Combustible Gas Storage Warehouse Monitoring System

Internet of Things

Higher National Diploma in Software Engineering

23.2F

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Declaration

I certify that this project does not incorporate without acknowledgement, any material previously submitted for a Diploma in any institution and to the best of my knowledge and belief, it does not contain any material previously published or written by another person or myself except where due reference is made in the text. I also hereby give consent for my project report, if accepted, to be made available for photocopying and for inter library loans, and for the title and summary to be made available to outside organizations

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Abstract

Gas is an important energy source used in industries and homes, and it is being used daily. This daily requirement requires heavy production and supply of gas, thereby, it will need to be stored and produced in secure facilities. Storing gas requires heavy safety measures in order to prevent destructive accidents caused by extreme temperatures or gas leaks.

This report will provide an overview of how IOT can be used to provide robust monitoring features for a warehouse and how efficient monitoring and alerting features can help prevent possible gas related accidents. The IOT system will use MQ2 gas sensors and DHT11 temperature and humidity sensors to detect an gas leaks or temperature spikes in the warehouse environment. The system will also make use of LEDs, Buzzers and Fans as the main actuators to demonstrate how industrial alarm systems and exhaust fans will begin to operate whenever any leakages or temperature spikes are detected.

The system will also explore the programming of the entire operation with the help of the ESP32-WROOM 32 programming board to provide the functionality of the entire IOT system. Additionally, we will provide an overview of how the data from the system can be displayed on to a mobile application and how alerts and warnings can be sent to the mobile application from system to device through the online cloud storage platform called Firebase which will provide real-time storage to instantly update the database and the data on the mobile device with new sensor data.

Acknowledgements

Firstly, we would like to pay our gratitude to National Institute of Business Management for providing us with the necessary resources and challenges that guided us to implement this project successfully, as well as for giving us the mental and physical fortitude to complete this project. This acknowledgement reaches out to everyone in the administration as a sign of gratitude for guiding us to ensure the success of our project

Next, I would like to sincerely thank my group members for their active contribution and participation to this project. The time and effort they dedicated was remarkable and it was with great team effort that we were able to complete this project.

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Introduction

Gas storage warehouses and production centers face daily challenges as gas in general is highly flammable and will need to be stored safely in warehouses that will constantly monitor the warehouse environment to make sure it is safe for the gas. Small gas leaks or high temperatures can lead to extreme damage to the warehouse and the surroundings and to make sure such disasters are prevented and avoided, it is essential to constantly monitor the entire environment inside the warehouse and this is where IOT comes into play.

With the use of IOT, we can make sure that the temperature and any gas leaks can be detected all the time and will alert workers and users of the system if any abnormal conditions are detected that could cause harm to the safety of warehouse workers. The system will make sure if the temperature exceeds the programmed threshold, precautionary measures like sounding alarms, sending notifications and alerts and activating the exhaust fans to make sure the warehouse begins cooling or exhausting any gas particles surrounding the warehouse environment.

Key functionalities of the IOT system as mentioned above will include automated detection of any gas leaks, temperature variations and actuating alarms, fans and sending alerts and warnings to users of the system and workers of the warehouse. Real time databases like Firebase will be used for this prototype and a mobile application developed using Android to view data and receive any warnings and alerts if any issue is detected.

Methodology

1. System Components

- **ESP32 WROOM 32**

  This is a microcontroller which is having both Wi-Fi and Bluetooth capabilities. This allows the board to be able to transfer and receive data through local connections or through the internet using HTTP protocols. The ESP32 is also capable of hosting webpages on the internet.

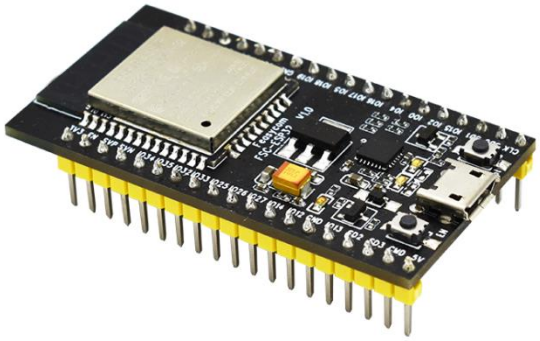

Figure 1: ESP32-WROOM-32

- **MQ2 Gas Sensor**

This sensor is used to detect any gas leak in the gas warehouse. Gases like Butane, propane, LPG, methane and some Natural Gases can be detected through this sensor. It requires 5 Volts to operate and it is an analog sensor, which reads values from 0-1024.

