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Smart Public Transportation using IOT

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***Abstract* - With the rapid increase in the urban population, the demand for the secure, reliable and intelligent public transportation system has also increased. The conventional public transportation systems lack real-time monitoring, auto safety, and proper communication with transport authorities. To address these issues, this paper presents an Internet of Things (IoT)-based Smart Public Transportation System. The proposed system utilizes an Arduino Mega 2560 microcontroller along with a set of sensors to monitor environmental conditions, passenger safety parameters and vehicle conditions. Temperature and humidity inside the vehicle are monitored using DHT11 sensor, obstacle detection using ultrasonic sensor and alcohol detection MQ-3 sensor to prevent alcohol-impaired driving. Additional modules such as GPS unit enable real-time positioning, and cloud-based data transmission and emergency messaging using GSM and IoT modules. Output devices like LCD display, buzzer and relay-operated motor provide local alerts and automated control actions. The proposed system is a scalable and cost-effective solution for the modern smart transportation system as it improves operational efficiency, passenger safety and facilitates remote monitoring by the transport authority.**

Keywords: Internet of Things (IoT), GPS tracking, GSM communication, safety monitoring, smart public transportation, Arduino Mega 2560, and intelligent transportation system.

I. INTRODUCTION

Fast growing urbanization and increasing population have put existing public transport systems under immense pressure. Therefore, safety, effectiveness, and real time monitoring are of paramount importance to the modern public transport. Although, safety, efficacy, and real-time monitoring are of great concern to modern public transport, public transport vehicles, such as buses and shared taxis, often face issues like passenger safety measures, delayed emergency response, real time monitoring, and real time monitoring of condition of vehicles. The standalone nature of conventional transport systems, with low automation, low connectivity, and poor communication between vehicles and transport authorities, increases risk to passenger safety and decreases operational efficiency.

Advances in Internet of Things (IoT) have made it possible for transforming a transport system into a connected intelligent system that is capable of collecting, processing, and exchanging data in real time. The use of IoT enables integration of various sensors, wireless communication modules, and embedded controllers to monitor driver behavior, environment, and condition of vehicles in real time. Real time visibility of driver behavior, environment, and condition of vehicles enables transport authorities to make informed decisions, to manage fleet of vehicles, and to offer better services.

Safety is one of the critical requirements of public transport. Accidents caused by obstacles, drunk drivers, or delayed response to emergency situation could have serious consequences. IoT based systems offer real time safety features through the use of gas sensor for alcohol detection and ultrasonic sensor for obstacle detection. Real time monitoring of the environment using temperature and humidity sensor enhances passenger comfort and awareness of condition of vehicles. The use of automated alarm and control system prevents accidents by stopping risky situations before they occur.

Another critical requirement of public transport is reliable real time tracking and communication. Real time tracking of location of vehicles, monitoring route of vehicles, and estimating arrival time of vehicles are realized through the integration of GPS with IoT. GSM module is used for communicating with transport authorities or control center in case of emergency situations. Real time data collected from sensors are stored in a cloud based data storage system. Cloud based data analytics system is used to evaluate performance of vehicles in the long run, to predict maintenance of vehicles, and to make informed decisions.

This paper proposes a Smart Public Transportation System using IoT. The proposed system integrates various sensors, Arduino Mega 2560 microcontroller, and wireless communication modules to offer safety and monitoring features to the transport system. The system offers passenger safety, operational efficiency, and real time monitoring of vehicles through cloud based system. The proposed system has a modular architecture and is cost-effective; therefore, it can be easily configured into the existing public transport vehicles.

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II. LITERATURE REVIEW

The Internet of Things (IoT) has emerged as a significant technology that has been transforming public transportation for the past few years. Its applications enable smart public transport systems to track and monitor in real time, make intelligent decisions, and ensure passenger safety. Within the last few years, various research works have been done to address the limitations faced by traditional public transportation systems such as nonreal-time monitoring, lack of fleet management, late response to emergency, and absence of safety features. The literature published so far indicates that research shifted from a basic IoT-enabled monitoring system to a smart transportation system with cloud computing, data analytics, and artificial intelligence. Thus, this section will review the related works in terms of architectures, sensing technologies, communication protocols, and safety-based applications in the smart public transportation system.

