SMARTBRIDGE INTERNET OF THINGS (IOT)

MINING WORKER SAFETY HELMET

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1. INTRODUCTION

1.1 OVERVIEW

In the mining industry, ensuring the safety of workers is a top priority. With its inherent risks and hazardous conditions, mining operations demand innovative solutions to protect the well-being of miners. In this context, the advent of the Internet of Things (IoT) has opened up new possibilities for enhancing safety measures. In this project, we introduce the Mining Workers Safety Helmet, an IoT-powered solution designed to revolutionize workplace safety and improve the overall well-being of mining personnel.

Key features of the Mining Workers Safety Helmet include the integration of sensors that collect real-time data on environmental conditions such as temperature, humidity, gas concentrations, and air quality. This continuous monitoring enables early detection of potential hazards, allowing miners to take immediate precautions or evacuate if necessary. The helmet also incorporates proactive alert systems that notify miners of hazardous conditions based on predefined safety thresholds, enabling swift responses to prevent accidents or health risks.

Furthermore, the IoT-enabled safety helmet acts as a communication hub, facilitating seamless communication between mining workers and supervisors. miners can relay vital information, seek guidance, or request assistance in real-time, enhancing coordination and promoting effective safety protocols. The helmet also integrates within the mining site, enabling efficient monitoring and emergency response.

1.2 PURPOSE

The purpose of the Mining Workers Safety Helmet project is to leverage IoT technology to develop an advanced safety helmet tailored specifically for mining operations. By integrating IoT capabilities into the helmet, this project aims to create a comprehensive safety solution that goes beyond traditional head protection. The IoT-enabled safety helmet enhances real-time monitoring, communication, and hazard detection, thereby reducing the risk of accidents and fostering a safer working environment for mining personnel.

2. LITERATURE SURVEY

2.1 EXISTING PROBLEM

a. Research Study: "IoT-Based Safety Helmet for Miners" by S. Sahoo, S. Swain, and P. Barik (2019):

This study focuses on the design and implementation of an IoT-based safety helmet for mining workers. The helmet incorporates environmental sensors, such as temperature and gas detectors, to monitor hazardous conditions. The collected data is transmitted wirelessly to a central monitoring system, enabling real-time monitoring and timely alerts to miners and supervisors. The study demonstrates improved safety measures and highlights the potential of IoT technology in mitigating risks in mining operations.

b. Research Study: "Smart Helmet for Coal Miners using Zigbee Technology" by M. M. E. S. Shaik et al. (2015):

This research explores the development of a smart helmet for coal miners using Zigbee technology, which is a wireless communication protocol commonly used in IoT applications. The helmet incorporates sensors for detecting hazardous gases, temperature, and humidity. The data collected by the sensors is wirelessly transmitted to a central control system, enabling remote monitoring and early warning notifications. The study emphasizes the importance of real-time monitoring and communication in improving safety conditions for coal miners.

c. Research Study: "IoT-Based Smart Helmet for Real-Time Monitoring and Alerting of Hazardous Events" by D. Thomas et al. (2017):

This study presents an IoT-based smart helmet system designed to monitor hazardous events and provide timely alerts to mining workers. The helmet integrates various sensors, including gas sensors, humidity sensors, and accelerometers, to detect potential dangers in the mining environment. The collected data is transmitted to a cloud-based platform, which performs real-time analysis and sends alerts to miners and supervisors. The research highlights the effectiveness of IoT technology in enhancing safety and reducing the risk of accidents in mining operations.

d. Research Study: "Design and Implementation of IoT-Based Mining Safety System" by M. S. Jadhav and S. B. Jadhav (2019):

This research focuses on the design and implementation of an IoT-based mining safety system that includes a smart safety helmet. The helmet integrates environmental sensors, location tracking, and communication modules to enhance safety in mining operations. The system allows for real-time monitoring of environmental conditions, worker location, and communication between miners and supervisors. The study showcases the benefits of an integrated IoT solution in improving safety and response times in mining environments.

2.2 PROPOSED SOLUTIONS

a. Real-time Monitoring and Hazard Detection:

Implement advanced environmental sensors within the safety helmet to monitor factors such as temperature, gas concentrations, humidity, and air quality.
Integrate real-time data transmission capabilities to send collected data to a central monitoring system.
Develop algorithms that analyze the data and generate alerts and warnings for miners and supervisors in case of hazardous conditions.

b. Communication and Collaboration:

Incorporate built-in communication modules, such as audio and visual channels, in the safety helmet to enable seamless communication between miners and supervisors.
Utilize IoT connectivity to establish reliable and secure communication networks within the mining site.
Enable two-way communication, allowing miners to report incidents, request assistance, and receive instructions in real-time.

c. Emergency Response and Alert Systems:

Implement emergency alert buttons or mechanisms on the safety helmet, enabling miners to quickly send distress signals in case of accidents, injuries, or dangerous situations.

