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IOT Based Electrical Vehicle Battery Management System with Charge Monitor and Fire Protection

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ABSTRACT:

The implementation of this technology would enhance the performance and improve efficiency and safety associated with electric vehicle operation through a battery management system. This prototype is controlled by an Arduino circuit that is used in capturing information about the battery parameters including voltage, current, and temperature. Real-time information concerning the battery parameters is displayed on the I2C LCD. Indicators are used for showing the state of the batteries. In case of any changes in the temperature, the information will be sent to a NodeMCU board, which in turn sends the information to the ThingSpeak IoT platform. Fire safety is enhanced in this prototype through detecting any abnormal temperature and activating the relays to either cool down the battery using a fan or isolate the battery from other circuits. The user can use switches and potentiometer to set the parameters. A DC motor is used to simulate the movement of the car using the battery system.

KEY WORDS: BMS using ioT Technology , Safety for Electric Vehicles, Detections of Fire and its Prevention, Real-Time Monitoring of the Battery, Prevention of Thermal Runaway.

I. INTRODUCTION

IoT-based Battery Management System with Arduino and ThingSpeak provides an advanced approach towards effective battery management. The system captures all kinds of battery data through sensors and then processes the data with the help of a microcontroller. Further, the processed data is transferred to the cloud where it can be visualized in graphical form. This makes the system very useful for users to make decisions based on battery behavior in real-time. Moreover, the proposed system includes safety features like overvoltage, overcurrent, and temperature sensing. In case of any unusual condition, the system triggers the appropriate protective circuit and takes necessary actions to save the battery from damage. Fire protection features in the system minimize the probability of any accident. With Arduino, the system proves to be economical and flexible to use. EVs are proving to be the solution towards decreasing pollution and dependency on fossil fuels. However, with their increasing popularity, it becomes imperative to monitor the battery performance, safety, and reliability. Battery efficiency, longevity, and overall vehicle performance are dependent on how well the battery is maintained and used. The BMS will monitor the battery parameters, such as voltage, current, temperature, and state of charge. Ineffective battery monitoring may lead to problems likeovercharging, deep discharge, overheating, and even battery fires. Thermal runaway can cause serious harm to the battery. Hence, the need of the hour is a monitoring system that would not just monitor the battery parameters but also protect the user from any adverse effects due to inefficient battery performance.

Table 1.1: Literature survey of some of the existing work :

S.No	**Author Name**	**Description of Work**	**Methodology / Focus**	**Key Finding(s)**
1	A. Kumar, R. Singh, and P. Verma	IoT-Based EV Battery Monitoring System	Uses IoT sensors and cloud	Real-time monitoring and efficient battery management
2	S. Reddy and M. Karthik	Smart Battery Management System for EVs	IoT-based monitoring	Improves battery performance and lifespan
3	P. Sharma, D. Gupta, and A. Mehta	Real-Time EV Battery Monitoring	Cloud + IoT	Accurate real-time data and remote access
4	K. N. Rao and V. Tejaswini	Battery Health Monitoring System	IoT-based tracking	Early fault detection and maintenance
5	M. Ali, S. Khan, and T. Hussain	Wireless Battery Management System	Wireless + IoT	Reduces wiring complexity
6	R. Mishra and P. Das	IoT-Based Energy Monitoring	IoT sensors	Improves energy efficiency
7	J. Lee, H. Park, and B. Kim	AI-Based Battery State Prediction	Machine Learning	Accurate battery prediction

8	S. Patel and N. Shah	Cloud-Integrated Monitoring	ESP32 + Cloud	Remote monitoring and visualization
9	L. Nguyen, P. Tran, and H. Hoang	Fault Detection in EV Batteries	Embedded IoT	Fast fault detection
10	D. Johnson and R. Williams	Battery Health Estimation	Deep Learning	High prediction accuracy

