VISVESVARAYA TECHNOLOGICAL UNIVERSITY

BELAGAVI, KARNATAKA-590 018

MINI PROJECT
REPORT ON

Safety Monitoring System for Underground Miners

Submitted in partial fulfilment of the requirements for the ***Min Project Work (21CSMP67)*** *course ofthe 6th semester.*

BACHELOR OF ENGINEERING

IN

COMPUTER SCIENCE AND ENGINEERING

Submitted By

YOGESH C	1JS21CS181
REETIK SINGH	1JS21CS184
R RAJESH	1JS22CS412

Under the guidance of

Dr. Supriya B N
Assistant Professor, CSE Department

JSS ACADEMY OF TECHNICAL EDUCATION, BENGALURU
Department of Computer Science and Engineering
2023 – 2024

JSS MAHAVIDYAPEETHA, MYSURU

JSS Academy of Technical Education

JSS Campus, Uttarahalli, Kengeri Main Road, Bengaluru – 560060

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the mini project entitled **"Safety Monitoring System for Underground Miners**" is a benefited work carried out by **Yogesh C, Reetik Singh and R Rajesh** bearing USN **1JS21CS181, 1JS21CS184** and **1JS22CS412** bonafide students of **JSS Academy of Technical Education** in the partial fulfillment for the award of the **Bachelor of Engineering** in **Computer Science & Engineering** of the **Visvesvaraya Technological University**, Belgaum, during the year 2023-24. It is certified that all corrections / suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The mini project report has been approved as it satisfies the academic requirements in respect of mini project work prescribed for the said degree.

Dr. Supriya B N	**Dr. P B Mallikarjuna**
Assistant Professor	Professor & HOD,
CSE Department	CSE Department
JSSATE, Bengaluru	JSSATE, Bengaluru

ACKNOWLEDGEMENTS

I express our humble pranamams to his holiness Jagadguru **Sri Sri Sri Shivarathri Deshikendra Mahaswamiji** who has showered their blessings on us for framing our career successfully.

I have been lucky enough to have received a lot of help and support from all quarters during the making of this mini project, so with gratitude, I take this opportunity to acknowledge all those whose guidance and encouragement helped us emerge successful.

I am thankful to the resourceful guidance, timely assistance and graceful gesture of our guide **Dr. Supriya B N**, Assistant Professor, Department of Computer Science and Engineering who has helped me in every aspect of our mini project work.

I am also indebted to **Dr. P B Mallikarjuna**, Head of the Department of Computer Science and Engineering for the facilities and support extended towards us.

I express my sincere thanks to our beloved principal**, Dr. Bhimasen Soragoan** for having supported me in my academic endeavors. And last but not least, I would be very pleased to express my heart full thanks to all the teaching and non-teaching staff of CSE department and my friends who have rendered their help, motivation and support.

Yogesh C	1JS21CS181
Reetik Singh	1JS21CS184
R Rajesh	1JS22CS412

ABSTRACT

The "Safety Monitoring System for Underground Miners" is an advanced technological solution designed to enhance the safety and operational efficiency of mining environments. This system utilizes an ESP32 microcontroller to integrate various sensors—including Light Dependent Resistor (LDR), gas sensors, fire sensors, DHT11 for temperature and humidity, and DS18B20 for precise temperature measurements—along with a panic button for emergency signaling. The collected data is processed in real-time by the ESP32 and transmitted to the AWS IoT platform using the MQTT protocol, ensuring secure and efficient cloud communication. The data is then stored in a MongoDB database, providing a robust and scalable solution for data management. A user-friendly Streamlit web interface offers real-time and historical data visualization, enabling continuous monitoring and quick response to potential hazards. Actuators such as buzzers and LEDs provide immediate auditory and visual alerts to miners, enhancing their ability to respond promptly to dangerous conditions. This integrated system significantly improves safety measures by offering timely warnings and facilitating effective emergency responses, thereby ensuring a safer working environment for miners and contributing to the overall efficiency of mining operations.

TABLE OF CONTENT

TABLE OF FIGURES

CHAPTER 1

INTRODUCTION

The "Safety Monitoring System for Underground Miners" is an advanced project aimed at improving the safety and operational efficiency of mining environments. Underground mining poses significant hazards due to the enclosed nature of the work, the presence of harmful gases, high temperatures, and potential fire hazards. Ensuring the safety of miners is paramount, and traditional safety measures often fall short in providing real-time alerts and comprehensive monitoring. This project harnesses the power of modern Internet of Things (IoT) technology, integrating a variety of sensors with the ESP32 microcontroller to create a robust safety monitoring system.

The ESP32 microcontroller serves as the central unit of this system, interfacing with a suite of sensors designed to monitor critical environmental parameters. These sensors include an LDR (Light Dependent Resistor) for measuring light levels, a gas sensor for detecting hazardous gases, a fire sensor for identifying potential fire outbreaks, a DHT11 sensor for monitoring temperature and humidity, and a DS18B20 sensor for precise temperature readings. Additionally, the system is equipped with a panic button, allowing miners to send immediate distress signals in case of emergencies. The actuators, consisting of a buzzer and LEDs, provide auditory and visual alerts to ensure that warnings are promptly communicated to the miners.

The data collected from these sensors is transmitted to the AWS IoT platform using the MQTT protocol. MQTT, known for its lightweight and efficient communication capabilities, ensures that data is reliably sent even in the challenging conditions of underground mines. AWS IoT provides a secure and scalable environment for data storage and processing, facilitating real-time monitoring and analysis. The integration of AWS IoT with MongoDB allows for efficient data management and retrieval, supporting both real-time monitoring and historical data analysis.

A key feature of this system is its web-based interface developed using Streamlit. This interface provides a user-friendly platform for visualizing the collected data, making it accessible to mine supervisors and safety officers. The real-time dashboard displays current sensor readings, historical trends, and alerts, enabling quick decision-making and proactive safety management. The system's ability to store and visualize data helps in identifying patterns and potential hazards, contributing to improved safety protocols and preventive measures.

The white LED serves as an indicator of normal conditions, providing a constant light source in the mining area. In contrast, the red LED, coupled with the buzzer, activates in response to emergencies, such as the detection of harmful gases or the activation of the panic button. This dual-indicator system ensures that miners are immediately aware of any dangerous situations, allowing for timely evacuation and intervention.

The project's primary objective is to enhance the safety and health of underground miners by providing continuous, real-time monitoring of environmental conditions. By leveraging IoT technology, the system offers a proactive approach to safety management, reducing the risks associated with underground mining operations. The integration of a web-based interface for data visualization further empowers safety officers with the tools needed to monitor conditions effectively and respond swiftly to emergencies.

In conclusion, the "Safety Monitoring System for Underground Miners" represents a significant advancement in mining safety technology. By integrating a comprehensive set of sensors with a powerful microcontroller and utilizing modern cloud-based solutions for data transmission and storage, the system provides a reliable and effective means of ensuring miner safety. The use of a web-based interface for data visualization further enhances its practicality, making it an invaluable tool for mining operations. This project not only aims to improve the immediate safety of miners but also contributes to long-term safety improvements through data-driven insights and preventive measures.

1.1 Objective:

The "Safety Monitoring System for Underground Miners" project is designed with several key objectives in mind, all aimed at enhancing the safety and operational efficiency of underground mining environments. The primary objectives of the project are as follows:

1. **Continuous Monitoring of Environmental Conditions:**

    - Implement a robust system that continuously monitors critical environmental parameters such as light levels, gas concentrations, temperature, humidity, and the presence of fire. This ensures that any changes in the environment are detected promptly, providing real-time data to enhance situational awareness.

