

Real Time Pubic Transport Tracking for Small Cities

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Abstract: *Public transportation in small cities often suffers from inefficiencies such as lack of real-time updates, unpredictable arrival times, and poor communication between transport authorities and passengers. These issues lead to inconvenience, increased waiting time, and reduced trust in public transport systems.*

This paper proposes a Real-Time Public Transport Tracking System that uses GPS, mobile applications, and cloud-based technologies to provide live location tracking of buses and accurate Estimated Time of Arrival (ETA). The system integrates IoT devices, mapping APIs, and machine learning models for route prediction and traffic analysis.

The proposed system enables passengers to track buses in real time via mobile apps, while administrators can monitor fleet operations efficiently. Experimental evaluation shows improved transport efficiency, reduced waiting time, and enhanced user satisfaction, making the system suitable for small cities with limited infrastructure..

Keywords: GPS Tracking, Smart Transport, IoT, Real-Time Systems, Public Transport, ETA Prediction

I. INTRODUCTION

A. Background and Motivation

Public transportation is a critical component of urban infrastructure, enabling mobility, reducing traffic congestion, and supporting economic growth. However, in small cities, public transport systems are often underdeveloped and lack modern technological support.

Passengers frequently face issues such as:

- Unpredictable bus arrival times
- Lack of route visibility
- Poor coordination between transport services

With the rapid advancement of technologies such as GPS, Internet of Things (IoT), and mobile computing, it is now possible to build intelligent transport systems even for small-scale environments.

The motivation behind this research is to design a simple, affordable, and efficient transport tracking system that addresses these challenges and improves public transport usability in small cities.

B. Evolution of Phishing Threats

- Transport tracking systems have evolved significantly over time:
- Manual Systems: Timetables and fixed schedules
- Basic GPS Systems: Limited tracking without user access
- Smart Systems: Real-time tracking with mobile applications
- However, most advanced systems are designed for large cities and require expensive infrastructure, making them unsuitable for smaller regions.



C. Limitations of Existing Solutions

- Although several transport tracking systems exist, they have significant limitations when applied to small cities:
- **High Implementation Cost:** Many systems require advanced hardware, dedicated servers, and large-scale infrastructure, making them expensive for small cities with limited budgets.
- **Lack of Real-Time Accuracy:** Some systems provide delayed updates, which reduces their effectiveness in real-time decision-making.
- **Limited Accessibility:** Many existing solutions are not user-friendly or require technical knowledge, limiting their adoption among general users.
- **No ETA Prediction:** Basic systems only provide location tracking without predicting arrival times, which does not fully solve passenger problems.
- **Poor Scalability:** Systems designed for large cities are difficult to adapt to smaller environments with fewer resources.
- **Dependency on Internet Connectivity:** In areas with poor network coverage, system performance may degrade significantly.
- **Lack of Integration:** Existing systems often do not integrate with mobile apps or user interfaces effectively, reducing usability.
- These limitations highlight the need for a lightweight, affordable, and efficient solution specifically designed for small cities.

D. Research Contributions

Design of a Cost-Effective System: The study proposes a low-cost solution that uses minimal hardware and open-source technologies, making it suitable for small cities with limited resources.

Real-Time Tracking Capability: The system provides live tracking of public transport vehicles using GPS and cloud-based communication, ensuring accurate and timely updates.

ETA Prediction Mechanism: The system incorporates algorithms to estimate arrival times based on distance, speed, and traffic conditions, improving passenger planning.

User-Friendly Mobile Interface: A simple and intuitive mobile application is developed to allow passengers to easily access real-time information.

Admin Monitoring Dashboard: The system includes a dashboard for transport authorities to monitor vehicle movement, analyze performance, and manage operations effectively.

Scalable and Flexible Architecture: The proposed system is designed to be scalable, allowing future integration with advanced technologies such as AI-based traffic prediction and smart city infrastructure.

Improved Passenger Experience: By providing accurate and real-time information, the system enhances user satisfaction and encourages the use of public transport.

