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Real-Time College Bus Tracking and Management System: A Software-Based Approach

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Abstract: *Transportation management is an important component of educational institutions to ensure student safety and operational efficiency. Many colleges still rely on manual tracking systems or hardware-based IoT solutions, which are expensive and difficult to maintain. This paper presents a Real-Time College Bus Tracking and Management System developed using a purely software-based approach. The system utilizes smartphone GPS technology, Flutter-based mobile applications, Node.js backend services, and MySQL database management to provide real-time tracking, attendance monitoring, and emergency alerts. Students and parents can view live bus locations, drivers can manage trips and attendance, and administrators can monitor fleet operations through a centralized dashboard. The proposed system reduces dependency on external hardware devices and minimizes operational cost. Testing results indicate stable real- time performance, reliable trip monitoring, and improved communication between stakeholders. Overall, the system provides a scalable, cost-effective, and user-friendly transportation management solution for educational institutions.*

Keywords: Bus Tracking System, GPS Monitoring, Flutter Application, Node.js, Real-Time Communication, Transportation Management

I. INTRODUCTION

Transportation management is an essential operational component of colleges and educational institutions. Every day, buses transport hundreds of students between campuses and residential areas. Ensuring the safety, punctuality, and accountability of these transportation services is a major responsibility of administrators.

Traditional transportation systems primarily depend on manual attendance sheets, telephone communication, and physical monitoring. These methods lack transparency and do not provide real-time tracking information. Parents often remain uncertain about bus arrival times, which creates anxiety and safety concerns.

In recent years, GPS-based tracking systems using IoT hardware have been introduced. While these systems improve tracking accuracy, they require installation of dedicated GPS modules, SIM cards, and maintenance support. Hardware failures, installation costs, and scalability limitations make such systems less practical for budget-conscious institutions.

With the advancement of smartphones equipped with built-in GPS and internet connectivity, it is now possible to design a fully software-based tracking system. This project proposes a Real-Time College Bus Tracking and Management System that uses smartphone GPS for location updates, eliminating external hardware dependency.

The system integrates real-time co-provided communication, automated attendance management, emergency alert systems, and administrative monitoring into a unified platform. This approach enhances operational efficiency and improves transportation safety.

II. LITERATURE SURVEY

Various studies have explored bus tracking and transportation monitoring systems using GPS and IoT technologies. Kumar et al. proposed a GPS-based school bus monitoring system using GSM modules to transmit location data.

Although the system basic tracking, it required additional hardware installation and incurred maintenance expenses.

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Sharma and Verma developed a hybrid tracking solution combining IoT devices with mobile applications. Their approach improved tracking visibility but faced challenges in scalability and hardware reliability. Patel et al. introduced a cloud-based vehicle monitoring system using mobile platforms. While it provided real-time tracking, the system lacked integrated attendance tracking and emergency notification features. Other research studies focused primarily on hardware-based GPS devices rather than software-centric models. Most systems did not provide comprehensive role-based access control or integrated transportation management features. The proposed system addresses these limitations by implementing a software-only architecture that combines tracking, attendance, emergency alerts, and administrative monitoring within a single framework.

III. PROBLEM OF STATEMENT

In many educational institutions, transportation management systems suffer from the following challenges:

- Lack of real-time visibility
- Manual attendance processes
- Poor communication between stakeholders
- High hardware installation costs
- Limited scalability

Manual monitoring methods are time-consuming and prone to human error. Hardware-based tracking systems increase operational cost and require regular maintenance. There is a need for a cost-effective, scalable, and automated transportation management system that provides real-time tracking, attendance automation, and emergency communication without relying on dedicated IoT hardware.

IV. EXISTING PROBLEM

The existing transportation tracking solutions mainly rely on:

1. Manual Record Keeping Attendance is recorded on paper, which can lead to inaccuracies and data loss.
2. Hardware-Based GPS devices dedicated GPS trackers installed in buses increase procurement and maintenance cost.
3. Limited Real-Time Communication, Parents and students often receive delayed updates.
4. Separate Systems for Attendance and Tracking Most systems do not integrate attendance tracking with GPS monitoring.
5. Scalability Issues Expanding the fleet requires proportional hardware investment.
6. These limitations highlight the necessity of a unified and scalable software-based solution.