2. **Real-Time Alerts and Notifications:**

   - Develop a reliable alert system that provides immediate notifications to miners and supervisors in the event of hazardous conditions. This includes visual alerts through LEDs and auditory alerts through a buzzer, ensuring that warnings are promptly communicated, and actions can be taken quickly to mitigate risks.

3. **Proactive Safety Management:**

   - Facilitate proactive safety measures by providing real-time data and historical trends. This allows for the identification of patterns and potential hazards, enabling supervisors to implement preventive measures and improve overall safety protocols.

4. **Integration with AWS IoT and MQTT Protocol:**

   - Utilize AWS IoT and the MQTT protocol for secure and efficient data transmission. This ensures that data from the sensors is reliably sent to the cloud for storage and analysis, even in the challenging conditions of underground mining environments.

5. **Efficient Data Storage and Management:**

   - Store collected data in a MongoDB database, providing a scalable solution for data management. This supports both real-time monitoring and the retrieval of historical data, allowing for comprehensive analysis and reporting.

6. **User-Friendly Web Interface with Streamlit:**

   - Develop a web-based interface using Streamlit to visualize collected data. This interface should be user-friendly and accessible, providing supervisors with real-time data.

1.2 Literature Survey:

Wei Chen; Xuzhou Wang 15 November 2021 Coal Mine Safety Intelligent Monitoring Based on Wireless [1] Sensor Network Wireless Sensor Network (WSN) explores the use of the latest WSN technology in coal mine safety intelligent wireless monitoring, especially the three key technologies that need to solve the WSN wireless communication, transmission routing protocol and positioning algorithm for underground safety monitoring. The application of wireless sensor network in coal mine safety intelligent monitoring system is proposed, this paper discusses the principle and advantages of wireless sensor network and the design basis of wireless sensor network in intelligent monitoring system of coal mine safety. Based on the current situation and existing problems of the low level of intelligence of coal mine safety monitoring system, the design scheme and monitoring mechanism of coal mine safety intelligent monitoring system are proposed, and the feasibility of wireless sensor network in the application of coal mine safety intelligent monitoring system is discussed. Finally, the gateway proposed in this research was tested by laboratory simulation, and the results showed that the gateway designed in this research had good reliability and stability and proposed a new solution for the design of coal mine safety monitoring system.

Abhishek Srivastav; Sandhya Shrivastava; Anil Kumar; Vipin Kumar; Shantanu Srivastava 2022 2nd Asian Conference on Innovation in Technology (ASIANCON) Coal Mine Safety Monitoring and Alerting System [2] The most crucial component of every industry is security. The only factor in the mining business is safety and security. The mining industry takes many safeguards to prevent accidents of any kind, including steel accidents. Temperature increases cause methane gas leaks and an increase in water levels in underground mines. Here, we give workers protection. When the danger can be suppressed by the worker, we alert the panic switch protection. To improve safety between employees in underground mines and 10 between the stationary landmine system, a dependable communication system should be implemented. There should never be a break in the communication network. This project suggests a Zimbi best wireless my supervision system with early warning intelligence. On IoT, the worker status can be followed.

Yingli Zhu; Guoping You 2019 Cross Strait Quad-Regional Radio Science and Wireless Technology Conference (CSQRWC) [3] In view of the problems of explosive, corrosion and accidents in underground coal mine production, this paper designs a monitoring system based on wireless sensor network, which can monitor the gas concentration, temperature and humidity parameters, and alarm when the parameters exceed the fixed value. Experiments show that the system is stable in performance, accurate in measurement, and helpful to improve mine safety and reduce accidents.

Yogendra S Dohare; Tanmoy Maity; Partha S Paul; Partha S Das 2014 International Conference on Signal Propagation and Computer Technology (ICSPCT 2014) [4] This paper presents a low power, cost-effective, and ZigBee protocol based wireless sensor network that provides an intelligent surveillance and safety system for underground coal mines. The system consists of wireless connection of several nodes. Sensor node mainly consists of ZigBee protocol based low power CC2530 transceiver integrated with a high performance, low power microcontroller on single chip. This integrated chip connected through RF connector on smartRF05 Battery Board. This small size, low power device is easily interfaced with desired miniature size sensors. Wireless sensor nodes join to other sensor node in specific multi-hop mesh network topology, that creates a ZigBee based wireless sensor network. This network can be easily placed in underground mines and it provides an effectively surveillance and safety system for underground coal miners. Especially, it provides the real-time data communication between miners and surface control room through highly secure, reliable wireless sensor nodes. The proposed system improves the existing miner's safety and early warning surveillance in underground coal mines.

Sri Divya*1, Pingili Siddartha*2, Pilli Pranay*3, Sailla Prashanth*4, Nallaganti Venu*5 Volume:06/Issue:04/April-2024 [5] A coal mine safety system is implemented for this project by using an IP address as a data transmission medium. The device is used to monitor a variety of parameters inside coal mines, including light detection, gas leakage, temperature and humidity levels, and fire detection. This sensor network is known as one large device and is installed in coal mines. Gas monitoring equipment is still running here to detect any potential problems, and a buzzer is used to alert the staff. In this framework,

Fire sensors are used to detect the presence of flame. When you turn on the lights, they illuminate automatically, and you can control them with the LED button.A notice is sent to the designated individual's mail to ensure proper response to any potential fire hazard. There is also a collection of constantly measured and recorded temperature values, which are displayed on the serial monitor and the website platform. A vibration sensor is also used to detect any movement in the mine.

CHAPTER 2

METHOD OF EXECUTION

PROBLEM STATEMENT:

Underground mining operations present significant safety challenges due to the hazardous environment miners work in. These hazards include potential gas leaks, fire outbreaks, and unstable temperatures and humidity levels, which can lead to dangerous situations. Ensuring the safety of miners is paramount and requires a robust system for continuous monitoring and alerting in real-time.