In 2021, Sharma et al. published a paper entitled "IoT-Based Intelligent Transportation System: A Review" in IEEE Access. The authors presented a comprehensive review of the IoT-enabled applications in the intelligent transportation system that includes real-time monitoring of vehicles, improved safety, and cloud-based data management using sensor networks [1].

Kumar and Patel published the paper "Smart Public Transportation System Using IoT and Cloud Computing" in the International Journal of Advanced Computer Science and Applications in 2021. The authors proposed an IoT- and cloud-enabled public transportation system, which helps in real-time tracking of fleet vehicles, passenger safety, and centralized monitoring by transport authority [2].

In 2022, Wang et al. published the paper "An IoT Framework for Real-Time Vehicle Monitoring in Smart Cities" in the Sensors journal. The authors proposed a GPS-based IoT framework with environmental sensors to enhance the fleet management and route optimization of vehicles, and improved service reliability in smart cities [3].

In 2022, A. Al-Fuqaha et al. proposed a system entitled "Design and Implementation of Smart Bus System Using IoT" in an IEEE international conference. The authors proposed an IoT-enabled public transport system with sensor, GSM, and GPS modules to generate real-time alerts, and provide safety to passengers traveling in public transport vehicles [4].

The authors Verma and Singh published the paper "Intelligent Transportation Systems: IoT-Based Applications and Challenges" in the Journal of Intelligent Transportation Systems in 2022. The paper presents the applications of IoT in transportation and discusses the challenges of scalability, interoperability, and data security [5].

In 2023, J. Chen et al. published the paper "IoT-Enabled Smart Transportation System for Urban Mobility" in the Sensors journal. The authors proposed an IoT-enabled transportation system that facilitates real-time passenger information and predictive analytics to reduce traffic congestion and enhance the efficiency of urban mobility [6].

In the same year 2023, Rao and Mehta proposed a system entitled "Smart Transportation Monitoring Using IoT and Embedded Systems" in the International Journal of Engineering Research and Technology (IJERT). The authors proposed a cost-effective embedded system that uses a microcontroller and sensor to identify hazardous conditions and provide safety in public transportation vehicles [7].

The authors A. Rossi et al. published a review paper entitled "A Review on Smart and Sustainable Transportation Systems" in Transportation Research Procedia in 2024. The authors emphasized the role of IoT technologies in reducing the energy consumption, emission, and operational costs, and improve the sustainability of the public transportation system [8].

In 2024, H. S. Al-Khalifa et al. proposed a system entitled "IoT-Based Public Transport Monitoring and Safety System" in the IEEE International Conference on IoT and Smart Systems. The authors proposed an IoT-enabled public transport monitoring and safety system with sensor, GPS module, and cloud service to facilitate real-time monitoring and ensure passenger safety [9].

Most recently in 2025, some researchers proposed intelligent and predictive transportation systems. The authors S. Gonzalez et al. published the paper entitled "Intelligent Public Transportation Using IoT and AI Techniques" in IEEE Access. The authors integrated IoT data with AI techniques to predict and enable real-time decision-making, intelligent fleet management, and predictive maintenance, which improves the reliability of transportation services and reduces operational downtime [10].

In summary, the literature from the past few years reveals that research has moved from a basic IoT-enabled monitoring system to intelligent and sustainable smart public transportation systems, which supports the proposed model for the IoT-enabled transportation system.

III. GAP ANALYSIS

Although remarkable contributions have been made towards the design and development of IoT-based smart

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public transportation systems, several knowledge gaps have been observed from the above literature review which need to be bridged. Firstly, the above-mentioned studies mostly focus on single modules such as vehicle tracking, passenger information system or environmental monitoring, etc. rather than the design and implementation of an IoT-based integrated safety monitoring and alert system architecture for public transportation. In addition, modules such as obstacle detection, driver condition monitoring, environmental monitoring, and alert generation are developed separately and hence there is no joint decision making and control system for public transport vehicles.

