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IOT BASED COAL MINE SAFETY SYSTEM USING ARDUINO

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Abstract
Now a day's due to global warming and climate changes there are challenging situation in field of coal mine. To reduce the cost and improve the productivity along with product quality the atomization in the field of coal mine is indeed necessary, which will also reduce the mine workers efforts. This paper proposes a design of a Wireless Sensor Network (WSN) with the help of controller which is able to monitor the temperature, humidity, gas ,ldr, in an underground mine. This system also controls the ventilation demand to mine workers depending upon present climate conditions within the mine field. This system utilizes the low power, cost effective controller a temperature sensor LM35, humidity sensor, fire sensors, gas sensor, for sensing the mine climate parameters and Wi-Fi for remote logging of data at central location to control the climate state with the help of motor and value control circuitry..
Keywords: Gas sensor, temperature sensor (LM35), Buzzer, CO Sensor(Mq2), WIFI (ESP8266/IOT),Arduino Uno (Microcontroller)

INTRODUCTION

The Internet of Things (IoT) is nothing more than machines that communicate with each other via the Internet. On a large scale, IoT applications vary. The European Research Cluster on the Internet of Things classifies key IoT technologies as major areas such as smart buildings, smart transport, smart power, smart business, smart health and smart environment. IoT is a trendsetting technology which stores all sensor data in the cloud where it is easily accessible from the web. This technology also involves sensors and actuators for data collection and internet distribution. We use cloud not only to store data, but also to analyse, capture and visualize data. Such an emerging technology can be used to make existing systems more efficient in various IoT applications such as agriculture, health, smart home, etc. The cloud's key features include on-demand service delivery, omnipresent connectivity, resource pooling, and elasticity. We have 493 coal mines in India. Coal is the world's most important commodity. [1]

Such petroleum products are the Earth's natural resources which help create energy and needs for some. Coal is a nonsustainable origin that cannot be widely replaced by humans, there are several mishaps of coalmines occurring in the mines, and the diggers are putting their lives at risky, by working in the coal mines, even once in a while they end up losing their lives in the coal mines that are an unfortunate part.[2]

LITERATURE SURVEY

T. Machappa, M. Sasikala, and M. V. N. Ambika Prasad exhibited a framework that electrical obstruction WeinanDeng and Huaxing Zhang, the building of highways in China has led to an increasingly serious problem leaving more and more coal under highways. Having as much as possible the unexploited coal and maintaining highway safety at the same time becomes a problem

that must be addressed as a matter of urgency. The paper addressed the characteristics of road deformations caused by underground mining, suggesting the rules to be followed while mining under highway protective coal pillar. Methods for the security mining of protective coal pillar under highway were put forward in the study on the basis of improving and integrating the existing methods for mining protective coal pillar[3]

Bo Tan;Yimeng Song ; Wendong Shi, The importance of the Coal Mine Production Safety Supervision and the specific issues that might occur under the concept of safety supervision function is proposed to create the Coal Mine Safety Production Supervision Program. The results, show that the addition of independent third parties to the coal mine production process implementation services in compliance with applicable guidelines, laws, rules and regulations and technical standards and the conduct of coal mining companies to establish an effective restriction framework can compensate for the government's macroscopic control and its own limitations.[5] The establishment of the system to provide a reliable guarantee for coal mine safety production. Yiqing Zhao, Yaodong Zhou, Cuiping Li and Zhiguo Cao, In the supply chain management (SCM) of coal companies, the volatility of the occurrence of raw coal and coal quality and the various limitations on mine production capacity are the major factors that need to be taken into account. This paper combines a supply chain model for coal mine planning with a linear programming model for production scheduling to allow coal companies respond quickly to changes in customer demand and boost supply chain and logisticsmanagement level**. [**6**]**

The aim of production management and scheduling optimization model is to optimize sales volume with customer demand constraints, lead time, resource constraints and supply chain inventory. To illustrate the model application and its ability to reduce planning and scheduling time and respond to uncertainty, an example of an open pit coal mine is used. Liu Xianglan,Big data has infiltrated various industries and their functions, has become important development factors in Research Article Volume 9 Issue No.10 IJESC, October 2019 23932 http://ijesc.org/ the global economy.