2.1 Block Diagram:

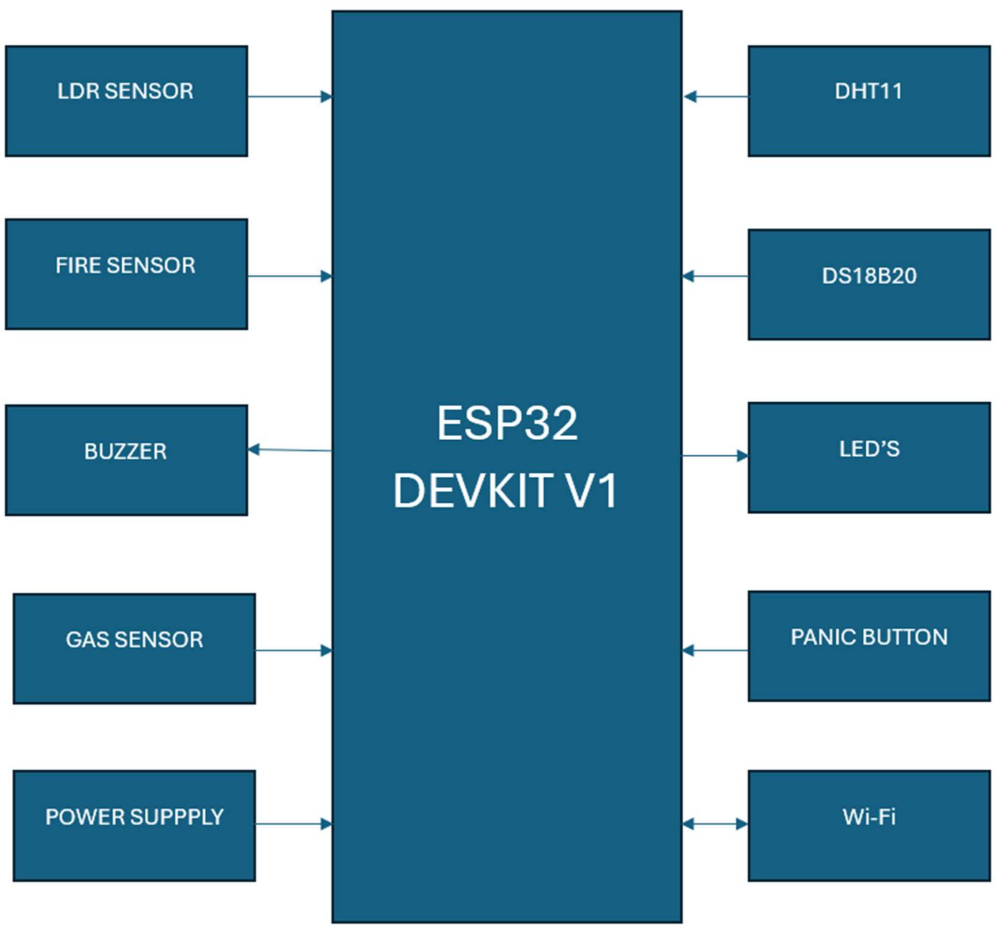

Figure 2.1 Hardware Block Diagram

1. Sensors:

- **LDR (Light Dependent Resistor):** Measures ambient light levels. The output is sent to the ESP32 for processing.
- **Gas Sensor:** Detects the concentration of hazardous gases. The sensor's output is transmitted to the ESP32.
- **Fire Sensor:** Identifies smoke or fire. The sensor sends its data to the ESP32.
- **DHT11 Sensor:** Measures temperature and humidity. The data is relayed to the ESP32 for analysis.
- **DS18B20 Sensor:** Provides precise temperature readings. It sends temperature data to the ESP32.
- **Panic Button:** Allows miners to send an immediate distress signal. When pressed, it triggers an alert signal to the ESP32.

2. ESP32 Microcontroller:

- **Processing Unit:** Collects and processes data from all sensors.
- **Communication Module (Wi-Fi):** Transmits processed data to the AWS IoT platform using the MQTTS protocol.
- **Actuator Control:** Manages the activation of actuators based on sensor data and panic button inputs.

3. Actuators:

- **Buzzer:** Emits an audible alarm when hazardous conditions are detected or the panic button is pressed. The ESP32 controls the buzzer based on sensor inputs.
- **LEDs (White and Red):**
  1. **White LED:** Indicates normal conditions. Controlled by the ESP32 to provide continuous illumination.
  2. **Red LED:** Activates during emergencies. The ESP32 manages the LED to signal danger.

4. Data Transmission:

- **AWS IoT Platform:** Receives data from the ESP32 via MQTT protocol. The platform ensures secure and efficient data transmission to the cloud.

5. Data Storage and Management:

- **MongoDB Database:** Stores data received from AWS IoT. Provides a scalable solution for data management, enabling real-time and historical data access.

6. Data Visualization:

- **Streamlit Web Interface:** Displays real-time and historical data on a web-based dashboard. Allows users to monitor environmental conditions and receive alerts.

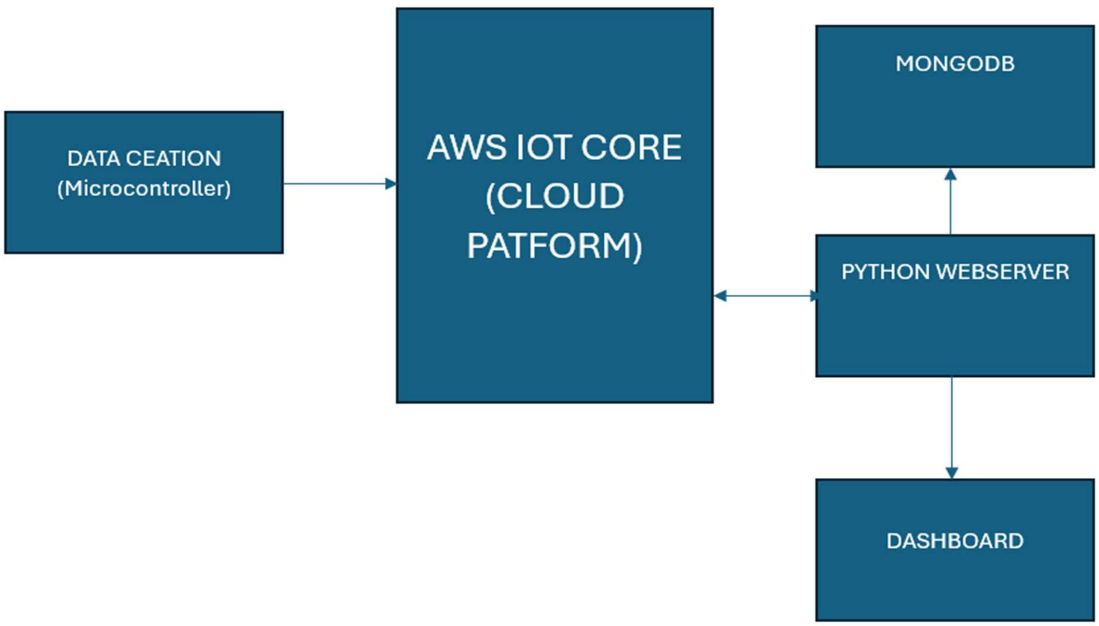

Figure 2.2 Software Block Diagram

Block Diagram Flow:

- Sensors collect environmental data and send it to the ESP32 Microcontroller.
- The ESP32 processes the data and makes decisions based on predefined thresholds.
- Actuators (buzzer and LEDs) are activated based on the sensor data and panic button input.
- The ESP32 transmits the processed data to the AWS IoT Platform via Wi-Fi using the MQTT protocol.
- Data is stored in the MongoDB Database for management and future access.
- The Streamlit Web Interface retrieves and visualizes the data for users, providing real-time monitoring and alerts.

- The system is powered by a Power Supply to ensure uninterrupted operation.

This block diagram content outlines the flow and interaction between different components of the Safety Monitoring System, providing a clear overview of how data is collected, processed, and utilized for monitoring and safety purposes.

2.2 Hardware Components:

2.2.1 ESP32 Microcontroller:

The ESP32 serves as the central processing unit for the Safety Monitoring System for Underground Miners. It is a versatile, low-power microcontroller developed by Espresso Systems, renowned for its high performance, integrated Wi-Fi and Bluetooth capabilities, and extensive I/O support, making it ideal for IoT applications. In this system, the ESP32 handles

Figure 2.3 ESP32 Microcontroller

collection, processing, and communication with AWS IoT. Its dual-core CPU, running at up to 240 MHz with up to 520 KB of SRAM and 4 MB of flash memory, provides sufficient computational power to efficiently manage complex algorithms and real-time data processing. The ESP32's energy-efficient design and various sleep modes optimize power usage, making it suitable for battery-powered devices, while its advanced power management features reduce power consumption without compromising performance.

2.2.2 Sensors:

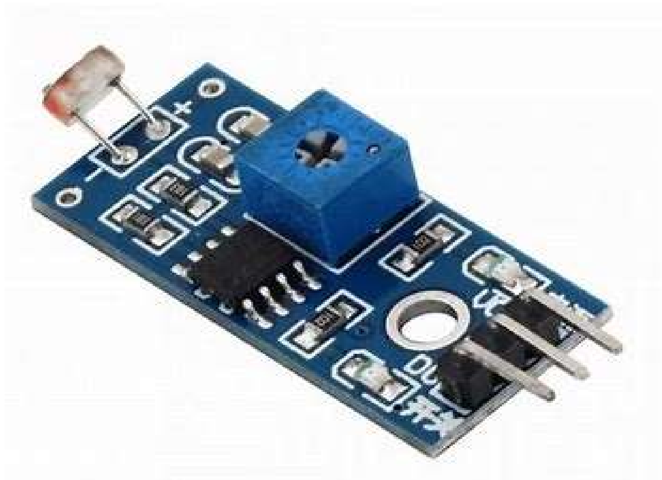

Figure 2.4 LDR Sensor

LDR (Light Dependent Resistor):

The Light Dependent Resistor (LDR) is an essential sensor for measuring ambient light intensity within the mining environment.