Connect the safety helmet to a centralized emergency response system that receives and responds to distress signals, facilitating swift emergency assistance.
Integrate sensors that can detect sudden falls, impacts, or abnormalities, triggering automatic alerts to the monitoring system and initiating emergency protocols.

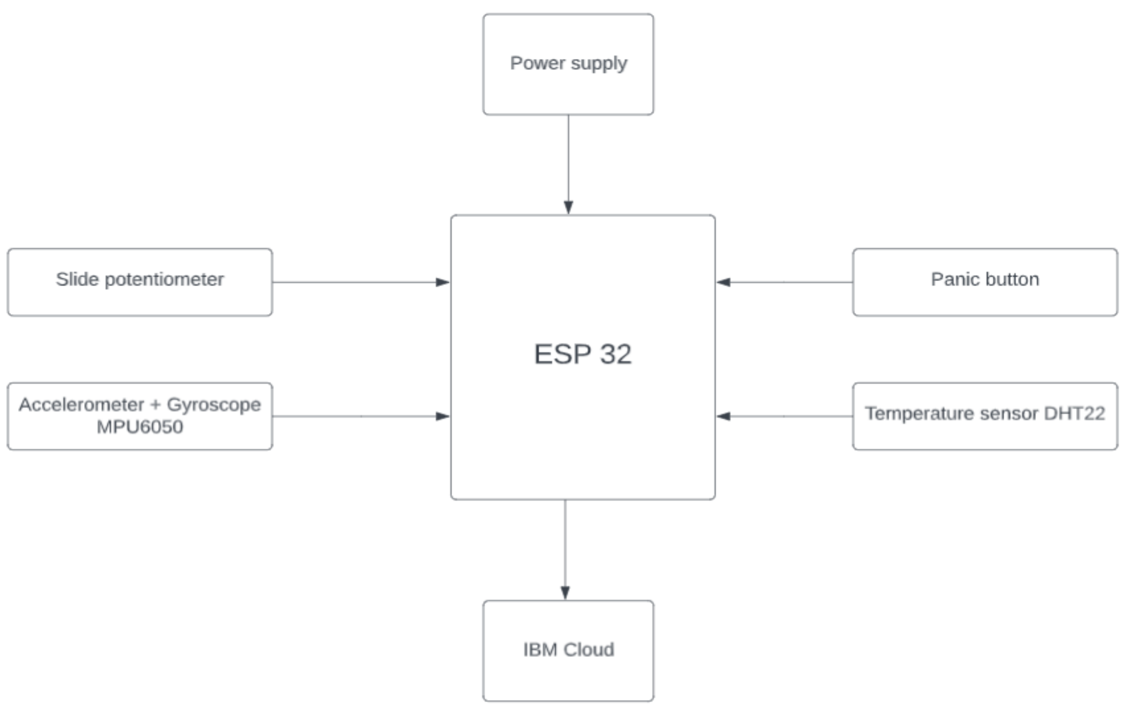
d. Data Analytics and Insights:

Develop a cloud-based platform or data management system to collect, store, and analyze the data generated by the safety helmets.
Utilize data analytics techniques to identify patterns, trends, and potential safety risks, allowing mining companies to proactively address safety concerns and implement preventive measures.Generate reports and insights from the collected data to improve safety protocols, training programs, and overall safety performance within the mining operation.