METHODOLOGY

An IoT-based coal mine safety system using Arduino involves integrating various sensors and communication modules to monitor environmental conditions and enhance worker safety. The system typically includes gas sensors (for detecting methane and carbon monoxide), temperature sensors, and humidity sensors. These devices are connected to an Arduino microcontroller, which processes the data and triggers alerts when dangerous levels are detected. Additionally, a Wi-Fi or LoRa module can be incorporated to transmit real-time data to a cloud server or a mobile application, allowing for remote monitoring by safety personnel

The methodology begins with setting up the sensors in strategic locations within the mine to ensure comprehensive coverage. The Arduino collects data at regular intervals, analyzing it to identify potential hazards. In case of a detected threat, such as high gas concentrations or extreme temperatures, the system activates alarms and sends notifications to the relevant authorities via the cloud. Regular maintenance and calibration of sensors ensure accuracy and reliability, thereby fostering a safer mining environment for workers.

To enhance the system's functionality, additional features can be integrated, such as GPS tracking for personnel and automated emergency response mechanisms. By incorporating RFID tags or wearable devices, the system can monitor the location of miners in real-time, ensuring their safety during hazardous situations. In the event of an emergency, the system can automatically relay the locations of all workers to rescue teams, facilitating quicker response times. Moreover, data analytics can be employed to analyze historical data for trend identification, enabling proactive measures to be implemented before incidents occur. This holistic approach not only improves immediate safety but also contributes to long-term risk management strategies within coal mining operations.

