IOT BASED COAL MINE SAFETY MONITORING AND ALERTING SYSTEM

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Abstract*— Installing and powering conventional coal mine monitoring systems is a challenging task fraught with danger. It is critical to keep and monitor the variables in the foreground to optimize the effectiveness & safety of miners due to the complicated mined environments and the large variety of activities done in coal fields. Therefore, the safety of coal miners cannot be guaranteed by using conventional monitoring techniques. This study illustrates a wireless tracking system based on a wise headgear and ZigBee technology. The shown wirelessly surveillance system is sensitive enough to identify and communicate dangerous conditions in coal mines, including the presence of methane gas, high temperatures, high humidity, and fire. This tracking device sends out distress alerts as necessary. In the situation of an emergency, a buzzer will ring, and data on the tracked parameters will be shown on the computer serving as the interface. The Variables are also wirelessly communicated to the command center, where they are used to assess the mine's security. This paradigm can be simply re-coded. The dependability and steadiness of the mechanism have been empirically proven.

***Keywords*—: – *Smart helmet, ZigBee, IOT, Monitoring system, Coal mine safety*.**

I. INTRODUCTION

The goal of this initiative was to make coal mines safer for employees. Workplace hazards in the coal mining sector include exposure to noxious gases, cave-ins, and fires. Employees are at risk since the present techniques for monitoring and warning on these threats are typically rudimentary and ineffective. This project uses IoT technologies to create a real-time alerting & surveillance system to solve this problem. The technology is based on a high-tech helmet that can detect and record data from a wide range of environmental factors. These sensors provide to a centralized monitor information system about the surroundings and the status of the person wearing them.

This information is analysed in real time by the centralized monitoring system to determine hazards in the coal mine. For instance, if the system detects excessive concentrations of dangerous gases, a warning may be sent to the employees and the appropriate authorities. The smart helmet may also be outfitted with Gps data, two-way communications, and flashing illumination to further enhance the wearer's safety.

A mining mishap is any mishap that takes place in the course of extracting metals or minerals from the earth. Several hundred thousand of miners are killed annually in the line of duty [1]. Most of these deaths that occur in mines that are underground. Coal mining is more riskier than igneous and sedimentary rocks because of the plain, often ineffective rock layers, the existence of CH4 gas, and the existence of coal particles.

Inadequate safety measures are mostly to blame for the majority of fatalities in today's world, especially in less developed countries and rural parts of more developed ones [2].For this reason, it is crucial to keep records of any factors that might lead to an accident. A gadget to monitor potentially life-threatening conditions in a mine site is shown in this work in progress. In this system, surveillance is carried out using sensors & Zigbee.

A safety feature with a personal button is also a feature of this system. When a sensor's reading goes beyond a predetermined threshold, a signal is sent to the appropriate application. The control room receives the alert and acts accordingly. Large numbers of lives might be lost if underground mines catastrophes are not effectively managed. Workplace hazards, such as toxic gases and unsafe temperatures, are tracked by a system of sensors. The data is then transmitted to experts for further review and action.

In retrospect, it is clear that the coal industry plays a major role in the country's fast economic and social growth. Numerous studies have been conducted by academics from all over the globe to increase the level of security. The energy found in coal mines is crucial to the development of civilization.

As a result of mining failures, security might be improved. A chain reaction of malfunctions or errors in industry is usually what leads to an incident. Many viable options exist. Mine-related initiatives, including the installation of safety lighting, may have a major effect. Both legislative action and the development of an underground coal mine tracking system are now underway. Multi-dimensional statistical analysis was used to look at the trend of coal mine accidents in China over the last decade and determine what role humans had in these tragedies. Large coal mine mishaps and fatalities were steadily declining, but random events still accounted for the vast majority of coal mine fatalities. Ninety-four point nine percent of the origins of these occurrences were attributed to human factors [3]. Intentional infringement, incompetence, and defective design contributed for 35.43%, 56.12%, and 4.54%, respectively.

To investigate potential irregularities inside a coal pillar, a technology that uses a spherical, penetration synthesized pulses radar was used. Direct matrices invert was used to create a velocity image of the pillar's interior. Low-velocity substance's location and existence were indicated by the reconstructed image. The tomogram's limited substance matched a clay seam in the centers [4].