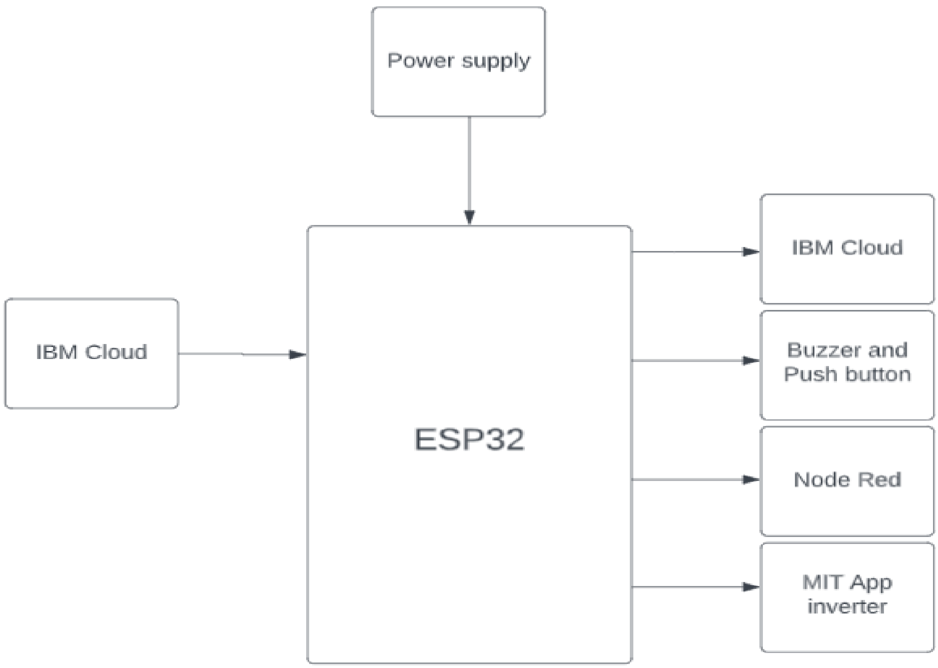
3. THEORETICAL ANALYSIS

3.1 Block diagram

The helmet unit :



Control unit :



3.2 SOFTWARE DESIGNING

The software requirements of this project:

WokWi : Wokwi is an online platform that allows users to simulate the mining worker safety helmet prototype and test Arduino, ESP32 and other microcontroller-based projects. It can be accessed through a web browser without installing any software.

Node-Red : Node-RED is a flow-based programming tool that allows users to visually create mining worker safety helmet applications by connecting nodes. It is typically used for IoT applications and can be installed on a computer or a server.

IBM Cloud: IBM Cloud is a cloud computing platform that provides various services for building and deploying applications. It can be used for hosting Node-RED instances and deploying the mining worker safety helmet application.

MIT App Inventor: MIT App Inventor is a web-based development environment that allows the creation of Android applications using a visual programming interface. It simplifies the app development process and does not require advanced coding skills.

4. EXPERIMENTAL INVESTIGATIONS

- Regulatory Compliance: The investigation would begin by ensuring that the safety helmets meet the required standards and regulations set by relevant authorities or organizations. This includes checking if the helmets comply with specific safety standards for mining industries.

- Impact Resistance: The primary purpose of a safety helmet is to protect the wearer from falling objects or potential impacts. The investigation would involve assessing the helmet's impact resistance capabilities by subjecting it to standardized tests, such as drop tests or impact simulations. This helps determine if the helmet can adequately absorb and distribute impact forces.

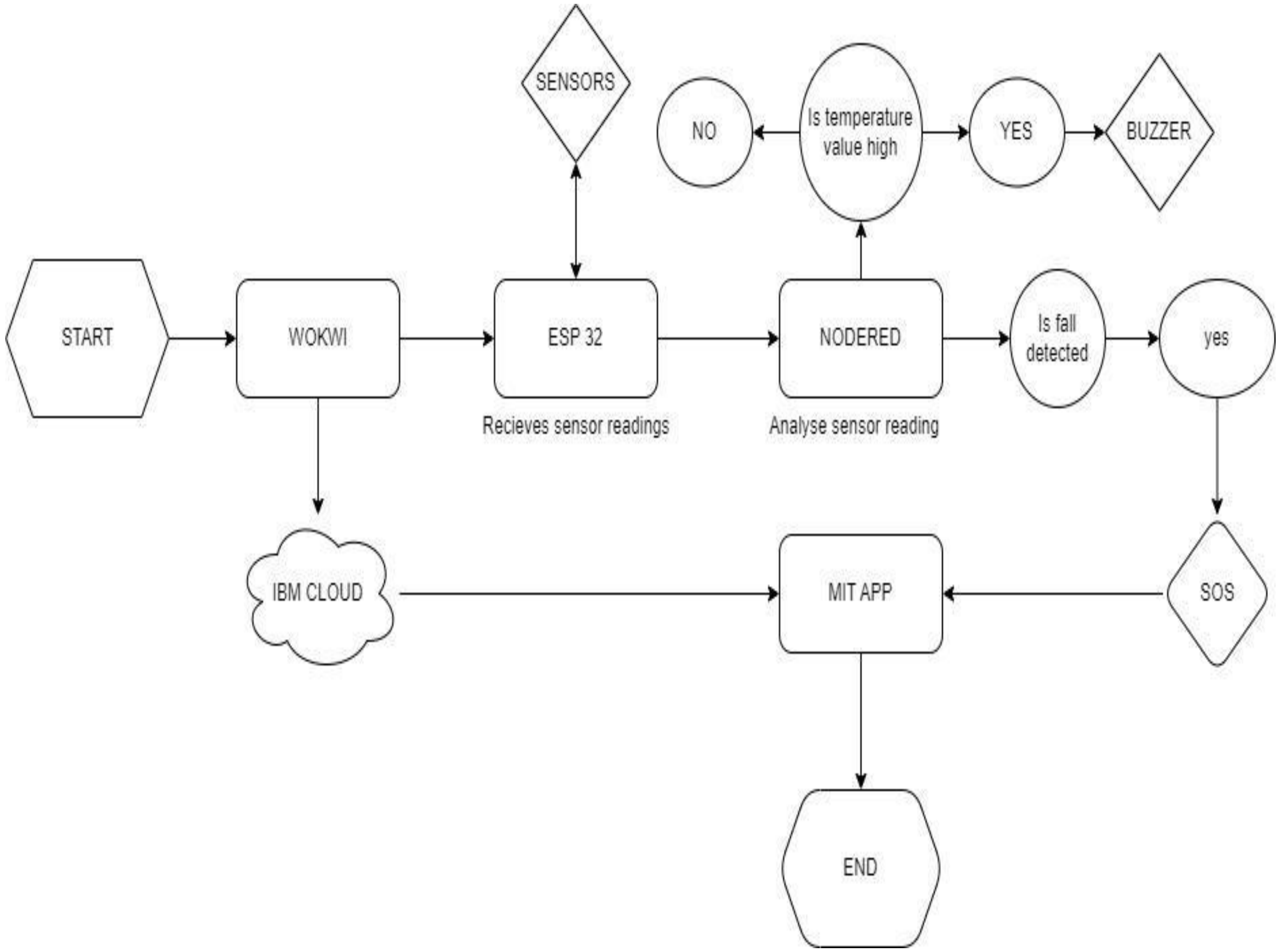
- Material Quality and Durability: The investigation would assess the quality of materials used in the construction of the safety helmet. This involves examining the strength, durability, and structural integrity of the helmet components, such as the shell, suspension system, and chin strap. It would also involve evaluating the helmet's resistance to environmental factors such as heat, moisture, and chemicals commonly found in mining environments.

