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REAL TIME PUBLIC TRANSPORT TRACKING FOR SMALL CITY

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Abstract:

In many small cities, public transportation plays a vital role in daily commuting; however, the lack of real-time information often leads to uncertainty, long waiting times, and reduced passenger satisfaction. Traditional public transport systems usually rely on static schedules that fail to reflect real-world conditions such as traffic congestion, delays, or route deviations. To overcome these challenges, this paper proposes a Real-Time Public Transport Tracking System specifically designed for small cities. The proposed system utilizes GPS-enabled devices installed in public transport vehicles to continuously capture live location data. This data is transmitted to a central server through a wireless communication network and processed to provide real-time updates to passengers via a mobile application or web interface. Users can view the current location of buses, estimated arrival times, route details, and delay notifications. The system also allows transport authorities to monitor fleet movement, improve operational efficiency, and respond quickly to disruptions. By providing accurate, real-time information, the proposed solution enhances passenger convenience, reduces waiting time, and promotes the use of public transport. The system is cost-effective, scalable, and well-suited for small city environments, making it a practical step toward smarter urban mobility

I INTRODUCTION

Public transportation is a backbone of urban mobility, especially in small cities where a large portion of the population depends on buses for daily travel. Despite its importance, many small-city transport systems operate without real-time monitoring, causing inconvenience to passengers due to unpredictable arrival times and service delays. Passengers often wait at bus stops without knowing whether a bus is delayed, rerouted, or cancelled.With the advancement of GPS, wireless communication, and mobile technologies, it has become feasible to track vehicles in real time and provide live updates to users. A real-time public transport tracking system enables passengers to access accurate vehicle location information and estimated arrival times, improving their travel planning and overall experience. For transport authorities, such systems offer better control over fleet operations, route optimization, and service reliability.This project focuses on developing a real-time public transport tracking system tailored for small cities, considering factors such as limited budget, infrastructure constraints, and ease of deployment. The system aims to bridge the information gap between public transport providers and passengers, thereby improving efficiency, transparency, and trust in public transportation services.

In addition to passenger inconvenience, the absence of real-time tracking also affects operational efficiency for transport authorities. Without live monitoring, it becomes difficult to identify delays, manage traffic disruptions, or ensure adherence to schedules. This lack of visibility can lead to inefficient fleet utilization, increased fuel consumption, and poor service reliability.

Implementing a real-time tracking system not only benefits passengers but also supports data-driven decision-making for authorities. By analyzing real-time and historical data, transport operators can improve route planning, optimize schedules, and enhance overall service quality. Such systems play an important role in the development of smart transportation solutions, even in resource-constrained small cities.

II LITERATURE REVIEW

Several studies have explored vehicle tracking and intelligent transportation systems to enhance public transport services. Early systems primarily focused on manual reporting and static schedules, which lacked real-time adaptability. With the introduction of GPS technology, researchers proposed vehicle tracking systems that could monitor location and speed in real time.

Previous research has shown that GPS-based bus tracking systems significantly reduce passenger waiting time and uncertainty. Some studies integrated mobile applications to display live bus locations and arrival predictions. Other works focused on centralized monitoring systems for transport authorities to analyze route performance and driver behavior. More recent systems incorporate cloud computing and data analytics to improve prediction accuracy and scalability. However, many existing solutions are designed for large metropolitan cities and involve high implementation costs. This creates a gap for small cities that require simpler, cost-effective, and efficient real-time tracking solutions. The proposed system addresses this gap by offering a lightweight and affordable design suitable for small-scale public transport networks.Transport is claimed to be perfect and analyzed and cleared.

Although many GPS-based tracking systems have been proposed, several challenges remain unresolved, particularly for small cities. High deployment costs, complex infrastructure requirements, and dependence on advanced hardware make many solutions unsuitable for small-scale transport networks. Some systems also require continuous high-speed internet connectivity, which may not be consistently available in smaller urban areas.