It operates on the principle that its resistance decreases as the light intensity increases, providing a reliable measure of light levels. This functionality is crucial in underground mining, where adequate lighting is vital for safety and operational efficiency. The LDR ensures that lighting conditions are monitored continuously, alerting the system if the light falls below safe levels, thereby preventing accidents due to poor visibility.

Gas Sensor (MQ-2):

The gas sensor, typically from the MQ series such as MQ-2 or MQ-7, is designed to detect hazardous gases like methane (CH4), carbon monoxide (CO), and other toxic substances. These sensors use sensitive materials that alter their resistance in the presence of specific gases, translating the change into measurable gas concentration levels. In the mining context, the gas sensor is a critical safety component, enabling early detection of dangerous gases. This early warning allows miners to take preventive actions before gas concentrations reach perilous levels, thereby safeguarding their health and safety.

Figure 2.5 MQ-2 Sensor

Fire Sensor:

The fire sensor, often an infrared smoke detector, plays a pivotal role in detecting smoke or flames within the mine. It operates by sensing infrared light scattered by smoke particles in the air, triggering an alarm when smoke is detected. This early warning system is vital for preventing fire-related incidents, allowing for swift evacuation and immediate response to extinguish the fire. In the high-risk environment of underground mining, such proactive fire detection is essential for ensuring the safety and protection of both miners and equipment.

Figure 2.6 Fire Sensor

DHT11 Sensor:

The DHT11 sensor is a dual-purpose sensor that measures both temperature and humidity, essential for maintaining a safe and comfortable working environment in the mine. Utilizing a capacitive humidity sensor and a thermistor, it provides accurate digital readings of temperature and humidity levels. This data is crucial for monitoring conditions that can affect miners' health and comfort, such as excessive humidity or extreme temperatures. The DHT11 ensures that environmental conditions remain within safe limits, contributing to the overall well-being of the miners.

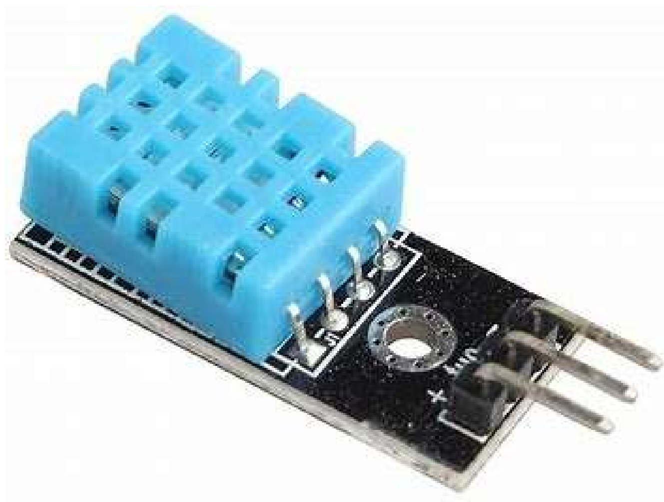

Figure 2.7 DHT11 Sensor

DS18B20 Sensor:

The DS18B20 sensor is a highly accurate digital temperature sensor that provides precise readings over a wide temperature range. Using a 1-Wire interface for communication, it can measure temperatures from -55°C to +125°C with an accuracy of ±0.5°C. This precision makes it invaluable for monitoring critical temperature points within the mine, ensuring that any unusual temperature fluctuations are detected early.

Figure 2.8 DS18B20

Maintaining optimal temperature conditions is crucial for preventing overheating and ensuring the safety and efficiency of mining operations.

Push Button:

The panic button is a crucial safety feature designed to provide miners with a direct means of sending immediate distress signals in emergencies. When pressed, it completes an electrical circuit, sending a signal to the ESP32 microcontroller to trigger an alert. This feature ensures that miners can quickly and easily call for help in urgent situations, significantly enhancing their safety by facilitating rapid response and assistance.

Figure 2.9 Push Button

2.2.3 Actuators:

Buzzer:

The buzzer is an actuator that emits an audible alarm when hazardous conditions are detected or when the panic button is activated. It functions by using an electromagnetic coil to produce sound waves when current flows through it. The frequency and volume of the sound can be controlled to ensure that the alarm is loud enough to be heard over the noise of the mining environment. This immediate auditory warning is crucial for alerting miners to potential dangers, enabling prompt evacuation and response to ensure their safety.

Figure 2.10 Push Button

LEDs (White and Red):

The LED indicators play a dual role in the safety monitoring system. The white LED provides continuous illumination under normal conditions, ensuring that miners have adequate visibility. This LED operates by emitting light when current flows through its semiconductor diode, offering an energy-efficient and long-lasting light source. In contrast, the red LED is designed to signal emergencies. It activates along with the buzzer when hazardous conditions are detected or the panic button is pressed, providing a clear and unmistakable visual warning. This dual-indicator system ensures that miners are promptly alerted to both normal and emergency conditions, enhancing their situational awareness and safety.

These sensors and actuators collectively create a comprehensive safety monitoring system,

Figure 2.11 LED’s

ensuring that miners are protected through continuous environmental monitoring and immediate alert mechanisms.

2.3 Software Requirements:

2.3.1 Arduino IDE:

Arduino IDE (Integrated Development Environment) is a cross-platform application used for writing and uploading programs to Arduino boards. Here are some key features:

- **Code Editor:** Provides a simple and user-friendly text editor to write and edit Arduino sketches (programs).
- **Libraries:** Includes a vast collection of libraries that help in extending the functionality of Arduino boards.
- **Board Manager:** Allows users to add support for different types of Arduino and third-party boards.
- **Serial Monitor:** Provides a built-in serial monitor to communicate with the Arduino board via serial communication.
- **Sketchbook:** A folder where all your Arduino sketches are saved.
- **Easy to Use:** Designed to be simple enough for beginners while flexible enough for advanced users.

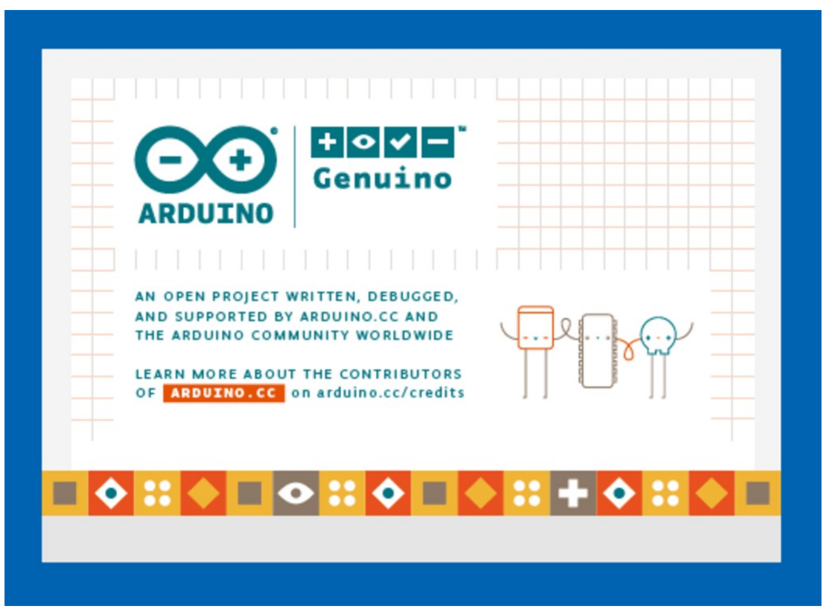

Figure 2.12 Arduino IDE

2.3.2 Mqttx:

MQTTX is a cross-platform MQTT 5.0 desktop client developed by EMQ for developers to develop, test, and debug MQTT services. Here are some features:

- Multi-Platform: Available for Windows, macOS, and Linux.
- User-Friendly Interface: Provides an easy-to-use interface for connecting to MQTT brokers, publishing, and subscribing to topics.
- Support for MQTT 5.0: Implements the latest MQTT 5.0 standard, ensuring compatibility with modern MQTT brokers.
- Multi-Tab: Allows multiple connections to different brokers or multiple sessions to the same broker.
- Message Formatter: Provides a built-in formatter for JSON, HEX, Base64, and plain text.