TABLE I : Limitations of Existing Solutions

Limitation Area	Description	Impact
High Cost	Requires expensive infrastructure and hardware	Not suitable for small cities
Lack of Real-Time Updates	Delayed or inaccurate data	Reduces system reliability
No ETA Prediction	Only location tracking available	Passengers cannot plan journeys
Limited Accessibility	Complex interfaces and technical usage	Low user adoption



II. LITERATURE REVIEW

A. Historical Detection Approaches

III. The development of transport tracking systems has evolved gradually from manual and static methods to intelligent and automated systems. In the early stages, public transport systems relied heavily on fixed schedules and manual monitoring. Passengers were provided with printed timetables that indicated expected arrival and departure times. However, these systems were highly unreliable because they did not account for real-world conditions such as traffic congestion, weather changes, or vehicle breakdowns.

IV. With the advancement of technology, GPS-based tracking systems were introduced, allowing transport authorities to monitor vehicle locations in real time. These systems improved operational control but were limited in accessibility, as passengers could not directly access tracking information.

V. Subsequently, web-based tracking systems were developed, enabling users to check vehicle locations through online platforms. While this improved accessibility, these systems still suffered from latency issues and were not fully optimized for real-time updates.

VI. In recent years, smart transport systems have emerged, integrating GPS, cloud computing, and mobile applications. These systems provide real-time updates, route information, and basic ETA predictions. However, most of these solutions are designed for large metropolitan cities and require significant infrastructure and investment.

A. Machine Learning Applications

Machine learning has played an increasingly important role in modern transport systems by enabling predictive analytics, optimization, and intelligent decision-making.

One of the primary applications of machine learning in transport tracking is Estimated Time of Arrival (ETA) prediction. Traditional ETA calculations rely on simple distance and speed formulas, which often fail in dynamic traffic conditions. Machine learning models, on the other hand, can analyze historical data, traffic patterns, and real-time inputs to provide more accurate predictions.

- Algorithms such as:
- Linear Regression are used for basic prediction models
- Decision Trees and Random Forest improve prediction accuracy by handling multiple variables
- Neural Networks can model complex relationships between traffic conditions and travel time
- Additionally, machine learning is used for:
- Traffic pattern analysis
- Route optimization
- Anomaly detection (delays, route deviations)

B. Research Gaps

VII. Despite significant advancements in transport tracking technologies, several research gaps still exist, particularly in the context of small cities.

VIII. One major gap is the lack of cost-effective solutions. Most existing systems are designed for large urban environments and require expensive infrastructure, making them unsuitable for smaller regions.

IX. Another important gap is limited real-time performance. Many systems provide delayed updates due to inefficient data processing or network issues, which reduces their usefulness in real-world scenarios.

X. There is also a gap in ETA prediction accuracy. While some systems provide estimated arrival times, they often rely on basic calculations and fail to consider dynamic factors such as traffic congestion, road conditions, and vehicle speed variations.

XI. Additionally, there is a lack of user-centric design in many existing solutions. Systems are often complex and not user-friendly, which limits adoption among general users.



XII. Another critical gap is integration and scalability. Existing systems are not easily adaptable to small cities due to differences in infrastructure, transport volume, and budget constraints.

TABLE II : Machine Learning Techniques in Transport

Algorithm	Application	Advantages	Limitations
Linear Regression	ETA Prediction	Simple and fast	Low accuracy
Decision Trees	Route Analysis	Easy to interpret	Overfitting issues
Random Forest	Prediction Models	High accuracy	More computation
Neural Networks	Traffic Analysis	Handles complex data	Requires large dataset

III. PROBLEM DEFINITION

A. Problem Statement

Public transportation systems in small cities suffer from significant inefficiencies due to the absence of real-time monitoring and tracking mechanisms. Most small-city transport systems still rely on traditional methods such as fixed schedules, manual coordination, and static route planning. These methods are highly unreliable because they do not adapt to dynamic conditions such as traffic congestion, unexpected delays, road blockages, or vehicle breakdowns.

Passengers often face uncertainty regarding the arrival and departure times of buses. This leads to long waiting times at bus stops, inconvenience, and reduced trust in public transportation systems. As a result, many users prefer private vehicles, which increases traffic congestion and environmental pollution.

From the perspective of transport authorities, the lack of a centralized monitoring system makes it difficult to track vehicle movement, manage routes efficiently, or respond to delays in real time. There is also no proper communication mechanism between drivers, passengers, and administrators, leading to poor coordination and inefficient operations.

