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Real-Time Bus Tracking for Smarter Transit

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ABSTRACT

Public transport networks tend to be plagued by uncertainty, causing lengthy wait times and passenger irritation. This project seeks to increase urban mobility by offering a real-time bus tracking system that provides precise Estimated Time of Arrival (ETA) estimates. Utilizing GPS technology, cloud computing, and IoT connectivity, the platform fills gaps in public transit visibility, enhancing efficiency and user satisfaction. The solution allows commuters to monitor buses using a web portal, providing assured and accessible real-time information. The solution improves public transport management, minimizing delay and increasing ease of use for regular commuters.

Keywords: *GPS tracking, IoT, cloud infrastructure, real-time bus tracking, public transportation efficiency..*

I. INTRODUCTION

Inefficiencies in public transport commonly lead to inconsistent bus timetables and frustrated commuters. The project tackles this by using real-time tracking, GPS, cloud computing, and IoT connectivity to make precise Estimated Time of Arrival (ETA) predictions. With a web-based system, commuters are able to see real-time updates of the bus's location, enabling them to plan journeys more effectively and save time. The system processes real-time user location information and live vehicle coordinates in a dynamic manner, responding to traffic conditions for accurate ETA calculations. Moreover, this project increases safety and reliability as it is equipped with ongoing vehicle tracking and sophisticated monitoring systems to avoid delays and unforeseen breakdowns. By combining state-of-the-art technology with public transportation, this project maximizes urban mobility, making public transport more accessible, efficient, and user-friendly.

II. LITERATURE REVIEW

The integration of Internet of Things (IoT) technology into public transportation systems has led to significant advancements in bus tracking solutions. One notable study by Murizah Kassim et al. (2022) presents an IoT-based bus tracking system that utilizes Global Positioning System (GPS) and Radio Frequency Identification (RFID) technologies. This innovative system provides real-time bus location updates, aiming to reduce passenger wait times significantly. By employing a mobile application interface, users receive alerts about bus arrival times and notifications regarding unauthorized route deviations. The GPS modules facilitate precise tracking of bus locations, while RFID tags are employed for bus identification and to provide information on seat availability. The Blynk app platform enhances user experience by allowing passengers to monitor bus locations, count onboard passengers, and receive timely notifications, thereby creating a more efficient and user- friendly public transit experience[1]

Another innovative approach is presented in the "Wander-Mate" application developed by Regish Nedumanni George et al. (2021). This GPS-based application addresses common challenges faced by public transport users, such as navigating unfamiliar areas and accessing information about intermediate stops. Key features of the application include offline bus service searches, a map-based view of nearby bus stops, and a location alarm that alerts users as they approach their destination. These functionalities are particularly beneficial for travelers during odd hours or in new locations, ultimately enhancing the overall journey experience[2]

Sharmin Akter et al. (2019) present a comprehensive cloud-based bus tracking system that harnesses the power of Internet of Things (IoT) technology to significantly enhance the efficiency of public transportation services. This innovative system empowers users to monitor bus locations in real time through a dedicated mobile application, which not only allows passengers to track buses but also facilitates online ticket purchases and seat selections. By minimizing the need for physical queuing, the system streamlines the boarding process, thereby improving the overall travel experience for passengers. The integration of these features addresses common pain points associated with public transport, such as uncertainty regarding bus arrival times and the inconvenience of long wait periods. The proposed system stands out by promoting sustainability within public transport networks. By providing reliable real-time tracking information, it encourages more individuals to utilize bus services, which can lead to reduced traffic congestion and lower carbon emissions. Enhanced reliability and user experience are crucial factors that contribute to increased ridership; as passengers gain confidence in the system's efficiency, they are more likely to choose buses over other forms of transportation. This shift not only benefits individual commuters but also supports broader environmental goals by fostering a more sustainable urban transport ecosystem[3]

Lastly, a study by Shubham Jain et al. (2019) focuses on enhancing the accuracy of school bus tracking systems through the implementation of a Kalman filter for precise location estimation. This GPS-based system collects real-time location data via satellite and processes it using Google Maps API to provide live updates on bus positions through both an Android app and a web interface. Such innovations are crucial for improving the safety and efficiency of school transportation systems, ensuring that parents can track their children's whereabouts effectively[4]

III. EXISTING SYSTEM

Current bus tracking solutions offer minimal location updates but with limited accuracy and efficiency. They tend to have poor or lagging real-time tracking, and therefore, offer inaccurate Estimated Time of Arrival (ETA) estimations. Most of these websites use outdated GPS tracking technology and are poorly integrated with user location data, limiting their ability to deliver accurate transit updates.

