SAMSUNG INNOVATION COMPUS IOT PROJECT REPORT

Topic : **Mine Monitoring Smart Safety Helmet**

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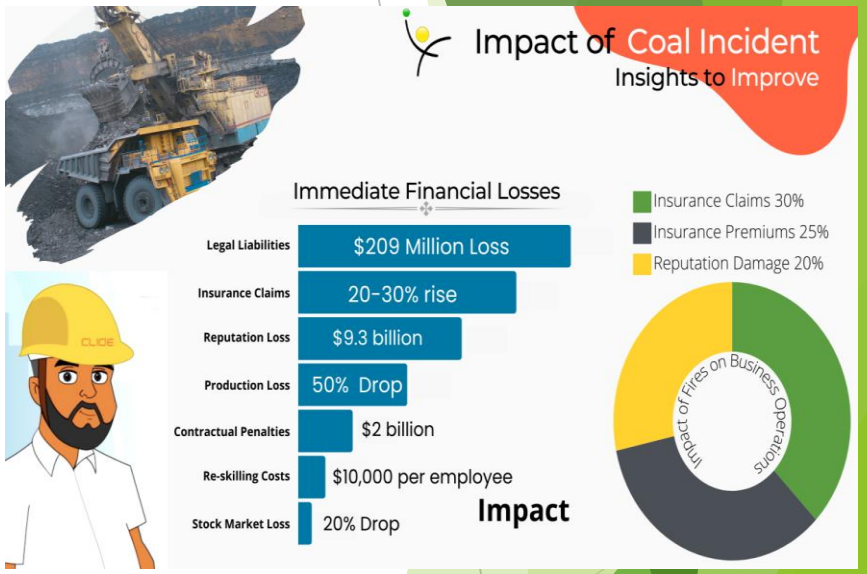
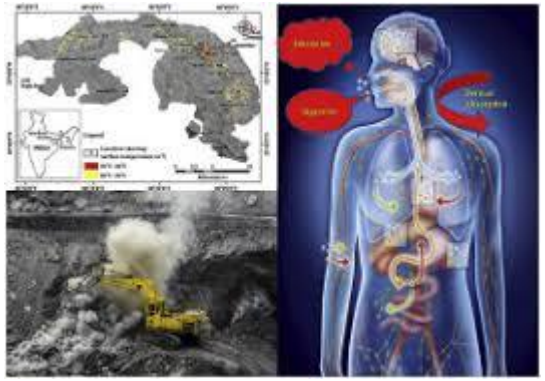
Problem Statement & Real-World Importance

- Coal mines are high-risk environments with frequent accidents.
- Miners face dangers from toxic gases, fire, high temperature, and poor ventilation.
- Lack of real-time monitoring and location tracking increases fatal incidents.
- Ensuring miner safety is critical to reduce injuries and save lives.





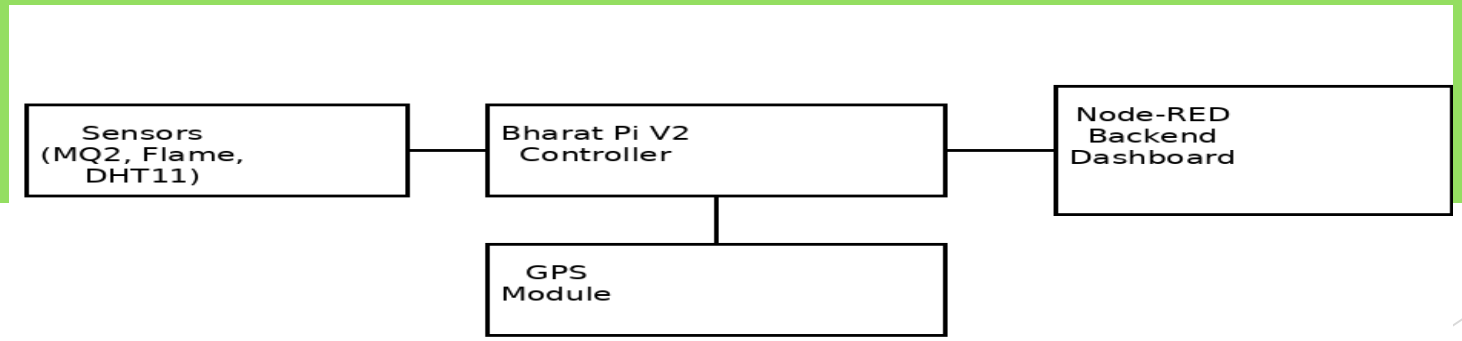
System Overview & Architecture

- Sensors on the smart helmet monitor gas, temperature, fire, and miner location in real time.
- **Bharat Pi V2** processes sensor data and detects unsafe conditions.
- Data and alerts are sent to **Node-RED dashboard** for live monitoring and safety control
- The system consists of **three main layers:**

Sensing Layer, Processing Layer, and Monitoring Layer.