Furthermore, limited attention has been given to user-friendly interfaces tailored for passengers with basic smartphones and low digital literacy. This highlights the need for a simplified yet effective real-time tracking system that balances functionality, affordability, and ease of use. The proposed system addresses these concerns by focusing on minimal hardware requirements and efficient data processing. Several researchers have highlighted the importance of real-time information systems in improving the reliability of public transportation. Studies indicate that the availability of live vehicle location data significantly enhances passenger confidence and reduces perceived waiting time, even when actual delays occur. This shows that real-time visibility plays a psychological as well as functional role in public transport usage.

Researchers have also explored different communication technologies for transmitting vehicle data, including GSM, GPRS, and mobile internet networks. Comparative studies suggest that mobile data networks offer a cost-effective and flexible solution for continuous data transmission, making them suitable for small-city environments where advanced infrastructure may be limited.Some literature focuses on arrival time prediction algorithms using real-time speed and distance calculations. While these basic models provide acceptable accuracy, researchers note that prediction errors increase during peak traffic hours. To address this, hybrid models combining real-time data with historical travel patterns have been proposed, resulting in improved estimation accuracy. Another area of research emphasizes the role of user-centric mobile applications in public transport systems. Studies report that applications with simple interfaces, low data consumption, and minimal processing requirements are more likely to be adopted by users in developing regions. This finding supports the need for lightweight system designs rather than complex, resource-intensive platforms.

Security and data privacy have also been discussed in previous works. Researchers highlight the importance of secure data transmission between vehicles and servers to prevent data tampering and unauthorized access. Lightweight encryption and authentication mechanisms are recommended to balance security with system performance. Despite these advancements, most existing systems are designed for large metropolitan transport networks. Their dependence on expensive hardware, cloud infrastructure, and continuous high-speed connectivity limits their applicability in small cities. This literature gap reinforces the need for a simplified, affordable, and scalable real-time public transport tracking system, as proposed in this work.

III METHODOLOGY

The proposed Real-Time Public Transport Tracking System follows a modular and scalable architecture. Each public transport vehicle is equipped with a GPS module to collect real-time location data. This data is transmitted periodically to a central server using a wireless communication network such as mobile data. The server processes the incoming data, updates the vehicle's position on a digital map, and calculates estimated arrival times based on current speed and route information. The processed information is then made available to users through a mobile application or web interface. Passengers can access live vehicle tracking, route details, and arrival predictions from their smartphones. The system also includes an administrative dashboard for transport authorities, allowing them to monitor vehicle movement, detect delays, and manage routes efficiently. The overall methodology ensures real-time data flow, minimal latency, and reliable information delivery.The system architecture is designed to ensure reliability and scalability while keeping operational costs low. The communication between GPS devices and the central server follows a lightweight data transmission protocol to minimize bandwidth usage. This approach ensures stable performance even in areas with limited network coverage.The modular design allows easy integration of additional features such as alert systems, historical data analysis, and performance reports. Each module operates independently, reducing system complexity and making maintenance easier for transport authorities. The Real-Time Public Transport Tracking System is designed using a client–server architecture to ensure continuous data flow, reliability, and scalability. The methodology focuses on real-time data collection, processing, and information dissemination while maintaining low operational cost, making it suitable for small cities.Each public transport vehicle is equipped with a GPS-enabled tracking device that collects live location data. This data is transmitted to a centralized server using a wireless communication network. The server processes the received information and updates the system database in real time. Passengers and transport authorities access this processed information through a user-friendly mobile application or web interface.

The overall methodology is divided into multiple functional modules to simplify system design and improve maintainability