II. PROBLEM STATEMENT

With the growing popularity of electric vehicles, there is an increasing need for a battery management system that can efficiently monitor the battery to determine its performance, efficiency, and life span. If the monitoring of parameters like voltage, current, and temperature is inadequate, then it can lead to serious problems during operation. This is because improper monitoring can reduce the efficiency of batteries and even affect its life span.One of the significant problems associated with the battery is overheating, which could potentially make the batteries unsafe and dangerous. When there is overcharging or deep discharging, the problem becomes more severe, causing reduced efficiency and shortening the life span. Conventional battery management systems, however, have some shortcomings, including the inability to monitor the battery remotely and locally. These batteries usually have no real-time monitoring feature, which makes it difficult to detect faults immediately. Moreover, there are no adequate alert systems that inform the user about any abnormality in the current or temperature. In addition, these batteries lack proper fire protection systems, thus making them prone to malfunction. In many cases, advanced battery management systems that have these features are complicated and costly, hence unsuitable for small businesses and academic research purposes.Therefore, this project proposes a cost-effective IoT-based battery management system based on Arduino and ThingSpeak.

III. METHODOLOGY

The approach towards the implementation of the IoT-based Battery Management System is to ensure that there is a continuous and systematic way to monitor the battery effectively. In this case, the initial step is to employ some sensors including voltage sensors, current sensors such as ACS712, and temperature sensors like LM35/DHT11 in collecting the live data from the battery. The sensors will constantly collect the data from the battery and transmit it to the Arduino microcontroller. The Arduino microcontroller receives the collected raw data and transforms it into valuable data which can be easily monitored and analyzed. The data collected

will then be checked against the set threshold limits, with the aim of detecting any anomalies including overvoltage, overcurrent, and overheating. For remote monitoring purposes, the ESP8266 Wi-Fi module is used to upload the collected data to the ThingSpeak platform through an API key, thus making it accessible remotely. On uploading to the cloud, the data will be displayed on the ThingSpeak dashboard through graphs, giving a user a chance to analyze battery performance even from far. In cases where there is a risk of danger, the system will activate the buzzer alarm and disconnects the battery automatically by turning off the relay.

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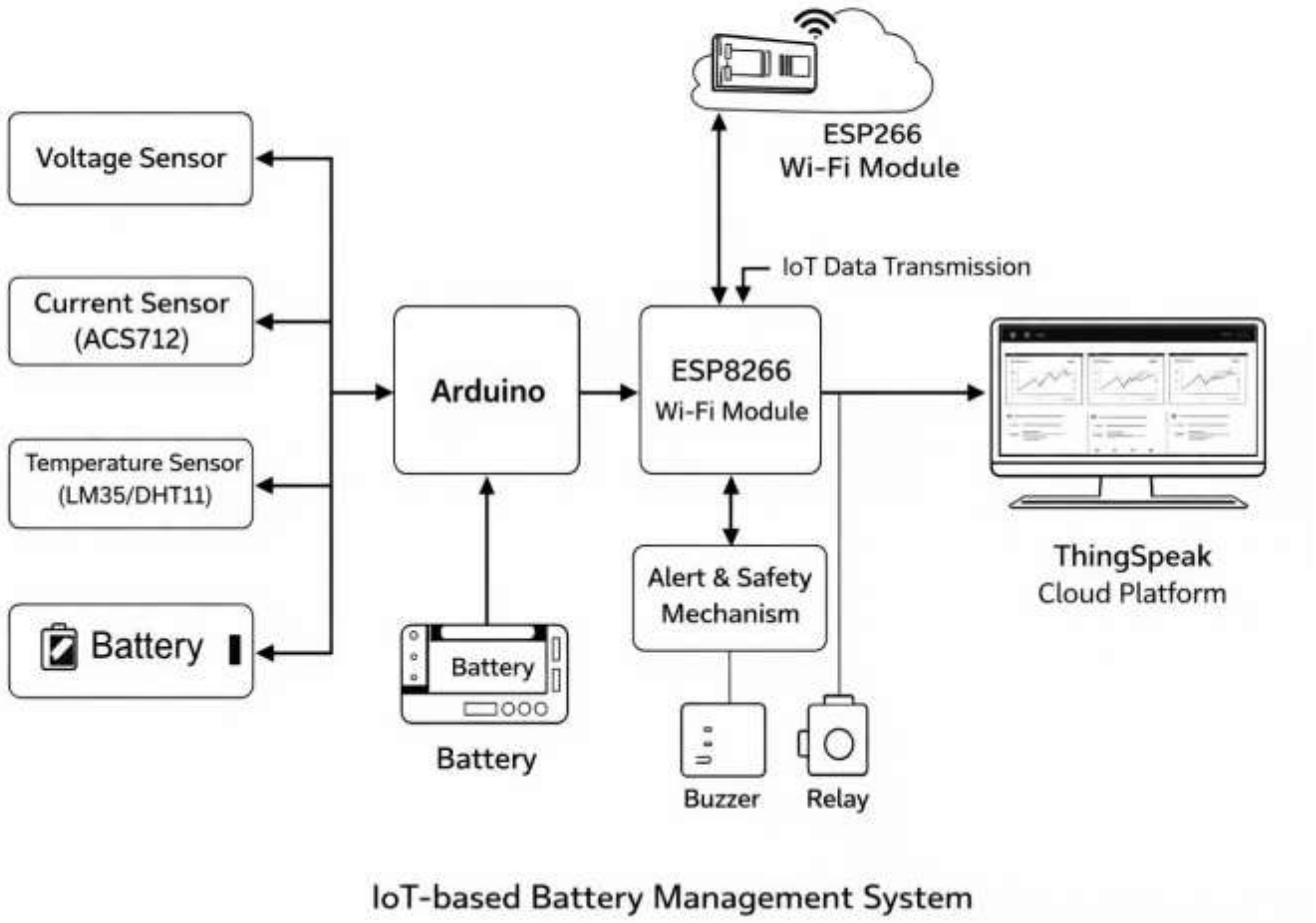