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CIRCUIT DIAGRAM:-

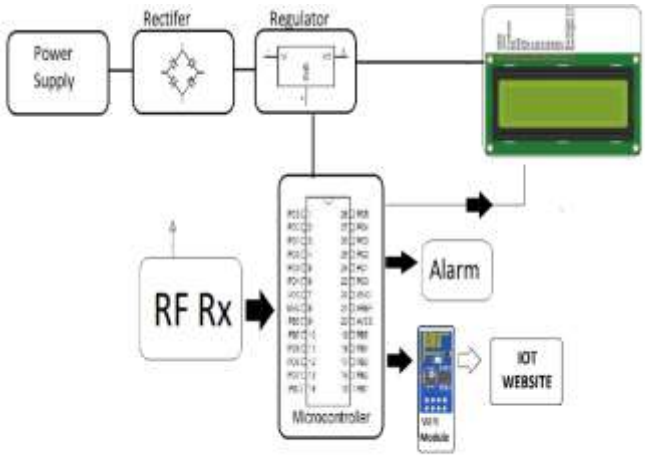

Fig 1 : Circuit Diagram of Iot Based Coal Mine Safety System Using Arduino

SCHEMATIC DIAGRAM:-

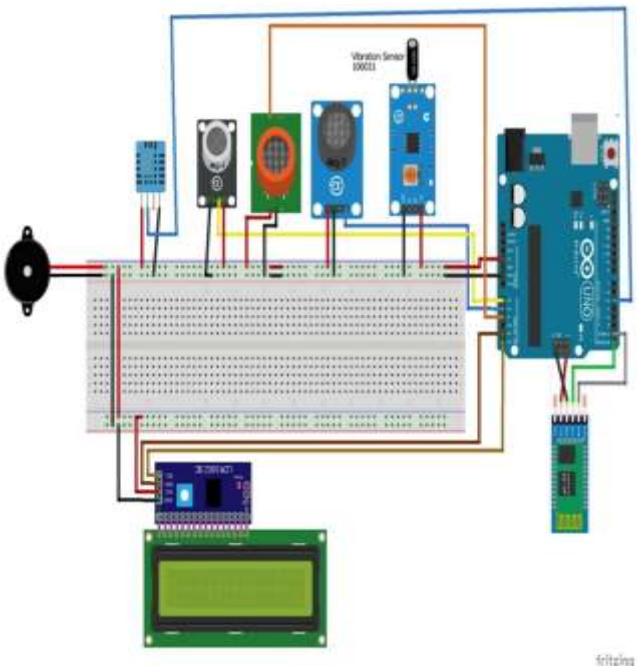

Fig 2 : Schematic Diagram of Iot Based Coal Mine Safety System Using Aurdino

HARDWARE KIT:-

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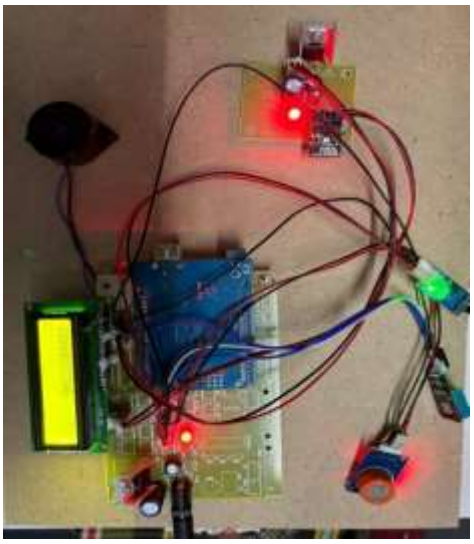

Fig 3 : Hard ware kit of Iot Based Coal Mine Safety System Using Aurduino

SOFTWARE DESCRIPTION:-

Arduino - Installation

We were prepared to learn how to set up the Arduino IDE after studying about the major components of the Arduino UNO board. We'll be prepared to upload our application to the Arduino board after we discover this. The hardware kit for wireless EV charging is displayed in Fig. 6.

In order to enable the board to receive the program through a USB cable, we need to first set up the Arduino IDE on our computer.

Fig 7 : USB Cable

Step 1 –An Arduino board (you can select your own board) and a USB cord are prerequisites. For the Arduino UNO, Duemilanove, Nano, Mega 2560, or Diecimila, a normal USB cable (A plug to B plug) is required; this is the same type of cable that you would use to connect a USB.

Step 2: Download Arduino IDE software.

You're able to The Arduino Official Website offers many versions of the Arduino IDE that can be downloaded to a computer or an external power source. It is necessary to ensure that an Arduino Diecimila is set up to draw power from the USB connection. The website served as the power source. You have to choose software that works with the operating system you have (Windows, iOS, or Linux). Once the file download is finished, it gets unzipped.

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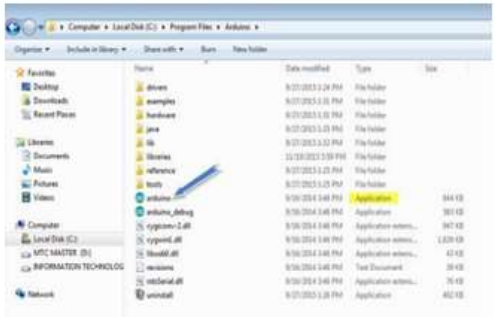
Step 3 − Power up your board.

The Arduino Mega, Duemilanove, Nano, and Uno all automatically draw power from an external power source or via a USB connection to the computer. Make sure the Arduino Diecimila is set up to take power from the USB connection if you're using one. A jumper, which is a little plastic component that slides onto two of the three pins between the power and USB connectors, was used to pick the power source. Verify if it is on the two pins that are nearest to the USB port.

The current method is a coin-based mobile charging system in which customers place coins in coin slots to begin charging their gadgets. Users should always have an appropriate number of coins in their-hands. Paying for a charging service may be done easily and conveniently and the cumbersome nature of this method for consumers to constantly have the appropriate number of coins is one of its drawbacks.[10]

Step 4 − Launch Arduino IDE.

The folder gets unzipped once the Arduino IDE software has been downloaded. An application icon with an indefinite label (application.exe) can be found inside the folder. To launch the IDE, double-click on the icon.



Step 5−Opening the initial project.

Following the software's launch, you have two choices:

· Start a fresh project.

· Launch a working example of a project.

Choose File → New to start a new project. You can choose File → Example → Basics → Blink to view an existing project example.

Step 6 − Select your Arduino board.

To avoid any error while uploading your program to the board, it is necessary to select the correct Arduino board name, which matches the board connected to the computer. Fig 8 shows the basic Arduino.

