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# Real-Time Transportation Tracking: A GPS Enabled Mobile Application Framework

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**Abstract**: The increasing reliance on mobile technologies and rapid adoption of IoT has opened new avenues for modernizing real-time monitoring and management of transportation systems. This paper addresses the long-standing challenges of uncertainty, safety, and communication among the users of transportation in educational institutions. The proposed framework is an IoT system integrating GPS devices mounted on college buses with tracking server and mobile application, enabling seamless communication between devices and end-users. Developed on Android™ platform in Kotlin and enhanced through Google Map APIs, the mobile application collects location data from the GPS device and communicates it to the application on request, enabling students, staff, parents, administrators, and emergency personnel to monitor bus movement in real time. Key features include live location visualization, estimated time of arrival, bus and driver information, and system security through user authentication and authorization. System evaluation demonstrates accuracy in tracking, reliability of updates, and usability across diverse network conditions. By combining open-source IoT tracking platforms with modern mobile technologies, the system contributes to the broader domain of smart campus solutions, providing a scalable and practical approach to intelligent transportation.

**Keywords:** Google Map, GPS, IoT, Kotlin, Mobile Application, Tracking, Transportation

## I. INTRODUCTION

Efficient and reliable transportation plays a critical role in the smooth functioning of educational institutions. Due to high traffic, unpredictable road and weather conditions, commuters (students and staff) face uncertainty regarding bus arrivals, delays, or route deviations, leading to inconvenience and safety concerns. Traditional transport management methods are often manual and reactive, lacking real-time visibility and proactive communication. With the rapid growth of mobile internet and GPS-enabled devices, Internet of Things (IoT) technologies offer an opportunity to transform conventional college transport systems into intelligent, real-time solutions.

This paper presents the design and implementation of a GPS-enabled mobile application framework for real-time college bus tracking, developed using Kotlin and integrated with Google Maps APIs. The framework is implemented as a Level-3 IoT system, where GPS-equipped buses act as IoT nodes, a centralized tracking server manages the data, and a mobile application serves as the user interface. The system is designed for a diverse set of users, including students and staff who rely on timely transport, guardians seeking assurance about their wards' safety, transport managers responsible for operations, and emergency personnel such as police, fire, or ambulance services who may need quick access to bus locations in critical situations.

The motivation for developing this system lies in bridging the gap between open-source IoT tracking platforms and the specific requirements of academic institutions. A survey on Real-Time College Transport Tracking Solutions is the base paper for the current research paper [1]. By ensuring transparency, reducing waiting times, and improving safety awareness, the framework enhances the daily commuting experience while also providing a scalable model for broader smart campus initiatives. This paper discusses the requirements, architecture, implementation, testing, and validation of the proposed system, highlighting its applications, challenges, and contributions to IoT-enabled intelligent transportation.

## II. SYSTEM REQUIREMENTS, ARCHITECTURE AND DESIGN

The proposed transportation tracking framework was envisaged to address the diverse needs of multiple stakeholders of any educational system, including students, staff, guardians, transport managers, and emergency personnel such as police, fire brigade, and healthcare providers.

  

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A. System Requirements

User groups of the system are essentially the aforesaid stakeholders. Each user group interacts with the system in different ways. Students and staff primarily rely on the application to obtain real-time bus location updates and estimated time of arrival (ETA) information to plan their commutes more efficiently. Guardians seek assurance of their wards' safety by being able to track the bus during transit. Transport managers require administrative access to permit intended students and staff to respective routes and allocate buses and drivers to those routes. In critical scenarios, emergency personnel benefit from authorized access to the live location of buses, thereby enabling rapid response during accidents or medical emergencies.

To meet these needs, the framework incorporates both functional and non-functional requirements. The functional requirements include GPS-based location acquisition, real-time visualization on Google Maps, ETA prediction, role-based access to information, and allocation of commuters, buses and drivers to routes. The non-functional requirements emphasize scalability, responsiveness under varying network conditions, accuracy of tracking, and a simple yet intuitive user interface to cater to a wide demographic of users. These requirements have been captured effectively through use cases as mentioned in Table I.

