IoT Enable Predictive Maintenance in Mining

Bachelor of Technology
In
Computer Science and Engineering (Internet of Things)

Design & developed by

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Department of Computer Science & Engineering

(Internet of Things)

CERTIFICATE

This is to certify that the project entitled "**IoT Enable Predictive Maintainance in Mining**", submitted by **B.Yashwitha (2211CS050008), B.Sri Vidhya (2211CS050009), K.Saranya (2211CS050041),** of II year IoT-Alpha **Department of Computer Science and Engineering, Malla Reddy University, Hyderabad**, is a record of bonafide work done by him/ her. The results embodied in this report have not been submitted to any other university or institute for the award of any degree or diploma.

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DECLARATION

We hereby declare that the project report entitled "**IoT ENABLE PREDICTIVE MAINTANANCE IN MINING**", has been carried out by us. This work has been submitted to **the Department of Computer Science and Engineering (Internet of Things), MallaReddy University, Hyderabad** for the award of the degree of Bachelor of Technology. We further declare that this project work has not been submitted in full or in part for the award of any other degree in any other educational institutions.

Place:

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ABSTRACT

The mining industry faces numerous challenges, including the maintenance of expensive equipment, operational downtime, and safety concerns in hazardous environments. In response to these challenges, IoT-enabled predictive maintenance has emerged as a transformative solution, leveraging the power of connected devices and advanced analytics to optimize equipment performance and enhance operational efficiency. IoT-enabled predictive maintenance relies on a network of connected sensors deployed throughout mining operations to continuously monitor equipment health and performance parameters in real-time. These sensors collect vast amounts of data, which are then analyzed using sophisticated analytics techniques, including machine learning algorithms. By analyzing historical data and detecting patterns and anomalies, predictive maintenance models can forecast potential equipment failures before they occur, allowing for proactive maintenance interventions.

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CHAPTER - 1

INTRODUCTION

1. Introduction

- The mining industry is a vital component of global infrastructure, providing essential resources for various sectors ranging from manufacturing to energy production.

- However, mining operations are inherently complex and fraught with challenges, including the maintenance of heavy machinery, operational downtime, and safety risks inherent in hazardous environments. In response to these challenges, there has been a growing interest in leveraging innovative technologies to optimize mining operations and enhance productivity.

- This approach combines the capabilities of the Internet of Things (IoT) with advanced analytics to transform traditional reactive maintenance practices into proactive and data-driven strategies.

- By deploying a network of connected sensors throughout mining equipment and infrastructure, companies can monitor the health and performance of critical assets in real-time. These sensors collect vast amounts of data on various parameters such as temperature, pressure, vibration, and fluid levels, providing insights into the condition of equipment components.

1.1 Problem Definition & Description

The mining industry faces several significant challenges related to equipment maintenance, operational efficiency, and safety.

1.2 Objectives of the Project

The objectives of IoT-enabled predictive maintenance in mining are aligned with the industry's goals of improving productivity, safety, and cost-effectiveness. By focusing on these objectives, mining companies can leverage the full potential of IoT technology to transform their maintenance practices and achieve sustainable competitive advantages in the global marketplace.

1.3 Scope of the Project

The scope of the project for IoT-enabled predictive maintenance in mining encompasses various aspects, including sensor deployment, data analytics, maintenance planning, integration, training, and performance monitoring.

CHAPTER - 2

SYSTEM ANALYSIS

The system analysis of an app designed to check website security involves assessing its functionality, technical components, security measures, and potential limitations. Functionally, it should accept website URLs, retrieve security information, and provide clear indications of security status. Its components include a user interface, backend server, security database, analysis algorithms, and reporting module. Security measures include secure communication, data privacy, secure storage, and coding practices. Potential limitations include false positives/negatives, scope limitations, dependency on external services, and user awareness. Usability and user experience are crucial for effective use of the app, requiring a user-friendly interface and clear result interpretation.

2.1 Existing System

2.1.1 Background & Literature Survey

1. Title: "An IoT-driven Predictive Maintenance Framework for Heavy Mining Machinery“

Researchers: James Brown, David Chen, and Sarah Lee 2019 saw the publication of IEEE Transactions on Industrial Informatics.In this paper, a new IoT-driven predictive maintenance system specifically designed for heavy mining equipment is presented.

2. Title: "Challenges and Opportunities of Implementing Predictive Maintenance Using IoT in Mining Industry“

Authors: Robert Johnson, Emma White, Andrew Smith

Published in: Proceedings of the International Conference on Mining Technology, 2023

Summary: This conference paper discusses the challenges and opportunities associated with implementing predictive maintenance using IoT in the mining industry. The paper provides insights and recommendations for mining companies considering the adoption of IoT-driven predictive maintenance solutions.

2.1.2 Limitations of Existing System

- IoT systems rely on sensors to collect data from mining equipment. However, sensors can be prone to failures themselves, especially in harsh mining environments with high levels of dust, moisture, and vibration.
- The quality of data collected by IoT sensors can vary, affecting the accuracy of predictive maintenance models.

- Issues such as sensor drift, calibration errors, and data noise can impact the reliability of insights generated by the system.
- Scaling up the system to accommodate additional equipment or integrating with new technologies and platforms may pose challenges.
- IoT systems generate large volumes of sensitive data related to equipment performance, maintenance activities, and operational processes.

2.2 Proposed System

2.2.1 Advantages of Proposed System

- **Sensor Deployment:** The proposed system will involve the comprehensive deployment of IoT sensors across critical mining equipment and infrastructure.
- **Real-Time Data Collection and Transmission:** The sensors will collect data in real-time and transmit it to a centralized data repository using wireless communication protocols or IoT gateways.
- **Advanced Analytics and Machine Learning:** The proposed system will leverage advanced analytics techniques, including machine learning algorithms, to analyze the collected data and develop predictive maintenance models.
- **Predictive Maintenance Alerts and Notifications:** Based on the insights generated by the analytics models, the system will generate predictive maintenance alerts and notifications.
- **Data Privacy and Security:** Data privacy and security will be prioritized in the design and implementation of the proposed system.
- **Integration with Existing Systems:** The proposed system will seamlessly integrate with existing enterprise systems such as asset management, inventory control, and maintenance management systems.

