

## Smart College Bus Tracker: Real-Time Location and ETA Predictor

MS. M. SOWNDHARYA\*, YUVARAJ K\*\*, RAHUL S\*\* SRICHANDIRAN S\*\*, SRIRAM S\*\*

\*(Assistant Professor, Department of Computer Science and Engineering,  
Arunai Engineering College. Mail ID: [sowndharyamadhivanan@gmail.com](mailto:sowndharyamadhivanan@gmail.com))

\*\* (Department of Computer Science & Engineering, Arunai Engineering College.  
Mail ID: [yuvarakumaravelu@gmail.com](mailto:yuvarakumaravelu@gmail.com), [gomathiseenu69548@gmail.com](mailto:gomathiseenu69548@gmail.com),  
[srijain30@gmail.com](mailto:srijain30@gmail.com), [sriram01400@gmail.com](mailto:sriram01400@gmail.com))

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### Abstract:

The increasing reliance on institutional transportation systems necessitates innovative digital solutions to address communication inefficiencies, punctuality issues, and safety concerns. This paper introduces the Smart College Bus Tracker, a real-time mobile application designed to enhance the student commuting experience by providing accurate updates on bus locations and Estimated Time of Arrival (ETA). Utilizing GPS technology and the Google Maps API, the application tracks college buses in real-time and dynamically adjusts arrival times based on speed, distance, and traffic conditions. Developed using the Flutter framework, it supports Android and iOS platforms, ensuring wide accessibility. The app includes separate login modules for drivers and students, offering role-specific functionalities like route configuration, live location updates, and bus selection. Firebase is employed for secure authentication and real-time data synchronization. The solution aims to reduce student wait times, eliminate uncertainty in bus arrival, and enhance overall transportation experiences on college campuses. Its modular architecture supports easy scalability and future integration with advanced technologies such as machine learning for predictive analytics and RFID for student attendance tracking. Initial testing in a controlled campus setting has shown high reliability and user satisfaction, indicating significant potential for adoption across educational institutions.

**Keywords — Real-Time Tracking, ETA Estimation, Flutter, Google Maps API, Mobile Application, GPS, College Transportation.**

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### I. INTRODUCTION

Transportation within college campuses often faces challenges such as inefficient communication and unpredictable delays, which negatively impact the commuting experience for students. A common problem is the uncertainty surrounding the exact location and arrival time of college buses, frequently resulting in missed rides or prolonged waiting periods [1]. To address these concerns, this project presents a smart, real-time bus tracking solution designed using modern technologies

including Flutter and the Google Maps API. The application aims to enhance convenience and efficiency by providing students with accurate bus location updates and Estimated Time of Arrival (ETA). It leverages GPS data to track the live location of buses and dynamically adjusts arrival times based on traffic and distance, offering a responsive and user-friendly experience [2] . With dedicated login modules for both drivers and students, the system ensures role-specific access and functionality. Developed to run on both Android and iOS platforms, the application ensures

broad accessibility. Firebase is used for secure authentication and real-time data synchronization. By integrating these technologies, the solution reduces uncertainty and wait times, thereby improving transportation reliability within college campuses. This approach offers a scalable model that can be adapted by educational institutions globally.

## **II. RELATED WORK**

Several bus tracking systems have been proposed for urban environments and school transportation. Applications like Where's My Bus and Moovit focus on public transport. However, they lack customization for institutional routes and user-specific access. Our approach specifically addresses the needs of a college ecosystem, with dual roles (driver-student), and secure, route-based configuration.

Numerous studies have explored smart transportation systems aimed at improving efficiency and safety in institutional commuting. [3] proposed a GPS-based college bus tracking system that enhanced student awareness of bus locations, reducing wait times and missed rides. Patel and [4] developed a real-time tracking application using GPS and Google Maps, highlighting the value of dynamic ETA updates in managing urban transportation. [5] examined the integration of mobile technologies in public transit systems, concluding that real-time data significantly improved commuter satisfaction and reduced operational inefficiencies. Similarly, [6] emphasized the importance of user interface design in real-time tracking apps, noting that clear route visibility and notifications boosted user engagement. Singh and Kaur (2022) explored the scalability of such systems using cloud-based platforms like Firebase for real-time synchronization and secure authentication. Moreover, [7] demonstrated how mobile-based tracking solutions could be tailored for educational institutions, offering separate modules for students and drivers to enhance system usability. These studies collectively underscore the effectiveness of combining GPS, mobile applications, and cloud technologies to develop

robust, user-centric transportation systems, laying the foundation for the Smart College Bus Tracker.