•**Sensing Layer** collects real-time environmental and location data using gas, temperature, flame, and GPS sensors mounted on the helmet.

•**Processing Layer** (Bharat Pi V2) analyzes the data and detects unsafe conditions, while the **Monitoring Layer** (Node-RED) displays live data and alerts on the dashboard.



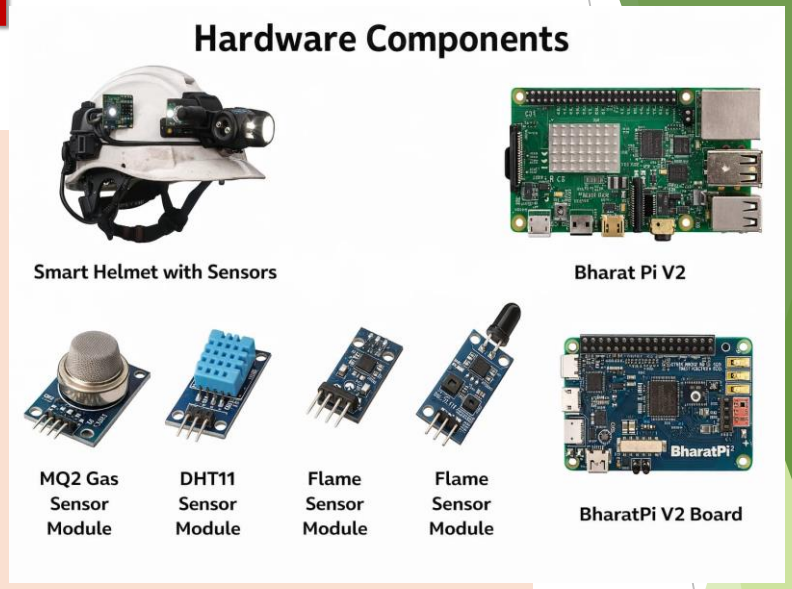
Objectives of the Project

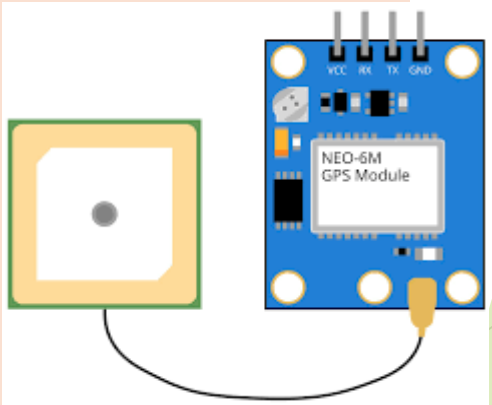
- To continuously monitor environmental conditions inside coal mines.

1. Detect hazardous gases
2. Monitor temperature
3. Detect fire
4. Monitor oxygen level
5. Track miner location using GPS
6. Send real-time data to dashboard

Hardware Components Used

- **Bharat Pi V2** – Main controller and processing unit.
- **MQ-2 Gas Sensor** – Detects harmful gases like methane and smoke.
- **Flame Sensor** – Detects fire or flame presence.
- **DHT11 Sensor** – Measures temperature and humidity.
- **GPS Module** – Tracks real-time location of the miner.
- Power Supply & Helmet Mounting Setup.
- **LCD Display (16×2 I2C):**Displays real-time sensor readings
- and safety status for on-site monitoring.
- **Buzzer-**Emits an audible alarm when dangerous conditions such as high flame level, high methane & carbon dioxide gases.





Software and Technologies Used

Backend (Device & Server Side)

- **Arduino IDE**
  - Used to write, compile, and upload code to the microcontroller.
  - Controls all sensors and handles data collection.
- **MQTT (Mosquitto Broker)**
  - Acts as a message broker between helmet and server.
  - Receives sensor data and forwards it to the dashboard.

Frontend (User Interface)

- **Node-RED Dashboard**
  - Visual interface for monitoring sensor data.
  - Displays temperature, gas level, flame status, and location in real time.

Software and Technologies Used

Communication Protocols

- **Wi-Fi**

  Connects the smart helmet to the internet.

  Sends sensor data wirelessly to the server.

- **MQTT Protocol**

  publish/subscribe protocol.

  Ideal for low-power IOT applications.