While technology may help in certain ways, for many people it won't be enough to overcome the obstacles they face. Coal mining has serious risks, therefore it's crucial that miners get the training they need to be safe [5]. Optic fibre detectors have already been created and put into use as a result of this study's findings to ensure the safe tracking of roofing strength and toxic gases in coal mines. The FOS-based mining hazard warning system is unparalleled because of its built-in reliability, scalability (to several locations), and ability to monitor multiple parameters simultaneously. They might be used to develop expert systems for anticipating and eliminating mining risks [6]. Unfortunately, fatal accidents often occur in deep mines. The creation of risk-free mining methods is essential. Innovative mining techniques may help with this issue. The driverless electric locomotives [7] is a crucial part of the smart mine infrastructure.

The remaining parts of the paper are structured as follows: The technique behind the current plan is covered in Part 2. Third part provides a high-level overview of the system. The functionality of the tracking apparatus and the intelligent helmet is described in Part 4. Part 5 details the review and evaluation of the output results, while the last section discusses the project's findings and its potential future expansion.

II. LITERATURE SURVEY

Both Abid[3] & MustafaAbro, t hey unveiled a wearable IoT suit. As its name implies, it is designed to protect the lives of those who risk theirs every day by working in mines. This model is constructed in such a manner that it can detect the presence of hazardous chemicals, the miner's pulse rate, the subterranean atmosphere, and the precise position of the miner via GPS. Typically, a Wi-Fi secured connection will be used to provide these settings to a technology that changes on the go via the network. [4]

Synonymous expression The undergraduates in this conceptual and detailed a gadget that can locate a coal miner to within a few feet. Workers' lives may be saved in the event of an emergency because to the pinpoint accuracy with which their position can be determined. The technology relies on radio-frequency identification tags to keep tabs on and pinpoint their whereabouts. This precise location may aid in rescue efforts as early as an occurrence is reported. Coal mining operations have been given a huge boost in efficiency because to the robotics developed by DKock. It was designed with South African miners in mind. Together, they investigated the problem of CID. Specifically, they used vibration analysis and the study of naturally occurring gamma rays to achieve their goal. A ZigBee-based safety system was proposed by Gaidhaane. [6] for use by miners. Gas levels are also monitored, which is important since deadly gases are the leading cause of mortality in mines. When the value exceeds the set limit, ZigBee sends a signal by sounding an alarm and activating a series of LEDs. An IoT-based wireless communication system was proposed by ChengQiang[7]; it would allow coal miners to monitor environmental conditions such as moisture, CH4, or warmth. The miner is alerted by a verbal transmission from the worker tracking on the floor channel.

Authors GuoFeng, YongpingWu, & many others. This technology, invented by the investigators, is effective for reducing dangers associated with mining for coal, gold, and other precious metals. If you need to pinpoint the precise position of the coal miner, this method is your best bet. This gadget makes tracking simple and expedites the arrival of necessary assistance in an emergency. This method has a number of drawbacks, the most significant being that Beta is a short-range wifi module and that wire is difficult to use.

Specifically, AlSuwaidi and Zemerll(2009)[8]. They proposed a method that uses GPS to solve a variety of problems. Any missing coal workers may be readily located with the use of GPS thanks to this app's precise location search capabilities. User technology is used to facilitate communication between users and the system. The client's mobile telephone is given the ability to enroll & log in, with the user's passwords and privileges being securely stored in the server's data. Coworkers led by PranjalHazarik[8] This coal miner-specific helmet was built for use in environments with potentially harmful gases including formaldehyde, particulate matter, and others that are encountered during underground mining extraction. This helmet is equipped with sensors to detect the aforementioned hazardous chemicals, and data is sent instantly to the control booth through a ZigBee-connected wifi router.

III. METHODOLOGY

When it comes to monitoring and detecting factors in a mine site, the Arduino is the tool of choice. Sensors for heat, moisture, infrared flame, and gases all offer real-time measurements. Each of these senses are linked to a computer and a transmitter. The information is transmitted to the mcu, while Zigbee WPAN IEEE 802.15.3 is used for communications between gate as well as the designated node. As was previously explained, the XBee technology is used to transmit the data to the command centre. When anything goes wrong, the system sends out an alarm message that is also presented on an Arduino-connected Lcd just at coalfield's entry.

In the event that any of the aforementioned sensors report an unexpected value, Arduino will be used to create and operate a beep to alert the user. A microprocessor and a button are all that's needed to power a wise helmet's computations. The mcu includes a ZigBee transmitter. For the benefit of all coalfield employees, this precautionary action has been implemented. A crisis settings allow a worker to alert the control room of a crisis, allowing for prompt hospital treatment to be provided in the event of illness or injury.