IV. PROPOSED SYSTEM

The proposed system, is a real-time platform that leverages GPS, IoT, and cloud computing to enhance public transportation efficiency. This project integrates various components, including GPS modules, ESP8266 for data transmission, cloud-based storage, and a web-based interface for real-time bus tracking. The system continuously collects location data from public transport vehicles, processes and predicts accurate Estimated Time of Arrival (ETA) based on traffic patterns and user location. The collected data is stored in the cloud, ensuring seamless

access and updates. By utilizing real-time monitoring and IoT connectivity e-Chakra not only minimizes wait times but also improves commuter convenience and transport reliability.

V. HARDWARE IMPLEMENTATION

The proposed effort aims to continuously monitor the bus location and user location to update the ETA's accordingly. The Fig 5.1 represents a system architecture centered around a Node.js server interfacing with various components. The Node.js server serves as the central unit, managing all incoming data from users and vehicles. On the left side, MongoDB is connected to the server to store user profiles and vehicle locations, allowing for efficient data retrieval and updates. A RESTful API is also implemented for enabling seamless communication between the frontend and backend. Additionally, GPS modules integrated into public transport vehicles transmit location data to the server for real-time tracking. Power to the system is managed through cloud services, ensuring that the application can scale according to user demand. On the right side, an ESP8266 module facilitates Wi-Fi connectivity for data transmission and a mapping API is used for visualizing vehicle locations on user devices.

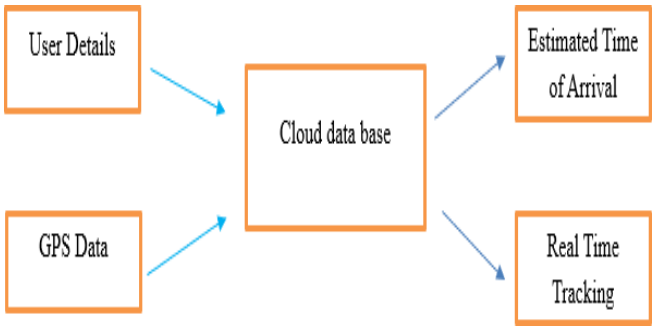

Fig 5.1 Block Diagram

VI. HARDWARE COMPONENTS USED

6.1 ESP 8266

The ESP8266 is a highly integrated Wi-Fi microcontroller. Operating at a voltage of 3.3V, it is designed to connect to Wi-Fi networks, enabling devices to communicate wirelessly. The ESP8266 features 17 GPIO pins, which can be used for various input/output functions, including PWM, I2C, and SPI communication. This microcontroller supports a variety of protocols, making it suitable for connecting different types of devices over the network.

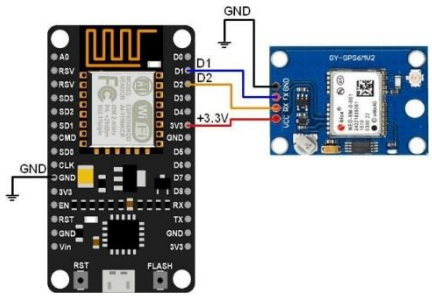

Fig 6.1 ESP 8266

6.2 GPS Neo 6m

The NEO-6M GPS module is a compact and efficient GPS receiver which features high sensitivity of -161 dBm

for tracking signals. The module can track up to 22 satellites across 50 channels simultaneously and offers a navigation update rate of 5 Hz, with a horizontal accuracy of about 2.5 meters under optimal conditions. This is used to track the buses in real time whose data then gets stored in database.

Fig 6.2 GPS Module

VII. SOFTWARE COMPONENTS USED

The web interface was built using HTML,CSS and JAVASCRIPT. It was hosted on RENDER to make the platform available to anyone who wants to access it throughout the globe. The GPS was coded through Arduino IDE to track the location of buses. The location of users were obtained from their mobile phone's in-built GPS's. The Backend server was created through Node.js and the database required to store the locations of buses and users was done on MONGODB.

