

# REAL-TIME PUBLIC TRANSPORT TRACKING FOR SMALL CITIES

Kavitha T<sup>1</sup>, Ashika T<sup>2</sup>, Kanagadharani K<sup>3</sup>, Megha R<sup>4</sup>

<sup>1</sup>Assistant Professor, Vivekanandha College of Engineering for Women, Tiruchengode, Tamilnadu, India

<sup>2,3,4</sup>Student of Vivekanandha College of Engineering for Women, Tiruchengode, Tamilnadu, India

\*\*\*

**Abstract** - The CityBus Tracking System is a real-time public transportation monitoring solution designed to enhance the efficiency and reliability of urban bus services. The system integrates GPS-enabled buses, a centralized database, and a user-friendly web interface to provide accurate and up-to-date information on bus locations, routes, and schedules. Users can track buses in real time, view estimated arrival times (ETA), select routes, and receive notifications when buses approach their subscribed stops. The ETA is calculated using the Haversine method, which determines the distance between the bus and bus stops based on geographic coordinates, combined with current bus speed to improve prediction accuracy. This approach enables commuters to plan their journeys effectively and reduces waiting time at bus stops. Additionally, the system includes an administrative dashboard that allows authorities to manage buses, drivers, routes, and stops efficiently. It also supports simulation of GPS data for testing and training purposes. Alerts are generated for delays, ensuring both administrators and commuters are informed in real time. By combining real-time tracking, predictive analytics, and automated notifications, the proposed system improves service reliability, enhances commuter convenience, and supports data-driven decision-making in public transportation. Overall, the CityBus Tracking System provides a comprehensive solution for modernizing urban transit and improving passenger satisfaction.

**Key Words:** Real-time Bus Tracking, Estimated Time of Arrival (ETA), GPS-Based Monitoring, Proximity Alerts & Subscriptions

## 1. INTRODUCTION

Urban public transit is essential to contemporary cities, yet commuters frequently encounter difficulties like erratic bus arrival times, delays, and a lack of real-time information. The CityBus Tracking System, an intelligent platform that offers real-time bus tracking, estimated time of arrival (ETA) at stops, and timely notifications for commuters, was created to address these problems. To guarantee that both passengers and administrators have access to precise and current information, the system incorporates GPS-enabled buses, a centralized database, and an interactive web-based interface. The website helps commuters plan their travels and cut down on waiting times by providing live maps, ETA information, and subscription-based alerts for their favorite destinations. In addition to functions for mimicking GPS updates and tracking delayed buses, it offers administrators

options to manage buses, routes, stops, and drivers. The CityBus Tracking System seeks to improve overall urban mobility, boost operational efficiency, and improve rider convenience by integrating real-time monitoring, predictive ETA computation, and alarm messaging.

## 1.1 REAL-TIME BUS TRACKING

One of the main features of the CityBus Tracking System is real-time bus tracking, which allows administrators and commuters to keep an eye on the whereabouts of buses as they travel their routes. The system continuously logs latitude, longitude, speed, and direction using GPS-enabled devices put on each bus. It then updates this data in a central database. Users are then able to see bus positions in real-time, spot delays, and make more effective travel plans thanks to the interactive maps that display the live tracking data. By giving precise arrival information, this function not only increases commuter convenience but also helps administrators manage fleet operations, identify delays, and guarantee improved service dependability.

## 1.2 ESTIMATED TIME OF ARRIVAL (ETA)

A key component of the CityBus Tracking System is the Estimated Time of Arrival (ETA), which tells passengers when a bus is expected to arrive at a designated stop. The bus's real-time GPS location, speed, and distance to the stop—which is calculated using the Haversine formula for precise geographic measurement—are used by the system to compute ETA. Users can get accurate and timely estimations because this data is updated constantly as the bus travels. Commuters can plan their trips more effectively, cut down on wait times at bus stops, and make well-informed travel selections by being aware of the anticipated arrival time. ETA also assists administrators in keeping an eye on bus performance and spotting service delays, which enhances overall operational effectiveness and raises passenger happiness.