2.3 Software & Hardware Requirements

2.3.1 Software Requirements

- Windows
- Moblie application
- Arduino IDE with libraries
- Programming language

2.3.2 Hardware Requirements

- Sensors
- Power Supply
- Gateway Devices
- Jumper wires
- Arduino Uno
- LCD display
- Laptop with 8GB RAM

2.4 Feasibility Study

2.4.1 Technical Feasibility:

The technical feasibility involves assessing the availability of required technologies, tools, and expertise to develop and maintain the application**.**

2.4.2 Robustness & Reliability:

The application's robustness and reliability will be ensured through rigorous testing, continuous monitoring, and prompt updates to address security vulnerabilities

2.4.3 Economic Feasibility:

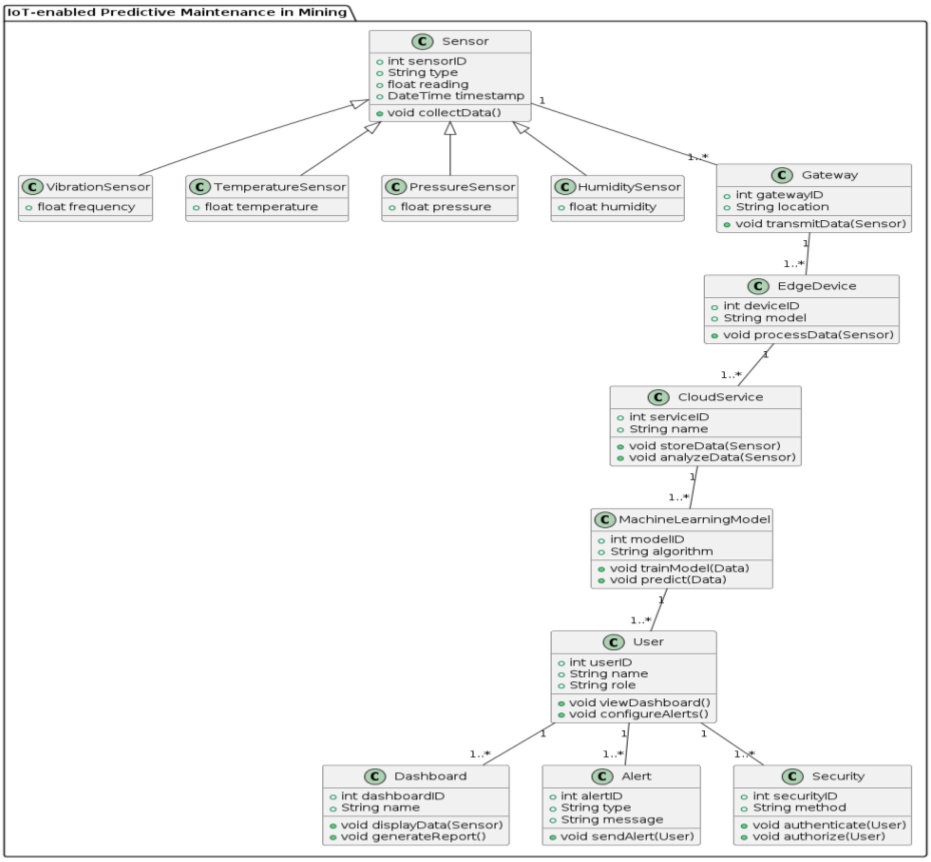
Economic feasibility involves evaluating the cost-effectiveness of developing and operating the application compared to potential benefits, considering factors such as development costs, hosting expenses, and potential revenue streams.

CHAPTER - 3

ARCHITECTURAL DESIGN

3.3 Project Architecture

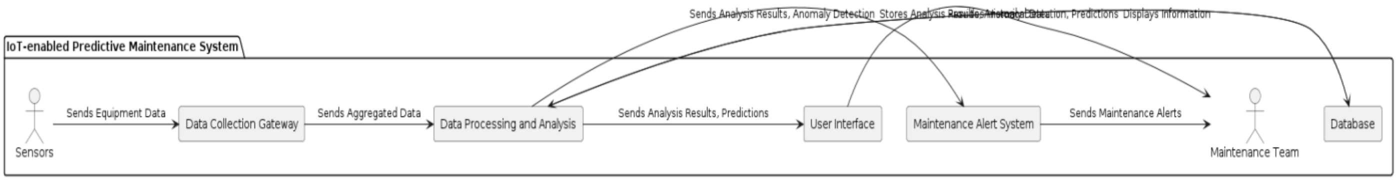
3.3.1 Architectural Diagram



- **Sensor**: Base class for different types of sensors.
- **VibrationSensor**, **TemperatureSensor**, **PressureSensor**, **HumiditySensor**: Derived classes From the Sensor class.
- **Gateway**: Responsible for transmitting data from sensors to the edge device.
- **EdgeDevice**: Processes data from the sensors before sending it to the cloud.
- **CloudService**: Handles data storage and analysis.
- **MachineLearningModel**: Used for training and predicting maintenance needs.
- **User**: Represents users interacting with the system.