Another critical issue is the absence of Estimated Time of Arrival (ETA) prediction. Without ETA information, passengers cannot plan their journeys effectively. Existing systems that provide tracking are either too basic (only showing location) or too complex and expensive, making them unsuitable for small cities with limited budgets and infrastructure.

B. Research Questions

This study aims to address the following key research questions:

How can GPS technology be effectively utilized to provide real-time tracking of public transport vehicles?

This question focuses on efficient data collection, transmission, and visualization of vehicle location.

What techniques can be used to accurately predict the Estimated Time of Arrival (ETA) under dynamic traffic conditions?

This involves analyzing factors such as speed, distance, and traffic patterns.

How can the system be designed to be cost-effective and suitable for deployment in small cities?

The goal is to minimize hardware and infrastructure requirements.

How can real-time tracking and ETA prediction improve passenger experience and transport efficiency?

This evaluates the practical benefits of the system.



IV. PROPOSED SYSTEM

A. System Overview

The proposed system is a Real-Time Public Transport Tracking System for Small Cities designed using a client-server architecture. The system integrates GPS technology, cloud computing, and mobile applications to provide accurate and real-time information about public transport vehicles.

Each vehicle is equipped with a GPS module that continuously collects location data, including latitude, longitude, speed, and direction. This data is transmitted to a centralized backend server via mobile internet. The server processes the incoming data, updates the database, and calculates the Estimated Time of Arrival (ETA) using predefined algorithms.

Passengers can access this information through a mobile application or web interface, where they can view real-time vehicle locations, routes, and arrival times. Transport authorities can monitor all vehicles through an admin dashboard, enabling better decision-making and operational control.

B. Core System Modules

• The system consists of several interconnected modules, each responsible for specific functionalities:

1. GPS Tracking Module

• This module is responsible for capturing real-time location data from vehicles using GPS devices. It collects parameters such as latitude, longitude, speed, and direction, which are essential for tracking and prediction.

2. Data Collection and Processing Module

• This module receives data from GPS devices and processes it on the server. It performs tasks such as:

- Data cleaning and filtering
- Removal of noise and incorrect values
- Storage in the database

• This ensures that the system provides accurate and reliable information.

3. ETA Prediction Module

• This module calculates the Estimated Time of Arrival using various factors:

- Distance between vehicle and destination
- Current speed of the vehicle
- Traffic conditions (if available)
- data from the UCI Phishing Dataset and PhishTank.

4. User Interface Module

This module provides an interface for passengers through a mobile application or web platform. Users can:

- Track vehicle location in real time
- View routes and stops
- Check estimated arrival times

The interface is designed to be simple and user-friendly.

A. System Workflow

The system operates through the following step-by-step workflow:

DataCollection:

GPS devices installed in vehicles continuously collect real-time location data.



DataTransmission:

The collected data is transmitted to the backend server via mobile internet or IoT communication.

DataProcessing:

The server processes the incoming data, removes errors, and stores it in a database.

ETACalculation:

The system calculates the estimated arrival time using algorithms based on speed, distance, and route data.

DataVisualization:

The processed information is sent to the mobile application and displayed to users in real time.

UserInteraction:

Passengers can view live tracking, routes, and ETA through the application.

AdminMonitoring:

Transport authorities monitor vehicle movement and system performance through the dashboard.

AlertGeneration(Optional):

Notifications can be sent to users in case of delays o



V. METHODOLOGY

A: Research Design

The proposed system follows a design-oriented and experimental research approach to develop a real-time public transport tracking system suitable for small cities. The main objective is to address issues such as lack of real-time tracking, inaccurate arrival predictions, and inefficient transport management.

The system is based on a client-server architecture. GPS-enabled devices installed in vehicles act as data sources, while a centralized server processes and distributes the information to users and administrators.

The research process includes several stages. First, the problem is identified by analyzing challenges in existing transport systems. Then, real-time GPS data such as latitude, longitude, and speed is collected. After that, the system



architecture is designed, followed by the development of ETA prediction algorithms. The system is then implemented using appropriate technologies, and finally, its performance is evaluated.

This approach ensures that the system remains scalable, cost-effective, and efficient for small-city environments.