- Ventilation and Heat Dissipation: Mining environments can be extremely hot and humid. Therefore, the investigation would assess the helmet's ventilation system and its ability to dissipate heat effectively. Proper ventilation helps prevent discomfort, heat-related illnesses, and fogging of visors or safety goggles.

- Visibility and Illumination: In underground mining or low-light conditions, visibility is essential for the safety of workers. The investigation would consider the helmet's design features related to visibility, such as reflective strips, built-in lighting, or compatibility with additional lighting attachments. The effectiveness of these features would be evaluated through visual inspections and user feedback.

- Communication and Integration: In some cases, safety helmets may include communication systems or integration capabilities with other safety equipment, such as gas detectors or location tracking devices. The investigation would involve assessing the functionality and reliability of these integrated systems to ensure seamless communication and data exchange.

5. FLOWCHART



6. RESULT

WOKWI

```
Acceleration: X =  0.00Y =  0.00Z =  9.81Fall detected!
Sending payload: {"temp":31.50,"Humid":70.00,"gas":0,"status":1,"SOS":0}
Publish ok
0
31.50
70.00
---
Acceleration: X =  0.00Y =  0.00Z =  9.81Fall detected!
Reconnecting client to hakody.messaging.internetofthings.ibmcloud.com
iot-2/cmd/command/fmt/String
subscribe to cmd OK
```

NODE RED

6/30/2023, 3:24:49 PM node: debug 16
iot-2/type/wokwi/id/1234/evt/Data/fmt/json : msg.payload : number

31.5

6/30/2023, 3:24:49 PM node: debug 16
iot-2/type/wokwi/id/1234/evt/Data/fmt/json : msg.payload : number

70

6/30/2023, 3:24:50 PM node: debug 16
iot-2/type/wokwi/id/1234/evt/Data/fmt/json : msg.payload : number

0

6/30/2023, 3:24:51 PM node: debug 16
iot-2/type/wokwi/id/1234/evt/Data/fmt/json : msg.payload : number

0

6/30/2023, 3:24:52 PM node: debug 16
iot-2/type/wokwi/id/1234/evt/Data/fmt/json : msg.payload : number