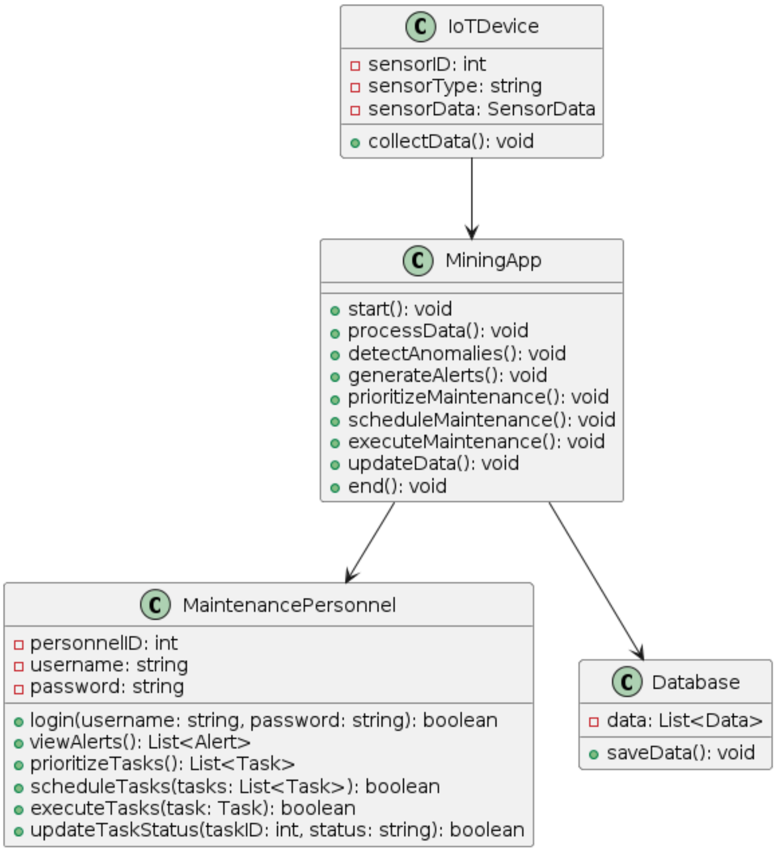
- **Dashboard**: Displays data and generates reports for the users.
- **Alert**: Sends alerts and notifications to users.
- **Security**: Manages authentication and authorization.

3.3.2 Data Flow Diagram:



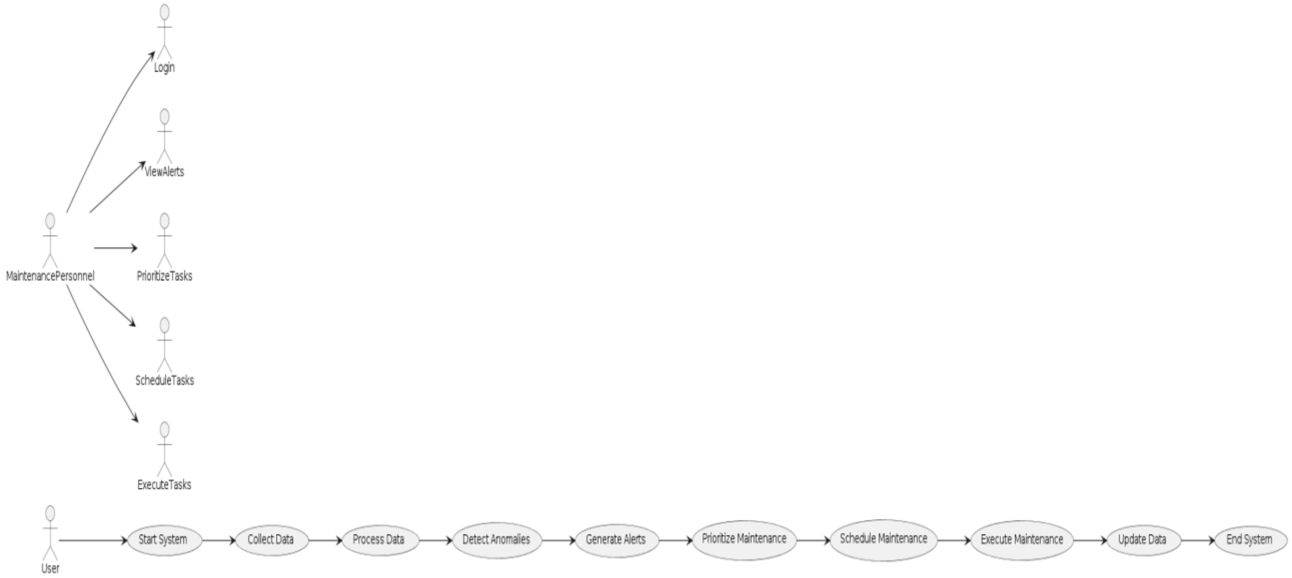
- **Actors:** Sensors and Maintenance Team represent the external entities interacting with the system.
- **Processes:** Represented as rectangles (DCG, DPA, MAS, UI) that perform the main functions.
- **Data Store:** Database (DB) stores and retrieves data for processing and analysis.
- **Data Flow:** Arrows indicate the flow of data between components.

3.2.3 Class Diagram:



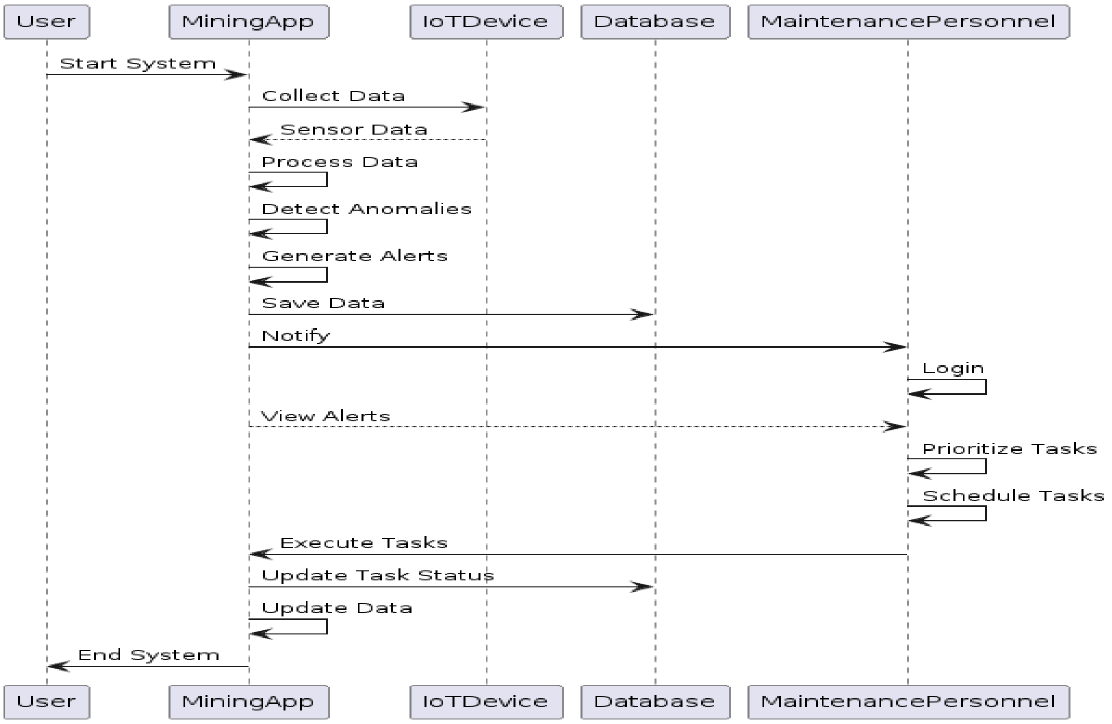
- **IoTDevice**: Represents the IoT devices (external sensors) used to collect data.
- **MiningApp:** Represents the main application responsible for processing sensor data, detecting anomalies, generating alerts, scheduling maintenance tasks, and updating data.
- **MaintenancePersonnel:** Represents the personnel responsible for maintenance tasks, including logging in, viewing alerts, prioritizing tasks, scheduling tasks, executing tasks, and updating task status.
- **Database:** Represents the data storage component of the application.