Figure 2: MQ2 gas sensor

- **DHT11 Sensor**

This sensor is used to detect both temperature and humidity. Provides float values for the temperature and humidity using 2 inbuilt methods of the DHT library called readTemperature() and readHumidity(). Requires 3-5 Volts to operate and the range of temperature varies between 0-50 degrees and the humidity from 20-99%

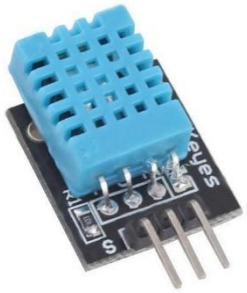

Figure 3: DHT11 sensor

- **LEDs**

LEDs are used in the system to act as an indicator that there is an issue or not in the warehouse. Red, Green and Yellow LEDs will be used to indicate the situations where there is a Danger, Warning or Safe.

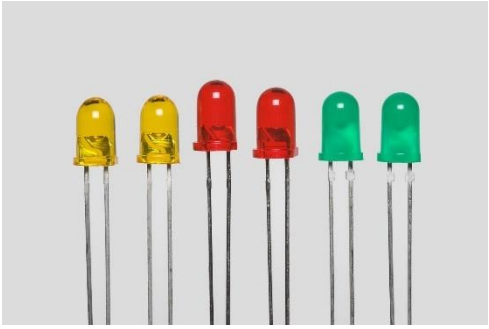

Figure 4: LEDs

- **Piezo Buzzer**

Piezo Buzzers act as the main indicator that there is an issue in the warehouse. These use electrical charges and signals to produce sound so whenever an abnormality in the readings from both the gas sensor and the Temperature and Humidity sensor are detected, an electrical signal can be sent to the piezo buzzer which will create an alarm sound. Working voltage can be from 3V to 250V depending on the type of buzzer being used.

Figure 5: Piezo Buzzer

- **Fan Module**

The fan module is used as an exhaust system in the warehouse to exhaust and send out detected gas particles in the environment and act as a cooling system for the warehouse whenever the temperature of the warehouse increases.

Figure 6: Fan Module

- **Firebase**

This is Google's mobile application development platform that also provides online databases that are easy to create and maintain for free cost. Real time database is used to provide real time monitoring and updates of the status of the warehouse.

Figure 7: Firebase

- **Android Studio**

Android Studio is an IDE that is used to develop android applications easily. The mobile application that will read and receive data and alerts will be an android based mobile application as it is easy to develop and easy to integrate with online platforms like Firebase.

Figure 8: Android Studio

2. Data Collection and Transmissions

For this system, we used MQ2 gas sensor and DHT11 sensor to gather real time gas readings of the environment from a range of 0-1024. From the DHT11 sensor, we gathered temperature and humidity data in float values which was possible to gather with in-built functions available in the DHT11 library by Adafruit which are readTemperature() and readHumidity().

The next requirement was to transmit this data to the live database provided by Firebase. ESP32 comes with an in-built Wi-Fi module which can transfer data across the internet through HTTP protocols. By providing the Wi-Fi SSID and password, we can establish the connectivity from the end of the ESP32 and when connected, data can be easily transmitted to the firebase. Wi-Fi provides a high bandwidth to allow more data packets to be transferred at a low latency.

Alerting mechanisms are implemented by checking the received sensor values against the thresholds that were set. Our main alerting system will be the combination of the Piezo buzzer and the LEDs, and the Fans will be activated to act as a precautionary measure when the alerts are activated.