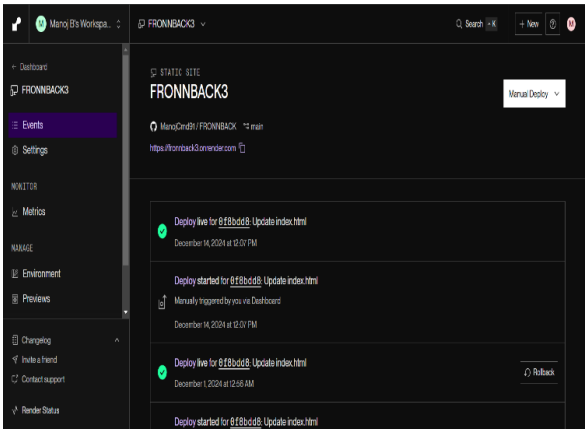

Fig 7.1 Server deployment using RENDER

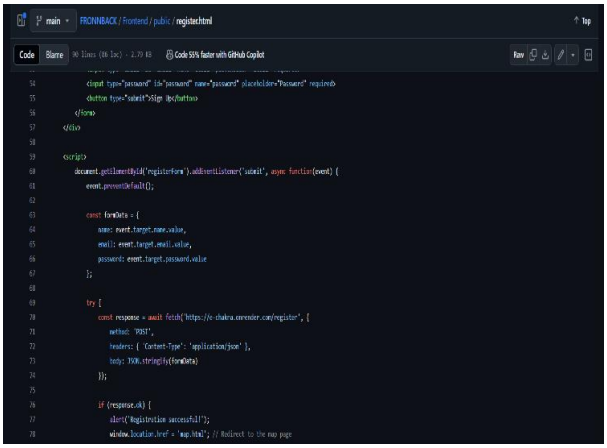

Fig 7.2 Front-End implementation using HTML, CSS and Javascript

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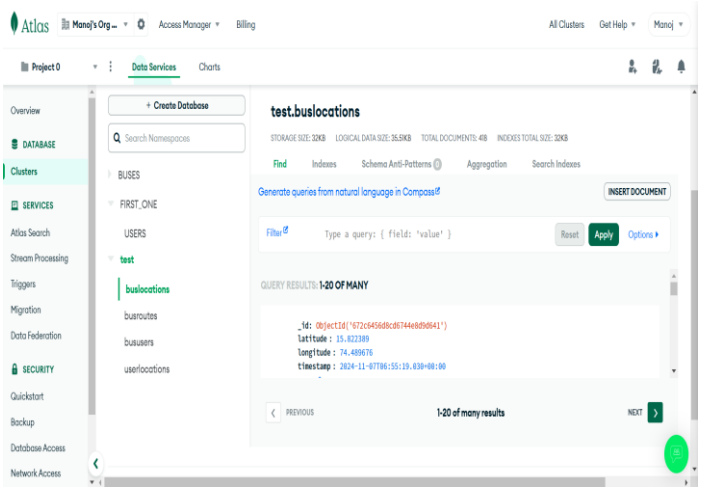
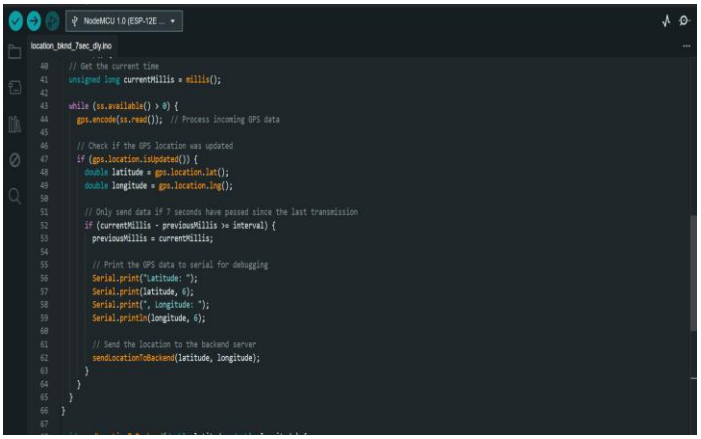