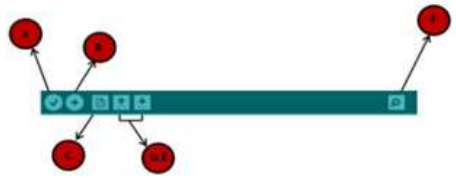


Fig 8 : Basic Arduino

Step 7 − Input your serial port selection.

It selects the Arduino board's serial device. Select the Serial Port menu under Tools. COM3 or above is most likely the port (COM1 and COM2 are typically designated for serial hardware ports). You

may check by unplugging your Arduino board and reopening the menu; the Arduino board should be the one whose entry vanishes. After reconnecting the board, choose the serial port.[11]

Step 8 − Upload the program to your board.

We need to run through the purpose of each symbol that shows up in the Arduino IDE toolbar before we go over how to upload our script to the board.

A − is utilized in order to detect compilation errors.

B: This is where an Arduino board program is uploaded.

C− The shortcut to start a fresh sketch.

D: This key opens an example sketch right away.

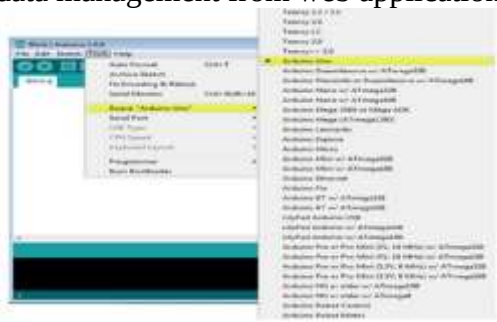
Applied to store your drawing.

To send and receive serial data to and from the board, an F-Series monitor is utilized.

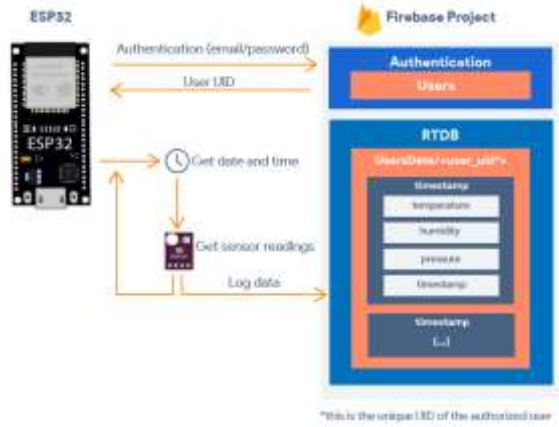
Click the "Upload" button in the surroundings now. After a little while, the RX and TX LEDs on the board will start to flash. The status bar displays the message "Done uploading" if the upload is successful.[12]

FIREBASE:-

Google's platform for developing mobile applications, Firebase, aids in the creation, enhancement, and expansion of apps. It offers numerous services, including hosting, real-time authentication, and data management from web applications, iOS, and Android.



The following diagram provides a high-level overview of the project we built.



1. The Firebase authentication procedures require the user to be configured. The ESP32 authenticates as a user using their email address and password.
2. The ESP obtains the user's UID following authentication;
3. The database is safeguarded using security regulations. The user can access just the database nodes that are located under the node that has its user UID. After ESPcan has the user's UID, the data is published to the database.
4. The BME280 sensor provides pressure, temperature, and humidity information to the ESP32.
5. It immediately obtains the epoch time upon receiving the readings (timestamp).
6. The ESP32 sends data to the database about temperature, humidity, pressure, and timestamp.
7. Periodically, the database is updated with new readings. The Fire Base real-time database will contain a record of every reading for you. [13]

project:

1. Create Firebase Project
2. Set Authentication Methods

3. Get Project API Key
4. Set up Realtime Database
5. Set up Database Security Rules
6. ESP32 Datalogging (Firebase Real-time Database

You can continue with the Firebase project **from this previous tutorial** or create a new project. If you use the Firebase project of that previous tutorial, you can skip to Section 4) Set up Real-time Database because the authentication methods are already set up.[14]

WORKING:-

The MQ-135 alcohol sensor consists of a tin dioxide (SnO2), a perspective layer inside aluminium oxide micro tubes (measuring electrodes) and a heating element inside a tubular casing. The end face of the sensor is enclosed by a stainless steel net and the back side holds the connection terminals. Ethyl alcohol present in the breath is oxidized into acetic acid passing through the heat element. With the ethyl alcohol cascade on the tin dioxide sensing layer, the resistance decreases. By using the external load resistance the resistance variation is converted into a suitable voltage variation. The circuit diagram and the connection arrangement of an MQ 135 alcohol is shown below.

