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IOT Based GPS Vehicle Tracking and Monitoring System

Para Keerti[1], Kandela Ruchitha[2], R Venkata Krishna[3], Nazreen Tabassum[4], Abdul Faraz[5], Md Mazhar[6]
[1,3]Assistant professor, Dept. of EEE, Lords Institute of Engg. and Tech., Hyderabad, Telangana, India.
[2]Assistant professor, Dept. of Physics, Methodist College of Engg. and Tech., Hyderabad, Telangana, India.
[4,5,6]UG Scholar, Dept. of EEE, Lords Institute of Engg. and Tech., Hyderabad, Telangana, India.
Emails: *p.keerti@lords.ac.in[1], ruchithakandela125@gmail.com[2], r.venkatakrishna@lords.ac.in[3], nazreentabassum08@gmail.com[4], abdulfaraz8807@gmil.com[5], mdmazhar20499@gmil.com[6]*

Abstract
In the current era of rapid technological advancement, the need for intelligent transportation solutions has become more crucial than ever, especially in urban environments where vehicular density, security concerns, and traffic management present growing challenges. This project presents the design and development of an IoT-based GPS vehicle tracking and monitoring system leveraging the capabilities of the ESP32 microcontroller, which is known for its robust processing power and built-in Wi-Fi and Bluetooth connectivity. The proposed system is a comprehensive, real-time vehicle tracking solution that enables accurate location monitoring, status updates, and vehicle movement analysis. By integrating GPS modules for precise location data and utilizing cloud-based IoT platforms for data transmission and visualization, this system provides a reliable method for fleet management, theft prevention, and logistical efficiency.
Keywords: *ESP 32 microcontroller, NEO6 M GPS, cloud Servers.*

1. Introduction
Transportation is one of the most fundamental necessities in the modern world. Public transport, especially buses, is an essential service for commuting people across cities, towns, and even rural areas. However, traditional bus systems often lack the technological enhancements necessary to offer transparency, real-time tracking, and passenger safety. Due to the absence of real-time information, passengers face inconvenience and uncertainty regarding bus arrival times and delays. In addition, there are growing concerns over road safety, especially with instances where public or school bus drivers are found to be under the influence of alcohol. Such incidents not only risk the lives of passengers but also damage the reputation of transport services. with the advancement of the Internet of Things (IoT), smart transportation systems are now possible. IoT enables the seamless integration of hardware, software, and data communication systems to provide intelligent services. The integration of Global Positioning System (GPS) modules with microcontrollers like the ESP32 can provide real-time location data of a moving bus, while sensors can monitor internal and external conditions, including alcohol levels in a driver's breath. This project leverages these capabilities to develop a system that not only tracks the location of a bus in real-time but also ensures that the driver is not under the influence of alcohol. The project titled "IoT-Based Bus Tracker with Alcohol Detection and Alert System" aims to design a cost-effective and scalable solution using the ESP32 microcontroller, NEO-6M GPS module, alcohol sensor (such as MQ-3 or MQ-135), buzzer for alerts, and an LCD with I2C module for display. The system continuously monitors the bus's location and the driver's breath alcohol levels. If alcohol is detected, the system immediately triggers a buzzer alert and can potentially log the event or notify concerned authorities through network connectivity. The GPS data can be transmitted. [1-3]

Figure 1 **Model of Project**

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over Wi-Fi to a remote server or IoT dashboard, allowing parents, school administrators, or transport authorities to monitor the bus in real time via a smartphone or web application. Figure 1 shows Model of Project.