Figure 3.1: Block diagram of system

The above Figure 3.1 depicts the design of the Internet of Things-based Battery Management System. Here, sensors such as voltage, current (ACS712), and temperature (LM35/DHT11) are employed to measure the battery characteristics on a constant basis. They send the readings to the microcontroller board (Arduino). It analyzes the readings to ensure that they are within acceptable boundaries. Then, the information gets transmitted to the cloud service provider through a wireless internet connection using the ESP8266 Wi-Fi module. In addition, the system is designed with a notification and safety feature where a buzzer and relay get triggered during abnormal battery readings such as overheating.

IV. SYSTEM DESIGN AND IMPLEMENTATION

The connection diagram and flowchart together explain the overall design and working of the proposed system.

A. HARDWARE INTERFACING :

The IoT based EV Battery Management System Hardware Interfacing involves connecting the various hardware modules through the main controller, which in this case is Arduino UNO. Voltage Sensor is interfaced through the analog pin of Arduino in order to get voltage readings from the battery. Current sensor is interfaced in series with the load in order to take current readings. Temperature sensor is interfaced with a digital pin of Arduino in order to get temperature readings. Relay is interfaced to one of the digital output pins in order to disconnect automatically in case of faults. 16x2 LCD is interfaced in parallel mode.

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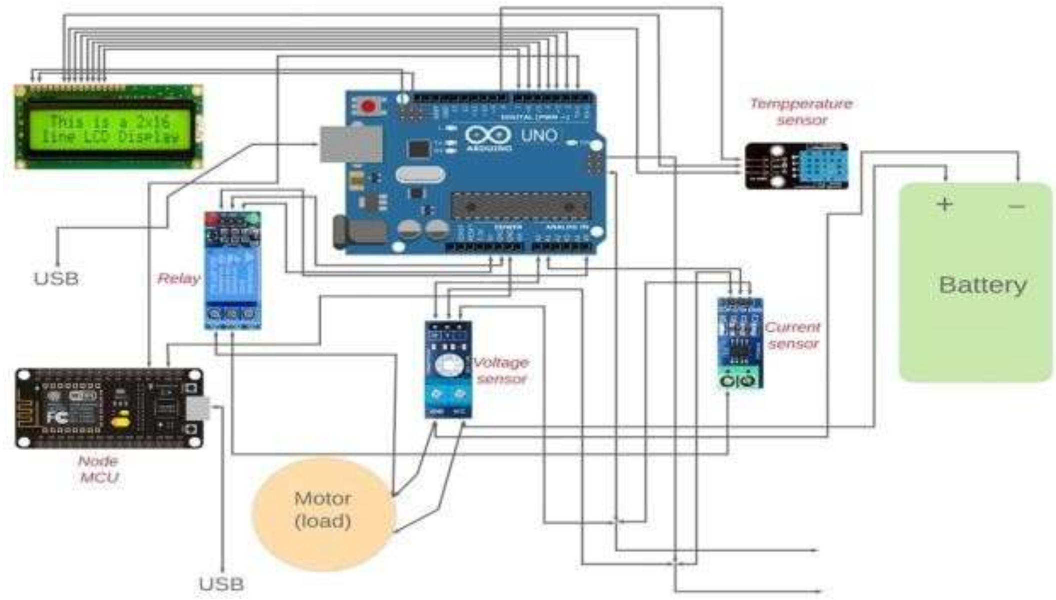