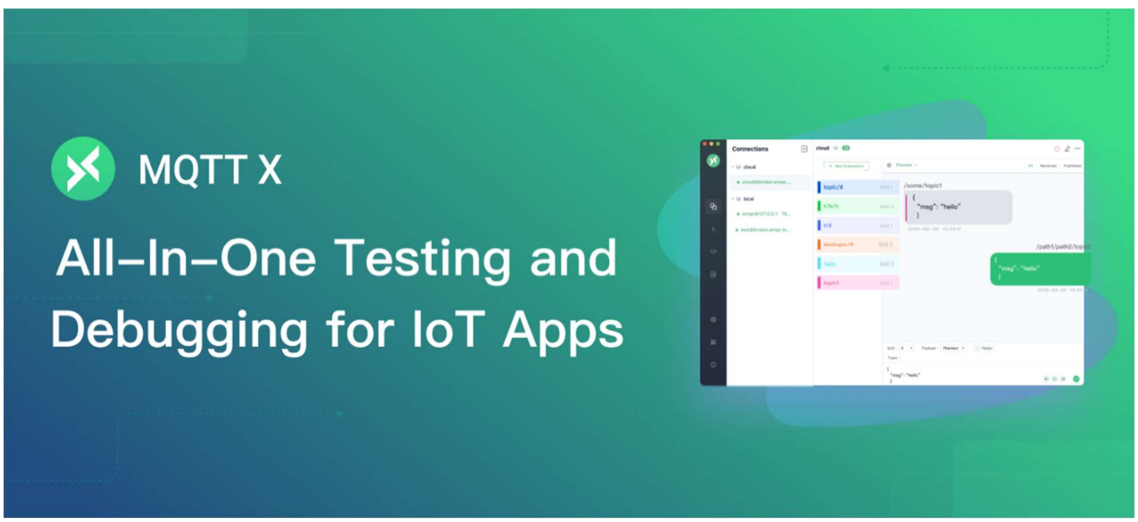

Figure 2.13 MQTTX

2.3.3 MongoDB:

MongoDB is a NoSQL, document-oriented database designed to store, query, and manage JSON-like documents [6]. Key features include:

- **Schema-less:** Supports dynamic schemas, which means documents can have different structures.
- **Document Storage:** Stores data in flexible, JSON-like documents, making it easy to store and query complex hierarchical data.

- **High Performance:** Optimized for read and write operations, making it suitable for high-performance applications.

Figure 2.14 MangoDB Compass

- **Scalability:** Provides horizontal scalability through sharding, allowing it to handle large amounts of data across many servers.
- **Aggregation Framework:** Allows for powerful and efficient data aggregation operations.
- **Indexing:** Supports various types of indexes to optimize query performance.
- **Replication:** Provides high availability with replica sets, ensuring data redundancy and failover capability.

2.3.4 AWS IoT Core:

AWS IoT Core is a managed cloud service that allows secure, scalable communication between Internet-connected devices and AWS cloud services [5]. Here are some key features:

- **Secure Communication**: Utilizes TLS for secure MQTT and HTTPS connections to protect data in transit. Supports mutual authentication for secure device communication.

- **Scalability**: Automatically scales to handle the number of connected devices and message traffic, accommodating millions of devices.

- **Device Shadows**: Provides a persistent virtual representation of each device, allowing applications to interact with devices even when they are offline.

- **Rules Engine**: Allows you to define rules to process and route incoming data to other AWS services like Amazon S3, Amazon DynamoDB, or AWS Lambda for further processing.
- **Message Broker**: Uses MQTT (Message Queuing Telemetry Transport) protocol to handle publish/subscribe messaging, providing low-latency and efficient communication.
- **Fleet Management**: Provides tools for managing and updating fleets of devices, including firmware updates and configuration changes.
- **Integration with AWS Services**: Seamlessly integrates with other AWS services such as AWS Lambda, Amazon Kinesis, and Amazon CloudWatch for enhanced data processing, storage, and monitoring.
- **Custom Authentication**: Supports custom authentication and authorization policies, including AWS IAM roles and policies for fine-grained access control.

AWS IoT Core is designed to handle the complexities of IoT device management and data processing, making it easier to build and deploy IoT applications at scale.