V. PROPOSED SYSTEM

5.1 System Architecture

The system follows a three-tier architecture:

1. Presentation Layer – Flutter Mobile Application
2. Application Layer – Node.js with Express.js
3. Data Layer – MySQL Database

Real-time communication is handled using Socket.io for instant location broadcasting.

System Workflow

Step-by-Step Explanation:

1. Start: The system is launched via the mobile application.
2. User Authentication: Secure login is performed using JWT-based authentication.
3. Role-Based Dashboard Users access: role-specific dashboards:

- Student
- Driver

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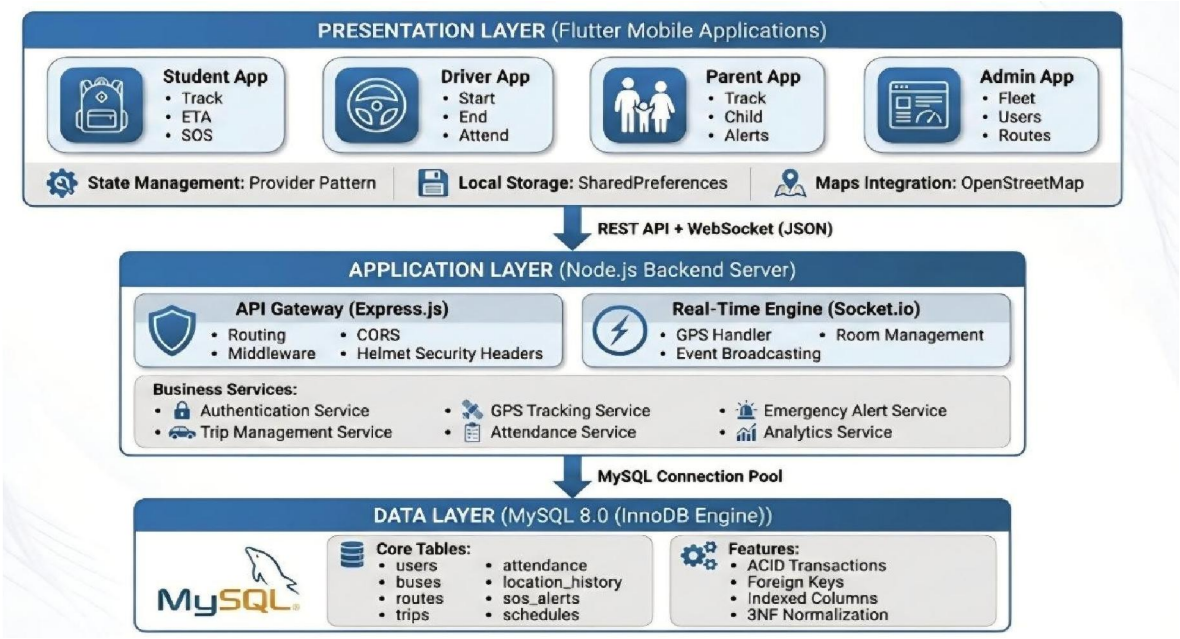
• Parent
• Administrator
4. Trip Start: The driver initiates the trip using the application.
5. GPS Data Collection: The smartphone collects latitude and longitude data.
6. Real-Time Update: Location data is transmitted to the server and broadcast to subscribed users.
7. Attendance Management: Drivers digitally mark student attendance during the trip.
8. Emergency Alert: SOS feature allows drivers to send alerts in case of emergencies.
9. Administrative Monitoring: Admins monitor live trips, bus status, and attendance records.
10. Trip End: The driver ends the trip, and trip data is stored for future reference.



VI. IMPLEMENTATION DETAILS

The frontend mobile application is developed using Flutter, enabling cross-platform compatibility. The backend server is implemented using Node.js with Express.js framework.Socket.io enables bi-directional communication between the server and clients. MySQL database stores user details, trip data, attendance records, and location history. Security features include Password hashing using bcrypt, JWT-based authentication, Role-based authorization include system ensures data consistency and reliable communication between all stakeholders.