Figure 4.1: Schematic diagram

The above Figure 4.1 shown , labeled Figure 4.1, depicts the complete interfacing of hardware for the proposed system design. In this case, the Arduino UNO is used as the central controller unit to connect all parts of the system. The voltages and currents are sensed from the battery and sent as inputs to the Arduino UNO board. Similarly, the temperature is sensed from the battery in order to check for any signs of overheating that may lead to a fire hazard. The relay circuit board operates on a command from the Arduino to cut off the battery whenever an unsafe situation occurs.

B. SYSTEM FLOWCHART :

This flowchart depicts the working principle of an IoT-based Electrical Vehicle Battery Management System which includes both charge monitoring and fire protection features. First of all, the system initializes, in which the Arduino UNO, sensor, and communication modules are prepared to work. Further, the system measures the parameter values of the electrical battery such as voltage, current, and temperature with respective sensors.

The data collected from the sensors will be processed by the controller to analyze whether the system has any abnormal conditions such as overcharging, high current, and overheating of the battery. If there is no fault in the system, then it monitors continuously. However, if the system identifies any abnormal condition, then it analyzes and implements the protection measure of disconnecting the battery with the help of a relay.

In parallel to the process discussed above, the measured data will be transmitted to the cloud server with the help of NodeMCU to facilitate the IoT-based remote monitoring. Thus, the collected data can be seen on a real-time basis by the users.

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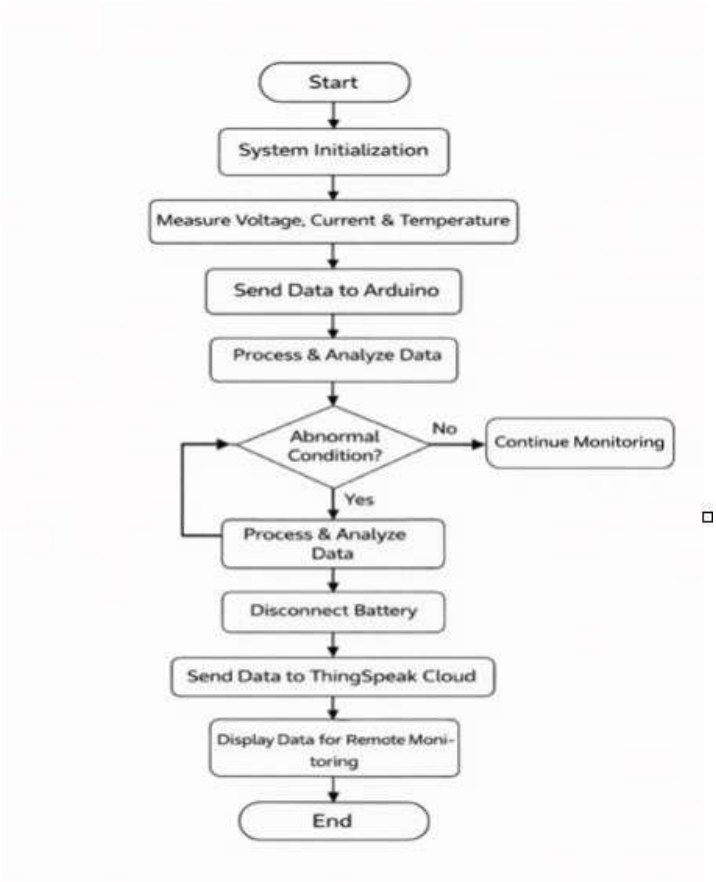

Figure 4.2: flow chart diagram

V. RESULTS AND DISCUSSION

The design of the Internet of Things (IoT)-Based Battery Management System for Electric Vehicles with Charging Monitor and Fire Protection was successfully executed and tested during different working conditions. Continuous monitoring of the battery voltage, current, and temperature was achieved through the use of sensors; data was then processed by the Arduino UNO. Real-time values were shown on the I2C LCD screen, providing a continuous observation of the state of the battery. During regular operation of the system, it worked normally, providing uninterrupted power supply to the load.