3.2.4 Use Case Diagram



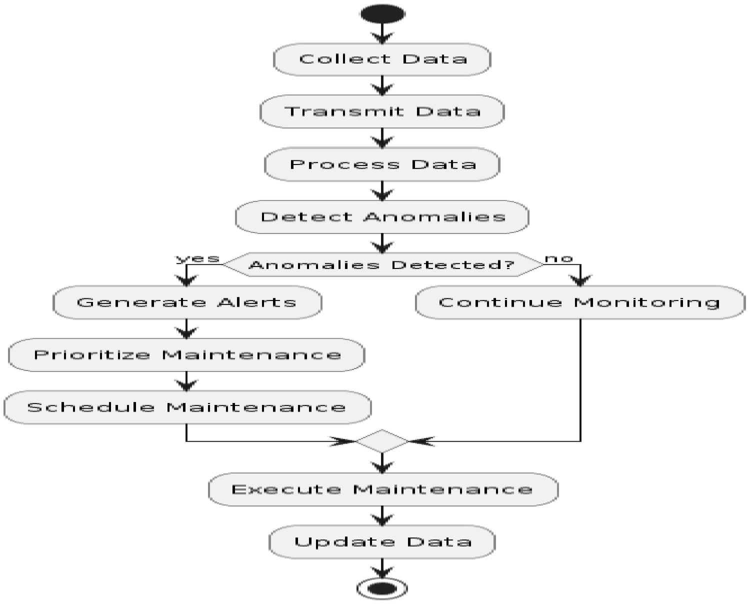
- **User:** Represents the user who interacts with the system.
- **Maintenance Personnel:** Represents the maintenance personnel who perform maintenance tasks.
- **Use Cases:** Represent the various functionalities provided by the system, including starting the system, collecting data, processing data, detecting anomalies, generating alerts, prioritizing maintenance, scheduling maintenance, executing maintenance tasks, updating data, and ending the system.

3.2.5 Sequence Diagram:



- **User**: Initiates the system by starting it and receives the end system notification.
- **MiningApp:** Collects data from the IoT device, processes it, detects anomalies, generates alerts, saves data to the database, and updates data.
- **IoTDevice:** Provides sensor data to the mining app.
- **Database:** Stores data and task status updates.
- **Maintenance Personnel:** Logs in, views alerts, prioritizes tasks, schedules tasks, and executes tasks.

3.2.6 Activity Diagram:



- The process starts with collecting data from sensors installed on mining equipment.
- The collected data is transmitted to the system for processing.
- The data is processed to identify anomalies.
- If anomalies are detected, alerts are generated, and maintenance tasks are prioritized and scheduled.
- If no anomalies are detected, the system continues monitoring.
- Maintenance tasks are executed based on the schedule.
- Data is updated after maintenance tasks are executed.
- The process stops.