  Ensures fast and reliable data transmission

Working of the Smart Helmet

Step-by-Step Working of the Project (IP → OP)

Step 1: Power ON the Smart Helmet

- Helmet is powered using battery.
- Microcontroller initializes all sensors and modules.

Step 2: Data Collection (Input Stage)

- DHT11 reads temperature and humidity.
- MQ-2 detects gas concentration.
- Flame sensor checks for fire.
- GPS module collects location coordinates.

Step 3: Data Processing

- processes sensor values.
- Values are compared with predefined safety thresholds.

◆ **Step 4: Local Alert Generation**

- If unsafe condition is detected:
- Buzzer turns ON.
- LCD displays warning message (Gas Leak / Fire / High Temp).

Working of the Smart Helmet

Step 5: Data Transmission

- Sensor data is sent via Wi-Fi.
- Data is published to MQTT topics.

◆ **Step 6: Server & Dashboard Handling**

- MQTT broker receives data.
- Node-RED subscribes to MQTT topics.
- Dashboard updates readings in real time.

◆ **Step 7: Monitoring & Action (Output Stage)**

- Supervisor monitors miner health and environment.
- Immediate action can be taken during emergencies.
- Miner safety and tracking are ensured.

Output, Visualization & Results

Live sensor data displayed on Serial Monitor:

```
Message (Enter to send message to 'ESP32 Dev Module' on 'COM4')
{"temp":27.3,"hum":35.0,"gas":483,"oxygen":21.0,"flame":0,"lat":13.016162,"lng":77.703110}
MQTT Published OK
{"temp":27.3,"hum":35.0,"gas":482,"oxygen":21.0,"flame":0,"lat":13.016116,"lng":77.703201}
MQTT Published OK
{"temp":27.3,"hum":35.0,"gas":473,"oxygen":21.0,"flame":0,"lat":13.016028,"lng":77.703308}
MQTT Published OK
{"temp":27.3,"hum":35.0,"gas":478,"oxygen":21.0,"flame":0,"lat":13.015958,"lng":77.703407}
MQTT Published OK
{"temp":27.3,"hum":35.0,"gas":478,"oxygen":21.0,"flame":0,"lat":13.015916,"lng":77.703453}
MQTT Published OK
{"temp":27.3,"hum":35.0,"gas":478,"oxygen":21.0,"flame":0,"lat":13.015905,"lng":77.703476}
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MQTT Published OK
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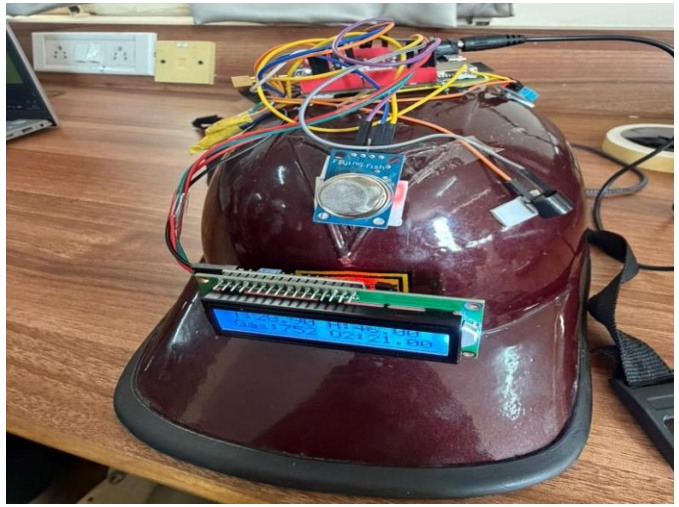
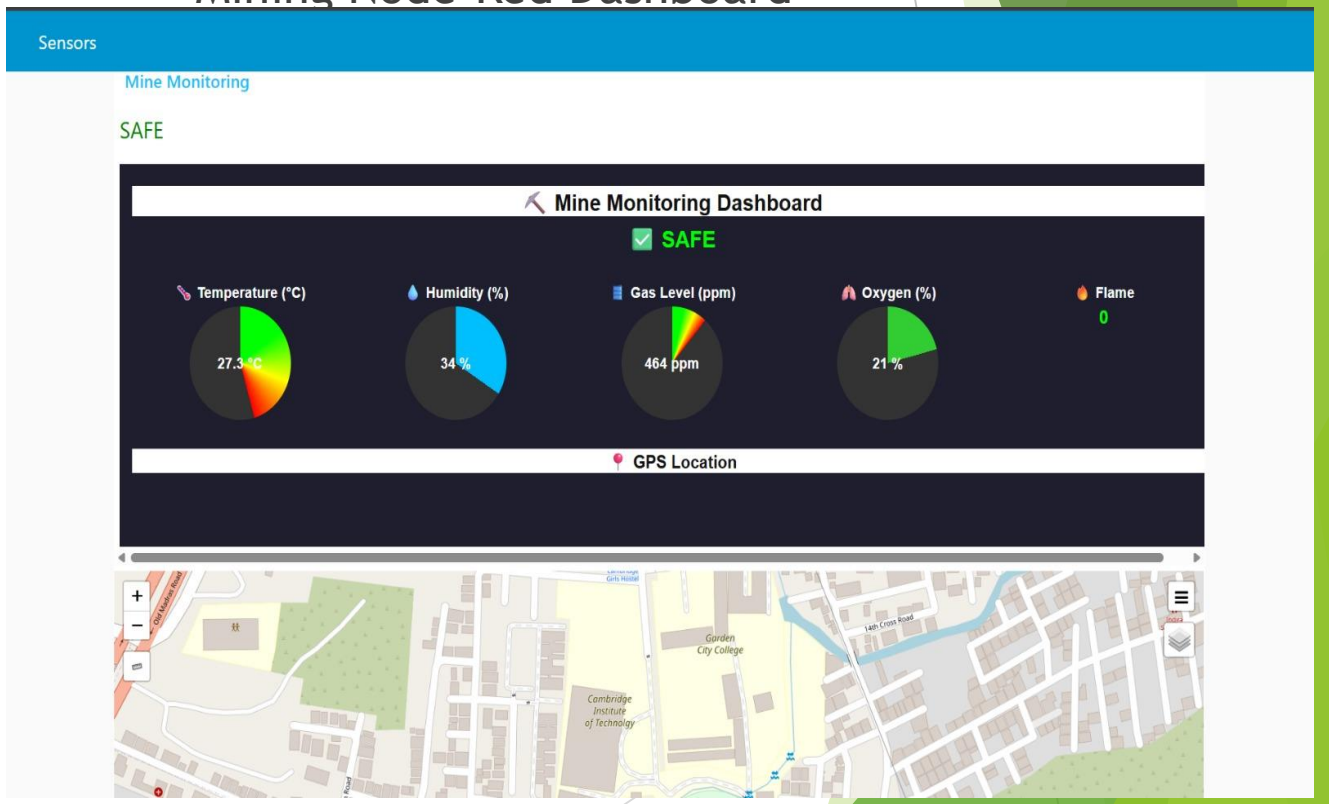


Mining Node-Red Dashboard



Applications & Future Scope