Secondly, most of the existing studies emphasize on either designing the conceptual model or performing simulation-based studies or cloud-based designs and a little focus has been given to embedded hardware implementation, which is the basic requirement for real-time public transportation systems, especially for developing countries where cost-effectiveness, simplicity, and ease of deployment are the primary concern. Moreover, the design and implementation of immediate local alert generation system using buzzer, LCD, relay for automated control, etc. have not been emphasized, which is essential for the safety of the driver and passenger.

Although a few recent studies have given emphasis on integration of IoT with analytics and artificial intelligence, such systems require high computational resources and infrastructure, which is not feasible for onboard embedded system applications. There is a lack of studies on designing rule-based decision-making models for onboard safety monitoring and alert generation which can be executed in microcontroller. There is also a lack of emphasis on designing scalable, modular, and reliable communication systems including IoT cloud platform and GSM-based alert generation system. In summary, the above literature review emphasizes the need for designing and developing a cost-effective, modular, and multi-sensor IoT-based smart public transportation system which is able to provide real-time safety monitoring, local alert generation, and remote monitoring, which is the focus of this work.

IV. METHODOLOGY

The Smart Public Transportation System using IoT provides real time vehicle monitoring, passenger safety, and communication with transportation authorities. This system is built using a modular hardware software co design approach. This system consists of different sensors, embedded controller, and wireless communication modules to develop a robust and cost effective system.

1. System Architecture

The system architecture is based on the Arduino Mega 2560 microcontroller which acts as the processing and controlling unit of the system. Several sensors are connected to the controller to monitor the vehicle and environmental conditions. Communication modules such as GPS, GSM and IoT modules are used for real time data transmission, vehicle tracking, and alerting the transportation authority in case of emergency. LCD display, buzzer and relay actuator are the output devices used for indication and actuation.

2. Sensor Data Acquisition

In order to monitor the vehicle conditions, several sensors are used in the system. The ultrasonic sensor is used to detect the obstacle during vehicle running to avoid accidents. MQ-3 alcohol sensor is used to check the presence of alcohol near to the driver to prevent drunk and drive. DHT11 sensor is used to monitor temperature and humidity inside the vehicle to ensure comfort to the passenger and to monitor the abnormal environmental conditions. Limit switch is used to monitor the door and mechanical constraints whereas the level sensor is used to monitor the fuel and liquid level for maintenance purpose.

3. Data Processing and Decision Logic

The data from all the sensors is processed by the Arduino Mega 2560 microcontroller based on the predefined threshold values. If any of the monitored parameters exceed the threshold value, the controller gives the alert signal. When the alert signal is generated, the buzzer starts buzzing, warning message is displayed in the LCD, and relay actuator is activated. The decision logic used here is a rule based approach where the decision is made based on the threshold values. This technique is simple and requires low processing power to execute in real time.

4. Communication and IoT

The GPS module gives the real time location of the vehicle which is send along with sensor data to the cloud platform using IoT module for real time monitoring and data storage. The GSM module is used to send the alert message to transportation authority in case of critical situation like alcohol presence, obstacle detection, and abnormal environmental monitoring. The use of two different communication modules helps to maintain the reliability of data transfer and acts as backup during the communication failure.

5. System Implementation and Testing

The complete system is implemented using low cost hardware components to ensure the real time implementation

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of the proposed system. The system is tested by monitoring the response of each sensor, communication modules, and alerting the system. The real time output is displayed in the LCD display as well as in the cloud platform to ensure the proper functioning of the system.

In summary, the methodology of the proposed system ensures the modular, scalable and hardware validated Smart public transportation system using IoT. The existing research gap in public transportation system is fulfilled by integrating multi sensor safety monitoring, real time local indication, and reliable remote monitoring.

V. SYSTEM DESIGN

The block diagram of the proposed Smart Public Transportation System using IoT depicts the interconnection of various sensors, communication modules, and output devices to a microcontroller. This helps in real time monitoring and enhances the passenger safety. The description of the block diagram is as follows.

