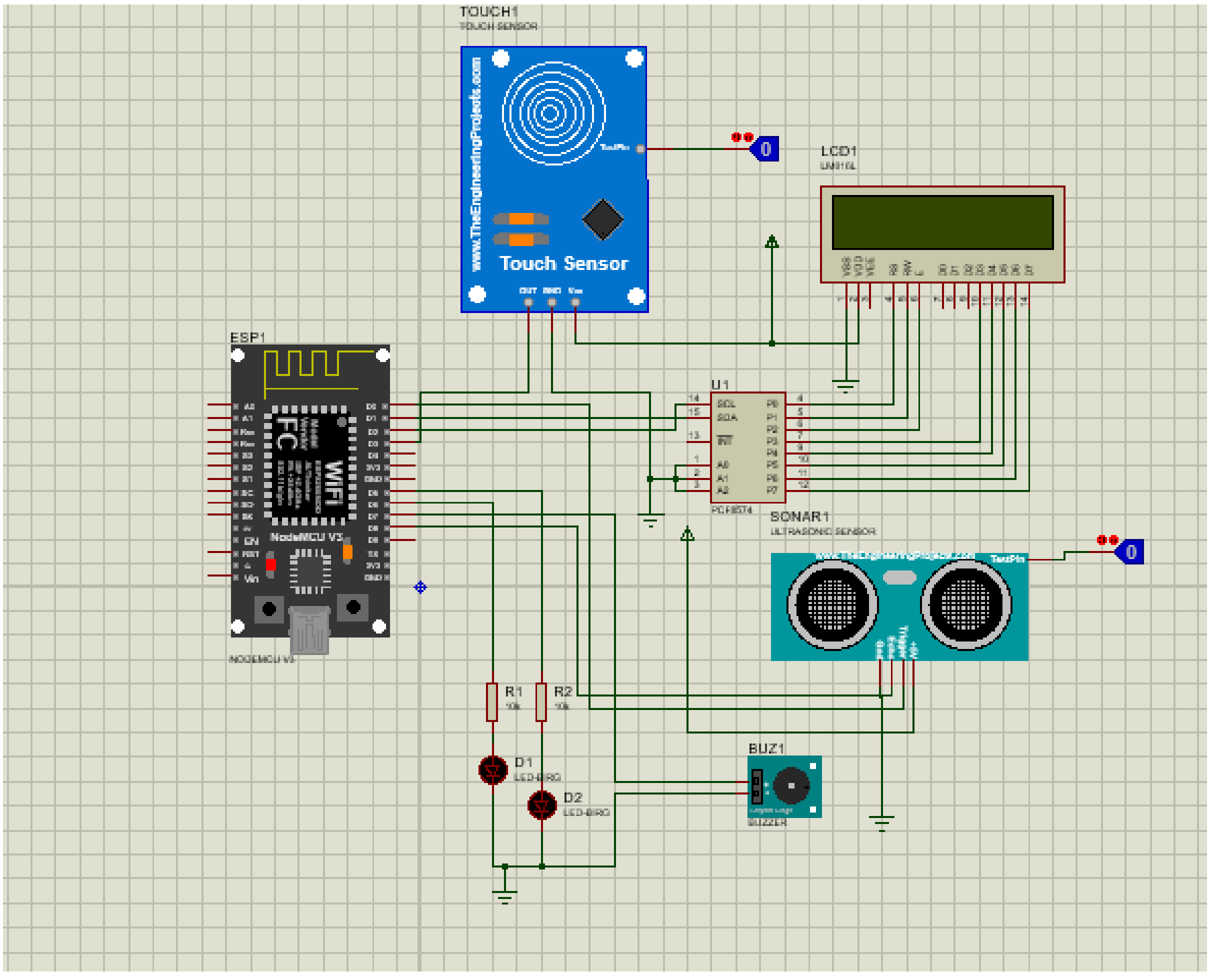
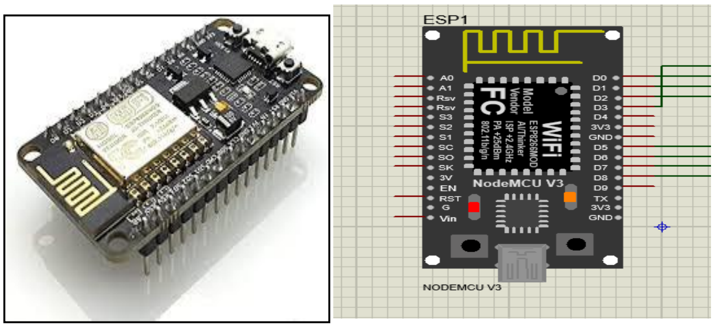


Figure 9: Circuit Diagram

Figure 11 above shows the overall schematic diagram with all connections outputs and inputs to the controller.