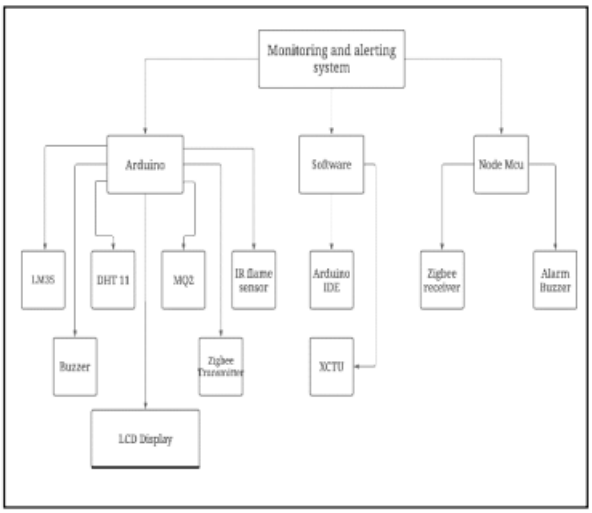

Fig. 1: Block Diagram Of Coal Mine Safety And MonitoringSystem.

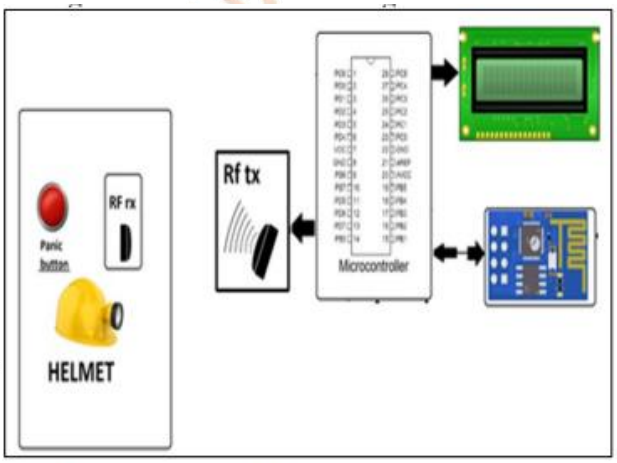

Fig. 2: Block Diagram of Smart Helmet

A. Sensor Technical Details -

The concept is meant to detect disease or fire and monitor parameters such as the temperature, volatiles like No2, Carbon dioxide, & moisture. In Table 1 we can see the sensors & their settings that were used in the prototype. The Analog output sensor is used to take readings of temperature since it is both compact and precise, to be within 3°F o [8]. With just a Micro controller sensor module, we can detect gas concentrations to within 85%, and with a DHT11 sensor, we can measure humidity to within 5% RH. An infrared flame sensors, also used for fire detection, was included in the prototype because of its superior sensitivity and precision compared to other kinds of flame sensors. These sensors endure a long time, are resistant to the coalfield's extreme temperatures and humidity, and don't break the bank.

Zigbee is a solution based on rules, making it ideal for low-cost and low-power M2M as well as IoT networking. ZigBee uses a cellular communication architecture to get rid of hub devices and create a self-healing architecture, allowing for far lower transmission rates than a Wifi. Mixed versions from various vendors are possible because to this, however it has been updated and refined. Zigbee is a widely used protocol because of its low power requirements and moderate bit rate [9].

Table 1: Specification table for selected sensors

Sr no.	Parameters	DHT11 Humidity sensor	MQ2 Gas sensor	LM35 Temperature sensor	IR Flame sensor	ZigBee Module
1	Sensing variable/Uses	Humidity	Gas concentration	Temperature	Fire	Transceiver
2	Operating Voltage	3.5V to 5.5V	5V	+4V to 30V	3.3V to 5V	2.1V to 3.6V
3	Operating Current	0.3 mA	800 mW	60 micro-A	15 mA	45 mA
4	Output Voltage	5.5 V	0 to 10 V	10 mV	Digital output (0 or 1)	–
5	Operating Temperature Range	0 to 50 degrees Celsius	-20 to 70 degree Celsius	-55 to 150 degrees Celsius	-25 to 85 degrees Celsius	-40 to 85 degree Celsius
6	Output/sensing Range	20% - 90%	300 to 10000 ppm	-55 to 150 degrees Celsius	760 to 1100 nm	4000 ft

B. *Flow Chart -*

The process flow of the surveillance system is shown in Fig. 3. The first step is to provide electricity to the experimental circuitry. The readings of the sensor we've connected to the Microcontroller UNO will need to be monitored from now on. When you've analysed the data and determined when abnormal conditions exist in the environment, you may assign a threshold value to each sensor.

A siren would ring, the measurements will be presented on an Lcd with an alarm text, & information will be sent via Zigbee network to the command center if the sensor is larger than the set threshold level. Whereas if sensor is below the set predefined threshold, the Beep would not activate, but the data will still be displayed on the LCD and sent to the command centre. At this point, the process stops moving forward.