Fig 7.3 MongoDB database to store user credentials and bus locations



```
// Get the current time
unsigned long currentMillis = millis();

while (ss.available() > 0) {
  gps.encode(ss.read()); // Process incoming GPS data

  // Check if the GPS location was updated
  if (gps.location.isUpdated()) {
    double latitude = gps.location.lat();
    double longitude = gps.location.lng();

    // Only send data if 7 seconds have passed since the last transmission
    if (currentMillis - previousMillis >= interval) {
      previousMillis = currentMillis;

      // Print the GPS data to serial for debugging
      Serial.print("Latitude: ");
      Serial.print(latitude, 6);
      Serial.print(", Longitude: ");
      Serial.println(longitude, 6);

      // Send the location to the backend server
      sendLocationToBackend(latitude, longitude);
    }
  }
}
```

Fig 7.4 GPS & ESP 8266 programming using Arduino IDE

VIII. RESULTS AND DISCUSSION

When a user registers on the platform, they provide essential details such as their location, name, mobile number, email, and destination they are at. This information is then processed and stored in a cloud database using Node.js and MongoDB. The integration of these technologies allows for efficient data management and retrieval, facilitating seamless communication between the user's device and the transport system.

In the operational framework, public transport vehicles continuously transmit their GPS coordinates via an ESP8266 module to the cloud. This data is analyzed to compute the ETA based on various HAVERSINE formula. Users can track their vehicle's location in real-time on an interactive map interface, enhancing their overall travel experience. By leveraging modern web technologies and real- time data analytics, this project aims to improve the efficiency of public transportation while providing users with a sense of control over their travel plans.

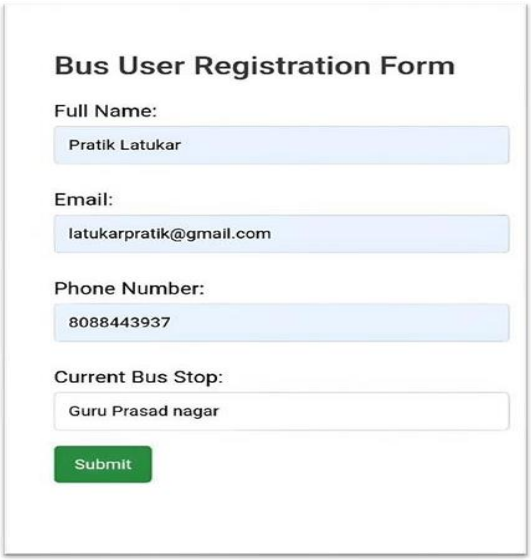


Fig 8.1 User Interface

The implementation of this project also emphasizes safety and reliability through its fault detection mechanisms. By monitoring critical components such as GPS accuracy and data transmission integrity, the system can proactively identify potential issues before they affect service. This includes monitoring for connectivity failures or discrepancies in vehicle location data. In case of detected faults, the system can initiate alerts to both users and operators, ensuring that any disruptions are addressed promptly.

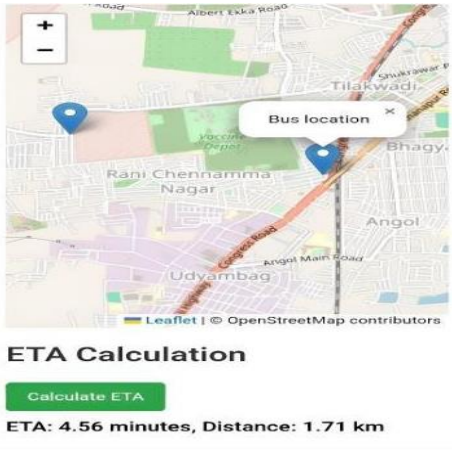


Fig 8.2 Map Integration

IX. CONCLUSION

In conclusion, this project presents an innovative solution to the challenges faced by public transport users, particularly in urban environments. By utilizing a web-based platform that combines real-time GPS data and user location inputs, it ensures that commuters receive accurate Estimated Time of Arrival (ETA) predictions for their vehicles. The integration of advanced technologies, such as Node.js for backend processing and MongoDB for data storage, allows for efficient handling of user information and vehicle tracking. Furthermore, the system's capability to provide live updates on vehicle locations enhances user experience by enabling seamless tracking through mapping services. Overall, this project not only addresses the need for reliable public transport ETA

information but also promotes the adoption of smart transportation solutions, thereby contributing to improved urban mobility and user satisfaction.

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