1

{"temp":31.5,"Humid":70,"gas":0,"sos":0,"status":1}

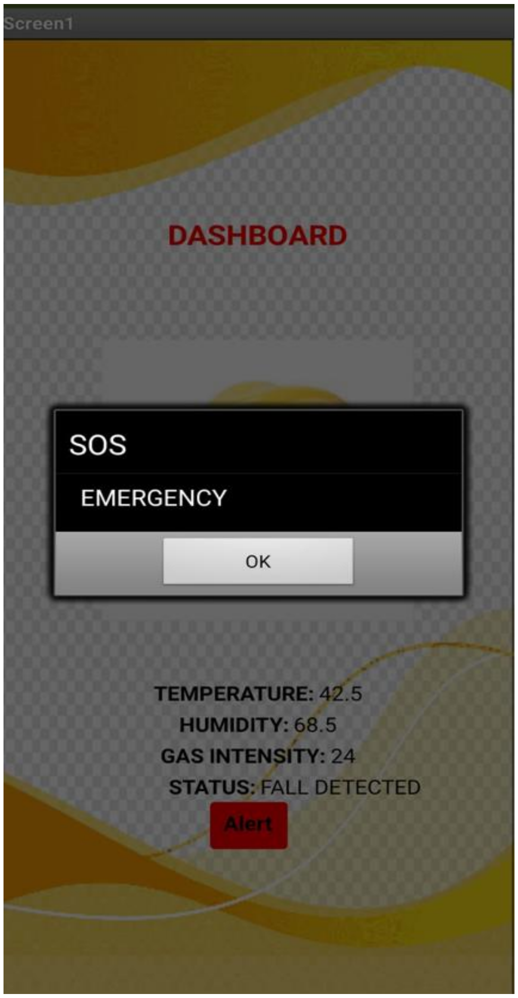
{"command":"alert"}

IBM CLOUD

The recent events listed show the live stream of data that is coming and going from this device.

Event	Value	Format	Last Received
Data	{"temp":31.5,"Humid":70,"gas":0,"status":1,"SO...	json	a few seconds ago

MIT APP INVERTER:


Screen1
DASHBOARD
SOS
EMERGENCY
OK
TEMPERATURE: 42.5
HUMIDITY: 68.5
GAS INTENSITY: 24
STATUS: FALL DETECTED
Alert


Screen1
DASHBOARD
TEMPERATURE: 45.9
HUMIDITY: 68.5
GAS INTENSITY: 24
STATUS: FALL DETECTED
Alert


Screen1
DASHBOARD
TEMPERATURE: 45.9
HUMIDITY: 68.5
GAS INTENSITY: 24
STATUS: STEADY
Alert

7.ADVANTAGES AND DISADVANTAGES

Advantages:

- Improved Safety: The mining worker safety helmet can help keep workers safe in dangerous mining environments. It can detect and alert them about potential risks like toxic gas, temperature changes, or humidity changes.

- Remote Monitoring: The helmet can be connected to a system that allows supervisors to monitor workers from a central control room. This means they can keep an eye on multiple workers at once, even from a distance, and provide help quickly if needed.

- Quick Response and Assistance: If an accident or emergency happens, the helmet can send immediate alerts with the help of a panic button to the control room. This helps in getting timely help, like medical assistance or evacuation, which can save lives.

- Data Analysis: The system can collect and analyze data from the helmets. This information can provide valuable insights into workers' conditions and work environments. It helps identify patterns, improve safety measures, and prevent accidents and injuries.

Disadvantages:

- Technical Complexity: Setting up and maintaining the system may require technical knowledge. It could be challenging for organizations without much technical expertise or resources to handle any problems that arise.

- Connectivity Issues: The system relies on a stable internet connection between the helmets and the control room. In areas with poor network coverage, maintaining a reliable connection might be difficult, affecting the system's effectiveness.

- Cost: Implementing the safety helmet system can be expensive. It involves buying the helmets, sensors, and communication devices, along with subscribing to an IoT platform and covering ongoing maintenance costs. For smaller mining operations with limited budgets, this could be a barrier.

8. APPLICATIONS

- Real-time Monitoring: The system allows supervisors and safety personnel to monitor mining workers' safety in real-time. They can receive instant alerts and updates through a mobile app, created using MIT App Inventor. This helps them quickly respond to any dangerous situations.

- Safety Alerts: The helmet system, combined with Node-RED and IBM Cloud, can detect hazardous conditions like high temperatures or abnormal movements. When these situations occur, alerts can be sent to the mobile app. This ensures that both the mining worker and the relevant people are immediately informed, so they can take action right away.

- Data Analysis and Insights: The system can analyze the data from the helmet's sensors using Node-RED. IBM Cloud services, like IBM Watson, can help with advanced analysis to find useful information. This can reveal patterns, trends, and potential safety risks. It helps in preventing accidents by taking proactive measures.

- Historical Data Tracking: The system can store past sensor data in the IBM Cloud. This data can be used for further analysis, identifying trends, and reporting compliance. By reviewing this historical data, mining companies can identify recurring safety issues, make corrections, and improve safety protocols.

- Remote Monitoring: With wokwi, Node-RED, and IBM Cloud integration, the system allows remote monitoring of mining worker safety. Authorized people can access real-time data and alerts through the mobile app from anywhere. Supervisors can keep an eye on multiple workers even if they are in different mining sites.

- Compliance and Reporting: The collected and analyzed data can be used for compliance purposes and generating safety reports. This helps mining companies show that they follow safety regulations, improve monitoring compliance, and assist with audits or inspections.