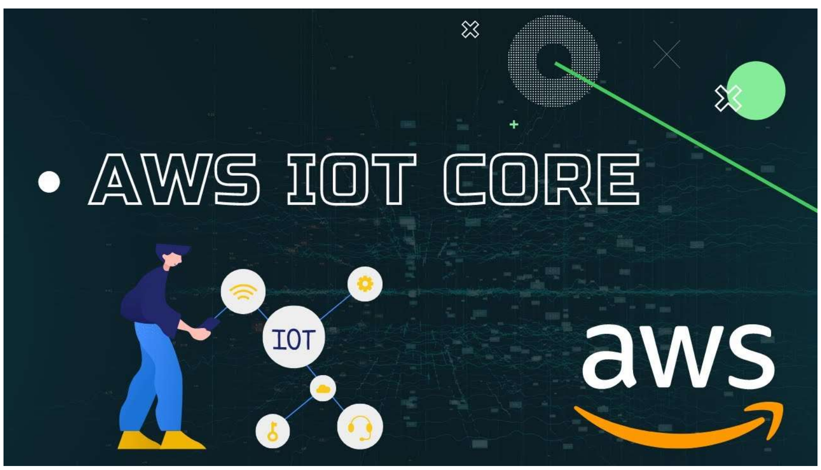

Figure 2.15 AWS IoT Core

CHAPTER 3

SYSTEM DESIGN

3.1 Architecture Diagram:

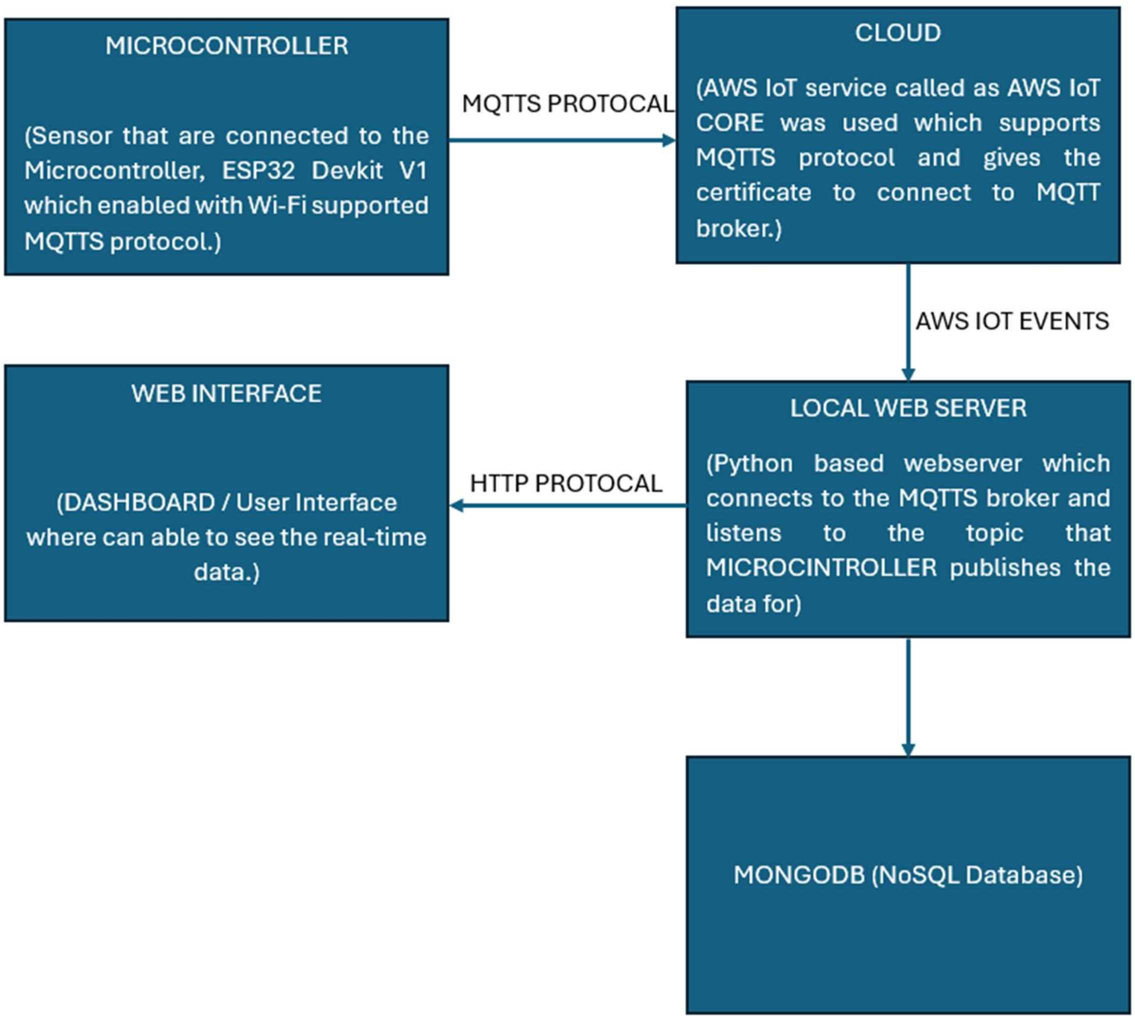

Figure 3.1 Architecture Diagram

The architecture of the "Safety Monitoring System for Underground Miners" is meticulously designed to deliver reliable, real-time safety monitoring through an integrated approach involving various hardware components, communication protocols, and software platforms. At the heart of the system is the ESP32 microcontroller, which acts as the central processing unit.

It interfaces with multiple sensors: the LDR (Light Dependent Resistor) for measuring ambient light levels, the gas sensor for detecting hazardous gases,

the fire sensor for identifying smoke or fire, the DHT11 for monitoring temperature and humidity, and the DS18B20 for precise temperature readings. Additionally, a panic button is included to allow miners to send immediate distress signals. The sensor data is continuously collected and processed by the ESP32, which uses its built-in Wi-Fi module to transmit this information to the AWS IoT platform via the MQTT protocol. The AWS IoT platform securely transfers the data to a MongoDB database, where it is stored and managed. For real-time visualization and monitoring, the system features a Streamlit web interface that retrieves data from MongoDB and presents it through a user-friendly dashboard. The architecture also includes actuators such as a buzzer and LEDs (white and red), which are controlled by the ESP32 to provide auditory and visual alerts based on the sensor data and emergency signals. A stable power supply ensures continuous operation of all components, accommodating fluctuations and providing reliable power to the system. This integrated architecture ensures effective real-time monitoring, immediate response to emergencies, and comprehensive safety management for underground mining operations.

3.2 Hardware Programming:

Generating hardware programming typically involves creating firmware that runs on the hardware components. This firmware handles the interactions between the hardware and other systems, such as sensors, actuators, and communication modules. Here’s a basic example of hardware programming for your Safety Monitoring System for Underground Miners using an ESP32 microcontroller. This example assumes that you have the following sensors connected:

- LDR (Light Dependent Resistor)
- Gas Sensor
- Fire Sensor
- DHT11 (Temperature and Humidity Sensor)
- DS18B20 (Temperature Sensor)
- Panic Button
- Buzzer

- White and Red LEDs

The goal is to read data from these sensors and send it to AWS IoT using MQTT. We'll use the Arduino framework for programming the ESP32.

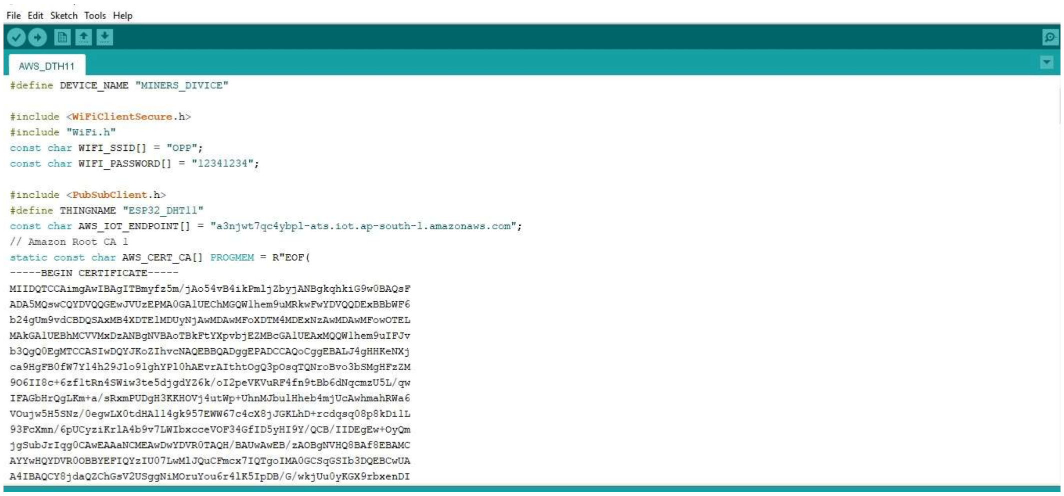

Figure 3.2 Screenshot of Arduino IDE with Code Snippet

PREREQUISITES

- Install the Arduino IDE.
- Install the ESP32 board package in the Arduino IDE.
- Install the necessary libraries:
- PubSubClient for MQTT
- DHT for DHT11
- One Wire and Dallas Temperature for DS18B20

Explanation

- **Wi-Fi and MQTT Setup**: Connect to the Wi-Fi network and set up the MQTT client.
- **Sensor Initialization**: Initialize the DHT11 and DS18B20 sensors.
- **Pin Definitions**: Define the pins for the LDR, Gas Sensor, Fire Sensor, Panic Button, Buzzer, and LEDs.
- **Reading Sensor Data**: Read data from all the sensors and the panic button.
- **Creating JSON Payload**: Create a JSON string with all the sensor data.
- **Publishing to MQTT**: Publish the JSON payload to the MQTT broker.

Figure 3.3 Serial Monitor Indicating Aws Connection

- **Handling Panic Button**: Turn on the buzzer and red LED if the panic button is pressed.