3.7.1 ESP8266



The system makes use of the E

Figure 12: ESP8266

gure 12.

3.7.2 Fingerprint Sensor

Figure 10:Fingerprint Sensor

Fingerprint sensor function as an access and registration of messenger to the fuel tank in this project.

Fingerprint sensor is connected to the ESP8266

The connections of the fingerprint sensor to the ESP8266 are shown on table 3 below

Table 1: Connections of Fingerprint Sensor and ESP8266

Fingerprint Sensor	**ESP8266**
Green wire	GRD pin
Red Wire	5V pin
Black wire(TX)	D3
Yellow wire(RX)	D4

3.7.3 I2C LCD 16 x 2 module

Figure 11:I2C LCD 16 X 2 Module

I2C Liquid Crystal display (LCD) displays the output from the fingerprint sensor , connection status of controller to server, fuel added with messenger ID and also fuel levels.

The connections are shown on table below

Table 2: Connections of LCD and ESP8266

I2C LCD 16 X 2 Module	**ESP8266**
GRD	GRD pin
VCC	5V
SDA	D1
SCL	D2

3.7.4 Potentiometer

Figure 12: Potentiometer

Potentiometer function as LCD display screen contrast controller

3.7.6 Ultrasonic sensor

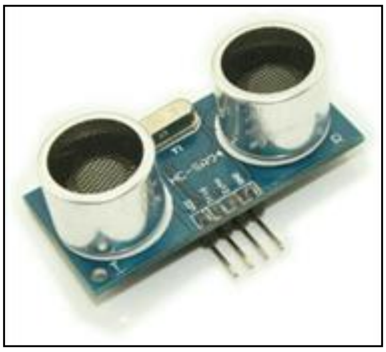


Figure 13: Ultrasonic sensor

The fig 17 above shows an Ultrasonic sensor used to measure fuel level in this project.

The connections are as follows

Table 3: Connection ESP8266 and Ultrasonic sensor

ESP8266	***Ultrasonic* sensor**
VCC (5V) pin	VCC pin
GRD pin	GRD pin
TRIG	D0
ECHO	D8

3.7.7 Buzzer

Figure 14: Buzzer

Buzzer is used as alarming sound device, showing that the tank is full in this project.

It was connected to the ESP8266 as shown

The connections are

Table 4: Connection of Buzzer to ESP8266

Buzzer	**ESP8266**
Positive pin	D7
Negative pin	GRD pin

CHARPTER 4: IMPLEMENTATION AND RESULTS

This chapter presents the data collected and the general output of the designed system after the whole system was set up in Chapter Three. This is illustrated using tables, figures and other relevant diagrams.