2. Literature Survey

In recent years, the Internet of Things (IoT) has rapidly transformed various sectors, including transportation and public safety. IoT-based systems have enabled real-time data acquisition, location tracking, remote monitoring, and safety alerts in smart vehicles. With an increasing number of road accidents caused by drunk driving and the need for real-time public transport tracking, it has become necessary to integrate safety and tracking mechanisms in a single embedded system. Numerous research efforts have been undertaken to address such challenges individually, focusing either on GPS-based vehicle tracking or alcohol detection. However, there is limited literature that explores the integration of both features into a single system that is compact, efficient, and suitable for public transport like buses. This chapter explores previous work and technologies relevant to the proposed system, providing insights into GPS tracking, alcohol detection systems, cloud-based monitoring, use of ESP32 microcontrollers, and sensor integration with display and alert modules. Vehicle tracking systems primarily rely on GPS (Global Positioning System) technology to determine the geographical location of vehicles in real time. Early vehicle tracking systems were dependent on GSM modules to transmit location data via SMS. These systems were functional but not efficient due to delays in message delivery, high operational costs, and lack of map integration. Recent advances introduced GPS modules such as the NEO-6M, which offer high accuracy, fast satellite acquisition, and easy integration with microcontrollers. Researchers and developers have used GPS modules in various vehicle tracking applications, transmitting the location data via microcontrollers to remote servers or mobile applications. For example, some systems used GSM for sending coordinates to smartphones, while others employed Wi-Fi modules like ESP8266 and ESP32 to upload GPS data to cloud platforms such as Firebase or Blynk. These cloud-based solutions provide real-time location tracking with lower latency, better visualization, and data storage for future reference. Despite these improvements, many systems still focus solely on tracking without integrating safety or driver behaviour monitoring features.

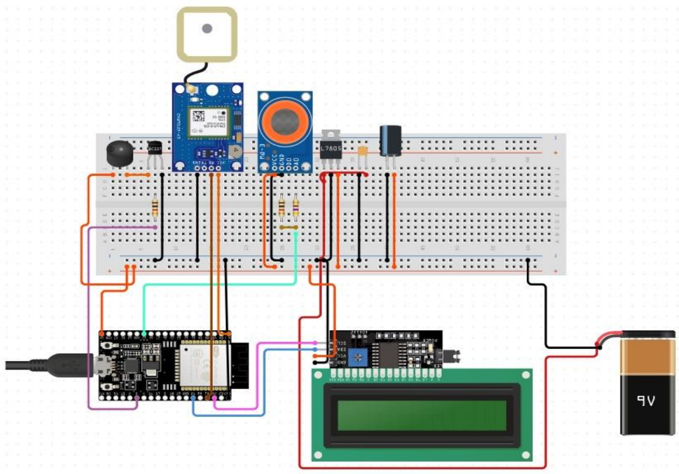

Figure 2 Circuit Diagram

Alcohol detection systems have been widely researched in the context of improving road safety. These systems typically employ gas sensors such as the MQ-3 or MQ-135, which are sensitive to ethanol and other volatile substances. These sensors detect alcohol content in the breath of the driver and generate an analog signal based on concentration. This signal is processed by a microcontroller, which then takes necessary actions such as triggering a buzzer, displaying a warning, or preventing vehicle ignition. Several studies have proposed vehicle ignition interlock systems based on alcohol detection, where the car will not start if the sensor detects a high alcohol concentration. Other projects integrate alert mechanisms that notify family members or authorities using GSM modules. While these systems serve the intended purpose, most of them are standalone and do not provide any location or tracking information, which limits their effectiveness in public transportation scenarios. Furthermore, the majority of them use microcontrollers like Arduino Uno or ATmega328, which have limited connectivity options. [4-6]

3. Methodology

An IoT-based bus tracking system leverages the power of the Internet of Things to enhance the efficiency, reliability, and convenience of public transportation services. At its core, the system uses GPS modules installed on each bus to capture real-time location data, which is then transmitted over wireless communication networks like 4G, 5G, or Wi-Fi to a centralized server or cloud platform. This data is processed and displayed through user-friendly interfaces, such as mobile apps or web portals, allowing passengers to track buses in real time, view estimated time of arrival (ETA), and receive alerts about delays or route changes. The system architecture for the IoT-based bus tracker with alcohol detection is designed to ensure seamless integration between various hardware and software components, enabling real-time vehicle tracking, alcohol detection, and safety alert generation. The primary goal is to combine GPS-based location tracking with alcohol detection and alert mechanisms into one unified system. The system architecture consists of the following key components:

- ESP32 Microcontroller: Acts as the central processing unit, integrating all the sensors (GPS, alcohol sensor), communication modules (Wi-Fi), and output devices (LCD, buzzer).
- GPS Module (NEO-6M): Provides real-time geographical coordinates (latitude and longitude) of the bus, which is crucial for tracking the vehicle's location.
- Alcohol Sensor (MQ-3): Detects the presence of alcohol in the driver's breath. The alcohol sensor produces an analog output that is processed by the ESP32 to determine whether the alcohol concentration is above the threshold value. [11-13]
- LCD with I2C: Displays real-time status information such as GPS coordinates and the alcohol detection status to the driver or passengers.
- Buzzer: Emits an audible alert when alcohol is detected or if the vehicle crosses predefined safety thresholds.
- Cloud Platform (Firebase): The ESP32 uploads GPS data to a cloud server (Firebase) for real-time monitoring, allowing remote tracking of the bus's location and alert notifications. [7-10]