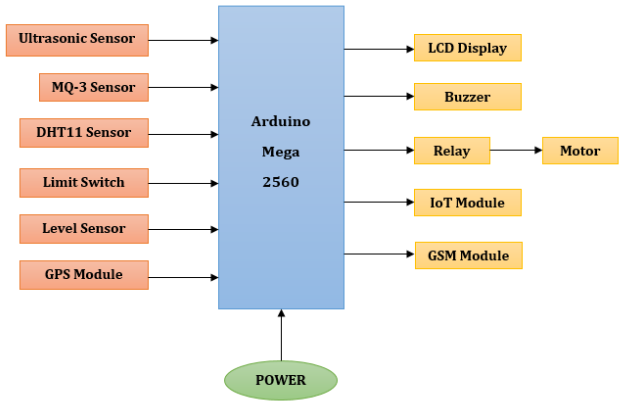

Figure 1: Block Diagram

Arduino Mega 2560 is the controlling unit of the proposed system. It continuously reads the inputs from various sensors connected to it and is processed as per the control logic developed. The selection of Arduino Mega 2560 is due to the fact that it can interface with multiple sensors simultaneously as compared to other Arduino boards. This makes it a suitable choice for the public transportation system.

An ultrasonic sensor is used to detect the obstacle in the path of the vehicle by calculating the distance between the vehicle and the obstacle. If the distance detected is less than the set limit, then the microcontroller sends the signal to activate the alert to alert the driver to prevent the collision. MQ-3 sensor is an alcohol sensor which is used to detect the presence of alcohol vapors around the driver seat. If the concentration of alcohol detected is beyond the set limit then the proposed system generates the warning signal and may even control the vehicle with the help of relay module.

DHT11 sensor continuously monitors the temperature and humidity level inside the vehicle to make sure the comfort of the passenger and also to detect any abnormalities. A limit switch is used to monitor the condition of the doors of the vehicle or the position of any mechanical mechanism to ensure safe operation. A level sensor is used to monitor the level of fuel or any liquid to ensure the maintenance of the vehicle to prevent the vehicle from breakdown.

A GPS module is used to provide the real time location of the vehicle. This information is processed by the Arduino board and sent to the cloud for monitoring by the transportation authority with the help of an IoT module. Along with this, the critical information and emergency messages are sent with the help of a GSM module in the form of SMS.

An LCD display acts as the user interface which provides the real time data of the sensor input and also displays the vehicle status. Along with this, the buzzer is activated during the time of an emergency to intimate the driver and passenger about the same. A relay module is used to control the external devices like motor or power circuit with the help of the sensor inputs to ensure automated actions such as controlling the engine or opening and closing of the door.

All the components of the proposed system are powered by a regulated power supply to ensure a constant voltage supply. In nutshell, the block diagram describes a real time multi sensor IoT based public transportation system which incorporates safety monitoring, automated control and reliable communication to increase the operational efficiency and passenger safety.

VI. RESULT AND DISCUSSIONS

The proposed Smart Public Transportation System using IoT is implemented and tested using an Arduino Mega 2560 board along with various sensors and communication modules. The performance of the system is verified using the responses of sensors, alert generation, communication, and integration of the system. From the experimental results, it can be concluded that the proposed system improves the safety, monitoring, and real-time communication of the vehicle.

The results for the ultrasonic sensor show that the sensor detects obstacles within the predefined range and alerts the driver through the buzzer and LCD. It indicates the alertness of the proposed system for collision avoidance when the vehicle moves at low speed. The MQ-3 alcohol sensor detects the presence of alcohol near the driver seat and alerts the driver and performs the relay control when the value of

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alcohol exceeds the threshold value. It reduces intoxicated driving of the vehicle and improves the safety of the passengers.

