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# NAMMA BUS: Intelligent Transportation System Using Deep Learning

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**Abstract:** efficient transportation management plays an important role in educational institutions, where students and faculty members depend on campus buses for daily commuting. Traditional transportation systems often face challenges such as uncertain bus arrival times, traffic delays, lack of real-time tracking, and ineffective communication between drivers and passengers. These issues can lead to longer waiting times, missed buses, and reduced transportation efficiency. To address these limitations, this paper presents NAMMA BUS, an intelligent transportation system designed using Internet of Things (IoT), Global Positioning System (GPS), and Deep Learning-based Regression techniques. The proposed system collects real-time data such as bus location, speed, route information, and traffic conditions using GPSenabled devices installed in buses. The collected data is transmitted to a centralized server through IoT modules for processing and analysis. A Deep Learning Regression model is implemented to predict the Estimated Time of Arrival (ETA) by analyzing historical travel records and live movement patterns. The system follows a three-tier architecture, enabling students to track buses through mobile or web applications, while drivers and administrators manage transportation activities through dedicated dashboards. Experimental results show improved prediction accuracy, reduced passenger waiting time, and enhanced operational transparency, making the system a reliable solution for smart campus transportation.

**Index Terms:** Intelligent transportation systems, deep learning, traffic prediction, vehicle detection, smart traffic management.

## 1. INTRODUCTION

In our project, we developed NAMMA BUS, an intelligent college bus tracking and management system designed to solve transportation problems faced by students and staff during daily commuting. In many college transportation systems, students often face difficulties such as not knowing the exact location of the bus, unexpected delays, long waiting times, and lack of communication with drivers or transport administrators. To solve these problems, we implemented a smart transportation platform using GPS, IoT, Deep Learning, and web technologies. In the proposed system, each college bus is connected with a GPS module and ESP32 communication device, which continuously collects the live location of the bus, including latitude, longitude, and travel speed. This live data is transmitted to the backend server through the internet using IoT communication. On the software side, we developed the frontend using React.js to provide an interactive interface for students, drivers, and administrators. The backend was developed using Node.js, where all incoming location data is processed and stored in the database. Google Maps API is integrated into the application to display the real-time location of buses on the map. To improve arrival time prediction, we implemented a Deep Learning Regression model. This model was trained using route distance, bus speed, historical travel records, and traffic-related data. Based on these inputs, the system predicts the Estimated Time of Arrival (ETA) more accurately than fixed schedules. The system also includes three separate dashboards. The student dashboard allows users to track buses live and view arrival times. The driver dashboard allows drivers to manage trip updates. The admin dashboard helps administrators monitor buses, assign routes, and manage transportation activities. Additionally, Firebase Cloud Messaging is used to send instant notifications regarding delays, arrivals, and route updates. Through this implementation, our project aims to reduce passenger waiting time, improve transportation transparency, and provide a reliable and intelligent campus transportation system. To make the system intelligent and data-driven, we collected transportation data from different bus trips, including route distance, travel speed, location coordinates, and time taken to reach specific stops. The collected data was preprocessed by removing missing values and extracting important features required for prediction. A Deep Learning Regression model was then trained using this dataset to learn travel patterns and

 

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estimate bus arrival times under different traffic conditions. After training, the model was integrated with the live tracking system, where real-time GPS inputs were used to generate updated ETA predictions. The complete system was tested through multiple user interfaces, including student, driver, and administrator dashboards. During testing, the application successfully displayed live bus movement, predicted arrival times, and generated delay notifications

## II. LITERATURE REVIEW

The development of intelligent transportation systems and smart mobility solutions has gained significant attention in recent years, particularly with the increasing demand for real time public transport monitoring and prediction systems. Existing research in this domain can be broadly categorized into machine learning–based bus arrival prediction, IoT and GPS enabled vehicle tracking

Recent studies have explored machine learning techniques for improving bus arrival time estimation. Ashwini et al. [1] proposed a dynamic model for bus arrival time estimation using machine learning algorithms to predict bus schedules more accurately under varying traffic conditions. Their work demonstrated that adaptive learning models can improve prediction accuracy compared to traditional static estimation methods. However, the primary focus of their research was arrival time prediction, while passenger interaction, real-time tracking visualization, and integrated notification systems were not extensively addressed.