9. CONCLUSION

In conclusion, the Mining Workers Safety Helmet is an innovative solution that leverages IoT technology to enhance safety measures in the mining industry. By integrating various sensors, real-time data monitoring, proactive alerts, and seamless communication capabilities, the helmet revolutionizes workplace safety and improves the overall well-being of miners. It enables early detection of potential hazards, prompt responses to dangerous conditions, and efficient coordination between workers and supervisors. With its innovative features and integration of advanced technologies, our project the Mining Workers Safety Helmet sets a new standard for ensuring the safety of miners and creating a safer mining environment.

10. FUTURE SCOPE

- Enhanced Sensor Capabilities: the project can incorporate additional sensors to monitor a broader range of environmental factors. This could include radiation levels, particulate matter, noise levels, and vibration, among others.

- Artificial Intelligence and Machine Learning Integration: By implementing AI and machine learning algorithms, the safety helmet can learn from historical data and patterns to predict potential risks and issue advanced warnings. This would enable miners to take preventative measures before hazardous situations arise, further improving safety outcomes.

- Wearable Health Monitoring: Integrating health monitoring sensors into the safety helmet can enable real-time tracking of vital signs such as heart rate and blood pressure.This feature would allow for the early detection of health issues or signs of fatigue, enabling timely interventions and minimizing the risk of accidents.

- Geolocation and Tracking: Incorporating GPS technology into the helmet enables effective tracking of miners' locations within the mining site. This feature would be particularly valuable in emergency situations, aiding in rapid response and rescue efforts.

- Integration with Digital Mining Systems: Integrating the safety helmet with other digital mining systems, such as automated machinery and monitoring platforms, would allow for seamless data exchange and coordination. This integration could enable real-time adjustments to mining operations based on safety information gathered by the helmets.