MQ – 135 Air Quality Sensor

The air quality sensor is also a MQ-135 sensor for detecting venomous gases that are present in the air in homes and offices. The gas sensor layer of the sensor unit is made up of tin dioxide (SnO2); it has lower conductivity compare to clean hair and due to air pollution the conductivity is increases. The air quality sensor detects ammonia, nitrogen oxide, smoke, CO2 and other harmful gases. The air quality sensor has a small potentiometer that permits the adjustment of the load resistance of the sensor circuit. The 5V power supply is used for air quality quality sensor.

FireSensor(Flame)

This sensor/detector can be built with an electronic circuit using a receiver like electromagnetic radiation. This sensor uses the infrared flame flash method, which allows the sensor to work through a coating of oil, dust, water vapor, otherwise ice.

Wifi Module

A wireless network uses radio waves, just like cell phones, televisions and radios do. In fact, communication across a wireless network is a lot like two-way radio communication. Here's what happens: A computer's wireless adapter translates data into a radio signal and transmits it using an antenna. A wireless router receives the signal and decodes it. The router sends the information to the Internet using a physical, wired Ethernet connection.

Buzzer:

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers and confirmation of user input such as a mouse click or key stroke. Buzzer is an integrated structure of electronic transducers, DC power supply, widely used in computers, printers, copiers, alarms, electronic toys, automotive electronic equipment, telephones, timers and other electronic products for sound devices. Active buzzer 5V Rated power can be directly connected to a continuous sound, this section dedicated sensor expansion module and the board in combination, can complete a simple circuit design, to "plug and play."

Data Analysis and Optimization:

Sensors: Deploy various IoT sensors for environmental monitoring (e.g., gas sensors for methane and carbon monoxide, temperature sensors, humidity sensors, and vibration sensors).

Wearable Devices: Use wearable technology for miners that tracks vital signs (heart rate, body temperature) and location.

CCTV and Drones: Integrate visual monitoring through cameras and drones to assess conditions in real-time.

2. Data Transmission

Ensure reliable communication protocols (like MQTT, LoRaWAN, or Zigbee) to transmit data from sensors to a central system or cloud platform.

Implement edge computing to process data locally and reduce latency for critical alerts.
3. Data Storage and Management
Use a cloud-based solution for scalable data storage, or on-premises solutions depending on connectivity and regulations.
Implement data management strategies for efficient querying, archiving, and retrieval.
4. Data Analysis
Descriptive Analytics: Summarize historical data to understand patterns and trends in safety incidents.
Predictive Analytics: Use machine learning models to predict potential hazards (e.g., gas leaks or equipment failures) based on historical data.
Anomaly Detection: Implement algorithms to identify unusual patterns that may indicate unsafe conditions.
5. Optimization Techniques
Risk Assessment Models: Develop models to evaluate the risk associated with different operations or areas within the mine.
Resource Allocation: Optimize the deployment of safety personnel based on real-time data and predictive insights.
Maintenance Scheduling: Use predictive maintenance strategies to minimize equipment failures and enhance worker safety.
6. Visualization and Reporting
Create dashboards that visualize key safety metrics, alerts, and trends for easy monitoring by mine operators.
Develop reports that highlight safety performance, incidents, and compliance with regulations.
7. Alerting and Response
Implement automated alert systems for real-time notifications of hazardous conditions to miners and management.
Develop response protocols that are triggered based on specific alerts or data thresholds.
8. Continuous Improvement
Regularly review safety data and incident reports to identify areas for improvement.
Incorporate feedback loops to refine predictive models and safety protocols.
9. Compliance and Training
Ensure compliance with local mining safety regulations and standards.
Provide ongoing training for miners on the use of IoT systems and safety procedures.
10. Collaboration and Communication
Foster a culture of safety where miners can communicate hazards and concerns.