CHAPTER- 4
IMPLEMENTATION &TESTING

4.1 Sample Code

```
//Including the necessary libraries

#include <SoftwareSerial.h>

#include <dht.h>

SoftwareSerial mySerial(2, 3); // RX, Tx

#define outPin 4 //dht11

#define buzzer 7

#define trigPin 8 //ultrasonic trigger

#define echoPin 9 //ultra sonic echo

int METAL=10;

int high=11;// sensor water levell

int med=12;

int low=13;

unsigned int mq2,SOIL,vib;


#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,16,2);  // set the LCD address to 0x3F for a 16 chars and 2 line display

dht DHT;

void setup() {

 Serial.begin(115200);//serialEvent for wifi module

 mySerial.begin(9600); //Bluetooth serial event

  pinMode(buzzer, OUTPUT);
```

```
pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(METAL, INPUT);
  lcd.init();
  lcd.clear();
  lcd.backlight();      // Make sure backlight is on
  // Print a message on both lines of the LCD.
  lcd.setCursor(0,0);
  lcd.print("IOT ENABLED");
  lcd.setCursor(0,1);
  lcd.print("  PREDICTIVE");
  delay(2000);
  digitalWrite(buzzer, HIGH);


  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("MAINTENANCE");
  lcd.setCursor(0,1);
  lcd.print("IN MININGS");
  delay(2000);
  mySerial.println("  IOT ENABLED PREDICTIVE MAINTENANCE IN MININGS");
  mySerial.println("**************************************************");
  delay(1000);
  // put your setup code here, to run once:
```

```
}


void loop() {
  long duration, distance;
int readData = DHT.read11(outPin);
   int t = DHT.temperature;  // Read temperature
  int h = DHT.humidity;   // Read humidity
  delay(50);
   mq2=analogRead(A0);
 delay(100);
SOIL=analogRead(A2);
       vib=analogRead(A3);
      delay(20);
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
distance=duration/2;
              delay(200);
      if(!(digitalRead(METAL)==LOW))
      {
      lcd.clear();
  lcd.setCursor(0,0);
```

```
lcd.print("METAL DETECTED");
digitalWrite(buzzer, LOW);
mySerial.print("METAL DETECTED");
delay(2000);
      }
lcd.clear();


lcd.setCursor(0,0);
lcd.print("T:");
lcd.print(t);
mySerial.println("TEMPERATURE(*C):");
mySerial.print(t);


  lcd.setCursor(5,0);
lcd.print("H:");
lcd.print(h);


mySerial.println("HUMIDITY(%RH):");
mySerial.print(h);


  lcd.setCursor(10,0);
lcd.print("S:");
lcd.print(mq2);


mySerial.println("SMOKE(PPM):");
```

```
mySerial.print(mq2);

lcd.setCursor(0,1);
lcd.print("S:");
lcd.print(SOIL);

mySerial.println("SOIL:");
mySerial.print(SOIL);

  lcd.setCursor(4,1);
lcd.print("V:");
lcd.print(vib);

mySerial.println("VIB:");
mySerial.print(vib);

  lcd.setCursor(10,1);
lcd.print("D:");
lcd.print(distance);

mySerial.println("DISTANCE(*CM):");
mySerial.print(distance);

delay(2000);
```

```
if(distance<30)
  {
     lcd.clear();

 lcd.setCursor(0,0);
 lcd.print("OBJECT DETECTED");
 lcd.setCursor(0,1);
 lcd.print(distance);

 mySerial.println("OBJECT DETECTED:");
 mySerial.print(distance);

 digitalWrite(buzzer, LOW);
 delay(2000);

    }if(mq2>300)
  {
     lcd.clear();

 lcd.setCursor(0,0);
 lcd.print("SMOKE DETECTED");
 lcd.setCursor(0,1);
 lcd.print(mq2);

 mySerial.println("SMOKE DETECTED:");
```

```
 mySerial.print(mq2);


digitalWrite(buzzer, LOW);
 delay(2000);


     }
if(t>40)
   {
       lcd.clear();


 lcd.setCursor(0,0);
 lcd.print("HIGH TEMPERATURE");
 lcd.setCursor(0,1);
 lcd.print(t);
 digitalWrite(buzzer, LOW);


 mySerial.println("HIGH TEMPERATURE:");
 mySerial.print(t);


 delay(2000);


     }
if(h>60)
   {
       lcd.clear();
```

```
  lcd.setCursor(0,0);

  lcd.print("HIGH HUMIDITY");

  lcd.setCursor(0,1);

  lcd.print(h);

  digitalWrite(buzzer, LOW);


mySerial.println("HIGH HUMIDITY:");

  mySerial.print(h);


  delay(2000);


      }
 if(vib>500)
    {
        lcd.clear();


  lcd.setCursor(0,0);

  lcd.print("VIBRATION  ");

  lcd.setCursor(0,1);

  lcd.print("DETECTED: ");

  lcd.print(vib);

  digitalWrite(buzzer, LOW);


mySerial.println("VIBRATION DETECTED:");
```

```
  mySerial.print(vib);


  delay(2000);


     }
 if(SOIL<50)
    {
       lcd.clear();


  lcd.setCursor(0,0);
  lcd.print("SOIL:DRY");
  digitalWrite(buzzer, LOW);


mySerial.println("SOIL DRY:");
  mySerial.print(SOIL);


  delay(2000);


     }
     if((digitalRead(low)==1)&&(digitalRead(med)==1)&&(digitalRead(high)==1))
{
      W=0;
    lcd.clear();
  lcd.print("  WATER LEVEL");
    lcd.setCursor(0, 1);
```

```
    lcd.print("****EMPTY****");
  digitalWrite(buzzer, LOW);

  mySerial.print("WATER LEVEL:EMPTY");

delay(2000);

  }
if((digitalRead(low)==0)&&(digitalRead(med)==1)&&(digitalRead(high)==1))
{
  W=1;
    lcd.clear();
  lcd.print("  WATER LEVEL");
    lcd.setCursor(0, 1);
    lcd.print("****LOW****");
  digitalWrite(buzzer, LOW);

  mySerial.print("WATER LEVEL:LOW");

delay(2000);

  }
if((digitalRead(low)==0)&&(digitalRead(med)==0)&&(digitalRead(high)==1))
{w=2;
```

```
        lcd.clear();
  lcd.print("  WATER LEVEL");
    lcd.setCursor(0, 1);
    lcd.print("****MEDIUM****");

  mySerial.print("WATER LEVEL:MEDIUM");



delay(2000);

  }
if((digitalRead(low)==0)&&(digitalRead(med)==0)&&(digitalRead(high)==0))
{
  w=3;
  lcd.clear();
  lcd.print("  WATER LEVEL");
    lcd.setCursor(0, 1);
    lcd.print("****HIGH****");

  mySerial.print("WATER LEVEL:HIGH");

delay(2000);
```

```
}
digitalWrite(buzzer,HIGH);


                delay(4000);
lcd.clear();
lcd.print("SENDING DATA");
Serial.write("AT+CIPSTART=\"TCP\",\"184.106.153.149\",80\r\n");
          delay(4000);
          delay(4000);
Serial.write("AT+CIPSEND=130\r\n");
          delay(5000);
Serial.write("GET /update?api_key=WYOPZ0OCFUV6QYGE&field1=");
          delay(1000);
Serial.print(t);


          delay(500);
Serial.write("&field2=");
Serial.print(h);
          delay(500);
Serial.write("&field3=");
Serial.print(mq2);
          delay(500);
Serial.write("&field4=");
Serial.print(SOIL);
```

```
        delay(500);
  Serial.write("&field5=");
  Serial.print(vib);
        delay(500);
  Serial.write("&field6=");
  Serial.print(distance);
        delay(500);
  Serial.write("&field7=");
Serial.println(digitalRead(10));
         delay(500);
  Serial.write("&field8=");
  Serial.print(w);
        delay(1000);
   lcd.clear();
  lcd.print("SENT DATA");
        delay(4000);
  digitalWrite(buzzer,HIGH);


}
```

4.2 Execution Flow

1. **Login:** The user logs into the app using their credentials.
2. **Dashboard Overview:** Upon login, the user is presented with a dashboard displaying key metrics and alerts related to mining equipment health and maintenance status.
3. **Equipment Monitoring:**

- The user selects a specific mining equipment from the dashboard to view detailed information.
- The app retrieves real-time sensor data from the selected equipment, displaying parameters such as temperature, vibration, and operating hours.
- Historical performance metrics and predictive analytics insights are also displayed, highlighting trends and potential issues.

