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Real-Time Public Transport Tracking for Small Cities

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Abstract: Public transport systems in small cities face problems due to the unavailability of real-time tracking and communicating systems. This paper proposes a real-time public transport tracking system that utilizes GPS technology and a cloud backend for real-time bus tracking and alerting. The proposed system is implemented as a cross-platform mobile application for passengers, administrators, and drivers. The proposed system is efficient in terms of time and cost. The proposed system is implemented and tested, and the results show that it is accurate and efficient in terms of time. The proposed system is cost-effective for small cities.

Keywords: Real Time Tracking, GPS, Public Transport, Flutter, Firebase, Smart Transportation, Mobile Application

I. INTRODUCTION

1.1 Synopsis
Real-time transport tracking systems are significant for the efficient management of public transport. The proposed system helps in the efficient management of public transport by allowing the live tracking of buses through the use of GPS. The system allows the user to get information through a mobile app.

1.2 Importance of Real-Time Tracking
Generally, the absence of real-time information results in uncertainty. The proposed system helps in reducing the time taken for travel. The proposed system helps in the efficient management of transport.

1.3 Challenges in Public Transport Systems
While designing a real-time tracking system, there are certain challenges that need to be considered. The challenges are as follows:

- GPS accuracy problems
- Network delays
- Information synchronization
- Scalability of the system for a number of users

1.4 Objectives
The objectives of the proposed system are as follows:

- Development of a real-time bus tracking system
- Development of accurate time prediction for buses
- Role-based access to the system
- Development of a user-friendly system

II. LITERATURE REVIEW

Insights into the existing research and technologies in real-time tracking systems can be derived from the literature review section.

[1] The studies related to real-time transit systems indicate that real-time information can reduce the perceived waiting time and enhance commuter satisfaction.
[2] GPS tracking systems make use of mobile applications to ensure accurate tracking and estimation of time of arrival, which is convenient for the user.
[3] Web-based transport systems make use of cloud computing to ensure scalability and real-time data synchronization.

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[4] IoT tracking systems make use of sensors and cloud computing to ensure accurate tracking and data analysis.

[5] Advanced tracking systems make use of crowd monitoring and predictive technologies to enhance transport management and planning.
[6] Some tracking systems make use of machine learning to predict and enhance transport management and planning.

[7] Hybrid tracking systems make use of mobile applications and cloud computing to ensure accurate tracking and data management.

Summary:
Existing research has improved the accuracy of tracking and user experience, but most of the tracking systems are implemented in large cities and incur infrastructure costs.

III. EXISTING SOLUTION

3.1 Traditional Transport Systems

Traditional transport systems generally operate based on fixed schedules, where timings are predefined and followed manually. These systems rely heavily on manual updates and lack dynamic adjustments based on real-time conditions. As a result, they are often unreliable and inefficient, especially in situations involving traffic congestion, delays, or unexpected route changes. Passengers are unable to access real-time information, which leads to uncertainty and increased waiting time.

3.2 Existing Tracking Systems

Existing transport tracking systems have evolved with the advancement of technology and include GPS-based, web-based, and IoT-based solutions. GPS-based systems use satellite data to track the real-time location of vehicles and provide location updates to users. Web-based systems allow users to access transport information through online platforms, making it easier to monitor schedules and routes. IoT-based systems integrate sensors and connected devices to collect and transmit data, enabling more advanced tracking and monitoring capabilities. These systems have improved the overall efficiency of transport management compared to traditional methods.

3.3 Limitations

Despite the advancements in existing tracking systems, several limitations still exist. Many systems lack consistent real-time updates due to network or system constraints. The infrastructure cost required to implement and maintain these systems can be high, making them less suitable for small cities. Scalability is another concern, as some systems struggle to handle a large number of users efficiently. Additionally, user interaction is often limited due to complex or non-intuitive interfaces. There are also challenges related to the accuracy of arrival time predictions, and in some cases, data management still involves manual intervention, which reduces overall system efficiency.

IV. PROPOSED SYSTEM

4.1 System Overview

The proposed system is a mobile-based application designed to provide real-time bus tracking and notification services. It enables passengers to monitor the live location of buses, receive estimated arrival times, and get timely alerts regarding delays or route changes. The system is developed to improve the efficiency, reliability, and user experience of public transportation in small cities.

4.2 Methodology

The methodology of the proposed system consists of multiple stages, including data collection, data processing, notification handling, and user interaction. In the data collection phase, GPS data is continuously collected from bus drivers using mobile devices. This location data is transmitted to the backend server in real time and stored in a cloud-based real-time database.