VII. OUTPUT

The application interface includes user-friendly dashboards with role-specific features to enhance usability.
The system generates the following outputs:

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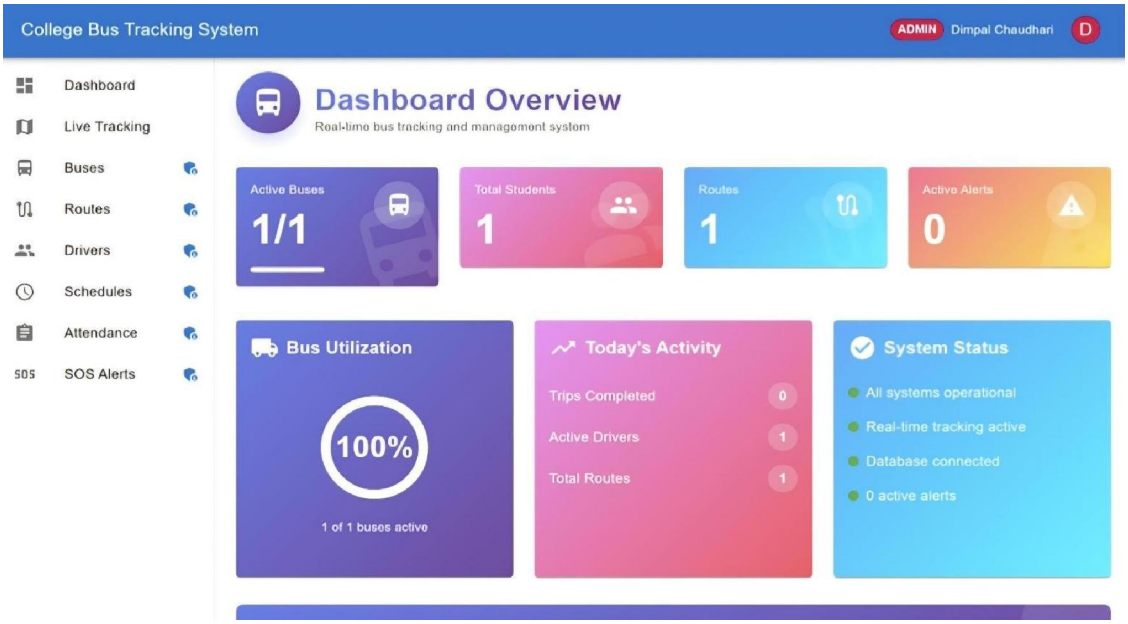