11. BIBLIOGRAPHY

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APPENDIX

WOKWI SIMULATION CODE

```
#include <DHT.h>
#include <Wire.h>
#include <WiFi.h>//library for wifi
#include <PubSubClient.h>//library for MQtt
#include <Adafruit_Sensor.h>
#include <Adafruit_MPU6050.h>
#define DHT_SENSOR_PIN  15 // ESP32 pin GIOP21 connected to DHT22 sensor
#define DHT_SENSOR_TYPE DHT22
#define BUZZER_PIN 4
#define BTN_PIN  25

const int threshold = 10000;  // Adjust this threshold as needed

void callback(char* subscribetopic, byte* payload, unsigned int payloadLength);
```

```
#define ORG "hakody"//IBM ORGANITION ID
#define DEVICE_TYPE "wokwi"//Device type mentioned in ibm watson IOT Platform
#define DEVICE_ID "1234"//Device ID mentioned in ibm watson IOT Platform
#define TOKEN "12345678"     //Token
String data3;
int statUS;
int sos;
//float h, t;

char server[] = ORG ".messaging.internetofthings.ibmcloud.com";// Server Name
char publishTopic[] = "iot-2/evt/Data/fmt/json";// topic name and type of event perform and format in which data to be
send
char subscribetopic[] = "iot-2/cmd/command/fmt/String";// cmd  REPRESENT command type AND COMMAND IS
TEST OF FORMAT STRING
char authMethod[] = "use-token-auth";// authentication method
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;//client id
DHT dht_sensor(DHT_SENSOR_PIN, DHT_SENSOR_TYPE);


//-----------------------------------------
WiFiClient wifiClient; // creating the instance for wificlient
PubSubClient client(server, 1883, callback ,wifiClient); //calling the predefined client id by passing parameter like server
id,portand wificredential
Adafruit_MPU6050 mpu;

void setup()
{
  Serial.begin(115200);
  dht_sensor.begin();
  while (!Serial)
    delay(10); // will pause Zero, Leonardo, etc until serial console opens

  Serial.println("Adafruit MPU6050 test!");

  // Try to initialize!
  if (!mpu.begin()) {
    Serial.println("Failed to find MPU6050 chip");
    while (1) {
      delay(10);
    }
  }
  Serial.println("MPU6050 Found!");
```

```
  mpu.setAccelerometerRange(MPU6050_RANGE_8_G);
  pinMode(BUZZER_PIN, OUTPUT);
  pinMode(BTN_PIN, INPUT_PULLUP);
  Serial.println();
  wificonnect();
  mqttconnect();

}


void loop() {
  //TempAndHumidity  data = dhtSensor.getTempAndHumidity();
  //delay(1000)
  float tempc =dht_sensor.readTemperature();
  float humip= dht_sensor.readHumidity();
  int a = analogRead(36);
  Serial.println(a);
  Serial.println(tempc);
  Serial.println(humip);
  Serial.println("---");
  delay(1000);
  sensors_event_t accel, gyro, temp;
  mpu.getEvent(&accel, &gyro, &temp);

  float x = accel.acceleration.x;
  float y = accel.acceleration.y;
  float z = accel.acceleration.z;

  Serial.print("Acceleration: ");
  Serial.print("X =  "); Serial.print(x);
  Serial.print("Y =  "); Serial.print(y);
  Serial.print("Z =  "); Serial.print(z);
  if (digitalRead(BTN_PIN) == 0) {
      sos = 1;
  }
  else  {
     sos = 0;
  };


  if (tempc > 50.00 )
  {
      tone(BUZZER_PIN,500);
```

```
    delay(200);
    noTone(BUZZER_PIN);
  }
  else
  {
    digitalWrite(BUZZER_PIN, LOW);
  }

  float totalAccel = sqrt(x * x + y * y + z * z);

  // Check if the total acceleration is below the threshold
  if (totalAccel < threshold) {
    Serial.println("Fall detected!");
    statUS = 1;
    // Perform fall response actions here
  }

  PublishData(tempc, humip, a, statUS, sos);

  delay(4000);
  if (!client.loop()) {
    mqttconnect();
  }

  delay(1000);
}

void PublishData(float temp, float humid, int gas, int statUS ,int sos ) {
  mqttconnect();//function call for connecting to ibm
  /*
    creating the String in in form JSon to update the data to ibm cloud
  */
  String payload = "{\"temp\":";
  payload += temp;
  payload += "," "\"Humid\":";
  payload += humid;
  payload += "," "\"gas\":";
  payload += gas;
  payload += "," "\"status\":";
  payload += statUS;
  payload += "," "\"SOS\":";
  payload += sos;
  payload += "}";
```

```
  Serial.print("Sending payload: ");
  Serial.println(payload);


  if (client.publish(publishTopic, (char*) payload.c_str())) {
    Serial.println("Publish ok");// if it sucessfully upload data on the cloud then it will print publish ok in Serial monitor or else it will print publish failed
  } else {
    Serial.println("Publish failed");
  }

}



void mqttconnect() {
  if (!client.connected()) {
    Serial.print("Reconnecting client to ");
    Serial.println(server);
    while (!!!client.connect(clientId, authMethod, token)) {
      Serial.print(".");
      delay(500);
    }

     initManagedDevice();
     Serial.println();
  }
}
void wificonnect() //function defination for wificonnect
{
  Serial.println();
  Serial.print("Connecting to ");

  WiFi.begin("Wokwi-GUEST", "", 6);//passing the wifi credentials to establish the connection
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
}
```

```
void initManagedDevice() {
 if (client.subscribe(subscribetopic)) {
   Serial.println((subscribetopic));
   Serial.println("subscribe to cmd OK");
 } else {
   Serial.println("subscribe to cmd FAILED");
 }
}


void callback(char* subscribetopic, byte* payload, unsigned int payloadLength)
{

 Serial.print("callback invoked for topic: ");
 Serial.println(subscribetopic);
 for (int i = 0; i < payloadLength; i++)
 {

    data3 += (char)payload[i];
 }
 Serial.println("data: "+ data3);
 if(data3=="alert")
 {
    Serial.println(data3);
    //digitalWrite(BUZZER_PIN, HIGH);
    tone(BUZZER_PIN,1000);
    delay(500);
    tone(BUZZER_PIN,500);
    delay(500);
    tone(BUZZER_PIN,1000);
    delay(500);
    noTone(BUZZER_PIN);

    //digitalWrite(BUZZER_PIN, LOW);
 }
 else if(data3=="{\"command\":\"alert\"}")
 {
    Serial.println(data3);
    //digitalWrite(BUZZER_PIN, HIGH);
    tone(BUZZER_PIN,1000);
    delay(500);
    tone(BUZZER_PIN,500);
    delay(500);
    tone(BUZZER_PIN,1000);
```