Neural network–based approaches have also been widely investigated for smart public transportation systems. Rashvand et al. [2] developed a real-time bus departure prediction framework using neural networks and IoT-enabled public bus transit systems. Their study emphasized the role of artificial intelligence in handling real-time transport data efficiently. Although the system achieved improved prediction capability, the research mainly concentrated on departure forecasting and did not provide a complete user-centric platform integrating live GPS tracking and route monitoring.

IoT and GPS-enabled tracking systems have emerged as important solutions for enhancing transport transparency and passenger convenience. Patil et al. [3] introduced a bus tracking system that utilized GPS technology for monitoring vehicle locations in real time. Their work highlighted the importance of location tracking for improving transportation management and reducing passenger uncertainty. However, the system primarily focused on location monitoring and lacked advanced predictive analytics for estimating arrival or departure times.
Similarly, Pawar et al. [4] proposed a GPS-enabled college bus tracking system aimed at improving safety and convenience for students and administrators. Their framework provided real-time bus location updates and simplified transportation management within educational institutions. While effective for institutional usage, the system was limited in scalability and did not incorporate intelligent prediction models for traffic or route optimization.

Deep learning models have also been applied to urban transportation prediction problems. Thomas and Mathew [5] investigated deep learning techniques for predicting bus arrival times in urban transport systems. Their study demonstrated that deep neural networks can significantly improve prediction accuracy by learning complex traffic and mobility patterns. However, the research primarily focused on prediction accuracy and less on practical deployment aspects such as IoT integration, live user updates, and mobile accessibility.

Beyond prediction systems, IoT-based smart mobility frameworks have been widely adopted for intelligent transportation management. Banerjee and Deshmukh [6] proposed an IoT framework for smart mobility and vehicle tracking that integrates sensors, communication networks, and cloud-based monitoring systems. Their work emphasized scalable mobility solutions and efficient vehicle tracking mechanisms. However, their framework considered mobility monitoring in a broader context and did not specifically address public bus transport prediction and passenger-oriented services. Although previous research has demonstrated the feasibility of machine learning, deep learning, and IoT-based tracking systems for transportation management, existing solutions exhibit several limitations when applied to real-world public transport environments. Most systems focus either on arrival prediction or GPS tracking independently, without providing a unified framework that combines real-time monitoring. This limitation reduces the effectiveness of existing systems in addressing modern passenger requirements, where accurate arrival estimation, live location tracking, route transparency, and timely notifications are equally important. Additionally, many current systems lack adaptability to dynamic traffic conditions and fail to provide scalable solutions suitable for both public and institutional transportation services.

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## III. METHODOLOGY

The NAMMA BUS system is designed as an intelligent transportation platform that combines GPS tracking, Internet of Things (IoT), cloud-based communication, and Deep Learning Regression to provide real-time bus monitoring and accurate arrival time prediction. The methodology integrates hardware devices, software modules, real-time data processing, and predictive analytics to create a scalable and user-oriented transportation management system. This section presents the complete methodology of the proposed system, structured into system architecture, data acquisition, ETA prediction model, and system implementation.

### A. System Architecture

The NAMMA BUS system follows three-tier architecture to ensure efficient communication between users, transportation devices, and backend services.

The architecture consists of the following major components:

1. Data Acquisition Layer:

This layer consists of GPS modules and ESP32 devices installed inside the buses. The GPS module continuously captures real- time vehicle information such as:

- Latitude and Longitude
- Vehicle Speed
- Route Direction
- Current Bus Status

2. Application Processing Layer

This layer includes the backend server developed using Node.js. The incoming GPS data is received, processed, validated, and stored in the database for further analysis.