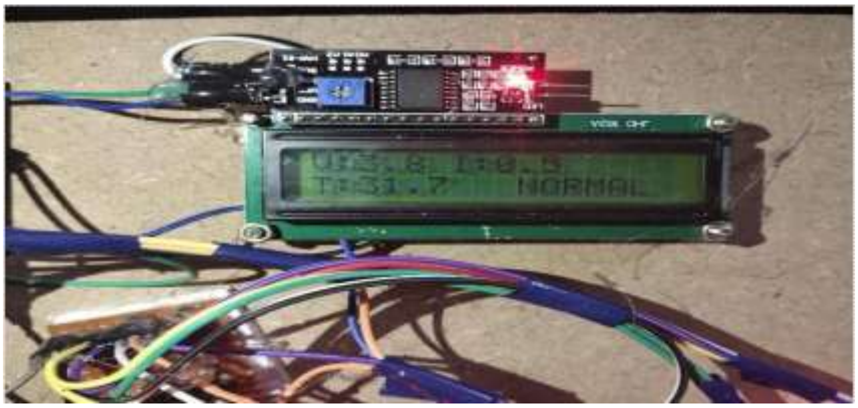

Figure 5.1: System Parameters

To facilitate IoT function, the NodeMCU sent the battery information to the cloud-based platform of ThingSpeak. This allowed for the remote monitoring process as well as the graphical display of the information. Furthermore, LEDs helped in showing the battery status like charging, charged completely, and low battery, giving clarity regarding system performance. The use of DC motor as vehicle load gave stable performance at varied loads.