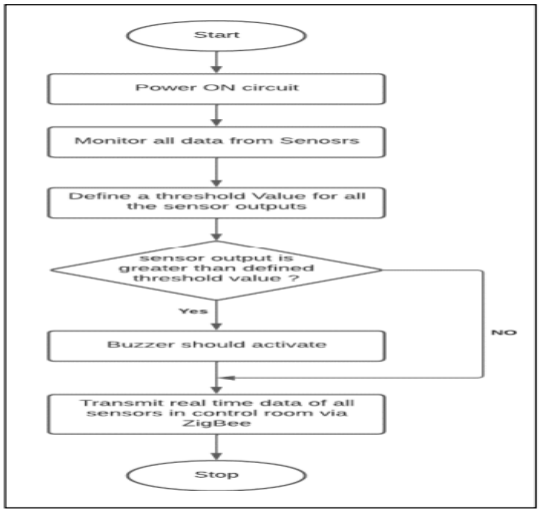

Fig. 3: Flow Chart For Controller Programming

IV. WORKING

The Circuit receives data from the Esp8266, which then uploads it to the web. The circuit receives its voltage from a direct current (DC) power source. This is a schematic of the monitor & alert platform designed into the helmet. It will consist of an Arduino ide, Wlan nodes, and many sensors like the DTH11 sensing element as well as the Infrared fire detector. We want to employ monitors that track heat, gas levels, and smoke detectors to keep mine

workers safe. In addition, it will include a cable that links to an LCD screen at the coal mine works gate. In addition, the Zigbee chip will send the information captured by the sensor to the control booth, where it will be processed and used to perform the necessary steps as quickly as possible. The schematic circuit layout is seen in Fig. 4.

Other preventative measure, the "smart headgear," will have a ZigBee receiver, a pushbutton, as well as an alarm. Any employee who feels unwell or needs treatment may hit the pushbutton to sound the alarm and transmit a ZigBee signal to the command centre.

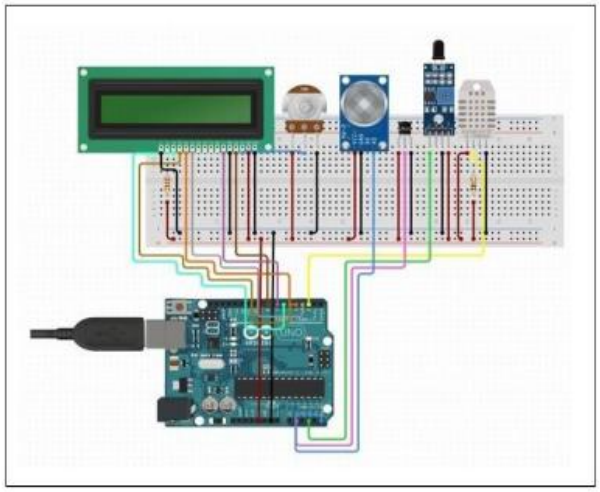

Fig. 4: Circuit Diagram of Coal Mine-Side Monitoring System.

V. RESULTS & DISCUSSIONS

IoT ideas & devices are utilised to build a compact, efficient, yet low-cost prototype. Throughout in this validation process, LM35 detectors were able to accurately detect the heat, and the results were good. Additionally, the DTH11 detector was employed to keep a close eye on humidity levels. Upon detecting elevated gas levels, the Mq2 detector effectively triggered the display's alert system. The infrared gas sensor might potentially identify burning and issue warning to the user. The Zigbee System was created for data transmission after extensive testing over a variety of locations & ranges. Uwb was the most action and achieve protocol, and it worked perfectly. Figure 5 depicts the coal mine prototype, while Figure 6 depicts the command center working model. However, the bike helmet was functioning normally and showing a signal of assistance.

The helmet carries messages to the command centre when an incident arises. Figure 8 depicts the smart helmet's integrated drive & ZigBee chip. Coal miners become lightheaded when co2 or CH4 levels increase in the mine. They may press the buzzer on their headgear in this situation to notify the central management staff and speed up the recover.

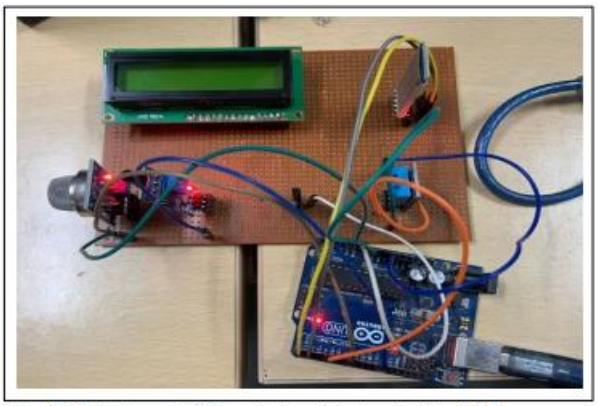

Fig. 5: Prototype Of Monitoring System in Coal Mine

Fig. 6: Prototype Of Monitoring System in Control Room.