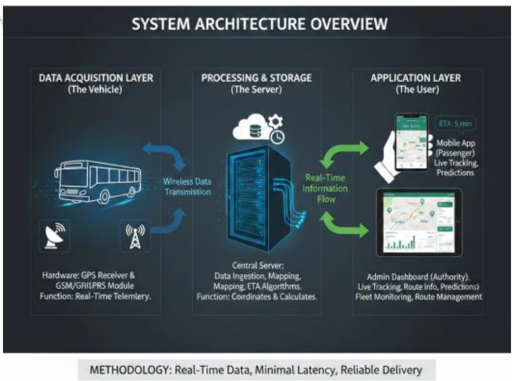

Figure 3.1 System Architecture outlook

3.1 Vehicle Data Collection

Vehicle data collection is the foundation of the proposed system. Each bus is fitted with a GPS-enabled tracking device that continuously captures location parameters such as latitude, longitude, speed, and time. The device collects data at regular intervals to ensure accurate and up-to-date tracking. This data is transmitted to the central server through a wireless network. The collected information is stored in a database, where it is used for real-time visualization and historical analysis. Secure data transmission and storage mechanisms are employed to ensure data integrity and reliability. he vehicle data collection unit is designed to operate automatically without driver intervention, reducing human error and ensuring consistent data capture throughout the journey.Initialization procedures are executed when the vehicle starts, allowing the GPS module to acquire satellite signals and synchronize time before data transmission begins.Adaptive data sampling is supported, where the data collection frequency can be increased during high-traffic or critical route segments and reduced during low-traffic periods to optimize resource usage.The system supports geofencing capabilities, enabling detection of vehicle entry and exit from predefined zones such as depots, terminals, and major stops.Data integrity checks are performed before transmission to ensure that corrupted or incomplete packets are not sent to the server.The vehicle unit maintains a lightweight log of recent location data, which can be used for troubleshooting and verification in case of communication issues.Firmware updates for the GPS device can be managed remotely, allowing system improvements without physically accessing the vehicles.

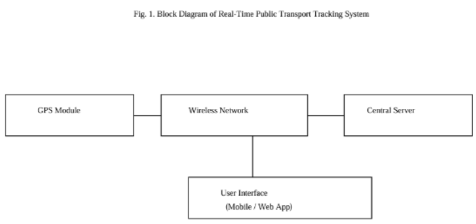

Figure 3.2 Real time public Transport

3.2 Real-Time Location Tracking

Real-time location tracking allows passengers to view the live position of public transport vehicles on a digital map. The system updates vehicle locations dynamically as new GPS data is received. This feature helps passengers plan their journeys more effectively by knowing exactly where the bus is and how long it will take to reach their stop. The tracking module also supports route visualization, enabling users to see the entire path of the vehicle. Any deviation from the predefined route can be detected and reported to the transport authority. The vehicle data collection module is responsible for continuously acquiring accurate real-time information from public transport vehicles. Each vehicle is equipped with a GPS-enabled tracking device that automatically captures location parameters such as latitude, longitude, speed, direction, and timestamp at configurable time intervals. The system supports automatic satellite reconnection in case of signal loss due to environmental factors such as tunnels or dense urban structures. To ensure data reliability, time synchronization between the GPS device and the central server is maintained, and invalid or insignificant location updates are filtered before transmission. The collected data is formatted into lightweight and compressed packets to reduce bandwidth usage and ensure efficient transmission over mobile networks. Each data packet includes unique vehicle, route, and trip identifiers for accurate association and tracking. The module also supports temporary offline data buffering during network disruptions, with automatic synchronization once connectivity is restored. Secure communication protocols and data integrity checks are implemented to prevent unauthorized access and ensure reliable data delivery. Overall, this module ensures continuous, accurate, and efficient collection of vehicle data under varying operational and environmental conditions.