## 1.3 GPS-BASED MONITORING

One of the main features of the CityBus Tracking System is GPS-Based Monitoring, which uses Global Positioning System (GPS) technology to continuously track and record bus movements. Every bus has a GPS unit that periodically transmits its current latitude, longitude, speed, and direction to a central database. With the use of this data, the system is able to evaluate movement patterns, see real-time bus

whereabouts on interactive maps, and identify delays or deviations. GPS-based monitoring helps managers manage fleet operations, optimize routes, and guarantee timely service in addition to improving commuter convenience by giving precise and current location information. The concept encourages efficiency, dependability, and transparency in urban public transit by utilizing GPS technology.

### 1.4 PROXIMITY ALERTS & SUBSCRIPTIONS

The CityBus Tracking System's user-focused Proximity Alerts & Subscriptions feature enables commuters to sign up for their preferred bus stops and get timely alerts when busses are coming. Using real-time GPS data, the system continuously calculates the projected arrival time by tracking the distance between busses and subscribing stops. An alert is created to notify passengers in advance when a bus enters a specific proximity range or is anticipated to arrive within the user-set notification time. This function improves convenience, shortens wait times, and facilitates effective trip planning for commuters. It also lets customers keep track on delayed buses, making public transportation more dependable and responsive.

### 2. RELATED WORKS AND LITERATURE SURVEY

By utilizing smartphones' built-in GPS capabilities, the 2019 study on GPS-Based Bus Tracking Using Smartphones offers a creative and economical method of monitoring public transit. The technology employs drivers' smartphones to gather real-time location data, which is subsequently sent to a central server via mobile internet connectivity, rather than depending on specialized GPS equipment installed in buses. This greatly lowers implementation costs and increases the system's scalability, particularly in poorer nations where financial limitations are a big issue. A backend server for data processing, a mobile application for drivers, and a mobile or web user interface for passengers make up the usual system design. Latitude and longitude coordinates are continuously recorded by the driver's smartphone, which then periodically updates the server. Passengers can see the current location of buses by processing these updates and seeing them on a map interface. Additionally, the system can provide commuters with helpful information by estimating arrival times based on current position and speed. Since cellphones are more accessible and require less setup than specialist tracking devices, one of the main benefits mentioned in the report is their simplicity of deployment and maintenance.

The goal of the 2021 GPS-Based Bus Tracking System project was to use continuous location monitoring to increase the effectiveness and dependability of public transportation. Real-time coordinates were recorded by the system using specialized GPS modules mounted in buses. These coordinates were then sent to a centralized server via wireless communication technologies like GSM or GPRS.

Following processing, the gathered data was shown on a web-based interface that administrators and passengers could access. This made it possible for users to estimate arrival times at different locations and track bus movements in real time. The study focused on increasing service transparency and cutting down on passenger wait times. It also emphasized how crucial centralized data management is for improved operational planning and decision-making. However, compared to smartphones, the system required hardware installation and maintenance, which raised implementation costs.

In order to improve tracking accuracy and efficiency, the 2023 study presented an Internet of Things (IoT)-based method for bus tracking that integrates several smart devices and communication technologies. The system collected and sent real-time bus location and movement data using sensors, GPS modules, and Bluetooth Low Energy (BLE) devices. This data was sent to cloud platforms via IoT gateways, where it was processed and examined. The study emphasized how IoT solutions may offer better connectivity between buses and control centers, predictive insights, and continuous monitoring. Additionally, improved route planning and performance evaluation were made possible by the incorporation of data analytics. Notwithstanding its benefits, the system had drawbacks such greater complexity, more expensive setup, and reliance on network infrastructure.

The usage of IoT technology was extended in 2024 by research on vehicle monitoring systems, which included a variety of sensors for tracking the movement and performance of vehicles. To provide thorough vehicle monitoring, the system combined GPS, temperature sensors, fuel sensors, and communication modules. For analysis and visualization, the data gathered from these sensors was sent to a centralized system. The study focused on real-time tracking, better fleet management, and increased safety through ongoing observation. Additionally, it showed how IoT promotes scalability, enabling the system to effectively manage several vehicles. However, there were issues with data security and system upkeep, and the installation necessitated substantial infrastructure.