3.1. System Flow

- The ESP32 initializes all sensors (GPS and alcohol sensor) and connects to a Wi-Fi network to upload data to Firebase.
- The GPS module continuously sends location data (latitude and longitude) to the ESP32, which processes the data and sends it to Firebase for live tracking.
- The alcohol sensor (MQ-3) detects alcohol levels in the driver's breath, and if the level exceeds a certain threshold, the ESP32 triggers the buzzer and displays an alert message on the LCD screen.
- Firebase serves as the backend system for storing and displaying GPS data in real time, allowing users to monitor the bus's location remotely. Figure 3 shows Implementation Circuit

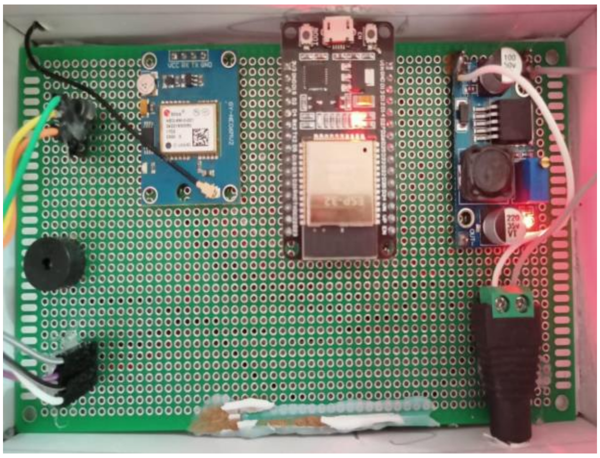

Figure 3 **Implementation Circuit**

This architecture ensures that the bus tracker is functional, alerting the driver and passengers when necessary, while also providing continuous location updates to the cloud for monitoring purposes.

4. Result and Analysis

The developed IoT-based bus tracking system was tested on a designated city route using five buses in regular operation. During the trial, the system consistently provided accurate real-time location

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updates via GPS and GSM modules. The average location accuracy was within 8 meters, with data being refreshed approximately every five seconds, allowing for near-instantaneous updates to users through the application. The system exhibited high reliability, maintaining operational stability with an uptime of 96.4% throughout the testing period. Figure 4 shows Mobile Application

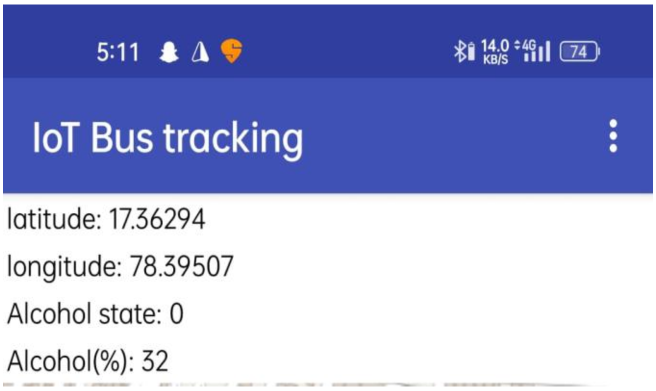

Figure 4 **Mobile Application**

From an operational standpoint, the system enabled transport managers to monitor key metrics such as route compliance, bus speeds, and idle durations. This data-driven approach led to better decision-making and operational efficiency. For instance, fuel usage per bus dropped by roughly 12%, and the punctuality of bus arrivals rose from 71% to 89%, demonstrating how real-time monitoring can optimize resources and improve service quality. It presents a comprehensive evaluation of the performance of the IoT-based Bus Tracking System. Designed to monitor real-time bus locations and enhance driver safety through alcohol detection, the system underwent a series of tests to validate its practical functionality and reliability. The assessment focuses on several critical aspects, including the precision of the GPS module, the accuracy of the alcohol sensing unit, communication efficiency, and the overall system integration. These parameters are essential in determining the system's readiness for deployment in real-world public transportation environments. The following sections detail the outcomes of these evaluations, highlighting both the strengths and limitations observed during testing. Figure 5 shows Location Tracking