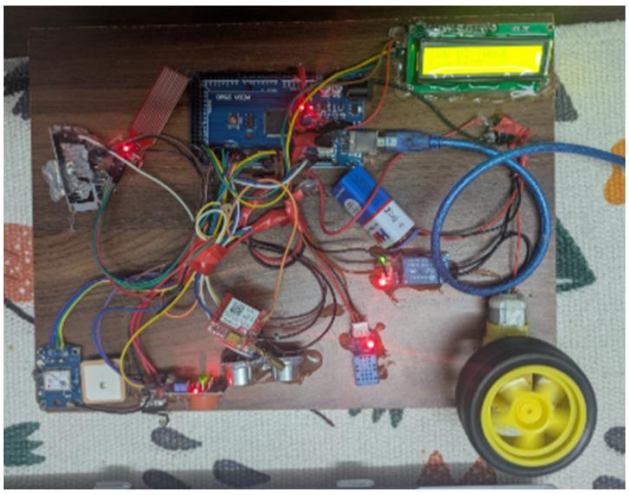

Figure 2: Proposed Hardware

The DHT11 temperature and humidity sensor monitors the temperature and humidity of the vehicle continuously. The measured values are displayed in the LCD and sent to the IoT platform. It monitors the comfort of the passenger and detects any abnormalities in the temperature and humidity. The limit switch detects the status of the door and indicates that the proposed system monitors the safe operation of the vehicle. The level sensor monitors the level of fuel or fluid in the vehicle. It prevents vehicle failure due to the lack of fuel or fluids.

The GPS module monitors the location of the vehicle continuously and sends the location to the cloud using the IoT module. It helps the transport authority to monitor the vehicle at any time. In case of any emergency or critical conditions, the GSM module sends an SMS to the authority. It alerts the authority in case of an emergency or critical condition even in the absence of the internet. The use of both the IoT and GSM modules improves the reliability of the proposed system and reduces the dependency on a single network.

The integration of the LCD and buzzer alerts the driver and passengers locally. The relay module performs control actions without human intervention. The proposed system has low latency and runs stable. It indicates that the proposed system uses a lightweight and rule-based decision mechanism which is suitable for real-time embedded transportation applications. In summary, the experimental results prove that the proposed system is a low-cost, modular, and reliable IoT-enabled solution for smart public transportation. The existing works improve the safety of the public transportation using a single or a few functionalities, and only a few works use real-time hardware implementation. However, the proposed system uses real-time hardware implementation and proves the practicality of the proposed system. The experimental results prove that the integration of multi-sensor safety monitoring, reliable communication, and local alert improves the safety of the passenger, efficiency of the vehicle, and response of the system. Therefore, the proposed system is a suitable system for practical implementation in public transportation.

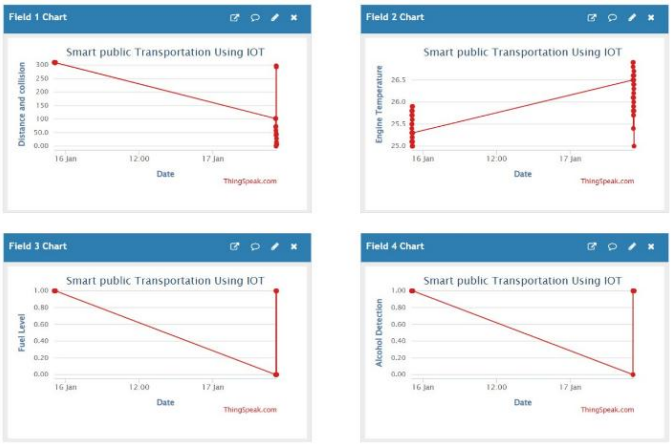

Figure 3: IoT Thingspeak Output

VII. CONCLUSION

In this article, we designed and developed a Smart Public Transportation System based on Internet of Things (IoT) to improve the passenger safety and vehicle monitoring, and to optimize the functionality of the public transportation services. The proposed system utilizes various sensors interfaced with Arduino Mega 2560 to monitor the obstacle, driver alcohol, temperature, humidity, gas, door, fuel and coolant level in real-time. The proposed system employs a sensor-based monitoring with IoT-enabled and GSM-enabled modules to provide a real-time alert to the passenger and remote monitoring to the transport authority.

The results and discussions section clearly explain that the proposed system performs well under real-time operation and generates the alert using LCD display and buzzer and performs the automated controlling action using relay. Moreover, the use of GPS and cloud enable to monitor the vehicle at anytime and anywhere. In contrast to the majority of the existing work, the proposed work is not focused on specific features; it provides a cost-effective, hardware-validated, real-time and reliable framework to meet the transportation needs of the smart cities.

In summary, the proposed IoT-enabled smart public transportation system overcomes the major shortcomings of the existing transport system and is an integrated, modular and scalable architecture. The results of the proposed work are encouraging and show that the integration of IoT in public

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transportation enhances safety, security and quality of services, which ultimately leads to the design of smart and sustainable urban transportation infrastructure.

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