RESULTS:-
The system ensures the safety of miners and personnel by continuously monitoring the sensor readings and triggering the piezoelectric buzzer in the event of hazardous conditions exceeding predefined thresholds. The audible alerts serve as immediate warnings, enabling prompt action and evacuation if necessary.The coal mine safety and monitoring system offers an efficient solution to mitigate potential risks and enhance safety in coal mines.

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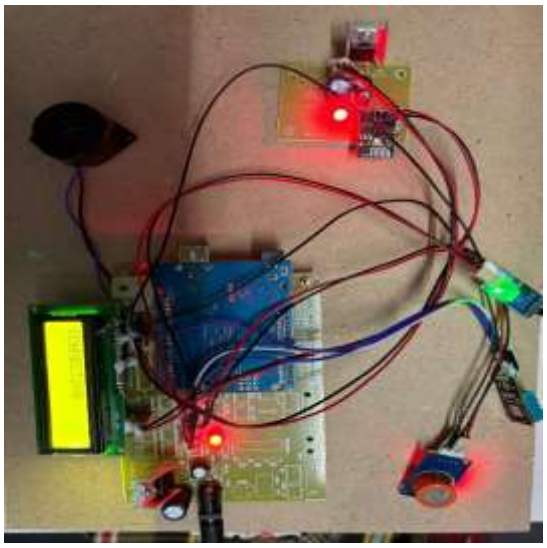

Fig 9 : Final Output Kit

CONCLUSION

The development of coal mining protection for employees using micro controller , Gas Sensor, Temperature and Humidity Sensor, Fire sensors continues to track the safety of mining and update information to the IoT site. By using this tool, we guarantee the safety of workers.

This system checks for parameters including gas quantity, gas pressure, temperature, and vibrations. An alarm is attached closely to the LCD screen; the LCD screen alerts the miners right in time when any of the sensor values go beyond the threshold.

As technology evolves, the potential for IoT-based safety systems in coal mining will continue to expand, driving innovations that can lead to safer, more efficient, and environmentally responsible mining practices. Investing in these areas will be crucial for the future of mining safety

FUTURE SCOPE

1. Real-Time Monitoring

Environmental Sensors: Use Arduino-based sensors to monitor gas levels (e.g., methane, carbon monoxide), temperature, humidity, and air quality in real-time.Wearable Devices: Equip miners with wearable devices that track vital signs and environmental conditions, sending alerts when thresholds are exceeded.

2. Automated Alerts and ResponsesAlert Systems: Develop systems that trigger alarms and notifications to both miners and management in case of hazardous conditions.Automated Ventilation Control: Use IoT to adjust ventilation systems based on real-time data, ensuring safe air quality levels.

3. Data Analytics and Predictive Maintenance

Data Collection and Analysis: Gather and analyze data over time to identify patterns and predict potential hazards or equipment failures.Predictive Maintenance: Use data from machinery to anticipate failures and schedule maintenance, reducing downtime and enhancing safety.

4. GPS and Tracking SystemsLocation Tracking: Implement GPS and RFID technology to track miners' locations in real time, enhancing safety and coordination during emergencies.

Evacuation Planning: Use tracking data to improve evacuation plans and response strategies.

5. Enhanced Communication SystemsMesh Networks: Establish reliable communication systems in underground environments using mesh networks to ensure constant connectivity.Emergency Communication: Develop systems that allow miners to send distress signals quickly in emergencies.

6. Training and SimulationVirtual Reality (VR): Use Arduino in conjunction with VR to create realistic training simulations for miners, preparing them for emergencies.Gamification: Implement gamified training modules that engage miners while teaching them safety protocols.

7. Integration with Drones and RoboticsInspection Drones: Utilize drones equipped with cameras and sensors for remote inspections of hard-to-reach areas.Robotic Assistance: Deploy robots for hazardous tasks, reducing miners' exposure to danger.

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8. Regulatory Compliance and ReportingAutomated Reporting: Create systems that automatically generate reports for regulatory compliance, ensuring that safety standards are met.Real-Time Compliance Monitoring: Use IoT to continuously monitor compliance with safety regulations, providing alerts when standards are not met.

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