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Mqtt Based Monitoring System For Coal Mines Using Raspberry Pi

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Abstract: Nowadays due to global warming and climate changes there are challenging situations in coal mines. To reduce the cost as well as to improve the productivity along with product quality the automation in the field of coal mine is necessary, which will also reduce the mine workers efforts. This project proposes a design of a IOT system with MQTT protocol, by the help of Raspberry pi controller which is able to monitor the temperature, humidity, gas and status of smoke in an underground mine. This system utilizes low power, cost effective Raspberry pi, a temperature sensor, humidity sensor and gas sensor for sensing the mine climate parameters and Wi-Fi for remote logging of data at central location to control the climate state. Every sensor value gets reported through the MQTT protocol at every certain interval of time. If there is any sudden increase in any of those sensor values along with the data log, ten seconds of video has been captured and sent to the server's mail.

Index Terms - Internet of Things (IOT), Message Queuing Telemetry Transport(MQTT),Sensors,Light Detecting Resistor(LDR).

I. INTRODUCTION

Traditional coal mine monitoring systems tend to be wired network systems, which play an important role in coal mine safe production. With continuous enlargement of exploiting areas and extension of depth in coal mines, many laneways become blind areas, where there are lots of hidden dangers. Moreover, it is inconvenient to lay cables which are expensive and consume time. In order to solve the problems, we will design a coal mine safety monitoring system based on IoT, which can improve the level of monitoring production safety and reduce accidents in the coal mines. Also with the help of MQTT protocol we are able to get those parameter values quickly without any loss of data.[7]]The MQTT protocol allows for reliable communication between devices, ensuring that data from various sensors and devices in the coal mine can be transmitted and received efficiently. By leveraging IoT devices such as Raspberry Pi, we can collect real-time data on factors like temperature, gas levels, and humidity, which are crucial for ensuring the safety of miners and detecting potential hazards. This data can then be analyzed and visualized to provide valuable insights for monitoring and controlling the coal mine operations effectively.

II.AIM

- The objective of the system is to develop a safe environment for mine workers. Monitor real-time data from sensors in the coal mine,Detect potential hazards and ensure miner safety. To level up the process of effective coal production and control system,To maintain day-to-day activity of Log for improvements in cloud,Facilitate remote monitoring and control of the coal mine.
- The aim of the project is to monitor, control coal mines and to collect information of the mines using different sensors by interfacing it to Raspberry Pi to send that information to the users using MQTT protocol.

III.PROPOSED SYSTEM

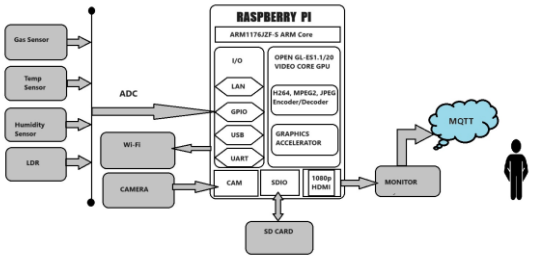

Fig.1 Block Diagram of MQTT based monitoring system for coal mine using raspberry pi

The sensors are interfaced with the Raspberry Pi. The sensors used to sense the environment conditions of the coal mines. The value is set so that if there are any changes in the environment of the mines.

Case 1 : As the sensor's value passes the threshold voltage then the data will get forwarded to the Raspberry Pi to take some action and the buzzer will alert the workers who are working in the mines. And the video recording of the incident will be shared with the user with the help of MQTT protocol.

Case 2: If the sensor's value is normal or less than threshold value then the data will be stored in the cloud and the user can see that data whenever he wants to monitor or see what all things are going in the mines.

IV.WORKING PRINCIPLE

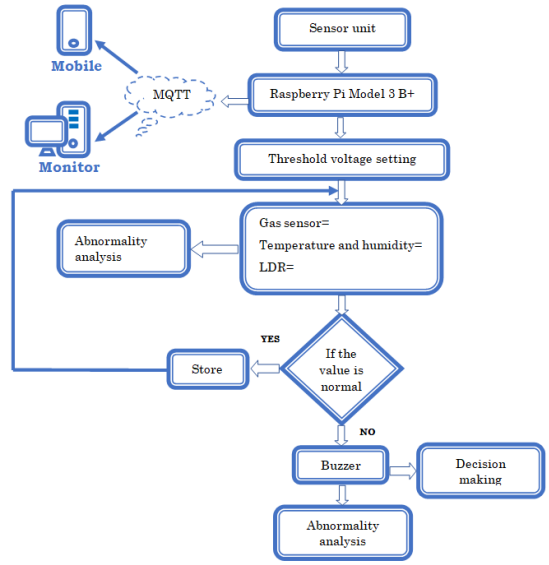

Fig.2 operational flowchart of the system.