A more sophisticated system that tracked bus whereabouts and more accurately anticipated arrival times was implemented in the 2024 study on real-time GPS tracking paired with ETA prediction. To gather data in real time, the system made use of embedded devices including microcontrollers and GPS modules that were put in buses. Algorithms that computed speed and distance were used to process this data in order to forecast arrival times at future stops. In order to improve user accessibility, the results were presented via online interfaces and mobile applications. The study emphasized how crucial user-friendly interfaces and real-time data processing are to enhancing the passenger experience. Limitations including reliance on present speed

and lack of interaction with traffic conditions were also covered.

An open-access dataset with actual bus GPS trajectories was made available by the 2024 study, which was a useful tool for creating and evaluating prediction models. Researchers were able to evaluate travel patterns and develop machine learning models for ETA prediction thanks to the dataset's comprehensive information, which included timestamps, locations, and route details. The study highlighted how crucial large-scale, high-quality datasets are to enhancing system performance and prediction accuracy. Additionally, it promoted the application of data-driven strategies for public transportation system optimization. But issues including data cleaning, dealing with missing numbers, and guaranteeing data consistency were also brought to light.

### 3. PROPOSED METHODOLOGY

The CityBus Tracking System will be a sophisticated and all-inclusive solution for real-time monitoring and managing of buses in an urban area, ultimately leading to greater levels of efficiency in urban public transport processes and improved experiences for those using them to travel from one place to another. The system integrates GPS-enabled buses with a central database and web-based user interfaces for tracking bus locations in real-time, provides estimated times of arrival (ETA) for arriving at each stop along bus routes, and sends alert notifications regarding late buses and proximity to user-subscribed buses. Users will be able to register in the system, subscribe to user-preferred bus stops, and thereby receive the up-to-date information needed to plan their trips more effectively and reduce their wait at bus stops. The system provides an administrative dashboard for operators to manage bus routes, buses, bus stops, and bus drivers/bus operators, as well as simulations of real-world locations using GPS data for testing and optimizing various bus routes in the system's database. By providing real-time location extracts, predictive ETA calculations via Haversine distance, and maps of bus stops using Folium, the overall objective of the proposed system is to maximize the quality of each and every user experience while achieving the best possible operational efficiencies and data-based decision-making opportunities by city transportation entities.

Commuters can check the Estimated Time of Arrival (ETA) for buses at particular stops, monitor live bus whereabouts on an interactive map, and subscribe to notifications for their chosen routes or stations using the system's user-friendly interface. To ensure precise and dynamic predictions, the ETA is computed using the bus's current speed and the distance between it and the stop. The system also offers proximity-based alerts, which let users know when a bus is getting close to the stop they have chosen within a predetermined window of time. This function greatly increases convenience and facilitates more efficient trip planning.

From an administrative standpoint, transport authorities can effectively manage buses, routes, stops, and drivers thanks to the system's extensive dashboard. Administrators can monitor bus movements in real time, add or amend transportation data, and use speed analysis to identify delays. Additionally, the system has a GPS simulation function that allows bus movement to be tested and shown without the need for real hardware. This guarantees that the system can be successfully validated and maintained prior to real-world implementation.