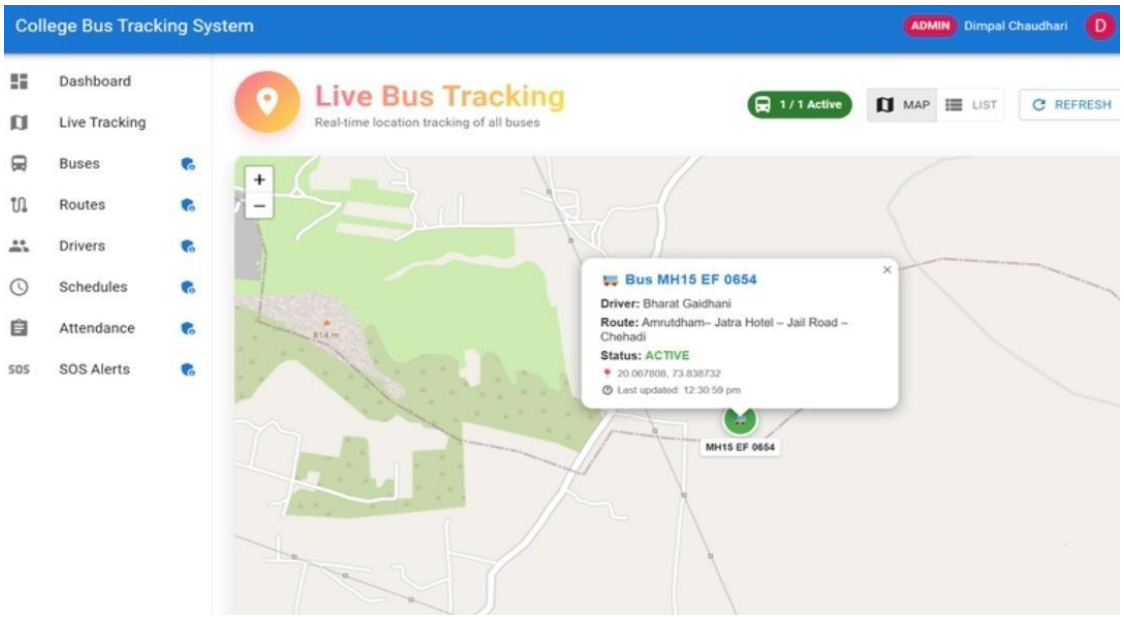

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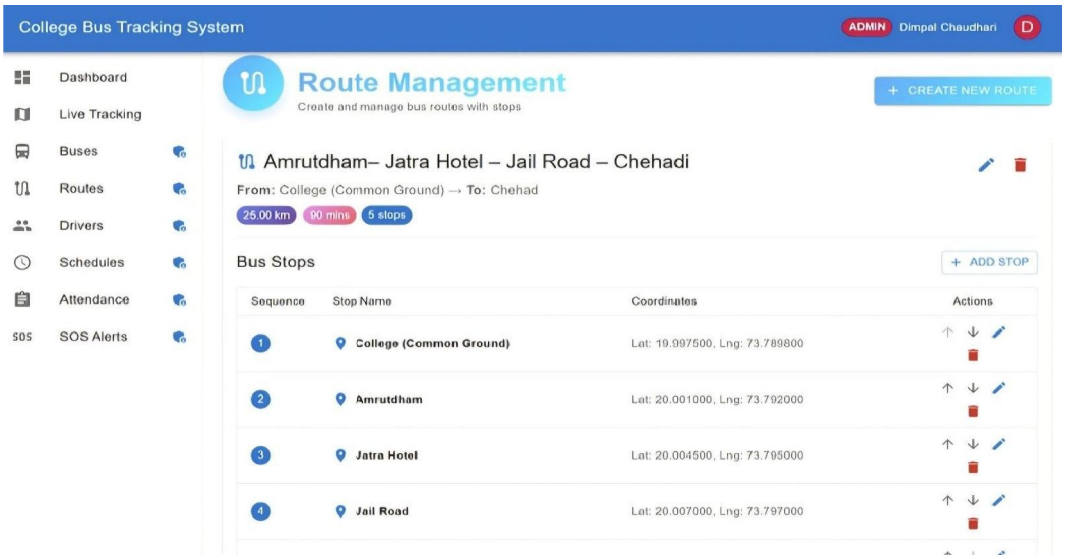