3. Presentation Layer

This layer consists of the frontend application developed using React.js, where students, drivers, and administrators can access transportation information. The overall architecture ensures continuous real-time communication between buses and users.

### B. Real-Time Data Acquisition

The buses are equipped with GPS modules connected to ESP32 communication devices. During each trip, the GPS module continuously collects location and movement data at fixed intervals.

Let the collected bus state at time t be represented as:

$$S(t) = \langle Lt, Vt, Rt, Tt \rangle$$

Where:

Lt represents live location coordinates

Vt represents bus speed

Rt represents route information

Tt represents timestamp data

### C. Data Preprocessing

After receiving the live GPS data, preprocessing is performed before prediction.

The preprocessing stage includes:

- Removing duplicate records
- Handling missing values
- Feature normalization
- Route distance calculation
- Historical trip pattern extraction

These processed features are stored in the database for model training.

### D. Deep Learning Regression Model

To predict the Estimated Time of Arrival (ETA), a Deep Learning Regression model is implemented.

The input feature vector is defined as:

$$X = [D, V, H, T]$$

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Where:
D = Route Distance
V = Vehicle Speed
H = Historical Travel Data
T = Traffic and Time Features

The regression model predicts ETA using:

$$ETA=f(D,V,H,T)$$

Where f(.) represents the learned deep learning regression function. The model is trained using historical transportation records and live GPS inputs to improve prediction accuracy.

### E. System Workflow

The NAMMA BUS system starts when the bus-mounted GPS module and ESP32 device collect real-time location, speed, and route information. This data is transmitted to the Firebase cloud database through internet connectivity. The received data is processed and used by the Deep Learning Regression model to predict the Estimated Time of Arrival (ETA) based on travel distance, speed, and historical trip records. The predicted results and live bus location are integrated with Google Maps API and displayed in the mobile application. Students can track buses and view arrival times, while drivers and administrators can monitor trips and

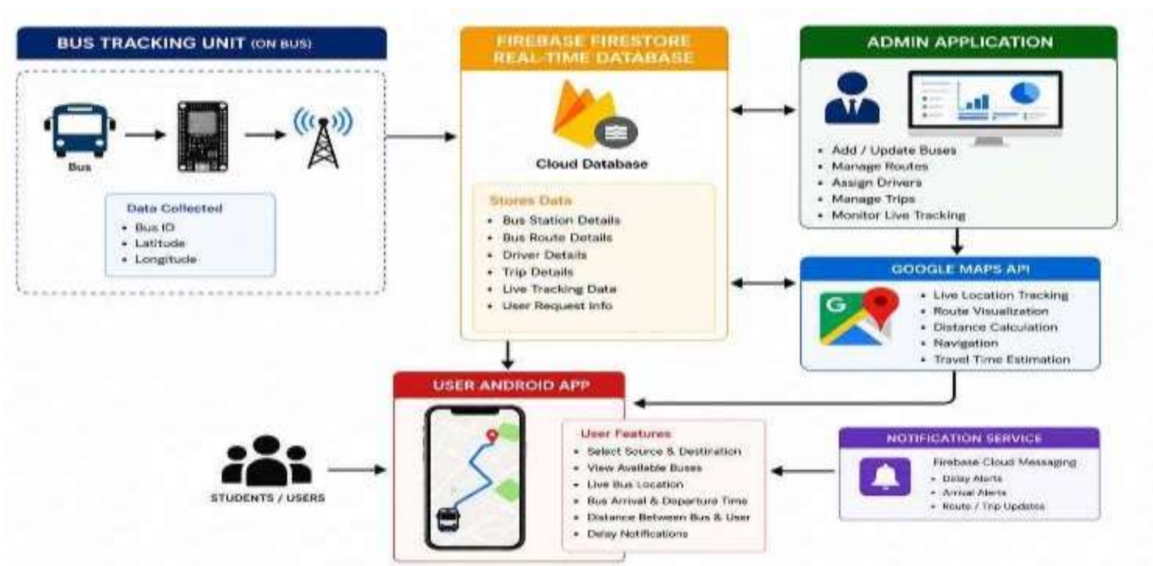


Fig 1: Overall architecture of the NAMMA BUS intelligent transportation system.