4. **Alerts and Notifications:**

- If any abnormal conditions or potential failures are detected by the predictive maintenance system, the user receives alerts in real-time.
- The user can view detailed information about each alert, including its severity, recommended actions, and potential impact on operations.

5. **Maintenance Planning:**

- The user accesses maintenance schedules and plans within the app.
- Upcoming preventive maintenance tasks and recommended actions based on predictive analytics are displayed.

6. **Data Analysis:**

- The user utilizes built-in tools to analyze historical equipment data, identify trends, and generate reports.
- Insights gained from data analysis help the user make informed decisions regarding maintenance strategies and operational improvements.

7. **Collaboration:**

- The user collaborates with colleagues and maintenance teams within the app.
- Tasks are assigned, progress is tracked, and communication is facilitated through messaging or collaboration features.

8. **Feedback and Improvement:**

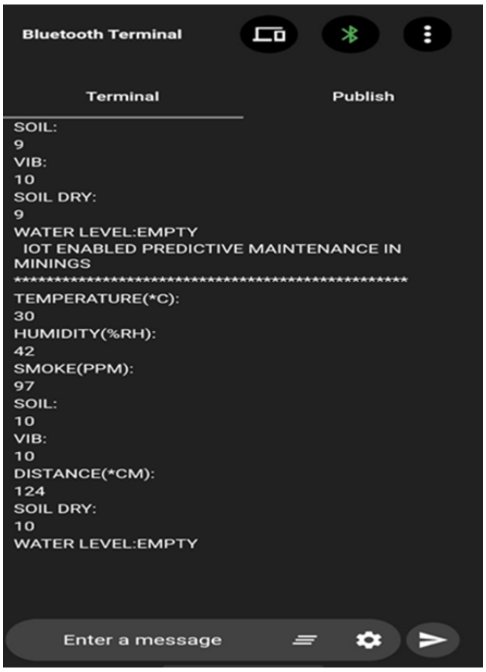
- The user provides feedback on the app's usability, performance, and features.

- Feedback is collected and used to continuously improve the app, enhancing user experience and functionality.

9. **Logout:** The user logs out of the app, ending the session.