3.3 Wiring Diagram:

Ensure that all sensors and components are connected to the ESP32 according to their specifications. Pin numbers in the code should match your wiring.

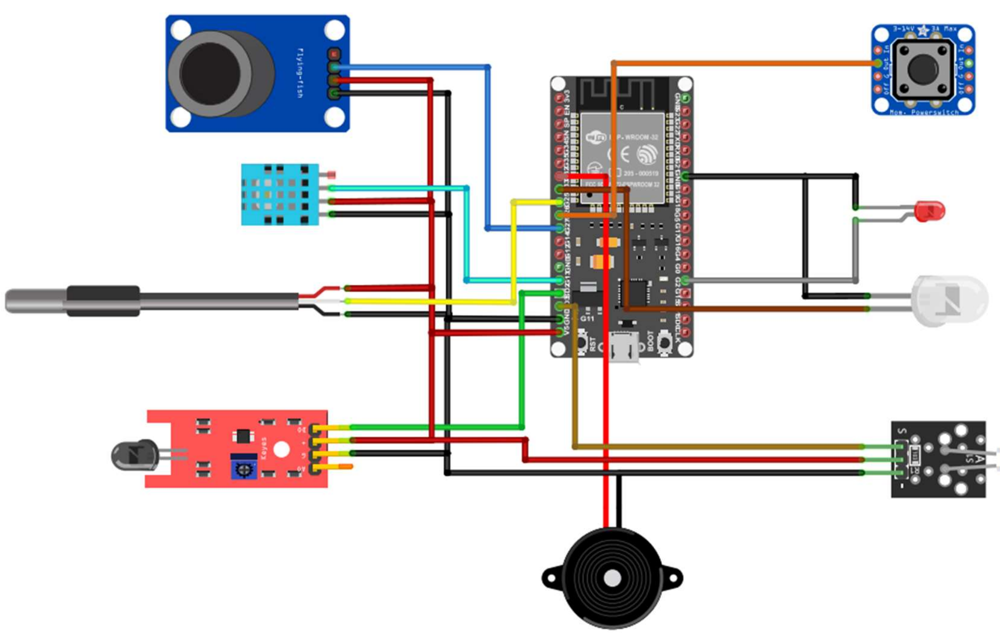

Figure 3.4 Hardware Circuit Diagram

3.4 Hardware Testing:

Hardware testing is crucial for ensuring that your electronic systems function correctly and reliably. By systematically testing each aspect of your hardware, you ensure that your Safety Monitoring System is reliable and performs well under all expected conditions. We have used MQTTX to verify the data which has sent by the Controller generated by sensor based on the conditions the sensor undergone (text environment).

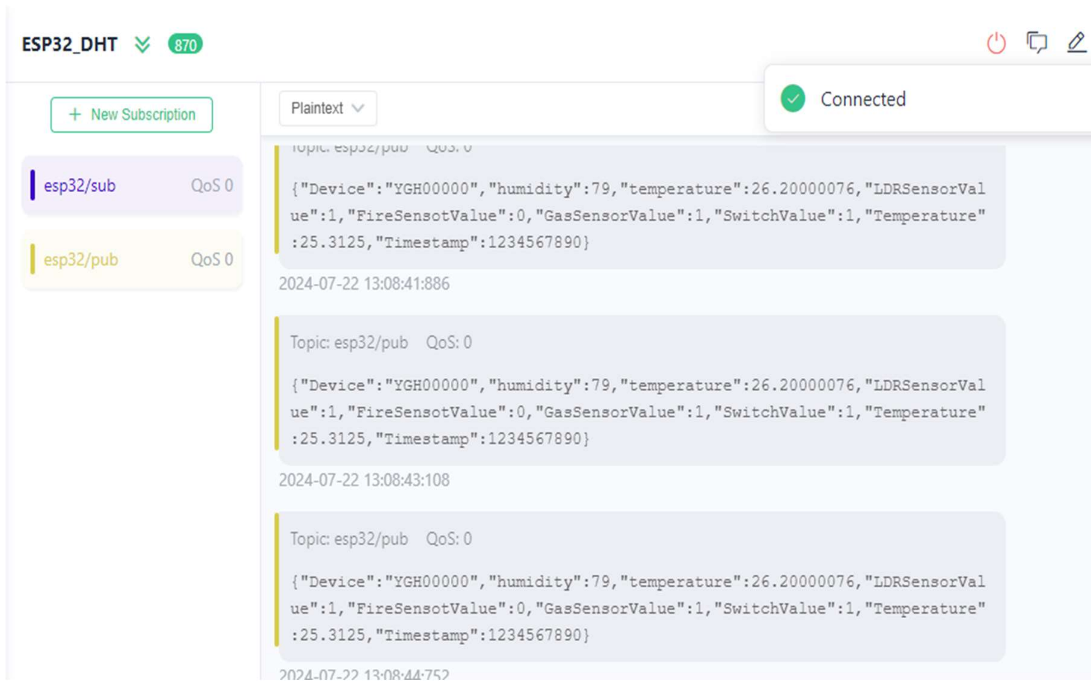

Figure 3.5 Data View in MQTTX Window

Testing and Debugging

- **Monitor Serial Output**: Open the Serial Monitor (Tools > Serial Monitor) to view sensor readings and MQTT connection status.
- **Verify MQTT Messages**: Use an MQTTX client tool to subscribe to the topic and check the messages sent by the ESP32.
- **Adjust and Iterate**: Based on test results, tweak the sensor thresholds, payload format, or MQTT settings as needed.

3.5 Software Programming:

For the backend of your Safety Monitoring System using Python and Streamlit, we'll create a web application that can display sensor data stored in MongoDB. Here's a step-by-step guide to get you started:

Prerequisites

1. Python Environment:

    - Ensure you have Python installed. You can download it from python.org.

```
data_preprocessing.py > ...
import paho.mqtt.client as mqtt
import ssl
import json
from pymongo import MongoClient
import time
import streamlit as st

# Define the AWS IoT endpoint and topic
AWS_IOT_ENDPOINT = "a3njwt7qc4ybpl-ats.iot.ap-south-1.amazonaws.com"
AWS_IOT_PORT = 8883
MQTT_TOPIC = "esp32/pub"

# Path to the certificate files
ROOT_CA_PATH = "C:/Users/vishw/Downloads/AmazonRootCA1(1).pem"
CERTIFICATE_PATH = "C:/Users/vishw/Downloads/ee8d5ee1fc7e18865454732b40216ac2209f07062173b08c7a8476e868bb097c-certif
PRIVATE_KEY_PATH = "C:/Users/vishw/Downloads/ee8d5ee1fc7e18865454732b40216ac2209f07062173b08c7a8476e868bb097c-private

# MongoDB Atlas connection string
MONGO_URI = "your-mongodb-atlas-connection-string"

# Connect to MongoDB Atlas
client = MongoClient("mongodb+srv://Vishwas:Vishwasgowda@django.zyn54ai.mongodb.net/?retryWrites=true&w=majority")
db = client['MINERS']
collection = db['rawdata']
```

Figure 3.6 Screenshot of Python Code

Python Libraries Used:

- SSL
- JSON
- PYMONGO
- PAHO MQTT
- TIME
- STREAMLIT

MongoDB Setup

MongoDB Connection:

- Ensure your MongoDB server is running and accessible. If you're using MongoDB Atlas, make sure you have the connection string.