TABLE I USER GROUPS & USE CASES

| Requirement Number | User Group | Use Case |
|---|---|---|
| SW_1.1 | Students and Staff | Register / Login / Logout |
| SW_1.2 | | Track Bus Location |
| SW_1.3 | | View Estimated Time of Arrival |
| SW_1.4 | | View Bus Details & Driver Details |
| SW_2.1 | Guardians | Register / Login / Logout |
| SW_2.2 | | Track Ward Bus Location |
| SW_2.3 | | View Ward Bus & Driver Details |
| SW_3.1 | Admin (Transport Manager) | Register / Login / Logout |
| SW_3.2 | | Allocate Students to Routes |
| SW_3.3 | | Allocate Drivers & Buses to Routes |
| SW_4.1 | Emergency Personnel (Police, RTO, Fire Brigade, Ambulance, Hospital) | Register / Login / Logout |
| SW_4.2 | | Track Bus Location |
| SW_4.3 | | View Bus Details & Driver Details |

B. System Architecture

The overall system follows client-server architecture and Level-3 IoT deployment model. In this architecture, GPS-enabled buses act as edge nodes that continuously collect and transmit location data. This data is relayed to a central tracking server, which manages storage, processing, and exposes application programming interfaces (APIs) for downstream applications. The mobile application, developed in Kotlin and integrated with Google Maps APIs, functions as the primary interface between end-users and the system. Through this architecture, location updates are transmitted seamlessly from the buses to the server and then to the mobile application, ensuring that users receive timely and accurate information. The high-level architecture diagram given in Fig. 1, captures the interaction between these layers and illustrates the flow of data across components.

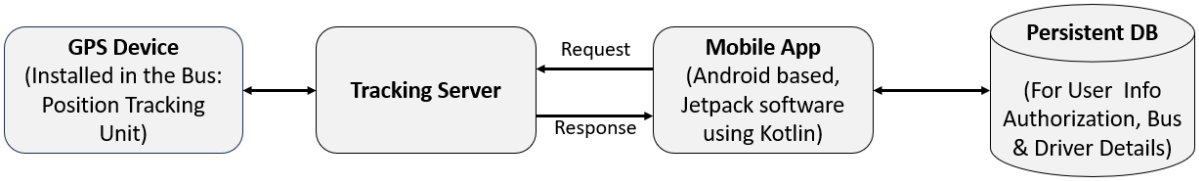


Fig. 1 System Architecture

C. Software Design

The design of the mobile application adopts an object-oriented approach, in line with standard AndroidTM development practices. Core design elements include user classes that define attributes such as login credentials and role-based permissions; bus classes that encapsulate details like route, driver information, and real-time location; and service classes that manage communication with the server to fetch GPS updates. Additionally, a map view class integrates with the Google Maps API to provide real-time visualization of bus routes and locations, while a notification manager handles

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alerts, ETAs, and emergency communication. The relationships between these components are described in the class diagram given in Fig. 2, which demonstrates how different system entities collaborate to deliver the required functionality. Together, these design considerations ensure that the framework is modular, maintainable, and adaptable for future extensions.