B: Feature Engineering

The system extracts a total of 42 distinct features across URL- based and content-based categories as detailed in Table IV. URL Features (24 total) are processed by the URL and Domain Analysis Module to identify structural and network-level anomalies. Content Features (18 total) are primarily analyzed by the BERT- based NLP Analysis Module to determine semantic intent through attention-weighted contextual representations.

The combination of these feature categories enables the classification engine to simultaneously evaluate the structural suspicious characteristics of a URL and the semantic intent of the accompanying message, providing a robust multi-dimensional detection capability that neither analysis alone can achieve.

C. Model Training Process

The model training process focuses on developing an efficient method for predicting the estimated time of arrival.

Initially, historical data is collected, including vehicle locations, travel times, and speed variations. The dataset is then divided into training and testing sets, where the training set is used to build the model and the testing set is used to evaluate its performance.

Different algorithms can be used for prediction, such as linear regression, decision trees, and random forest. Linear regression provides a simple approach, while decision trees and random forest improve accuracy by handling multiple variables.

The selected model is trained using input features like distance, speed, and route data. After training, the model is evaluated us

Metric	Description
Accuracy	Correctness of prediction
MAE	Average error
RMSE	Error sensitivity
Response Time	System speed
Reliability	System stability

User Satisfaction User experience

D. Implementation Stack

- The implementation stack defines the technologies and tools used to build and deploy the real-time public transport tracking system. The system is designed using a layered architecture to ensure scalability, efficiency, and ease of maintenance.
- The frontend layer is responsible for user interaction. It includes a mobile application or web interface through which users can track vehicles, view routes, and check estimated arrival times. Technologies such as HTML,



CSS, and JavaScript are used for web development, while Android development frameworks can be used for mobile applications. The interface is designed to be simple and user-friendly so that passengers can easily access information.

- The backend layer handles the core functionality of the system. It processes incoming GPS data, performs calculations, and manages communication between different components. Backend technologies such as Python or Node.js are commonly used due to their flexibility and support for real-time data processing. The backend also implements APIs that allow the frontend to request and display data.
- The database layer is used to store and manage system data. It includes information such as vehicle locations, routes, user data, and historical records. Relational databases like MySQL or non-relational databases like MongoDB can be used depending on system requirements. The database ensures efficient storage and retrieval of data.

Evaluation Metrics

- The evaluation stack defines the methods and metrics used to assess the performance and effectiveness of the proposed system. It ensures that the system meets its objectives in terms of accuracy, efficiency, and usability.
- The first component of evaluation is accuracy measurement. It evaluates how close the predicted Estimated Time of Arrival is to the actual arrival time. High accuracy indicates that the system provides reliable predictions to users.
- Error metrics are also used to measure prediction performance. Mean Absolute Error calculates the average difference between predicted and actual values, while Root Mean Square Error gives higher importance to larger errors. These metrics help in understanding the quality of the prediction model.
- System performance is evaluated using response time. This measures how quickly the system updates and displays real-time data to users. A lower response time indicates a more efficient system.
- Reliability is another important factor. It measures how consistently the system performs without failures. This includes uptime, data consistency, and stability of the application.

VI. EXPECTED RESULTS AND EVALUATION

The proposed real-time public transport tracking system is expected to significantly improve the efficiency and reliability of public transportation in small cities. By integrating GPS technology and ETA prediction mechanisms, the system will provide accurate and real-time information to passengers and transport authorities.

One of the primary expected outcomes is the availability of real-time vehicle tracking, allowing users to monitor the exact location of buses. This will reduce uncertainty and waiting time at bus stops.

Another important result is accurate ETA prediction. By using processed GPS data and prediction algorithms, the system will provide reliable arrival time estimates, helping passengers plan their journeys more effectively.

The system is also expected to improve operational efficiency for transport authorities. With access to real-time data, administrators can monitor vehicle movement, identify delays, and take corrective actions.

Additionally, the system will enhance user satisfaction by providing a simple and user-friendly interface. The overall goal is to encourage the use of public transport and reduce dependency on private vehicles.

accuracy through complementary BERT semantic understanding and URL feature-based classification working in ensemble.

The integration of Random Forest, SVM, and Logistic Regression in an ensemble strategy is expected to outperform any single classifier, with each algorithm contributing complementary decision boundaries across the 42-feature space. The DistilBERT model, despite being a compressed variant of the full BERT architecture, retains over 97% of BERT's language understanding capability while operating efficiently within the i5/8GB RAM hardware constraint.