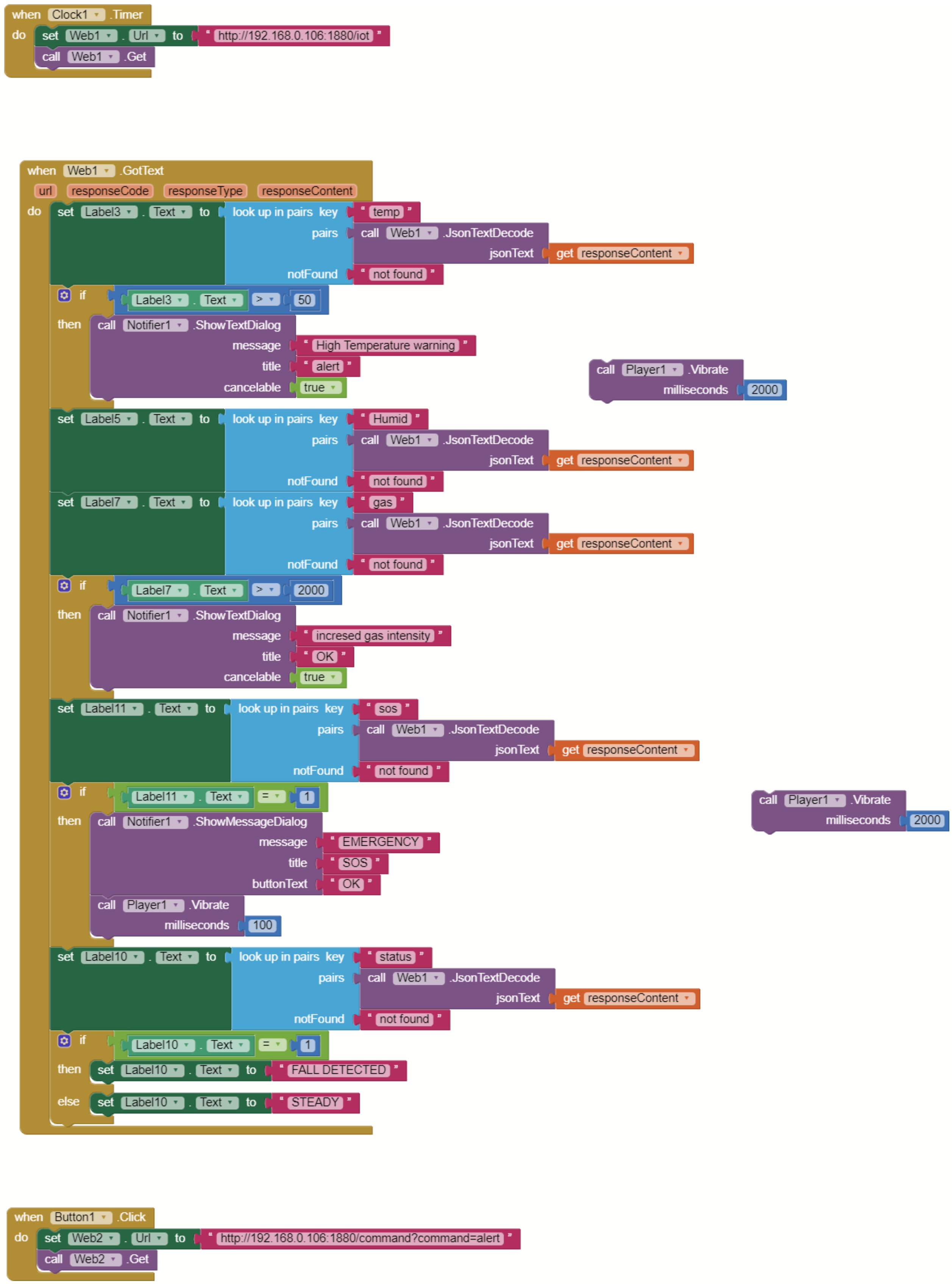
```
    delay(500);

    noTone(BUZZER_PIN);
    //digitalWrite(BUZZER_PIN, LOW);

  }
  else
  {
    Serial.println(data3);
    digitalWrite(BUZZER_PIN, LOW);
  }
data3="";

}
```

MIT APP INVENTOR BACKEND CODE



when Clock1 .Timer
do set Web1 . Url to " http://192.168.0.106:1880/iot "
call Web1 .Get
when Web1 .GotText
url responseCode responseType responseContent
do set Label3 . Text to look up in pairs key " temp "
pairs call Web1 .JsonTextDecode
jsonText get responseContent
notFound " not found "
if Label3 . Text > 50
then call Notifier1 .ShowTextDialog
message " High Temperature warning "
title " alert "
cancelable true
call Player1 .Vibrate
milliseconds 2000
set Label5 . Text to look up in pairs key " Humid "
pairs call Web1 .JsonTextDecode
jsonText get responseContent
notFound " not found "
set Label7 . Text to look up in pairs key " gas "
pairs call Web1 .JsonTextDecode
jsonText get responseContent
notFound " not found "
if Label7 . Text > 2000
then call Notifier1 .ShowTextDialog
message " incresed gas intensity "
title " OK "
cancelable true
set Label11 . Text to look up in pairs key " sos "
pairs call Web1 .JsonTextDecode
jsonText get responseContent
notFound " not found "
if Label11 . Text = 1
then call Notifier1 .ShowMessageDialog
message " EMERGENCY "
title " SOS "
buttonText " OK "
call Player1 .Vibrate
milliseconds 100
call Player1 .Vibrate
milliseconds 2000
set Label10 . Text to look up in pairs key " status "
pairs call Web1 .JsonTextDecode
jsonText get responseContent
notFound " not found "
if Label10 . Text = 1
then set Label10 . Text to " FALL DETECTED "
else set Label10 . Text to " STEADY "
when Button1 .Click
do set Web2 . Url to " http://192.168.0.106:1880/command?command=alert "
call Web2 .Get