Firstly, sensors are installed at different locations within the coal mine to collect data on various environmental parameters and detect potential hazards. These sensors can include gas detectors, temperature sensors. These sensors are connected to Raspberry Pi and data is then transmitted from Raspberry Pi to subscribers such as monitors or a mobile phone through MQTT protocol. This analysis helps in identifying abnormal conditions or potential safety risks, such as high gas concentration, increased temperature, low oxygen levels etc. If the system detects any abnormal conditions, it generates alerts or warnings. These alerts can be in the form of visual indicators, sound alarms. Also, after detecting the potential hazards, subscribers upload the data into the web with the help of its in-built Wi-Fi module. Also, the data is displayed on the monitor and alerts in the form of an alarm through a buzzer. For every change in the data there will be a change in the display. This project is continually evolving, with advancements in technology improving their effectiveness and accuracy. These systems play a critical role in mitigating risks and enhancing the safety of miners working in challenging underground environments.[3]

V. METHODOLOGY

It is used as the major controller unit in the system to control all the hardware components the system interfaces with the software using python coding language. The MQ2 gas sensor, DHT11 sensor and LDR sensor unit all are connected to the raspberry pi unit. Initially when the system is turned ON' raspberry pi starts running the code and checks for the hardware components connected to the system and all components start their respective functions.The MQ2 gas sensor detects the dangerous gas content in the mining atmosphere. LDR detects the darkness in the mining area, camera is turned on every time when there is sudden increase in sensor values the camera takes a video of that area and sends it to subscribers.All the data that are sensed are send to the main unit are directly uploaded to the cloud using IOT platform. The sensors will sense the surrounding atmosphere around the mining area and upload the collected data to the cloud.[2]
There are some threshold values set in the code, every time the data is received from the sensors the main unit will compare the data with threshold values if the received value is exceeds the threshold value then an emergency message is sent using Wi-Fi module to the main authority with the exceeded values, at the same time to alert the mining workers to move for a safe zone. Alarm buzzer will start ringing to alert the workers that the mining area is in danger, by this we can prevent the worker from being involved in any of the dangerous accidents.Since every data has been uploaded to the cloud using the IOT platform whenever any accident occurs the main authority can analyze the cause for the accident by checking the variations in the data and the reason for the accident. So, then they can take precautionary measures to avoid the same type of accident to reduce the losses caused by the accident.[2]

1.The method we are using different sensors and different technology such as various sensors:[2]

· Gas Sensor : MQ2
· LDR sensor
· ADC
· Temperature & Humidity sensor : DH11
· Raspberry Pi 3B+

Components Information:

Hardware Requirements
MQ2 sensor:

Sensors are the electronic devices used for interaction with the outer environment. There are various types of sensors available that can detect light, noise, smoke, proximity etc. One of such sensors used in safety systems to detect harmful gasses is the MQ2 Gas sensor. MQ2 gas sensor is an electronic sensor used for sensing the concentration of gasses in the air such as LPG, propane, methane, hydrogen, alcohol, smoke and carbon monoxide.
MQ2 gas sensor is also known as chemiresistor. It contains a sensing material whose resistance changes when it encounters the gas. This change in the value of resistance is used for the detection of gas.[3]When it comes in contact with the gasses the detection of gasses is done by the change in the value of resistance and also it is a metal oxide semiconductor type gas sensor. A voltage divider network present in the sensor measures the concentrations of gasses in the gas. It works on 5V DC Voltage and it is able to detect gasses in the concentration of range 200 to 10000 ppm.

Fig 3.1 MQ2 sensor

DHT 11:

It is one among DHTXX series of Humidity sensors. The other sensors in this series would be DHT22. Both these sensors are considered as Relative Humidity Sensors. Because, they will check humidity and temperature.The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. These sensors are cheap, small and slow yet they are very common amongst hobbyists.