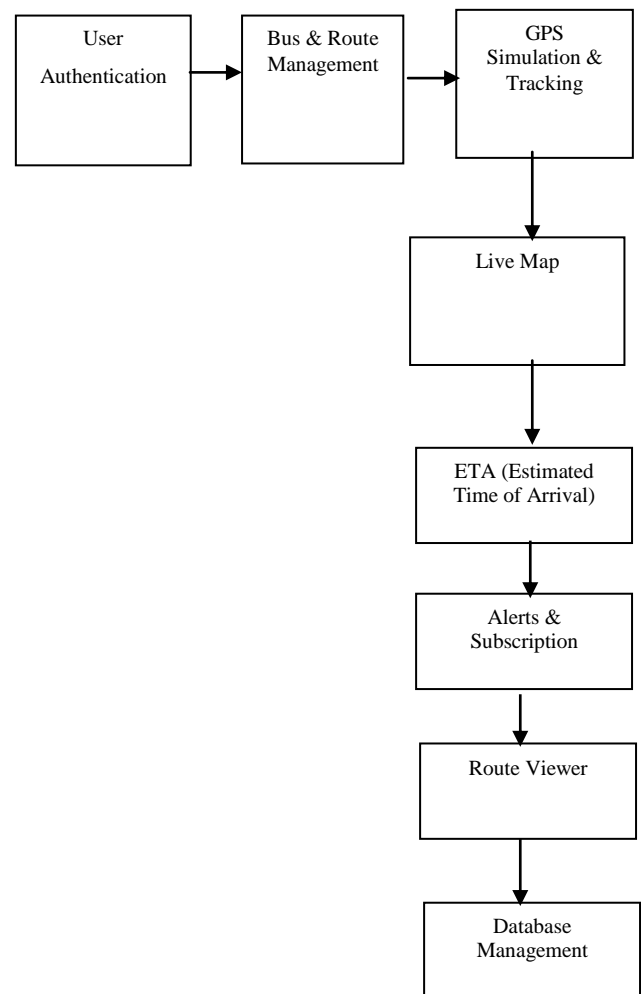


Fig – 1: System Flow Diagram

#### 3.1. USER AUTHENTICATION

The User Authentication Module is in charge of controlling system security and user access. It guarantees that passwords are safely kept via hashing and enables new users to register by entering their name, email address, and password. The module distinguishes between administrators and regular users by assigning responsibilities to users and supporting login capabilities. Regular users can access live

bus monitoring, ETA information, and subscription features, but only authorized users can carry out administrative duties thanks to role-based access.

### 3.2 BUS & ROUTE MANAGEMENT

Administrators can effectively control every facet of buses, routes, and drivers with this module. Buses can be added, updated, or removed by administrators, who can also appoint drivers and assign them to particular routes. In a similar vein, it is possible to define new routes and stops and to display current routes on a map for convenient access. This module guarantees efficient operation and efficient planning for urban transportation management by upholding an orderly structure of routes, buses, and stops.

### 3.3 GPS SIMULATION & TRACKING

Buses are tracked in real time by the GPS Simulation and Tracking Module. Each bus's GPS location, speed, and direction are recorded in the database. Simulated GPS data can be created to replicate bus movement along routes for testing and demonstration reasons. This module makes sure that the system always has the most recent bus location information, which is necessary for real-time tracking, calculating ETAs, and creating alerts.

### 3.4 LIVE MAP

On an interactive city map, the Live Map Module offers a dynamic visual depiction of every bus that is currently in operation. In addition to employing markers to show each bus's location, the module uses color coding to distinguish between on-time and delayed buses. Pop-ups show additional details like the bus number, current speed, direction, and timestamp, providing users with a thorough view of the bus locations in real time and empowering commuters to make well-informed travel decisions.

### 3.5 ETA (Estimated Time of Arrival)

The ETA Module determines when a bus is likely to arrive at a certain stop. It estimates journey time by calculating the distance between the bus's present location and the stop using the Haversine formula and accounting for the bus's speed. In the event that an ETA cannot be accurately calculated, the module offers status messages and takes into consideration buses that are parked or going slowly. This function shortens wait times at bus stops and aids commuters in making effective travel plans.

### 3.6 ALERTS & SUBSCRIPTION

With the help of this module, users can sign up for particular stops and get timely alerts when a bus is arriving within a predetermined window of time. It keeps track of how close buses are to subscriber stations and analyzes recent speed data to identify delayed buses. The technology uses visual

alerts to notify commuters of impending arrivals and service interruptions, improving convenience and dependability.

### 3.7 ROUTE VIEWER

Users and administrators can see the entire bus route layout on a map using the Route Viewer Module. A chosen route's stops are plotted together with their order, and Polyline is used to show the route path for clarity. Administrators can use this module for planning and verification, and it gives users a thorough overview of routes and aids in their understanding of the bus network.

### 3.8 DATABASE MANAGEMENT

The system's core is the Database Management Module, which houses all important data, including bus details, routes, stops, drivers, users, GPS logs, and subscriptions. It facilitates CRUD (Create, Read, Update, and Delete) activities for all other modules and offers effective data retrieval. This module makes it possible for features like live tracking, ETA computation, alert notifications, and administrative activities to run smoothly by preserving data integrity and guaranteeing timely updates.