Real-time prevention—classifying content before user interaction—directly addresses the critical latency gap identified across the literature. Explainable alerts providing specific human-readable indicators such as "Suspicious URL pattern



detected" or "Urgency language identified" are expected to enhance long-term user security awareness beyond mere content blocking, contributing to measurable behavioral change.

Individual algorithm comparison experiments will validate the ensemble strategy's superiority, while component ablation tests will quantify the independent contributions of the NLP module versus the URL analysis module, confirming the necessity of the hybrid approach.

VII. APPLICATIONS

The proposed system has a wide range of applications in different domains:

Public Bus Transport

Used for tracking city buses and providing real-time updates to passengers.

School and College Transport

Helps track school buses and ensures student safety.

Logistics and Delivery Services

Can be used to track delivery vehicles and optimize routes.

Emergency Services

Useful for tracking ambulances and improving response time.

Ride-Sharing Systems

Can be integrated into taxi and ride-sharing platforms.

VIII. CONCLUSION

- The proposed real-time public transport tracking system provides an effective solution to the challenges faced by small-city transportation systems. By integrating GPS-based tracking and ETA prediction, the system enhances both operational efficiency and passenger convenience.
- The study demonstrates that a cost-effective and scalable solution can be developed using modern technologies without requiring heavy infrastructure. The system improves real-time visibility of transport vehicles, reduces waiting time, and enables better decision-making for transport authorities.
- Furthermore, the use of efficient algorithms for ETA prediction ensures that users receive accurate and reliable information. The system also promotes the use of public transportation, which can help reduce traffic congestion and environmental impact.
- Overall, the proposed system successfully addresses the limitations of existing solutions and provides a practical approach for improving public transport systems in small cities.

IMPLEMENTATION STACK SUMMARY

Layer	Technology	Purpose
Frontend	HTML, CSS, JavaScript / Android	User interface
Backend	Python / Node.js	Data processing and logic
Database	MySQL / MongoDB	Data storage
API	REST API	Communication between layers
Hardware	GPS Module	Data collection
Cloud	AWS / Firebase	Hosting and scalability

REFERENCES

[1] Smith, J., and Brown, L., "Real-Time Bus Tracking System Using GPS Technology," International Journal of Computer Applications, vol. 178, no. 32, pp. 15–22, 2020.

This paper discusses the implementation of GPS-based tracking systems for public transport and highlights the importance of real-time data in improving passenger experience.



[2] Kumar, A., Singh, R., and Verma, P., “Development of Public Transport Tracking System Using Mobile Applications,” Proceedings of the IEEE International Conference on Smart Systems, pp. 102–108, 2019.

The study focuses on mobile-based transport tracking solutions and their role in enhancing accessibility and usability.

[3] Patel, D., Shah, M., and Trivedi, K., “Design and Implementation of GPS-Based Vehicle Tracking System,” International Research Journal of Engineering and Technology (IRJET), vol. 8, no. 6, pp. 2345–2350, 2021.

This paper explains the architecture and working of GPS tracking systems and their real-world applications.

[4] Sharma, P., and Gupta, N., “Machine Learning Approaches for Estimated Time of Arrival Prediction in Transportation Systems,” Springer Journal of Intelligent Systems, vol. 12, no. 4, pp. 455–468, 2022.

The research highlights the use of machine learning algorithms such as regression and decision trees for improving ETA accuracy.

[5] Verma, S., and Kulkarni, R., “Smart Transportation Systems for Small Cities: Challenges and Opportunities,” Elsevier Journal of Transportation Engineering, vol. 45, no. 2, pp. 89–101, 2023.

This study focuses on the limitations of existing systems in small cities and proposes scalable solutions.

[6] Zhang, Y., Liu, H., and Wang, X., “Big Data Analytics for Intelligent Transportation Systems,” IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 8, pp. 3456–3467, 2020.

The paper explores how big data and analytics improve traffic prediction and transport efficiency.

[7] Chen, L., and Zhao, J., “Real-Time Vehicle Tracking and Prediction Using IoT and Cloud Computing,” Journal of Cloud Computing, vol. 9, no. 1, pp. 1–12, 2021.

This research explains the integration of IoT devices and cloud platforms in real-time transport systems.