Table 2 & Table 3 display the findings of the analysis performed on the surveillance program's data, while fig 7 displays the results visually. While Table 2 details the surveillance system's outputs when everything is under management, contrasts the instruments' readings to their predetermined limits, and displays the hardware changes & their present status. Table 3 details the equipment modifications and evacuation outputs that are going to implemented in case of a manufacturing fault.

The experimental tracking program's real measurements are shown in Fig.7. The values from each sensor are uploaded to the user experience of the Arduino every five secs. Cautions such as "high gas sensor," "near the building," "moisture," & "elevated heat" are shown whenever the critical value is exceeded.

Table 2 : Result analysis of monitoring system

Sr no.	Parameter	Threshold value set	Sensor reading	Hardware changes	remark
1	Temperature (degree Celsius)	25	21.09	Buzzer off	Safe condition
2	Gas (PPM)	600	518.2	Buzzer off	Safe condition
3	Humidity(%RH)	45	33	Buzzer off	Safe condition
4	IR flame sensor (digital output)	0	0	Buzzer off	Safe condition

Table 3 : Result analysis of monitoring system

Sr no.	Parameter	Threshold value set	Sensor reading	Hardware changes	remark
1	Temperature (degree Celsius)	25	31.05	Buzzer on	unsafe condition
2	Gas (PPM)	600	694.1	Buzzer on	unsafe condition
3	Humidity(%RH)	45	48.3	Buzzer on	unsafe condition
4	IR flame sensor (digital output)	1	1	Buzzer on	unsafe condition

```
temperature: 21.09 °C
gas density: 561.00
Humidity = 33.5
* Close Fire *
temperature: 21.14 °C
gas density: 561.00
Humidity = 33.5
* Close Fire *
temperature: 21.19 °C
gas density: 563.00
Humidity = 33.5
* Close Fire *
temperature: 21.14 °C
gas density: 561.00
Humidity = 33.5
```

Fig. 7: Result of Monitoring System

In Figure 8, we see the winning solution for the wise headgear concept. The helmet carries messages to the command centre when an emergency occurs. The helmet has a Zigbee protocol as well as a pushbutton to activate it. Whenever the concentration of co2 or gases in an active mining increases, prospectors begin to feel lightheaded or Indeed any sensation of disquiet in wellbeing or damage in the bloodstream, those who can press the button on one‘s headgear, that also notifies the employees in the command center as well as significantly lowers the time it requires for people to be saved due to rapid intervention.

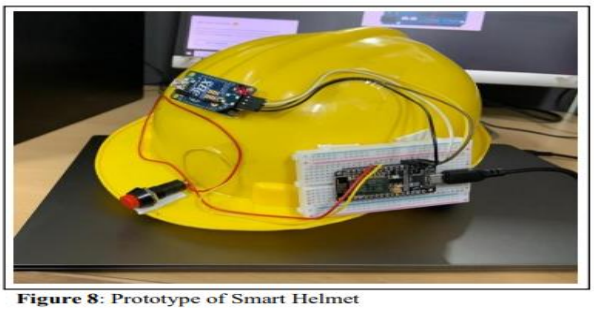

Figure 8: Prototype of Smart Helmet

The ZigBee data is analyzed in Table 4. The only two potential outcomes from pressing a button are 0 and 1. The outcome would be 1 if the pushing button is pushed, activating the device, and 0 otherwise, with the buzzer in its off state.

Table 4: result analysis of smart helmet

Sr.no	Sensor reading	Hardware changes	remark
1	0	Buzzer OFF	Safe condition
2	1	Buzzer ON	emergency

VI. CONCLUSION

In this work, we will discuss the Zigbee-based tracking network. Coal tragedies may be avoided with the help of the suggested method, which monitors the subterranean features of a mine. ZigBee is a low-power, low-size communication network that may easily be adapted to new situations. As an added bonus, the suggested solution eliminates the drawbacks of traditional powerline networking entirely. Therefore, this is an improvement above the standard method of ensuring workers rights in mining towns. In addition, a distress beacon sent via the smart helmet might be helpful in extreme weather or even when emergency treatment is required. The security of several sectors may benefit from this technology. There is a low barrier to entry for additional improvement and customization in light of future developments.

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