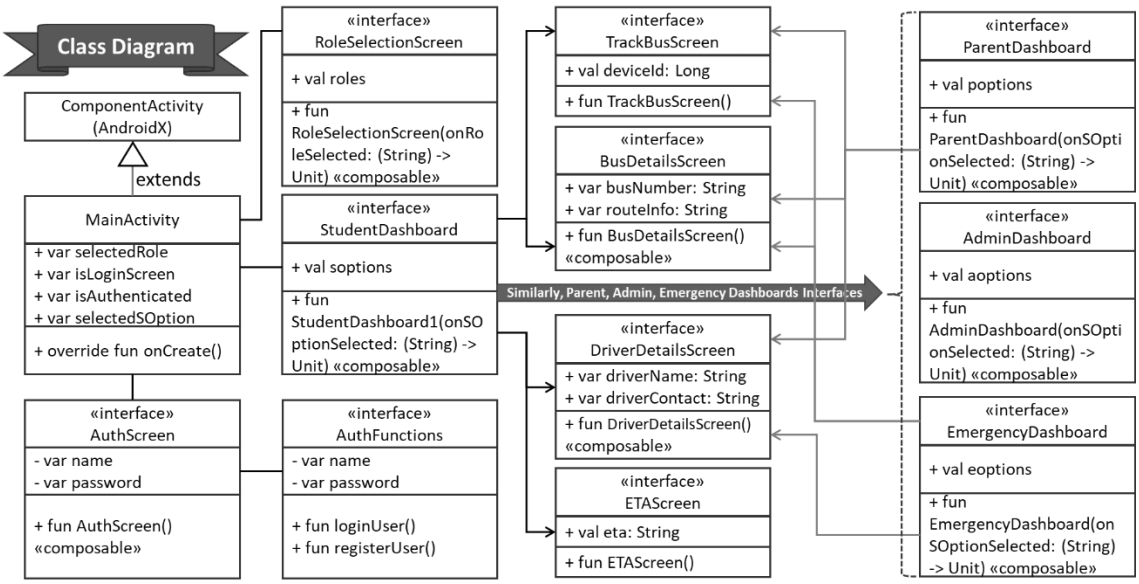


Fig. 2 Software Design

## III. IMPLEMENTATION

The mobile application was developed using the Kotlin programming language within the Android Studio environment, leveraging Google Maps APIs for map-based visualization and HTTP-based APIs for communication with the tracking server. The overall source code is organized into modular packages, including UI for user interface components, services for server communication and background tasks, models for data representations such as buses and users, and utils for common helper functions. This modular structure ensures separation of concerns, maintainability, and ease of extension in future versions.

A critical part of the implementation is the student interface for real-time bus tracking. Once a student selects the desired bus, the application retrieves live GPS coordinates from the server and plots the corresponding location marker on Google Maps. The system also updates the location marker dynamically as the bus moves along its route, ensuring that users can monitor progress in real time.

A representative snippet of the implementation is shown below, demonstrating how the application integrates with Google Maps and updates the bus marker using server-provided GPS coordinates:

```
class TrackBusScreen : AppCompatActivity(), OnMapReadyCallback {
        private lateinit var mMap: GoogleMap
        override fun onMapReady(googleMap: GoogleMap) {
                mMap = googleMap
                // Bus location from server (lat, lng)
                val busLocation = LatLng(latest.latitude, latest.longitude)
                mMap.addMarker(MarkerOptions().position(busLocation).title("College Bus"))
                mMap.moveCamera(CameraUpdateFactory.newLatLngZoom(busLocation, 15f))
        }
}
```

This snippet highlights the integration of Google Maps with Kotlin, where a marker is added at the bus's current location and the camera view is updated to provide real-time visualization. In practice, the coordinates are obtained dynamically from the tracking server through REST APIs and updated periodically as the bus moves.

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## IV. TESTING, VALIDATION AND RESULTS

The system underwent multi-stage testing to ensure reliability and accuracy. After powering up the GPS device, it was configured. Initial testing was performed by sending SMS commands to verify that the devices correctly reported location data (Fig. 3).