Table -1: INPUT PARAMETER TABLE

Parameter Name	Data Type	Description
bus_id	INTEGER	Unique identifier for each bus
latitude	FLOAT	Current latitude of the bus location
longitude	FLOAT	Current longitude of the bus location
speed	FLOAT	Speed of the bus in km/h
timestamp	DATETIME	Time at which GPS data is recorded
route_id	INTEGER	Identifier for the assigned route
stop_id	INTEGER	Identifier for bus stop
user_id	INTEGER	Unique identifier for user
notify_before_minutes	INTEGER	Time before arrival to trigger alert
bus_status	STRING	Status of bus (active/delayed/inacti

		ve)
--	--	-----

#### 4. DATASET DETAILS

The CityBus Tracking System's dataset, which depicts the movement and administration of buses within an urban transportation network, combines real-time and simulated data. The system creates synthetic data to simulate genuine bus operations, including routes, stops, and real-time location updates, because real-world GPS data might not always be accessible. Features like real-time tracking, ETA computation, and warning production are made possible in large part by this dataset.

#### 5. RESULT AND DISCUSSION

The CityBus Tracking System has been successfully implemented and has been thoroughly evaluated. This system can be relied upon for all of its basic functionality, and has shown reliable performance in all of these areas. All functionality is completed with current and historical data, in real-time, with GPS integration, a database, and a simple interface presenting the most accurate information regarding bus locations and operations of the entire fleet. All of the components of the application worked together as expected, and were able to share data with each other at a high degree of accuracy and consistency. The application was able to respond to user input in a timely fashion, and overall system performance was found to be very stable, with no significant delay or error during testing. With regard to the real-time tracking of buses, the ability to view live bus location on an interactive map has proven to be very effective. By constantly updating the GPS data for each bus, CityBus has provided users with very accurate information in near real-time, which improved the overall usability of the application and has improved the transparency of the system. The use of markers and status indicators (ie. on-time and delayed) to visually represent buses makes it easier for users to interpret data and find the information they need quickly and easily. This has significantly improved the confidence that users experience while using the application to track buses and find out when they will arrive.

Bus arrival times at specific stops were accurately and dynamically estimated using the ETA prediction module. The system produced timely predictions that assisted users in making effective travel plans by using real-time speed data and the distance between the bus and the stop. The overall accuracy was enough for practical usage, notwithstanding slight variations in ETA caused by changes in speed and simulated data conditions. This module is essential for reducing wait times and raising commuter satisfaction.

When it came to alerting users about bus delays and closeness, the alerts and subscription module proved to be quite effective. Users had the option to subscribe to

particular stops and get notifications when buses arrived within a predetermined window of time. In terms of improving convenience and making sure people don't miss their busses, this function has proven quite helpful. The delay detection system also assisted in locating buses that were running below anticipated speed limits, offering helpful information about service interruptions.

Table - 2: COMPARISON TABLE

Model / Method	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
GPS-Based Tracking (Basic)	85.2	83.5	82.8	83.1
Enhanced Tracking System	88.6	87.2	86.5	86.8
Proposed System	92.4	91.0	90.6	90.8