## **III.SYSTEM ARCHITECTURE**

The Smart College Bus Tracker application is designed using a modular architecture that ensures scalability, efficiency, and ease of maintenance. The frontend is developed using the Flutter framework, enabling seamless cross-platform compatibility for both Android and iOS devices. This ensures broader accessibility and a consistent user experience across platforms. The backend is powered by Firebase, which handles secure user authentication and supports real-time database operations. This allows instantaneous updates of location data and other user interactions within the app. For map integration, the application utilizes the Google Maps SDK, which provides accurate live location tracking of college buses. It also enables the visualization of routes and calculation of distances. The system supports distinct user roles, with dedicated dashboards for drivers and students. Drivers can share their real-time location, while students can view bus routes, select their bus, and monitor Estimated Time of Arrival (ETA).

The ETA is dynamically calculated using real-time GPS coordinates and vehicle speed, employing the Haversine formula to estimate distances between geographic points. This method ensures accurate predictions by accounting for Earth's curvature. Overall, the modular design of the app promotes easy future upgrades and integration with additional features like predictive analytics or RFID-based attendance tracking.

## **IV.FEATURES**

The Smart College Bus Tracker offers key features to enhance campus transportation through real-time technology. Live bus tracking enables students to visualize bus locations on a map, while dynamic ETA displays provide accurate arrival times for each stop [4]. The driver panel allows for starting or stopping trips, setting up routes, and broadcasting live updates. Students can select their bus, view its current location, and check the next stop. Push notifications inform users of delays or arrivals, ensuring timely communication. Secure login is

enabled via Firebase authentication, safeguarding user access and data [8].

## V. IMPLEMENTATION

The Smart College Bus Tracker is developed using Flutter, chosen for its widget-based architecture and reactive UI, which enable smooth and responsive cross-platform performance [9]. The driver's mobile device transmits GPS coordinates at regular intervals, allowing students to access live bus locations through Firebase's real-time synchronization features. This ensures minimal delay and accurate data exchange between users. Additionally, the app integrates the Google Maps API to render interactive maps and accurately represent geolocation data, enhancing user experience with clear visual tracking and route visualisation [10]

## VI. TECH STACK

<b>Student/Driver</b> (Mobile App - Flutter)   (Login)
<b>Firebase Authentication</b> (Email/Google SSO)   (Auth Success)
<b>Firestore Database</b> ✓ Bus Locations ✓ Routes/Schedules
<b>User Permissions</b>   (Fetch Real-Time Data)
<b>Google Maps API</b> ✓ Live Bus Tracking ✓ Route Optimisation ✓ ETA Calculation   (Display Data)
<b>Flutter UI</b> ✓ Map with Bus ✓ ETA Notifications ✓ Alerts

- Flutter
- Firebase Authentication & Firestore
- Google Maps API
- Dart Language

## VII. RESULTS

The Smart College Bus Tracker was tested within Arunai Engineering College, where it demonstrated effective real-time tracking with an average location refresh interval of three seconds. The system's ETA estimations remained consistent, maintaining a margin of error within  $\pm 1$  minute, which ensured reliable commute planning. User testing conducted with both students and drivers revealed a satisfaction rate of 92%, indicating strong usability and positive reception of the app's features and performance. These results suggest the system is well-suited for broader implementation in similar educational environments.

## VIII. CONCLUSION

The Smart College Bus Tracker effectively combines real-time tracking, dynamic ETA prediction, and role-based access to deliver an efficient and user-centric transportation solution for college campuses [11]. By leveraging technologies like GPS, Firebase, and Google Maps API, the system enhances both transparency and reliability in student commuting. Future enhancements include the incorporation of AI-based route optimisation to reduce travel time and improve scheduling, as well as RFID integration for automated student check-in and attendance tracking [12], [13]. These advancements aim to further streamline campus mobility and expand the system's functional capabilities

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