Applications:

- Improves **coal miner safety** by detecting hazardous gases and fire in real time.
- Enables **real-time location tracking** of miners inside underground mines.
- Provides **early warning alerts** for gas leakage, high temperature, and fire.
- Helps mine supervisors **monitor working conditions remotely**.
- Reduces **accident response time** during emergencies.
- Useful in **underground mining environments** with poor visibility and high risk.
- Enhances **worker health monitoring** through environmental sensing.
- Supports **safety compliance and regulations** in mining industries.
- Reduces manual inspection and **human error**.
- Increases overall **productivity and safety efficiency**.

Applications & Future Scope

Future Scope:

- Integration of **heart rate and SpO_2 sensors** for health monitoring.
- AI-based **predictive accident detection** using sensor data.
- Mobile app integration for **real-time alerts** to authorities.
- Cloud-based data storage for **long-term analysis**.
- Addition of **panic button** for emergency situations.
- Use of **LoRa/5G** for long-range underground communication.
- Advanced **battery management and solar charging**.
- Voice alert system for **hands-free warnings**.
- Integration with **smart mine automation systems**.
- Scalable deployment for **large mining operations**.

Conclusion & Learning Outcomes

Learning Outcomes:

- Gained practical knowledge of **IoT system design and architecture**.
- Learned interfacing of sensors like **DHT11, MQ-2, and flame sensor**.
- Understood **GPS-based location tracking** in IoT applications.
- Hands-on experience with **Arduino programming** using Arduino IDE.
- Learned usage of **MQTT protocol** for lightweight communication.
- Developed real-time dashboards using **Node-RED**.
- Improved understanding of **Wi-Fi communication in IoT systems**.
- Gained experience in **real-time alert and safety systems**.
- Learned end-to-end data flow from **sensor input to output visualization**.
- Enhanced problem-solving and **team collaboration skills**.

GitHub Link for software code

GITHUB-LINK:

https://github.com/Shyla-2006/Mining-Safety-Smart-Helmet/tree/main/Coal-Mining-Safety-Smart-Helmet