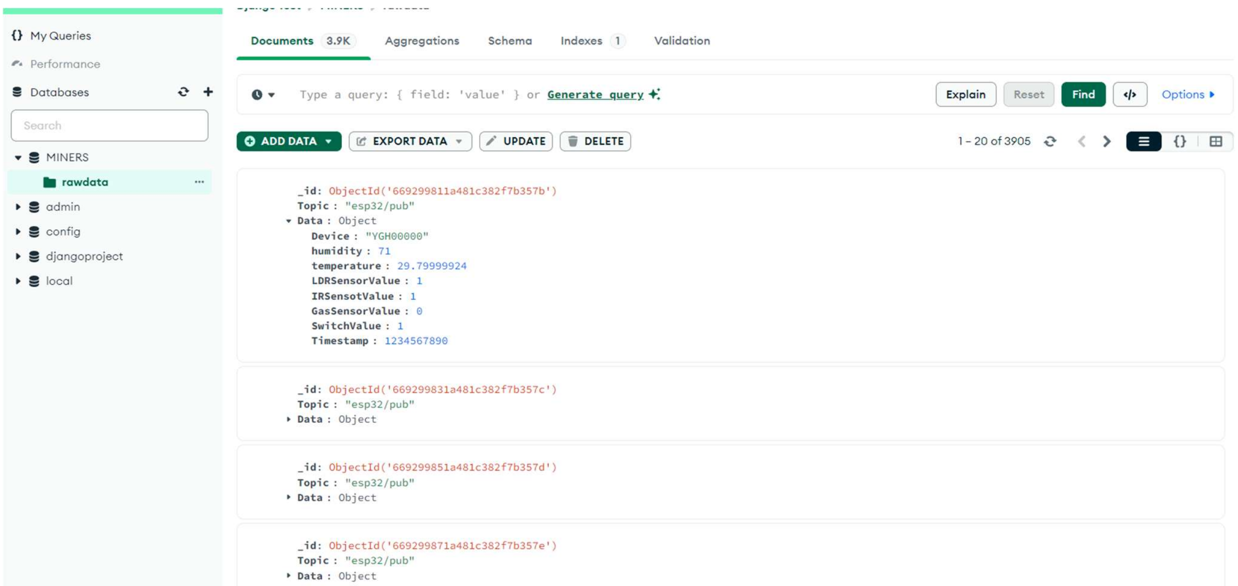

Figure 3.7 MangoDB Compass with Raw Data

CHAPTER 4

RESULTS & CONCLUSION

4.1 Results:

The implementation of the "Safety Monitoring System for Underground Miners" has yielded significant results in enhancing the safety and operational efficiency of underground mining environments. The system's architecture effectively integrates various hardware components, including sensors and actuators, with advanced communication and data management technologies. The ESP32 microcontroller, as the central processing unit, reliably collects and processes data from multiple sensors—such as the LDR for ambient light, gas sensors for detecting hazardous gases, fire sensors for smoke detection, and temperature and humidity sensors (DHT11 and DS18B20). This comprehensive data collection is complemented by a panic button feature, allowing miners to signal emergencies instantly.

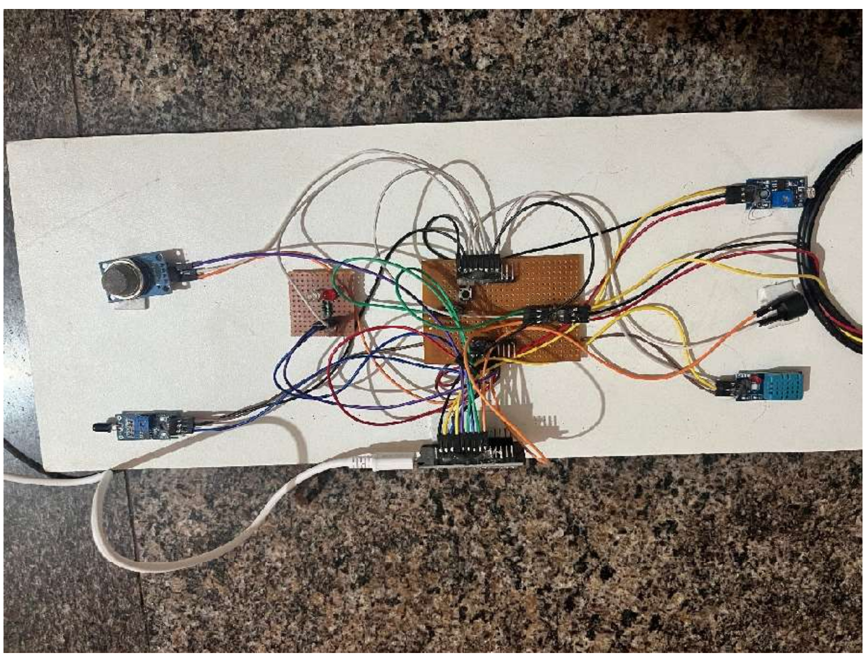

Figure 4.1 Assembled Components

Real-time data transmission to the AWS IoT platform via MQTT ensures secure and efficient cloud communication, with the data subsequently stored in a MongoDB database. This architecture supports continuous monitoring and historical data analysis, accessible through a user-friendly Streamlit web interface. The system's actuators, including a buzzer and LED indicators, provide immediate auditory and visual alerts in response to hazardous conditions or emergencies, significantly improving the miners' ability to respond swiftly. Overall, the system has demonstrated its capability to enhance safety by providing timely warnings, ensuring adequate visibility, and facilitating effective emergency responses, thereby contributing to a safer and more controlled mining environment.

4.2 Conclusion:

The "Safety Monitoring System for Underground Miners" represents a significant advancement in mining safety technology. By integrating a suite of sensors, actuators, and communication tools, this system provides a comprehensive solution for real-time environmental monitoring and hazard detection. The ESP32 microcontroller serves as the central hub, efficiently processing data from various sensors—such as light, gas, fire, temperature, and humidity sensors—and controlling actuators like buzzers and LEDs to deliver immediate alerts. The use of MQTT for data transmission to AWS IoT, coupled with secure data storage in MongoDB, ensures reliable and scalable management of critical safety data. The Streamlit web interface further enhances the system by offering intuitive data visualization, enabling quick and informed decision-making.

The results of deploying this system underscore its effectiveness in enhancing safety protocols within underground mining operations. By providing timely warnings and facilitating swift emergency responses, the system significantly reduces the risk of accidents and improves overall miner safety. The integration of real-time data monitoring, automated alerts, and comprehensive data analysis ensures that potential hazards are detected early, allowing for proactive measures to be taken. In conclusion, the "Safety Monitoring System for Underground Miners" not only advances technological solutions in mining safety but also fosters a safer working environment, ultimately contributing to the well-being of miners and the efficiency of mining operations.

4.3 Future Enhancements:

- LBS (Location based Service) to get the real-time location of the miners.
- FOTA (Firmware over thought the Air) Firmware Update.
- Power supply design to run the application on the battery power.

- Interactive Dashboard design for the supervisors and higher management.
- Business Analytics for the owner or the higher management
- Poper encloser design for the components to place so that it is wearable for the miners.
- Additional Miners health parameters monitoring such as heart rate, SPO2 etc.
- Deployment of the web server at AWS.
- Proper CI-CD pipeline setup.

REFERENCE:

1. Coal Mine Safety Intelligent Monitoring Based on Wireless Sensor Network | IEEE Journals & Magazine | IEEE Xplore
2. IoT Based Coal Mine Safety Monitoring and Alerting System | IEEE Conference Publication | IEEE Xplore
3. IEEE Xplore - Conference Table of Contents
4. [PDF] Design of surveillance and safety system for underground coal mines based on low power WSN | Semantic Scholar
5. docs.aws.amazon.com/iot/
6. MongoDB Documentation
7. docs.arduino.cc/learn/starting-guide/the-arduino-software-ide/
8. https://docs.streamlit.io/
9. https://www.python.org/doc/
10. https://mqtt.org/getting-started/