In the data processing phase, the system calculates the estimated time of arrival (ETA) of buses based on distance and speed. The processed data is then synchronized across all users to ensure that passengers receive up-to-date information. The notification system is responsible for sending push notifications to users regarding bus arrivals, delays, and route changes. This feature enhances communication between the system and users, ensuring timely updates.
The user interaction module allows passengers to search for buses based on routes, view live bus locations on a map interface, and receive real-time alerts. This makes the system user-friendly and accessible for daily commuters.

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4.3 System Architecture

The system architecture consists of a frontend, backend, database, and communication layer. The frontend is developed as a mobile application using Flutter, providing a responsive and interactive user interface. The backend is implemented using Firebase cloud services, which handle authentication, data storage, and real-time synchronization. The system uses a real-time database to store and manage location data efficiently. Communication between different components is achieved through API-based data exchange, ensuring seamless integration and fast data transfer.

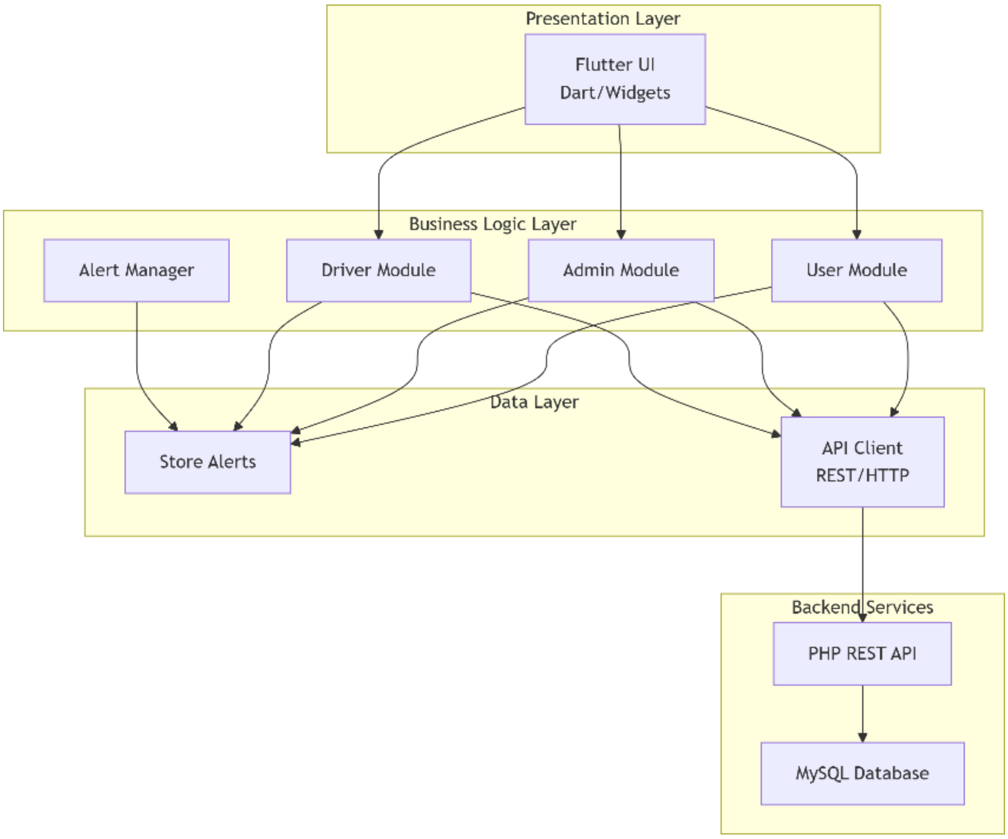

Fig. 1 System Architecture

4.4 System Modules

The proposed system is divided into three main modules: user module, driver module, and admin module. The user module allows passengers to register and log in to the application, search for buses, track their real-time location, receive notification alerts, and manage their profiles.

The driver module provides secure login access for drivers and enables them to send continuous GPS-based location updates to the system. It also allows drivers to access route-related information.

The admin module is responsible for managing the overall system. It allows administrators to add and manage buses, update routes and schedules, and monitor system performance. This module ensures smooth operation and maintenance of the transport tracking system.

V. RESULTS AND DISCUSSIONS

5.1 Test Configuration

The system was tested under multiple configurations to evaluate its performance and reliability. The testing involved scenarios with multiple users accessing the system simultaneously to analyze scalability. Additionally, the system was tested under varying network conditions, including high-speed and low-speed connections, to observe its behaviour in real-world environments. Different GPS conditions were also considered, such as urban areas with signal obstruction and open areas with strong signal reception.