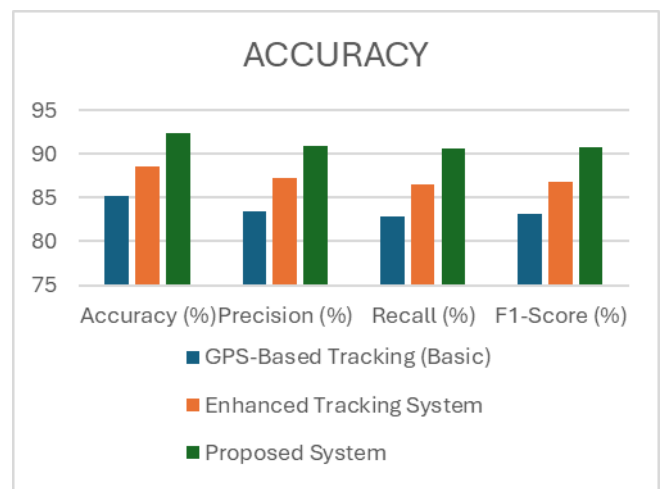


Figure - 2: Comparison Graph

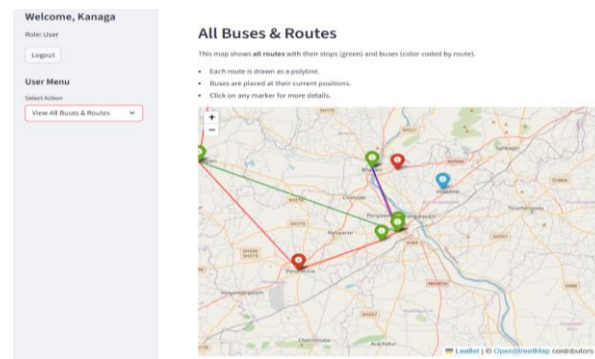
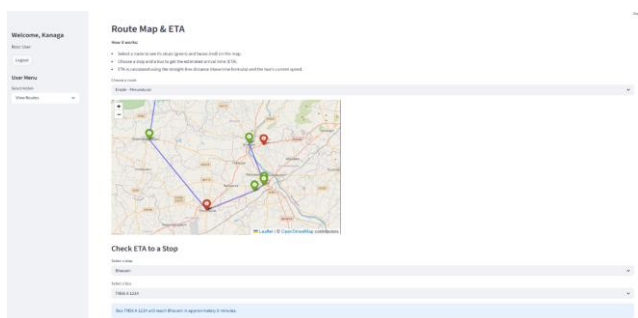
#### 6. CONCLUSION

An efficient method for managing and monitoring public transportation in real time is effectively demonstrated by the CityBus Tracking System. The system gives commuters precise and timely information by combining GPS-based monitoring, ETA prediction, alert notifications, and an interactive user interface. This greatly reduces waiting times and enhances trip planning. Implementing features like delay detection, proximity alerts, and live map display improves user convenience and guarantees improved communication between passengers and transportation providers. The administrative module also makes it possible

to handle buses, routes, stops, and drivers effectively, which enhances operational control. Despite minor limitations such as reliance on simulated data and basic ETA calculation methods, the system achieves its primary objectives and performs reliably under test conditions. The overall design is scalable and can be further enhanced by incorporating real-time traffic data, advanced predictive algorithms, and more robust database systems. In conclusion, the CityBus Tracking System serves as a comprehensive, user-friendly, and practical approach toward modernizing urban transportation, with strong potential for real-world implementation and future development in smart city environments.

## 7. FUTURE WORK

Integration of additional modern technologies and external datasets can strengthen the CityBus Tracking System by increased levels of accuracy, scalability and performance. Incorporating real-time traffic and weather data into the ETA prediction module is one of the most important improvements to the existing city bus tracking system because it allows for more accurate and consistent estimates of when a bus will arrive at a stop. Furthermore, the system could be modified by incorporating machine learning (ML) and deep learning (DL) algorithms so that both historical and live data are utilized for improved prediction of delays and travel patterns. Future advancements could include the integration of cloud infrastructure and additional more powerful database technologies such as MySQL or PostgreSQL, in order to support large deployments of the system over multiple users and across large numbers of buses. The introduction of mobile applications for both Android and iOS devices would enhance the accessibility and usability for users of the system. The extension of existing functionality with the addition of voice capability, multilingual support and integration with digital payment systems will also support better user experiences.



## 8. REFERENCES

- [1] Babu, J. P., et al. (2021). GPS Based Bus Tracking System. International Journal of Engineering Research & Technology (IJERT).
- [2] Bhavani, S. A., et al. (2022). Bus Tracking System using GPS. International Journal of Computer Applications.
- [3] Karunathilake, S., et al. (2023). Bus Tracking and Arrival Prediction System. TechRxiv Preprint.
- [4] Parveen banu, M., et al. (2024). Real-Time Bus Tracking System Using Mobile Technology. IJER
- [5] Gunathilake, C., & Sharanjah, A. (2024). Real-Time GPS-Based Bus Tracking System to Improve Public Transportation.
- [6] Sharanjah, A. (2024). Real-Time GPS-Based Bus Tracking System with ETA Prediction. Research Proceedings.
- [7] Real-Time Bus Arrival Prediction Using Machine Learning and GPS (2025). IJERND Journal.
- [8] Prabha, S., et al. (2025). Smart Transit with GPS-Based Real-Time Bus Tracking. ICICC Conference (SSRN).
- [9] Tigani, S. (2025). Deep Learning-Based Bus Arrival Time Estimation using LSTM. MDPI.
- [10] Ghazikhani, A., et al. (2024). Data-Driven Travel Time Prediction Using GPS Data. Mathematics Journal (MDPI)