3. Design Methodology

1. The main purpose of our system is to make sure that warehouses are provided with the necessary requirements to ensure that the gas they store, and produce will be safe from extremities like high temperature or gas leaks.
2. The main process of the system will be to monitor gas particle values in the environment and temperature data. Users will be able to read these values in real time without any delays. Actuators like piezo buzzers and fans will be actuated automatically whenever an abnormality is detected. Mobile applications will be used to view the data and any alerts and warnings in real time.
3. The main domain will be the Combustible Gas Storage Warehouse. The sensors will be the MQ2 gas sensor and the DHT11. Actuator domain will be the LED, Piezo Buzzers and the 5V Fan module. IOT gateway domain will be ESP32-WROOM-32 microcontroller which will act as the main hub for communications between online servers and sensor data as it is built with Wi-Fi capabilities. The database will be Firebase, and the endpoint of the system will be the values and alerts received on the Mobile Application.
4. Services provided in this system will be real-time alerting which is automatic based on the values from the sensor and conditions we program into the microcontroller.
5. The Architecture level of this system is Level 2. This is because the rate in sensing the data generated is huge which is why we used Firebase as the cloud storage for the sensed data. Data analysis is done locally, and control actions can be triggered through the mobile application.

6. Functions: Read sensor data, provide real time monitoring by storing the data real time to the firebase storage, provide alerts and notifications to the mobile application, trigger actuators when a value goes beyond the set threshold value. With all these functions mentioned we have the following Functional Groups: Monitoring Functions, Alerting Functions.
7. When we consider the Operational view of our application, service hosting and providers will be done by Firebase. Storage options will be provided by Firebase at no cost, and it is real-time, making it suitable for our application. The device considered will be a mobile device which is based on the Android operating system.
8. In the integration phase, we began by connecting the sensors to the ESP32-WROOM-32 microcontroller. Once the data from the sensors were gathered and read through the Serial Monitor, we began to add thresholds to differentiate suitable conditions and negative conditions and manipulated the sensor data to reach negative conditions to verify if the system was working as required. Afterwards, we began to provide the Wi-Fi SSID and password and provided the newly created Firebase project which consisted of a Firebase project link and database URL which was all required to establish connection between the microcontroller and Firebase. Once established and the data was stored in Firebase, we began making the mobile application using Android Studio and connected the newly connected application to Firebase so we could read the data stored in the database which was provided by the sensors.