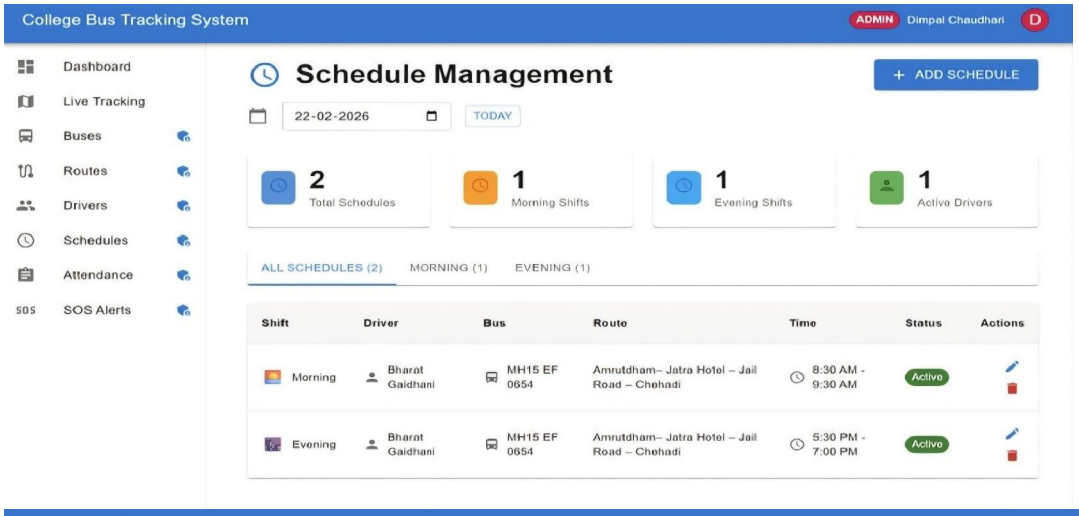

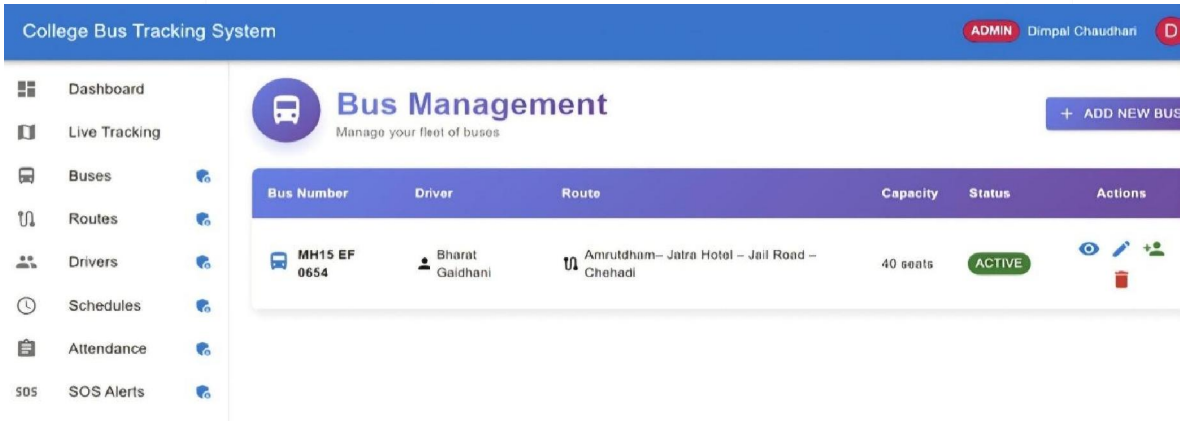

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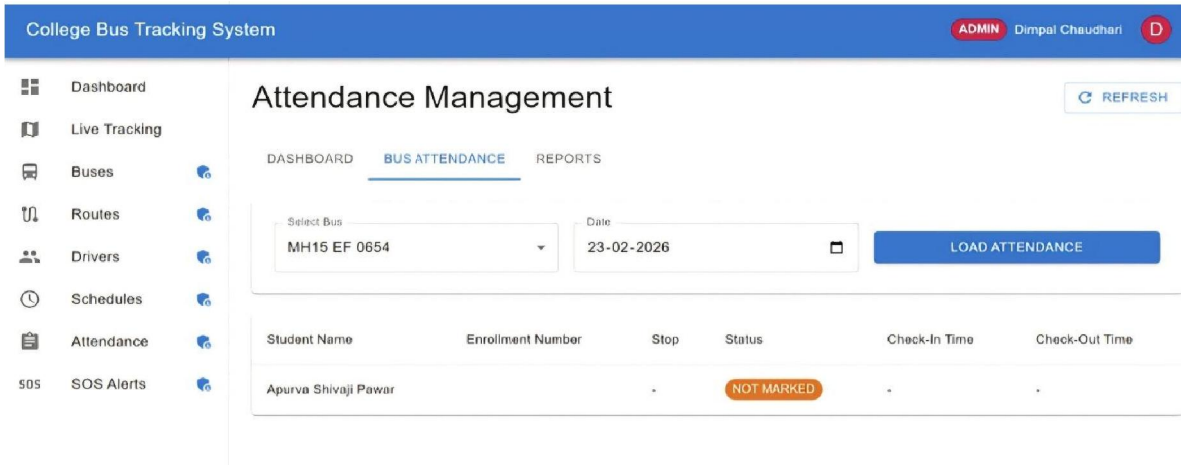
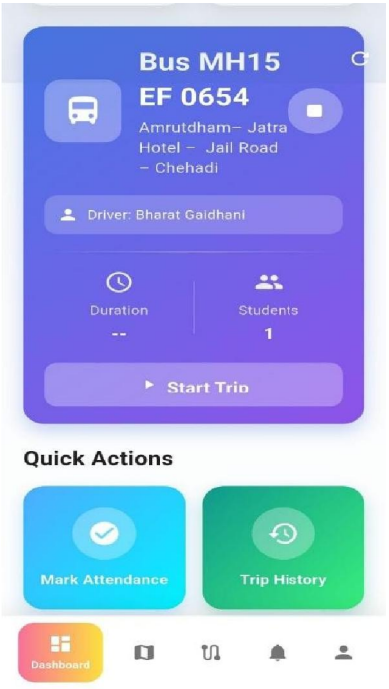
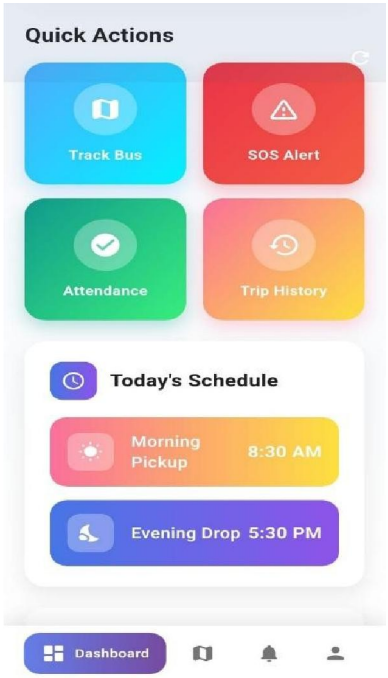


Mobile application student/driver dashboard





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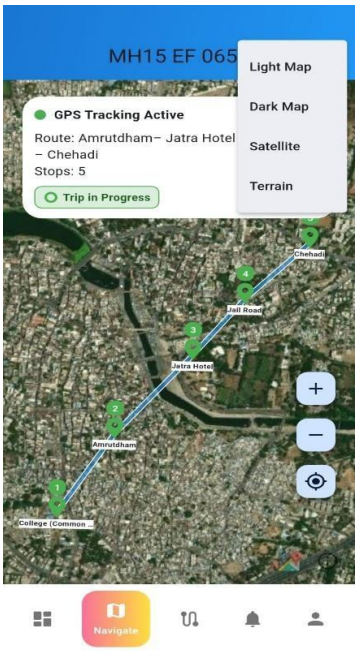

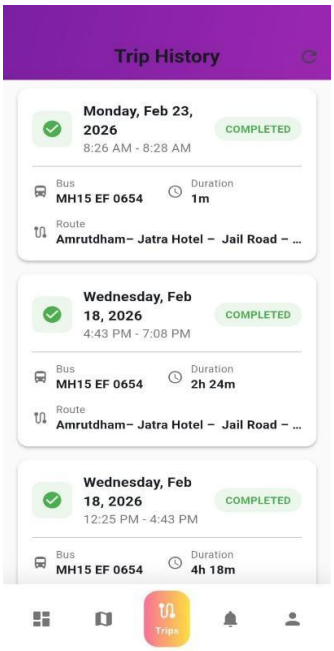

VIII. CONCLUSION

The Real-Time College Bus Tracking and Management System provides a scalable and efficient alternative to hardware-dependent transportation monitoring systems. By utilizing smartphone GPS and real-time communication protocols, the system reduces infrastructure cost while maintaining reliability. The integration of attendance tracking, emergency alerts, and administrative monitoring enhances operational transparency and student safety. The proposed system demonstrates that software-centric architectures can effectively modernize transportation management in educational institutions.

IX. ACKNOWLEDGMENT

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