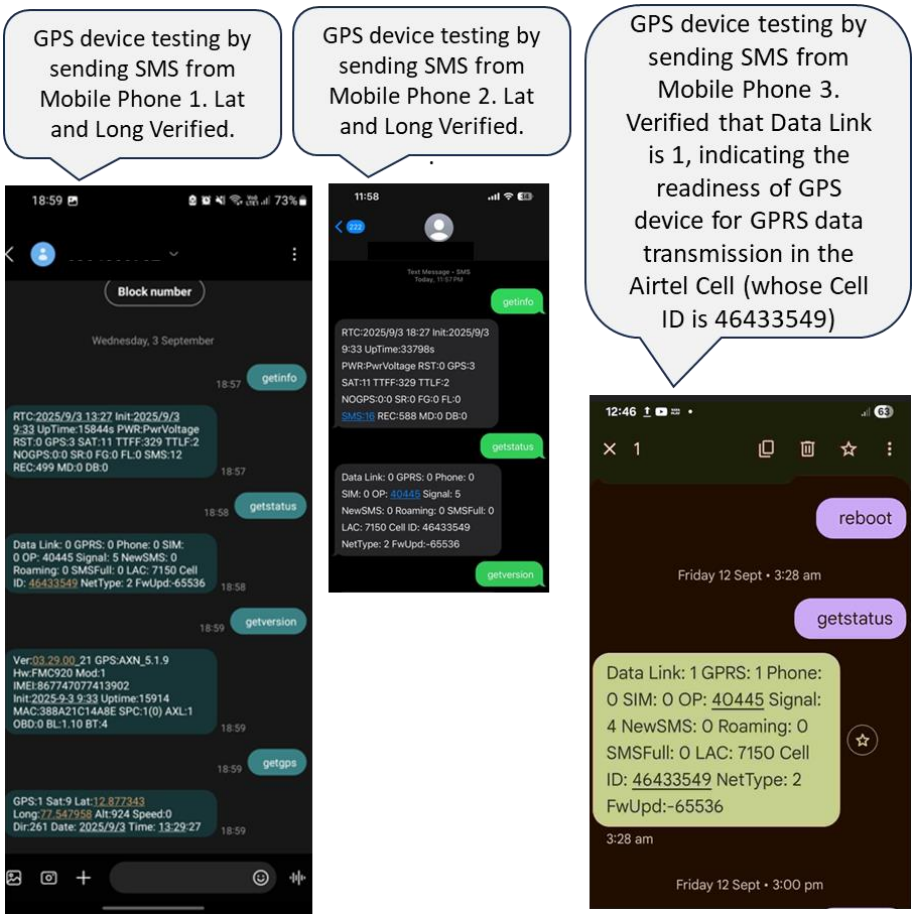


Fig. 3 Initial testing which confirmed the proper functioning of GPS device

This was followed by integration testing with the Tracking server, confirming that GPS coordinates were received, processed, and displayed correctly within the server interface (Fig. 4).

Data noted down from Video Recording

| Video Time | Location displayed on Map | Near by location displayed on Map | Latitude | Longitude |
|---|---|---|---|---|
| 0:00 | Mahakavi Kuvempu Road | MKK Road | 12.9980216 | 79.5579499 |
| 0:52 | MKK Road | Rajaji Nagar | 12.9981816 | 79.5576733 |
| 1.55 | Rajaji Nagar | Rajaji Nagar Metro Parking Area | 12.9995466 | 79.5499166 |
| 3:57 | Hot Coffee | 20B Main Road | 13.0066649 | 77.5487066 |

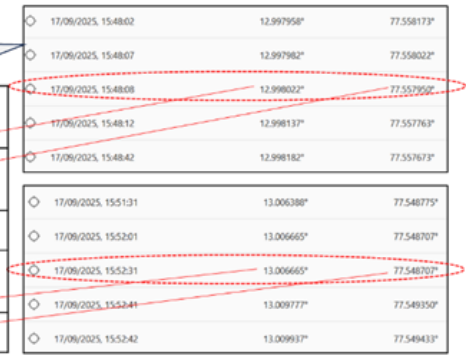


Fig. 4 Lat-Long sown on Google Map matched with the Lat-Long sensed by GPS Device

**Static location testing** was conducted on Google Maps to ensure that the mobile application correctly visualized bus locations under controlled conditions. Google map aptly showed the ORION Mall Lat and Long (Fig. 5).