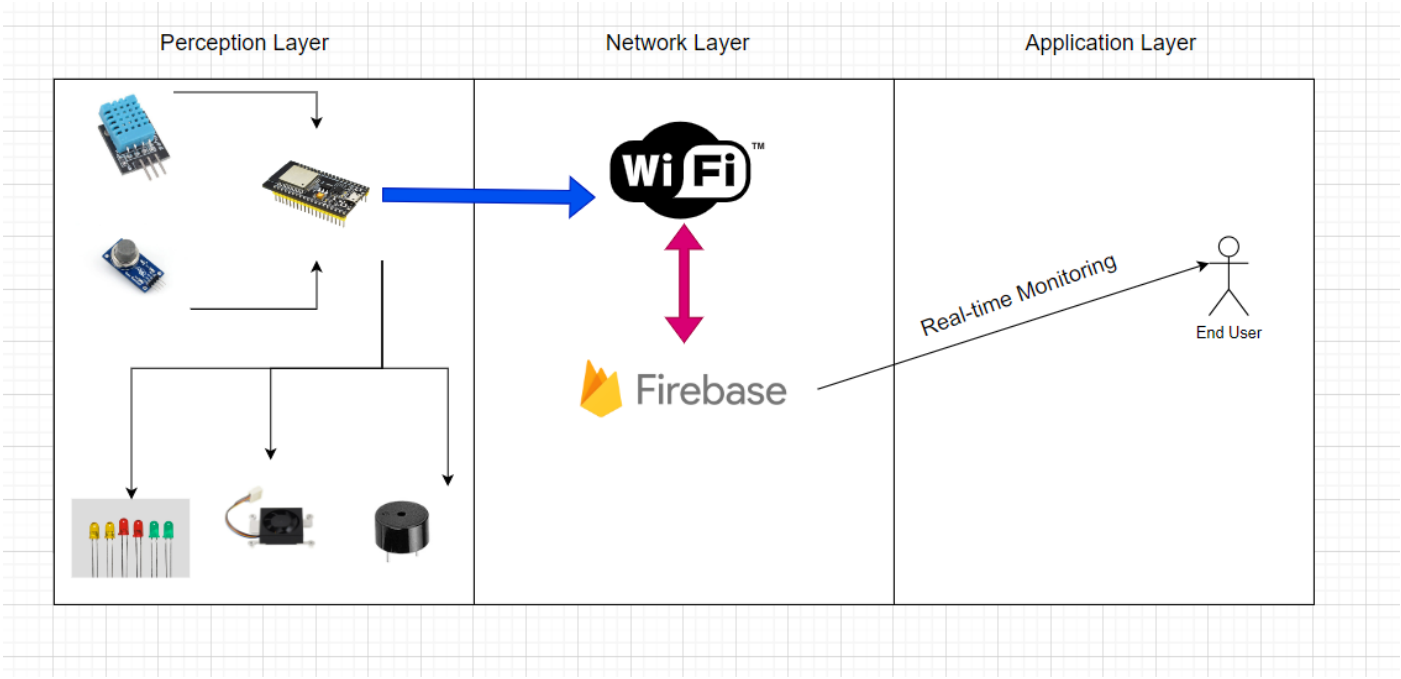

Figure 9: 3-layer architecture

Discussions

Progressing with the development of this system we came across several issues related to connectivity between the ESP32 microcontroller and the local machine which we ran the programs. Initially, the board and it's port does not appear in the device manager, and this required us to install an additional library from Silicon labs which was the CP2102 driver. Installing this helped us to identify the ESP32 board on to our machine.

We further came across issues establishing a connection between Firebase and the microcontroller, which was later on solved after referring several resources from the internet.

Future Implementations

For our future implementations we plan to integrate security features into this application with the help of a touch pad sensor and RFID tags to authenticate users to the warehouse as a measure to prevent internal sabotages that cause damage to any gas pipelines or containers.

Moreover, we plan to make use of additional gas sensors to detect various kinds of gases in the warehouse so it will help pinpoint what kind of gas leak there is surrounding the warehouse, and this allows us to take better precautionary measures to fix and solve the gas leak issue.

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Gantt Chart

Task	Week 1	Week 2	Week 3
Component Selection			
Sensor and Actuator Testing			
Microcontroller programming			
Firebase Integration with Microcontroller			
Mobile App development with Firebase connection			
System Testing and Debugging			

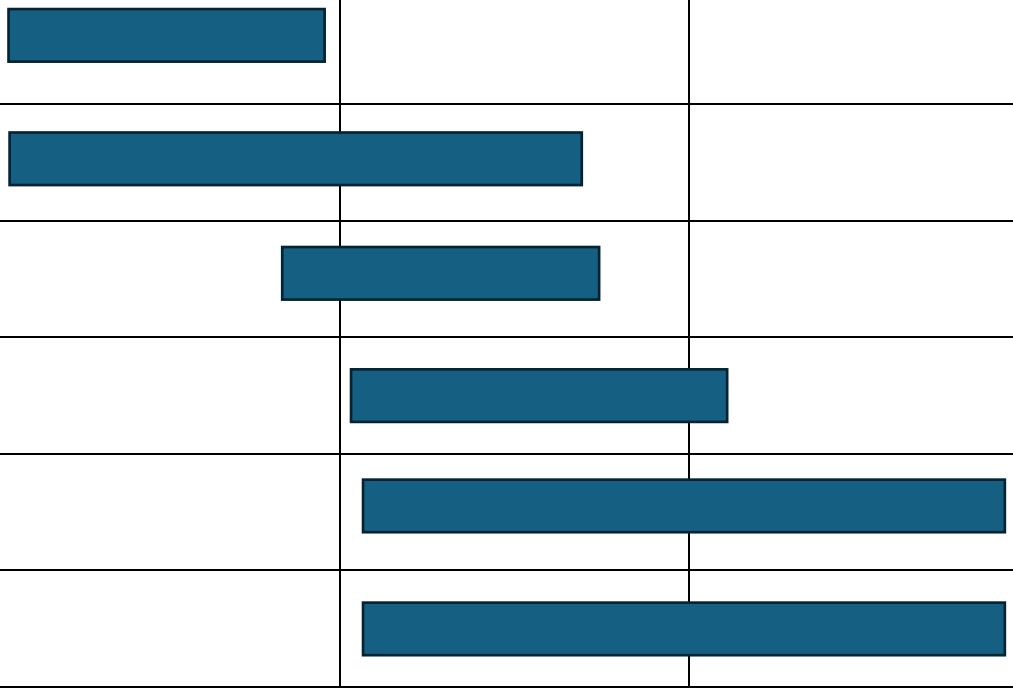

Figure 10: Gantt Chart