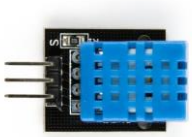

Fig.3.2 DHT11 sensor

LDR Sensor: An LDR is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits.Light Dependent Resistors are created from an unprotected semiconductor material such as cadmium sulphide that alters its electrical resistance from thousands of Ohms in the dark to only a few hundred Ohms when light cascades on it, forming quantifiable hole- electron pairs. This obvious impact is an increase in conductivity with a decrease in resistance for an increase in brightness. The photo-resistive cells have a long retort time, which necessitates a response time of several seconds and a change in light intensity.

fig.3.3 LDR sensor

Analog-Digital Converter:

The ADS1015 and ADS1115 are great analog to digital converters that are easy to use with the Raspberry Pi using its I2C communication bus. The ADS1015 is a 12-bit ADC with 4 channels, and the ADS1115 is a higher precision 16-bit ADC with 4 channels. Both have a programmable gain from 2/3x to 16x so you can amplify small signals and read them with higher precision.

Fig 3.4 ADS1015

Raspberry Pi 3B+:

The third cohort model is the Raspberry Pi-3 Model B+. This influential credit-card sized single board processor outperforms the original Raspberry-Pi Model B+ and Raspberry Pi-2 Model B in several bids. The Raspberry Pi-3 Model B, while preserving the standard board setup, provides you with a more powerful computer that is 10 times quicker than the previous iteration. Raspberry Pi also includes wireless Bluetooth and LAN connectivity, giving it the ideal platform for creating powerful connected designs.The Raspberry Pi 3 Model B+ is the latest product in the Raspberry Pi 3 range, boasting a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT.The dual-band wireless LAN.

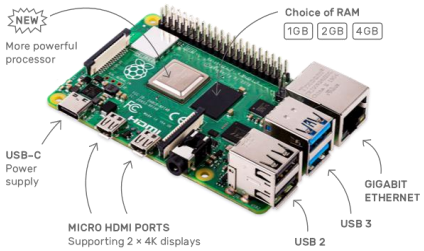

Fig 3.5 Raspberry Pi 3b+ model

Jumper Wires:

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed. Fairly simple. In fact, it doesn't get much more basic than jumper wires.

Fig 3.6 Jumper wire

Buzzer:

It's a system that combines a DC power source with electronic transducers. They're typically found in timers, alarm clocks, electronic toys, and a variety of other goods that generate sound. Buzzers are of two types which are active buzzer and passive buzzer. Sound is generated only when the buzzer is electrified. It spawns sound at a single frequency. It operates at a noticeable frequency of 2 KHz.

Fig 3.7 Buzzer

2.Software Requirements:
Raspbian OS:

Raspbian is a Debian-based PC working gadget for Raspberry Pi. There are quite a few variations of Raspbian which includes Raspbian Stretch and Raspbian Jessie. It has been formally provided by way of the Raspberry Pi Foundation as the foremost operating machine for the family of Raspberry Pi single-board computers. Raspbian was once created by using Mike Thompson and Peter Green as an impartial project. Raspbian is exceedingly optimized for the Raspberry Pi line's low performance ARM CPUs. Raspbian makes use of PIXEL, Pi Improved X home windows Environment, Lightweight as its essential computing device surroundings as of the state-of-the-art update. The scripts and documents created are run on the Raspbian OS.

MQTT Protocol:

MQTT is a standards-based messaging protocol, or set of rules, used for machine-to-machine communication.Smart sensors, wearables, and other Internet of Things (IoT) devices typically have to transmit and receive data over a resource-constrained network with limited bandwidth.MQTT relies on the TCP protocol for data transmission. MQTT sends connection credentials in plain text format and does not include any measures for security or authentication.

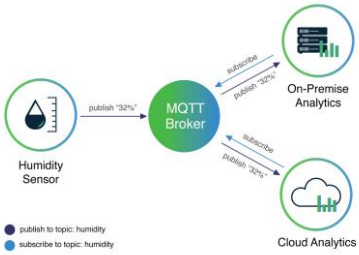

Fig 4.1 MQTT architecture

Python:

Python is a multi-worldview programming dialect: protest arranged programming and organized writing computer programs are completely upheld, and there are various dialect highlights which bolster practical programming and viewpoint situated programming (counting by meta programming and by enchantment strategies). Numerous different standards are bolstered utilizing expansions, including configuration by contract.

Thingspeak:

ThingSpeak is an open source software written in Ruby which allows users to communicate with internet enabled devices. It facilitates data access, retrieval and logging of data by providing an API to both the devices and social network websites. ThingSpeak was originally launched by ioBridge in 2010 as a service in support of IoT applications.ThingSpeak has integrated support from the numerical computing software MATLAB from MathWorks, allowing ThingSpeak users to analyze and visualize uploaded data using MATLAB without requiring the purchase of a MATLAB license from MathWorks.

VI. ACKNOWLEDGEMENT

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