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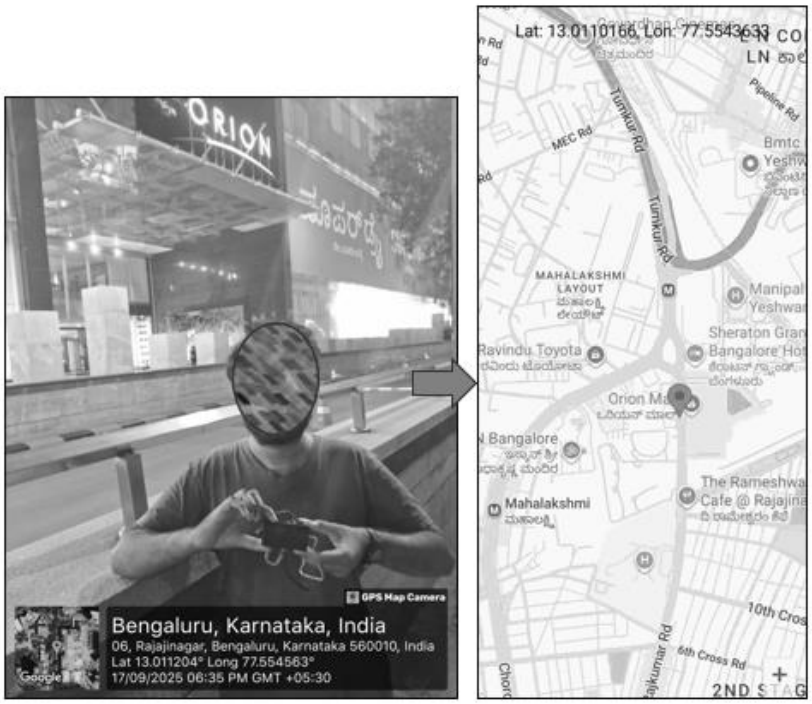


Fig. 5 Static System Testing (Left: GPS device. Right: Google Map showing the location on the mobile phone)

'Real-Time Field Testing of the system' has been carried out in three stages:

1) Firstly, field testing involved riding in the Metro trin along a 2 km route in Bangalore Urban area for approximately 4 minutes, tracking the movement on Google Maps.
   - The observed results demonstrated accurate, real-time updates, validating both the IoT communication chain and the mobile interface.

   **Result:** The Android Studio interface with the mobile phone was retained during the testing to monitor the Logs.
2) Two Android mobile phones with the App installed on were carried by walk (slow pace) for a kilometre distance.
   - Both the mobile phones displayed the Latitude and Longitude aptly and the tracking on the map looked similar on both the mobile phones.

   **Result:** This time the Apps were running on the mobile phone without the Android Studio interface.
3) After all UI improvements, the final build was made and APK was generated using the Android Studio. The APK was downloaded to 3 different Android mobile phones for final field testing. The final Field Testing was planned for commutation in the Bus, as the intended installation of GPS device is eventually in a college Bus. Following strategy was used to prove the simultaneous usage of the system, as several users could access the system simultaneously:
   - Mobile-1 was dedicated for tracking the device and recording purpose. Login to the App was done with STUDENT role.
   - Mobile-2 was used for taking the screenshots of Track Bus Screen at different locations all along the route. Login to the App was done with GUARDIAN role.
   - Mobile-3 was used for taking the screenshots of ETA Screen all along the route. Login to the App was done with STUDENT role.

   Result: The App tracked the GPS device aptly in all the three mobile phones. The ETA displayed by the Mobile-3 were also convincing as shown in Fig. 6.

**Inference:** These staged tests provide confidence in the system's functionality and readiness for real-world deployment, highlighting the robustness of the Level-3 IoT framework and its practical applicability in college transportation management.