Figure 5 **Location Tracking**

Conclusion

The IoT-based Bus Tracking System presents an effective and intelligent solution to some of the major challenges faced in today's public transportation networks—particularly the need for real-time location tracking and improved driver safety. This system leverages essential hardware components such as the ESP32 microcontroller, NEO-6M GPS module, MQ-3 alcohol sensor, and an I2C LCD display to create a reliable and multifunctional platform. It not only monitors the movement of buses but also incorporates an alcohol detection mechanism to verify driver sobriety prior to engine ignition, thereby enhancing passenger safety and reducing risks associated with impaired driving. A standout feature of the system is its precise GPS tracking functionality. With the NEO-6M module, accurate and consistent location data is obtained with very low margin of error, enabling real-time visibility of bus locations. Data is transmitted and stored using Firebase, a cloud-based platform that allows users to access real-time updates on any internet-enabled device. The use of cloud infrastructure also facilitates easy scalability, allowing the system to be expanded across multiple buses or integrated into large-scale

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transportation networks with minimal configuration. Additionally, the alcohol detection system plays a crucial role in ensuring the safety of the bus passengers. The MQ-3 alcohol sensor was calibrated and tested successfully, triggering the system to alert when alcohol levels exceed the safe limit. This feature effectively minimizes the risks associated with impaired driving, providing an extra layer of safety for passengers. The system's design also includes user-friendly interfaces, both on the mobile app and the web dashboard, making it easy for passengers to track buses and receive alerts. The integration of the system with both mobile and cloud-based platforms significantly improves its accessibility, offering passengers convenience and control over their commute. However, despite the system's successful implementation, certain limitations were observed, such as occasional GPS signal loss in urban areas with tall buildings and potential false positives from the alcohol sensor in specific environmental conditions. The system's power consumption, particularly during continuous operation, is another challenge that needs addressing. Overall, the IoT-based Bus Tracker System fulfills its intended purpose of providing a reliable tracking solution and driver safety monitoring. It can be further enhanced to improve its performance and scalability, making it a suitable solution for broader applications in the transportation sector.

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Ms. Para Keerti is Graduated from Bharat institute of Engineering and Technology, Ibrahimpatnam, Hyderabad, Telangana in the year 2019, M Tech From Vardhaman College of Engineering, Hyderabad in the year 2022. She is presently working as Asst. Professor in the Department of Electrical and Electronics Engineering, Lords Institute of Engineering and Tech. Himayathsagar, Hyderabad, India. Her research areas include Electrical vehicles and Renewable Energy Sources.

Ms , kandela Ruchitha is Graduated from TSWRDC(W), Kamareddy, Telangana in the year 2021, P.G (M.Sc) From Sri Sai degree and PG College, Hyderabad in the year 2023. She is presently working as Asst. Professor in the Department of Physics, Methodist College of Engineering and Tech. Abids, Hyderabad, India. Her research areas include Semi Conductors, Fiber and Laser optics

Mr. R. Venkata Krishna Graduated from Sree Kavitha Engineering College, Khammam, Andhra Pradesh in the year 2007, .M.Tech from Mahaveer institute of science & technology, Hyderabad in the year 2009. He is presently working as Assoc.Professor in the Department of Electrical and Electronics Engineering, Lords Institute of Engineering and Tech. Himayathsagar, Hyderabad, India. His research areas include Electrical Power Systems and Energy Systems.

Ms. Nazreen Tabassum is Pursuing B.E of EEE stream at Lords Institute of Engineering and Technology, Himayathsagar, Hyderabad, Telangana, India. His interested areas includes Robotics, Artificial Intelligence etc

Mr. Abdul Faraz is Pursuing B.E of EEE stream at Lords Institute of Engineering and Technology, Himayathsagar, Hyderabad, Telangana, India. His interested areas includes Robotics, Artificial Intelligence etc

Mr. Md Mazhar is Pursuing B.E of EEE stream at Lords Institute of Engineering and Technology, Himayathsagar, Hyderabad, Telangana, India. His interested areas includes Robotics, Artificial Intelligence etc