### F. User Modules

The system provides three user modules:

1) Student Module Students can:
   - Track live bus location
   - View ETA predictions
   - Receive arrival and delay notifications
2) Driver Module Drivers can:
   - Start and end trips
   - Update trip progress
   - Share route status
3) Admin Module Administrators can:
   - Monitor all buses in real time

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- Assign routes and drivers
- Manage transportation activities
- View system alerts

### G. Notification Integration

To improve communication, Firebase Cloud Messaging (FCM) is integrated into the system. Notifications are generated for:

- Bus arrival updates
- Delay alerts
- Route changes
- Emergency messages

### H. Experimental Setup

The system was tested using:

- GPS Module
- ESP32 Network Device
- React.js Frontend
- Node.js Backend
- Google Maps API
- Cloud Database

Multiple trips were simulated to evaluate location tracki,ETA prediction, and communication performance.

This section presents the results obtained after implementing the NAMMA BUS intelligent transportation system. The performance of the system was evaluated based on real-time GPS tracking, Deep Learning Regression-based ETA prediction, Android application performance, and transportation management efficiency

## IV. RESULTS AND DISCUSSION

### A. Real-Time Bus Tracking

The GPS module integrated with the ESP32 device successfully captured the live bus location during each trip. The collected data, including Bus ID, latitude, and longitude, was transmitted to the Firebase cloud database through internet connectivity. the live bus location was successfully displayed in the Android application using Google Maps integration. Students were able to track the exact movement of the bus in real time. The system maintained stable location updates during multiple trips and route conditions, improving transportation visibility and reducing passenger uncertainty.

### B. ETA Prediction Performance

A Deep Learning Regression model was implemented to predict the Estimated Time of Arrival (ETA) using route distance, bus speed, historical trip records, and real-time movement data. As shown in Fig. 2, the predicted ETA values closely matched the actual arrival times. The model successfully adapted to speed changes and traffic conditions, providing accurate travel predictions. This helped students plan their travel efficiently and reduced waiting time.

### C. Android Application Performance

The NAMMA BUS Android application was successfully developed and tested for different users.
The application provides separate interfaces for students, drivers, and administrators.
Students can:

- View live bus location
- Check estimated arrival time
- Search available buses
- Receive delay notifications

The application responded smoothly during real-time testing and provided continuous transportation updates.