  

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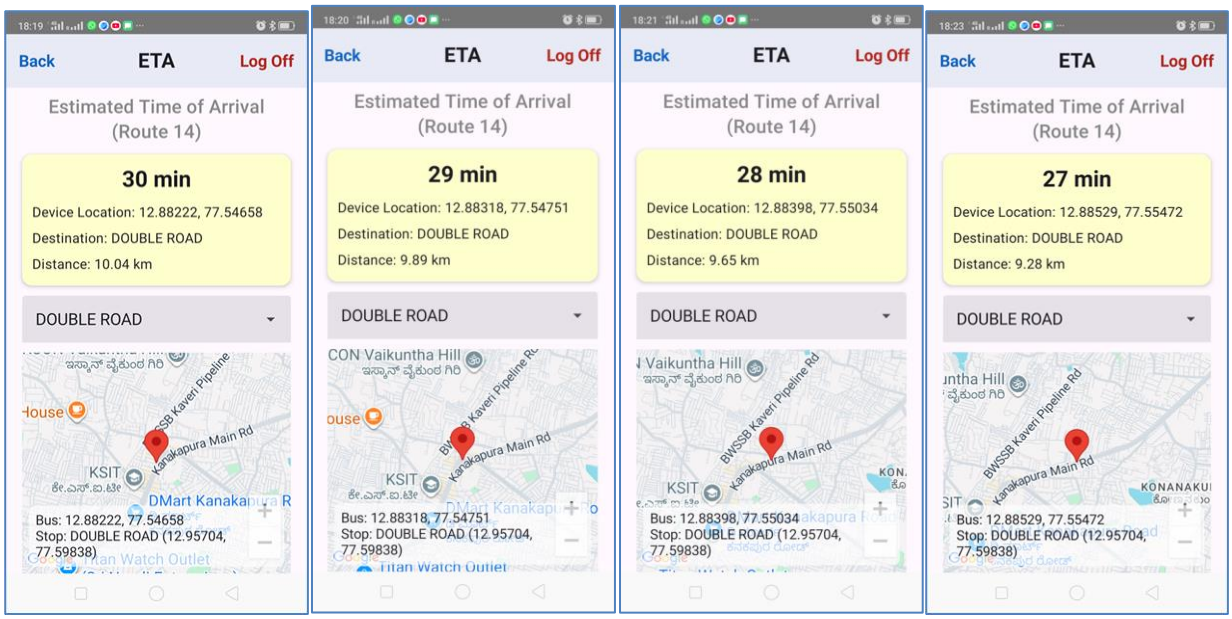


Fig. 6 Screenshots of the App depicting the 'Real Time Testing' of 'Estimated Time of Arrival (ETA)

## V. FUTURE SCOPE

The present system can be extended in several directions to enhance functionality and scalability. Incorporating driver behaviour monitoring through sensor analytics and fuel efficiency tracking would improve operational management. The system can also be expanded to support multi-campus or city-wide transport networks, with real-time congestion and rerouting features powered by live traffic APIs. Additionally, linking the application with emergency response services and automated notification modules would strengthen safety mechanisms. From a technical perspective, migrating to a microservices architecture and adopting cross-platform frameworks can improve performance and ease of maintenance. These extensions would transform the current implementation into a comprehensive smart transportation ecosystem suitable for broader institutional and public deployments.

## VI. CONCLUSION

The implementation of a real-time college bus tracking system using GPS technology and a mobile application interface demonstrates the practical fusion of IoT, cloud-based tracking servers, and mobile computing. The developed system successfully enables students, parents, and college authorities to monitor bus locations, enhancing safety, transparency, and punctuality in transport management. Through systematic testing, from GPS device validation to live route tracking, the system proved reliable and responsive under real-world conditions. This work not only illustrates the viability of scalable IoT-based transport monitoring but also lays a foundation for further extensions such as predictive arrival estimation, driver behaviour analysis, and emergency response integration. Overall, the project contributes toward the broader vision of intelligent campus mobility solutions leveraging modern mobile and cloud technologies

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