4.1 hardware presentation

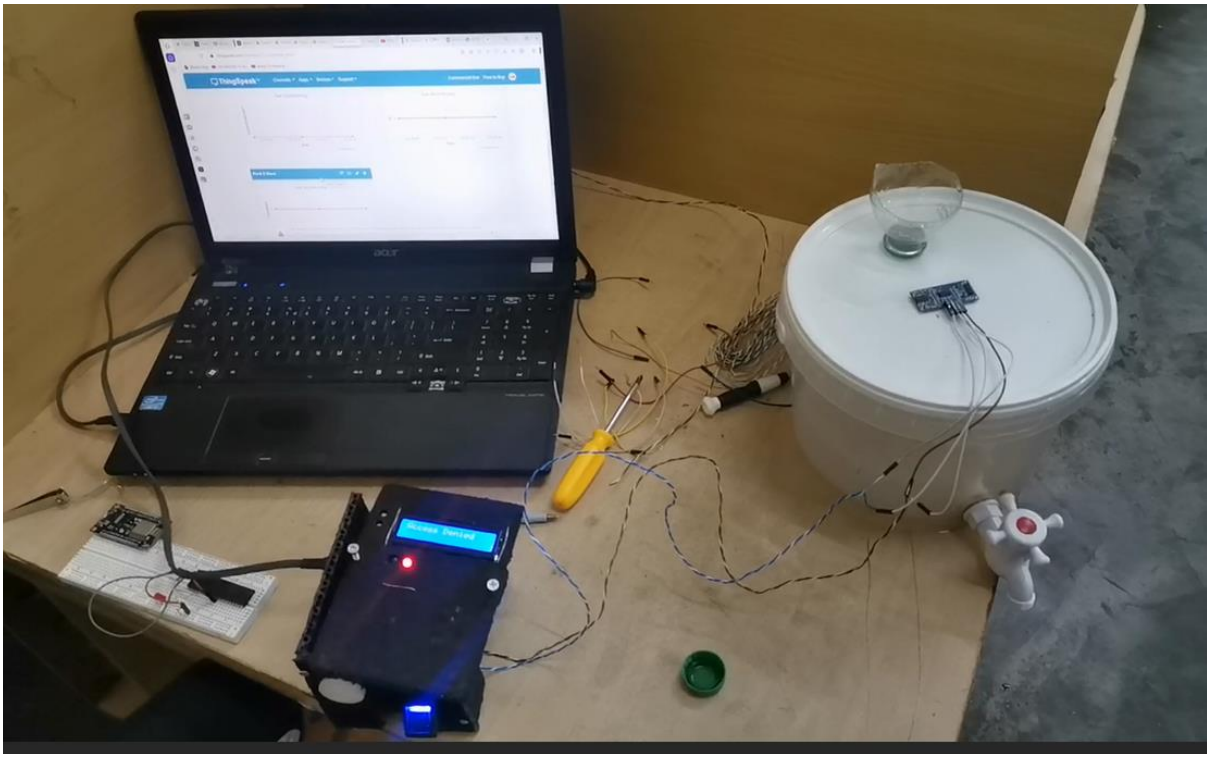


Figure 19: overall fuel monitoring system

This figure above shows overall fuel monitoring and security system comprising of a fuel tank with a Ultrasonic sensor to measure level, fingerprint sensor to register messenger details, buzzer for notification if the tank is full during refill, 2 LEDs thus green for showing authorization or fingerprint recognized and red for unauthorized, LCD for display and lastly inside that black box there is a microcontroller for the whole system which will record and send data to cloud server.

4.2 server results

Figure 20: Thing Speak display

Figure above shows three graphs in Thing Speak , 1 , this shows the variation of fuel level regularly ,2, the second graph shows ID of messenger when they refill with time the refill takes place ,3, it shows the amount of fuel added.

CHAPTER 5: CONCLUSION AND DISCUSSION

5.1 Discussion of Performance

According to the past performance of fuel monitoring as published by S.Boopathi et al. (2015), pp. 45–50 in the journal article Smart Generator Monitoring System, the system was able to monitor on a GSM module. The system was not able to remotely monitor and update the cloud server. The resultant system built by the author can now monitor fuel levels remotely using cloud servers (Think speak) and graphs. Using a cloud server like Thing Speak has no location barrier; anyone provided with the API keys can monitor the data from anywhere. The system also provides a notification alert to show the fuel has reached the minimum level to allow a messenger to drive to the designated server room to refill the fuel. [9]

Unlike the past performance of the fuel security system as published by S. Khan et al. (2013) in the journal article "Real Time Generator Fuel Level Measurement and Data Acquisition System, the system can only show data of persons that had access to the fuel without access control. The resultant system built by the author requires fingerprints to be scanned on the fingerprint sensor for access control to the tank. Once the fingerprint sensor authenticates the messenger using the enrollment database, the system allows the messenger to refill the fuel tank.[11]

5.2 Conclusion

The project successively designed and developed a monitoring and security system for fuel generators in server rooms. The system records fuel level on the sensor and uploads real-time data to the Think Speak cloud server. The main scope of the project problem statement, preventing malicious acts involved in monitoring the fuel, was successfully achieved, thereby reaching the aims and objectives of the project.

5.3 Limitation of Project Prototype

- The system does not provide a notification of fuel level it should reach after the refill by the messenger, the system should be upgraded to reach that security levels which should be included in future work.

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