4.3 Testing

4.3.1. Test case 1



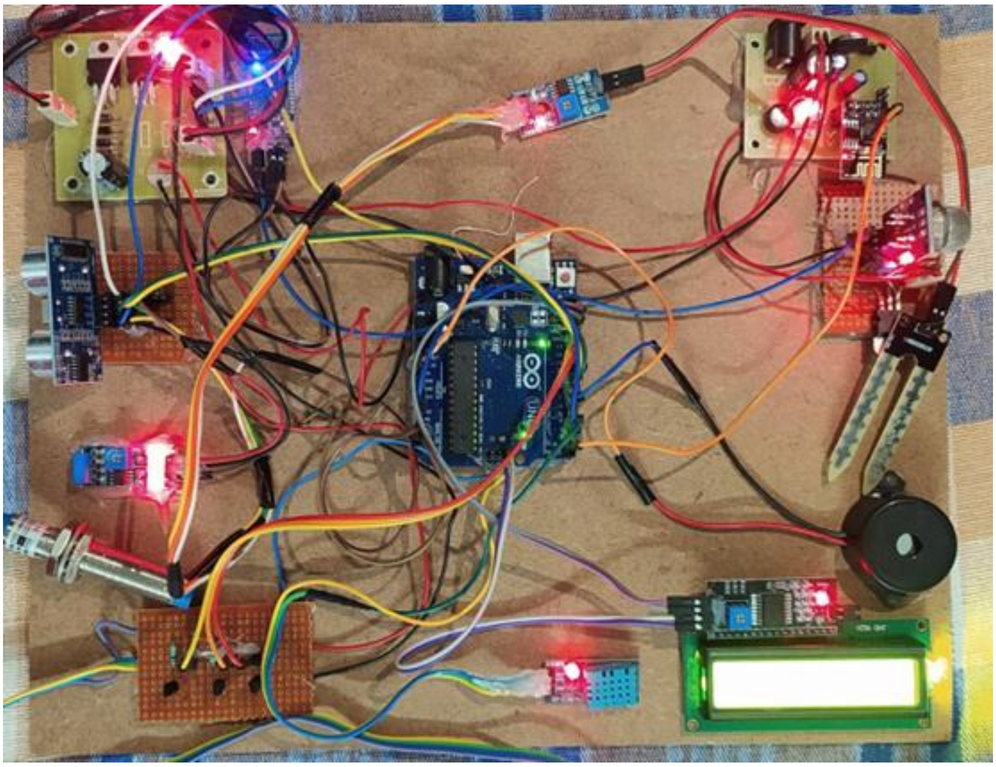
Data readings in Bluetooth terminal 1

4.3.2 Test case 2

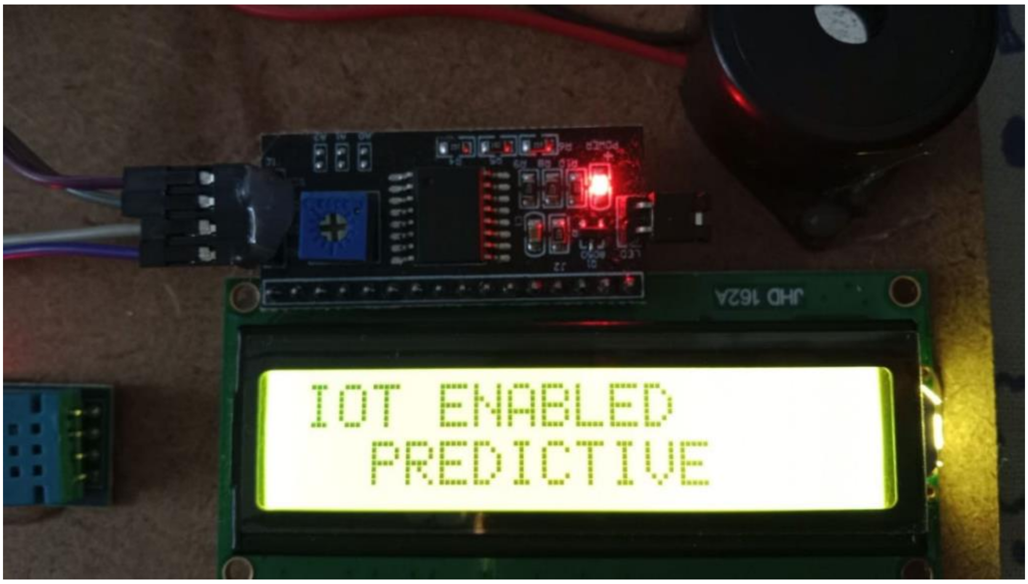
Data readings in Bluetooth terminal 2

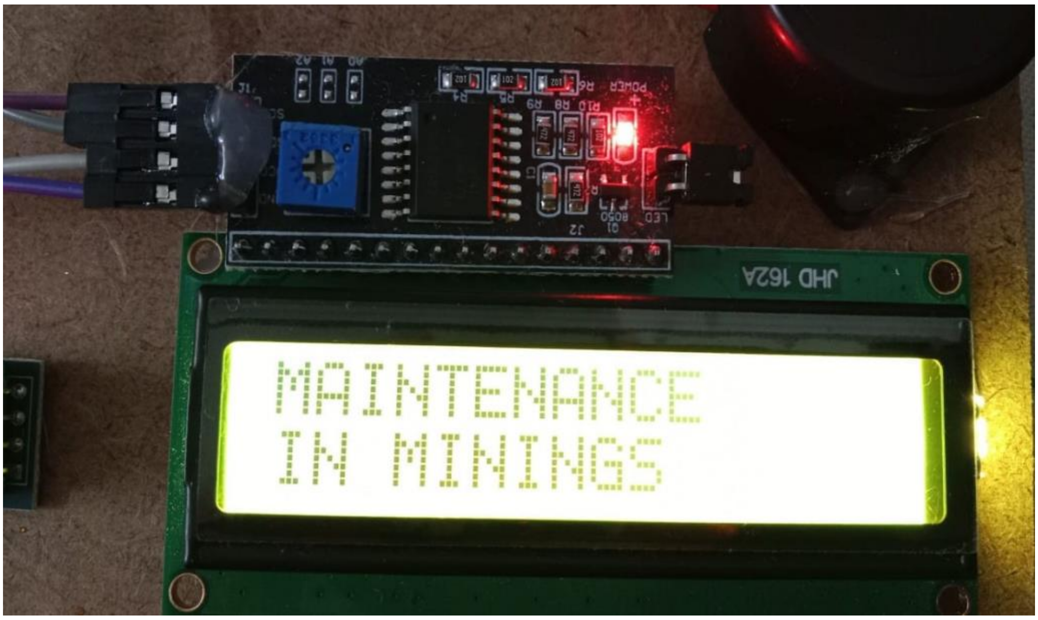
CHAPTER-5

RESULTS

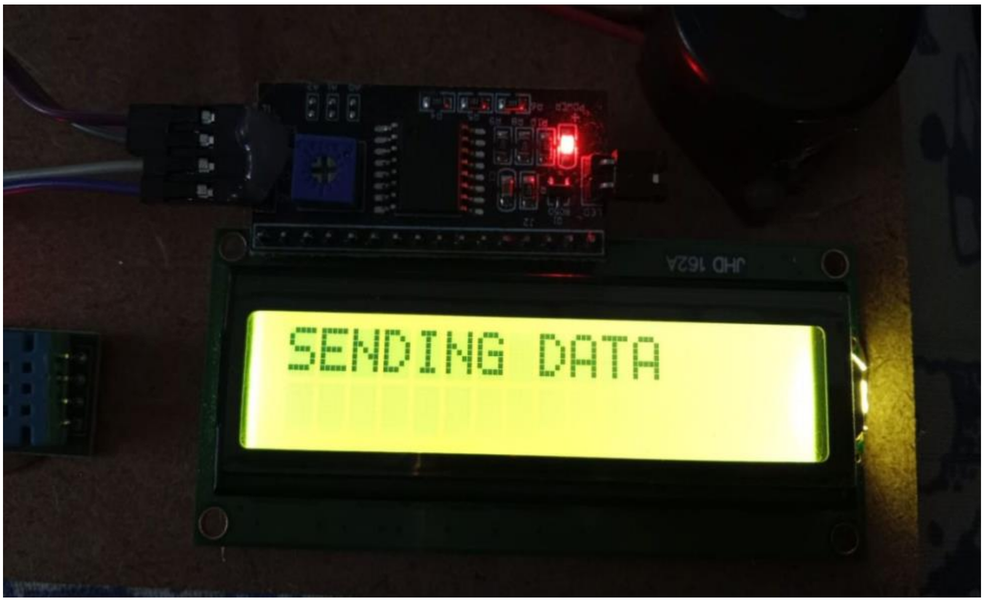


Connections with sensors





LCD Display



Sending data to cloud

Reading data from sensors

Water level

CHAPTER-6
CONCLUSIONS & FUTURE SCOPE

6.1 Conclusion

IoT-enabled predictive maintenance in mining significantly enhances operational efficiency, safety, and cost-effectiveness. By leveraging real-time data from IoT sensors, mining operations can proactively address equipment issues before they lead to failures, reducing downtime and maintenance costs. This approach not only improves equipment reliability and extends its lifespan but also enhances worker safety by preventing accidents. Additionally, it supports sustainability efforts by optimizing resource use and minimizing environmental impact. Overall, IoT-enabled predictive maintenance is a transformative solution that drives productivity and innovation in the mining industry.

6.2 Future Scope

The future scope for IoT-enabled maintenance in mining is expansive and promising, driven by continuous advancements in technology and increasing industry adoption. Key areas of future development include:

1. **Integration with Advanced Analytics and AI**: Combining IoT with advanced analytics and artificial intelligence (AI) will enable even more precise predictive maintenance. AI algorithms can analyze vast amounts of data to identify patterns and predict failures with greater accuracy, leading to smarter maintenance schedules and improved decision-making.
2. **Expansion of IoT Networks**: As IoT technology becomes more affordable and robust, the deployment of more comprehensive sensor networks will become feasible. This expansion will provide more detailed and widespread monitoring of equipment and environmental conditions, enhancing the predictive capabilities of maintenance systems.
3. **Edge Computing**: Implementing edge computing in IoT networks will allow for faster data processing and real-time analytics at the source of data generation. This will reduce latency, improve response times, and enable immediate actions based on real-time insights, enhancing the efficiency of predictive maintenance.
4. **Enhanced Connectivity and 5G**: The adoption of 5G technology will greatly improve the connectivity and data transmission capabilities of IoT devices. This will facilitate more reliable and faster communication between devices and central systems, supporting more complex and data-intensive predictive maintenance applications.
5. **Integration with Digital Twins**: Digital twin technology, which creates virtual replicas of physical assets, can be integrated with IoT systems to simulate and analyze equipment performance in real-

time. This allows for more accurate predictions and proactive maintenance strategies, leading to optimized operations and reduced downtime.