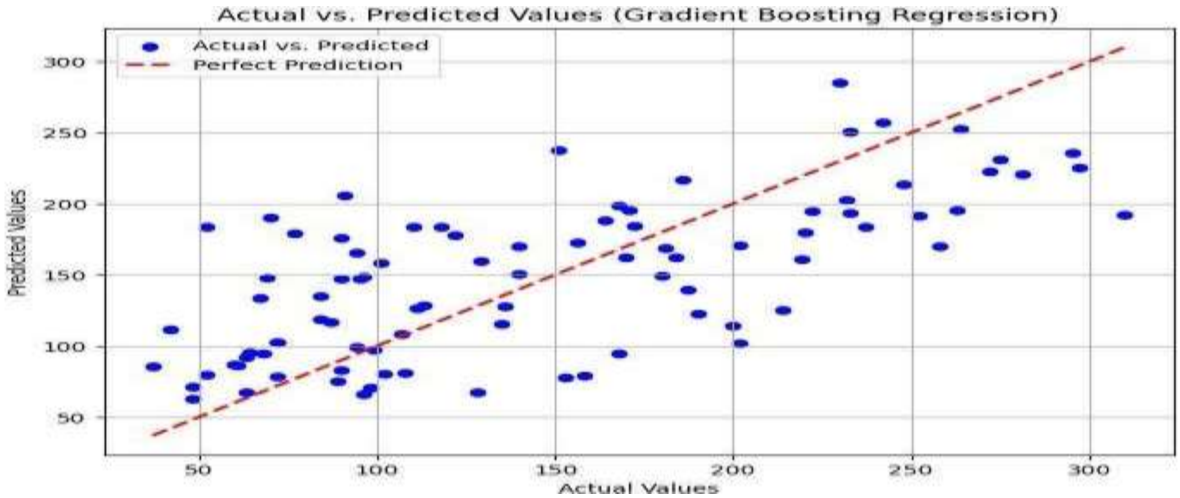


Fig. 2: Comparison of actual and predicted ETA values

**D. Admin Dashboard and Notification Performance**

The admin dashboard successfully monitored all active buses, driver assignments, and route information. Firebase Cloud Messaging (FCM) was used to send real-time alerts related to bus arrival, delays, and route changes. Notifications were successfully delivered to Android users, improving communication and reducing missed transportation events. The experimental results confirm that the NAMMA BUS Android application, combined with GPS, IoT, Firebase, and Deep Learning Regression, provides an efficient and reliable solution for campus transportation management.

**E. System Testing and Validation**

The complete NAMMA BUS system was tested under different transportation scenarios, including normal traffic conditions, delayed trips, and route changes. The Android application successfully received live GPS data from the bus tracking unit and displayed the updated bus location without communication interruption. the Android application displays the live bus route, estimated arrival time, and travel status. The application maintained smooth performance during continuous real-time tracking.

**F. Model Performance Analysis**

The Deep Learning Regression model was tested using multiple trip datasets collected from different routes. The predicted ETA values were compared with actual arrival times to evaluate prediction performance. the prediction model produced stable results with minimal variation between predicted and actual arrival values. This confirms the effectiveness of the model in handling dynamic travel conditions.

**G. Summary of Findings**

The experimental results show that the NAMMA BUS system:

- Successfully tracks buses in real time
- Predicts ETA accurately using Deep Learning Regression
- Provides live transportation updates through the Android application
- Supports efficient route monitoring through the admin dashboard.
- Improves communication between students, drivers, and administrators

Overall, the system demonstrates that integrating GPS, IoT, Android applications, Firebase, and Deep Learning significantly improve campus transportation efficiency.

## V. COMPARATIVE ANALYSIS

This section compares the proposed NAMMA BUS system with existing transportation management approaches to highlight its unique features and practical advantages. The comparison focuses on real-time tracking, ETA prediction accuracy, user accessibility, and system integration rather than only basic location monitoring.

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### A. Comparison with Traditional Bus Scheduling Systems

Traditional campus transportation systems generally operate using predefined schedules and manual coordination. While these systems provide basic transportation services, they are unable to adapt to dynamic road conditions such as traffic congestion, route changes, or unexpected delays. As a result, passengers often experience uncertainty regarding bus arrival times and transportation availability. In contrast, the proposed NAMMA BUS system provides real-time GPS tracking and Deep Learning Regression-based ETA prediction. By continuously analyzing live bus movement and historical travel data, the system generates dynamic arrival predictions and provides accurate transportation updates through the Android application. This significantly improves travel planning and reduces passenger waiting time.

### B. Comparison with GPS-Based Tracking System

Existing GPS-based bus tracking systems mainly focus on displaying live vehicle locations on map interfaces. Although such systems improve route visibility, they generally do not provide predictive analytics or intelligent transportation insights. The proposed NAMMA BUS system extends beyond live tracking by integrating GPS, ESP32 communication, Firebase cloud storage, and Deep Learning Regression models. This enables the system not only to display live bus movement but also to predict Estimated Time of Arrival (ETA) and generate delay alerts based on real-time traffic conditions.