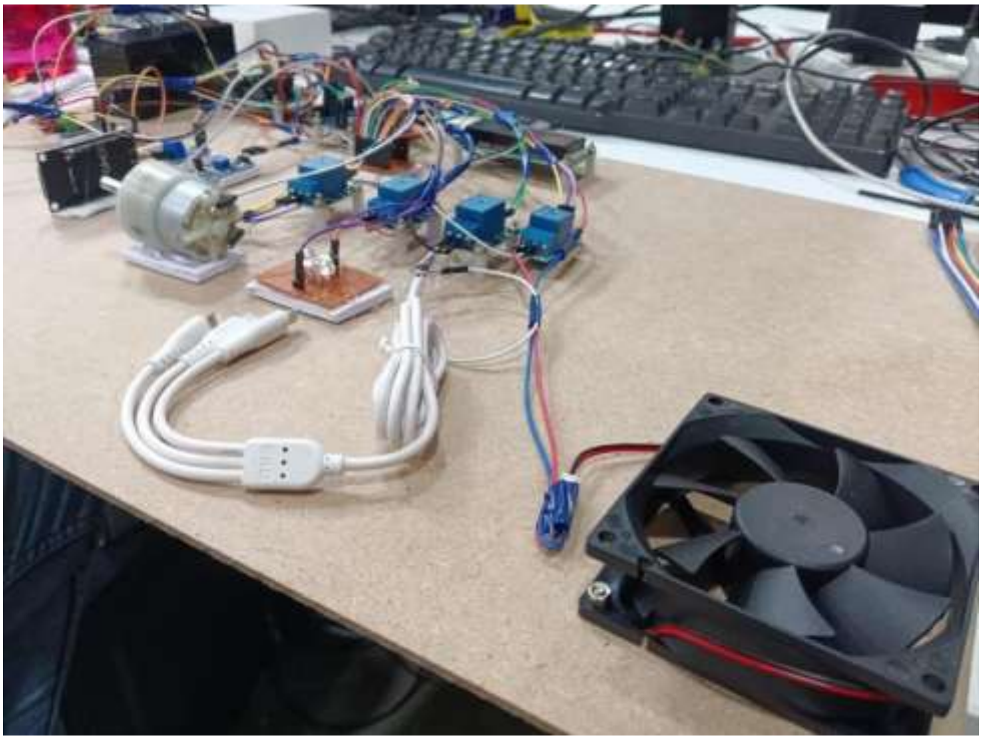

Figure 5.2: placements and connections

In case of abnormality, particularly if the temperature was higher than the pre-set limit, the system engaged fire safety measures. Disconnecting the battery from the relay module and initiating cooling was essential to avoid overheating and any risks. Control functions such as potentiometers and switches enabled users to set the threshold and control the system manually.

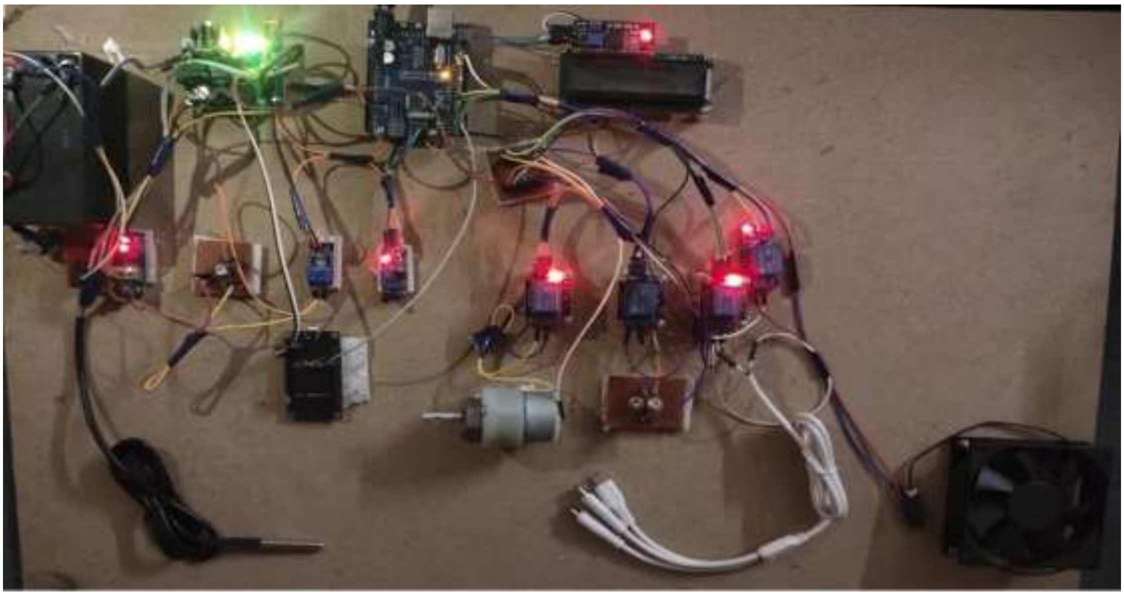

Fig 5.2 Overall Hardware

VI. CONCLUSION

The proposed IoT-Based Electric Vehicle Battery Management System with Charge Monitoring and Fire

Protection was successfully designed and implemented, showing an effective way of how battery safety and efficiency can be enhanced. Firstly, the system constantly monitors battery parameters such as voltage, current, and temperature, providing accurate assessment of the state of batteries. Secondly, by connecting to the ThingSpeak cloud, the device offers remote monitoring and access to battery data, thus providing an opportunity for further analyses and decision-making on the basis of these results. Thirdly, the system

contains advanced security elements that allow identifying potential threats before they occur. For example, when over-temperature conditions are detected, a fan starts operating and cooling the battery down. In addition, the battery is automatically isolated from the other elements using a relay to protect against

hazardous situations that might otherwise arise. Finally, the proposed IoT-based system relies on simple

devices and components, which made its implementation cost-effective and feasible in comparison to other similar projects. Specifically, the use of such popular components as Arduino and NodeMCU greatly simplified the whole development process while maintaining high efficiency and flexibility of the system. Thus, the system can be easily used for large-size electric vehicles in the future.

VII. REFERENCES

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