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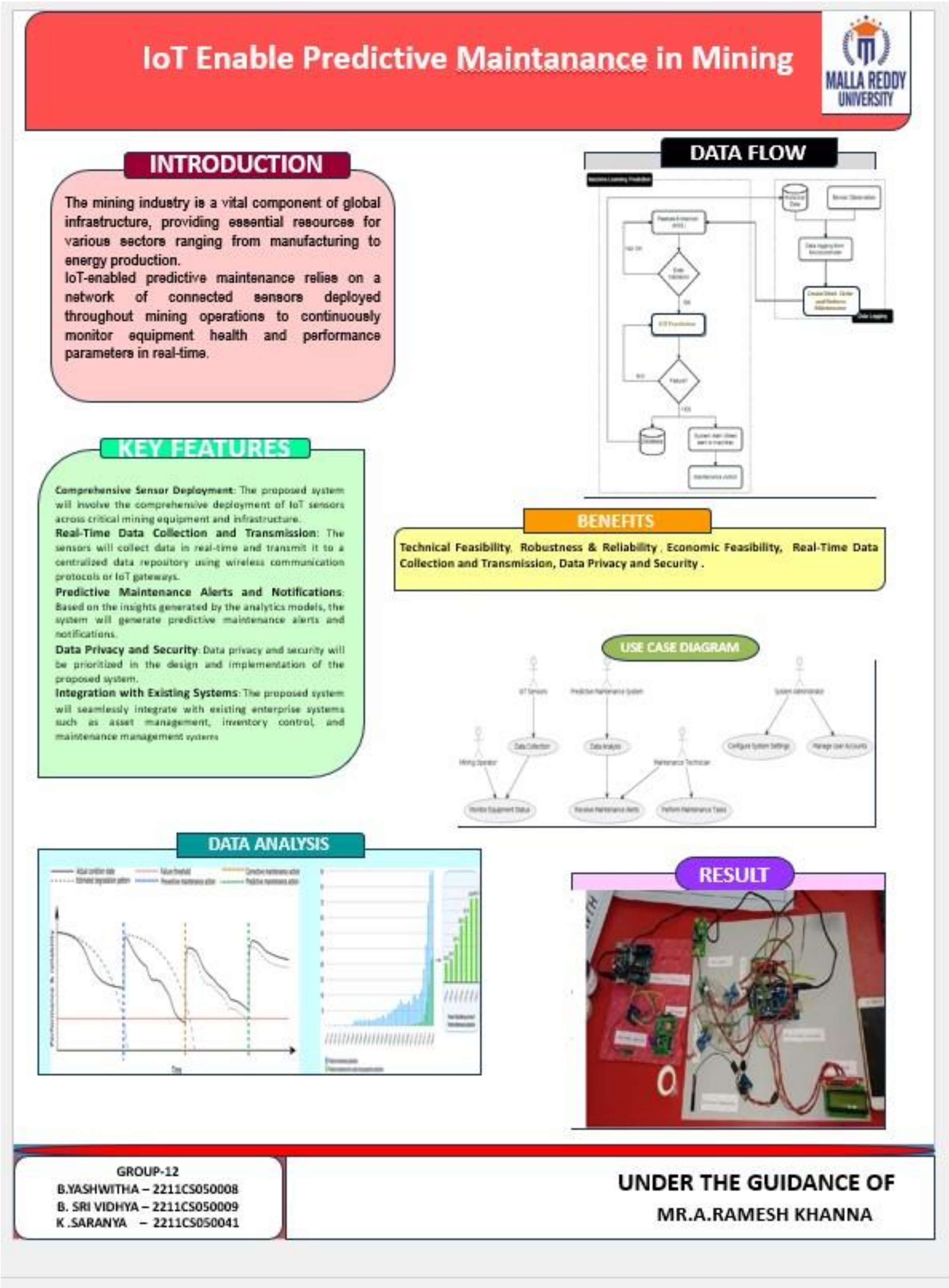
Poster



IoT Enable Predictive Maintanance in Mining
MALLA REDDY UNIVERSITY
INTRODUCTION
The mining industry is a vital component of global infrastructure, providing essential resources for various sectors ranging from manufacturing to energy production.
IoT-enabled predictive maintenance relies on a network of connected sensors deployed throughout mining operations to continuously monitor equipment health and performance parameters in real-time.
KEY FEATURES
Comprehensive Sensor Deployment: The proposed system will involve the comprehensive deployment of IoT sensors across critical mining equipment and infrastructure.
Real-Time Data Collection and Transmission: The sensors will collect data in real-time and transmit it to a centralized data repository using wireless communication protocols or IoT gateways.
Predictive Maintenance Alerts and Notifications: Based on the insights generated by the analytics models, the system will generate predictive maintenance alerts and notifications.
Data Privacy and Security: Data privacy and security will be prioritized in the design and implementation of the proposed system.
Integration with Existing Systems: The proposed system will seamlessly integrate with existing enterprise systems such as asset management, inventory control, and maintenance management systems
DATA FLOW
BENEFITS
Technical Feasibility, Robustness & Reliability, Economic Feasibility, Real-Time Data Collection and Transmission, Data Privacy and Security.
USE CASE DIAGRAM
DATA ANALYSIS
RESULT
GROUP-12
B.YASHWITHA – 2211CS050008
B. SRI VIDHYA – 2211CS050009
K.SARANYA – 2211CS050041
UNDER THE GUIDANCE OF
MR.A.RAMESH KHANNA