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5.2 Performance Analysis

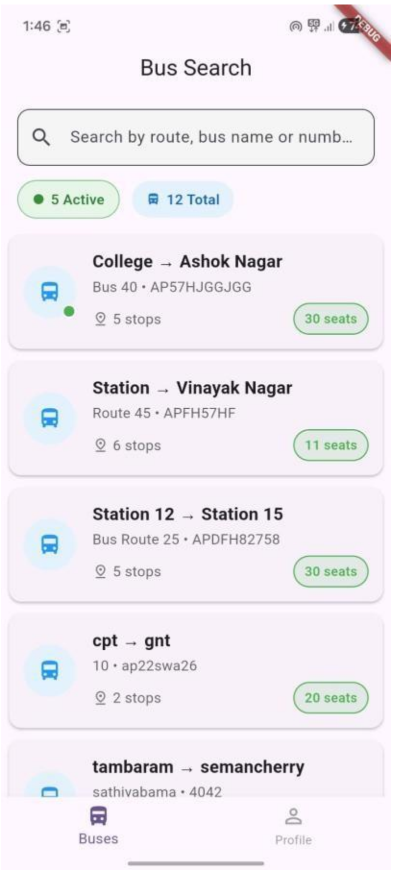
The performance of the system was analyzed based on several key factors. The system was able to provide real-time updates with minimal delay, ensuring that users received accurate and timely information. It effectively handled multiple users without performance degradation, demonstrating good scalability. Furthermore, synchronization between devices was smooth, allowing consistent data updates across all users in real time.

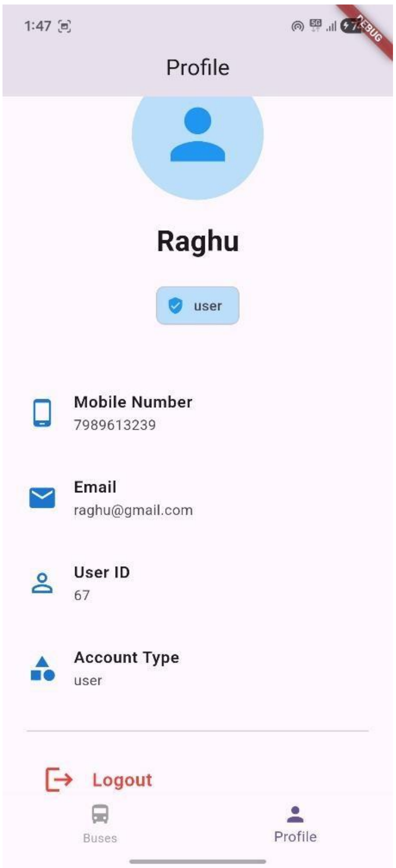
5.3 Accuracy

The accuracy of the system was evaluated in terms of location tracking and estimated time of arrival (ETA) predictions. The system demonstrated high accuracy in tracking the real-time location of buses using GPS data. The ETA predictions were reasonably accurate under normal conditions, providing useful information to passengers. Additionally, the system ensured regular updates, which contributed to maintaining reliable and up-to-date information.

5.4 User Experience

The user experience was assessed based on usability and overall satisfaction. The system helped in minimizing the waiting time for passengers by providing real-time updates. It enabled effective travel planning by allowing users to track buses and estimate arrival times. The user interface was designed to be simple and intuitive, making it easy to use. Notification features were also effective in keeping users informed about important updates such as delays and route changes.





5.5 Challenges

During the operation of the system, several challenges were identified. The system heavily depends on network connectivity, and performance may be affected in areas with poor internet access. GPS instability in certain environments, such as densely built urban areas, can impact location accuracy. Additionally, latency issues may occur in low- connectivity zones, causing slight delays in updating information.

5.6 Improvements

Based on the observed challenges, several improvements were made to enhance system performance. Data synchronization was optimized to reduce delays and improve consistency across users. The user interface and user

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experience were enhanced to make the application more intuitive and responsive. Backend performance was also improved to handle larger user loads and ensure smoother operation of the system.

VI. CONCLUSION AND FUTURE WORK

The proposed system is successful in improving the efficiency of public transport. The system is efficient in reducing uncertainty and improving communication. The system is also cost-effective and suitable for small cities.

Future Enhancements

- Online ticket booking integration
- AI-based traffic prediction
- Route optimization algorithms
- Multi-city deployment
- Integration with smart city systems

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