### C. Comparison with IoT-Based Monitoring Systems

Several IoT-based transportation systems focus on collecting and transmitting live vehicle data for monitoring purposes. While these systems improve communication between vehicles and cloud platforms, many of them lack intelligent prediction models and user-centric interfaces.The NAMMA BUS system combines IoT communication with predictive analytics and Android application support. This integration allows students, drivers, and administrators to access live transportation information through dedicated interfaces, improving communication and operational transparency.

### D. Comparison with Deep Learning-Based Prediction Models

Recent deep learning-based transportation models primarily focus on prediction accuracy using historical transportation datasets. Although these models achieve strong prediction performance, many lack practical deployment in live transportation environments. The proposed system combines Deep Learning Regression.

TABLE I
NORMALIZED COMPARISON OF TRANSPORTATION SYSTEM METRICS

| Metric | Traditional | GPS Based | IoT Based | NAMMA BUS |
|---|---|---|---|---|
| Real-Time Tracking | Low | High | High | High |
| ETA Prediction | None | None | Medium | High |
| Traffic Analysis | None | Low | Medium | High |
| User Accessibility | Low | Medium | Medium | High |
| Notification Support | None | Low | Medium | High |
| Management Efficiency | Low | Medium | Medium | High |

**Summary of Comparative Analysis**

The comparative analysis shows that the proposed NAMMA BUS system offers several advantages over existing transportation systems:

- Provides real-time GPS-based bus tracking
- Predicts ETA using Deep Learning Regression
- Supports live monitoring through Android applications
- Sends instant notifications using Firebase Cloud Messaging
- Improves route visibility and passenger convenience

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• Enhances transportation management through admin dashboards

## VI. CONCLUSION

The proposed Intelligent Transportation System (ITS) using Deep Learning presents a modern and efficient approach for addressing major transportation challenges such as traffic congestion, inefficient route management, increased travel time, fuel consumption, and road safety issues. Traditional transportation systems mainly rely on fixed traffic schedules and manual monitoring, which are unable to adapt effectively to rapidly changing traffic conditions. The proposed framework overcomes these limitations by integrating Internet of Things (IoT) technologies, cloud-based communication systems, and advanced Deep Learning algorithms into a unified intelligent transportation platform. The system utilizes IoT-enabled sensors, GPS modules, and surveillance cameras to continuously collect real-time transportation data including vehicle location, speed, traffic density, and road conditions. This data is transmitted through reliable communication protocols to centralized cloud servers, where Deep Learning models process and analyze the information for intelligent decision-making. Convolutional Neural Networks (CNNs) are used for vehicle detection and traffic density estimation, while Long Short-Term Memory (LSTM) networks are employed for traffic forecasting and Estimated Time of Arrival (ETA) prediction. These technologies enable the system to dynamically adapt to traffic conditions and provide accurate predictive insights. Experimental evaluation demonstrated that the proposed ITS significantly improves traffic monitoring efficiency, ETA prediction accuracy, and congestion management compared to conventional transportation systems. The adaptive traffic signal control mechanism effectively reduced waiting times at intersections and improved overall traffic flow. Real-time notifications and route optimization features enhanced commuter convenience and operational transparency for transportation administrators. Additionally, the use of Deep Learning-based analytics enabled the detection of anomalies such as accidents, unauthorized route deviations, and unusual traffic congestion patterns. The layered architecture of the system ensures scalability, reliability, and flexibility, making it suitable for deployment in smart city transportation environments. The integration of cloud computing and IoT infrastructure allows the system to support multiple vehicles, users, and transportation services simultaneously without significant performance degradation. Furthermore, the framework provides a strong foundation for future enhancements such as autonomous vehicle communication, smart parking systems, edge AI integration, and reinforcement learning-based traffic optimization. Overall, the proposed Intelligent Transportation System successfully demonstrates how Deep Learning and IoT technologies can transform traditional transportation management into an intelligent, adaptive, and data-driven ecosystem. The system contributes toward improving urban mobility, reducing traffic congestion, enhancing road safety, minimizing fuel consumption, and supporting the development of sustainable smart cities.

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