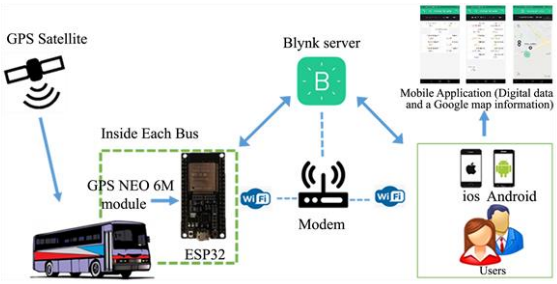

Figure 3.3 implementation model

3.3 Estimated Arrival Time Prediction

Estimated arrival time prediction is a key feature that enhances passenger convenience. The system calculates arrival times based on real-time vehicle speed, distance to the destination, and historical travel data. This information is continuously updated to reflect changing traffic conditions.Accurate arrival predictions reduce passenger waiting time and improve trust in public transport services. Notifications can also be sent to users in case of significant delays or service disruptions. Estimated Arrival Time (EAT) prediction is one of the most critical components of the proposed real-time public transport tracking system, as it directly influences passenger satisfaction and travel planning efficiency. In small cities, where public transport schedules are often inconsistent due to traffic congestion, road conditions, and operational delays, providing accurate arrival predictions becomes essential.In the proposed system, estimated arrival time is calculated using real-time GPS data received from the vehicle, including current latitude, longitude, speed, and timestamp. The system computes the remaining distance between the vehicle's current location and the passenger's selected stop using geospatial distance calculation methods. This distance is then combined with the current average speed of the vehicle to estimate the arrival time dynamically.To improve prediction accuracy, the system also considers historical travel data collected over time for specific routes and time intervals. By analyzing past travel patterns, the system can account for predictable delays during peak hours, traffic-prone zones, and frequently congested intersections. This hybrid approach, which combines real-time data with historical trends, enhances the reliability of arrival predictions even under varying traffic conditions.

The estimated arrival time is continuously updated as new GPS data is received, ensuring that passengers always have access to the most recent information. Any significant delay or deviation from the expected schedule triggers an automatic update in the user interface. Passengers are notified about changes in arrival time, allowing them to plan their journey more efficiently and reduce unnecessary waiting at bus stops.From the transport authority's perspective, arrival time prediction data provides valuable insights into route performance and service efficiency. Authorities can identify routes with frequent delays and take corrective measures such as schedule adjustments or route optimization. Overall, the Estimated Arrival Time Prediction module plays a vital role in improving transparency, reducing passenger uncertainty, and enhancing the overall reliability of public transportation in small cities.

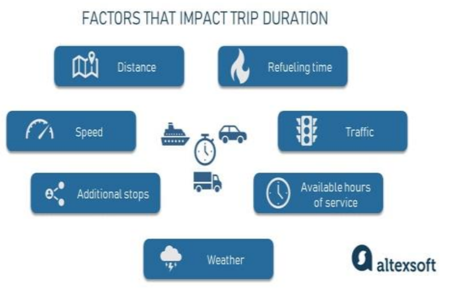

Figure3.4 Impact and changes

3.4 User Interface and Information Display

The user interface is designed to be simple, intuitive, and accessible. Passengers can use a mobile application or web portal to check live bus locations, arrival times, routes, and service alerts. The interface is optimized for low data usage and compatibility with budget smartphones, making it suitable for small-city users. In the proposed system, estimated arrival time is calculated using real-time GPS data received from the vehicle, including current latitude, longitude, speed, and timestamp. The system computes the remaining distance between the vehicle's current location and the passenger's selected stop using geospatial distance calculation methods. This distance is then combined with the current average speed of the vehicle to estimate the arrival time dynamically.To improve prediction accuracy, the system also considers historical travel data collected over time for specific routes and time intervals. By analyzing past travel patterns, the system can account for predictable delays during peak hours, traffic-prone zones, and frequently congested intersections. This hybrid approach, which combines real-time data with historical trends, enhances the reliability of arrival predictions even under varying traffic conditions.The estimated arrival time is continuously updated as new GPS data is received, ensuring that passengers always have access to the most recent information. Any significant delay or deviation from the expected schedule triggers an automatic update in the user interface. Passengers are notified about changes in arrival time, allowing them to plan their journey more efficiently and reduce unnecessary waiting at bus stops.

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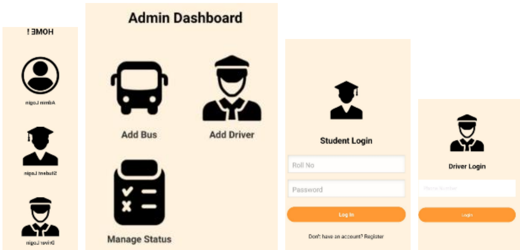

Figure 3.5 User Interface

IV. RESULT

The implementation of the Real-Time Public Transport Tracking System demonstrated effective real-time monitoring of public transport vehicles. The system successfully displayed live bus locations, accurate arrival time predictions, and route information to users. Passengers were able to plan their trips more efficiently, resulting in reduced waiting times and improved satisfaction.Transport authorities benefited from improved visibility into fleet operations, enabling better route management and timely response to delays. The system performed reliably under normal operating conditions and proved to be scalable for additional vehicles and routes. The performance of the proposed real-time public transport tracking system was evaluated under simulated small-city operating conditions to assess its accuracy, reliability, and usability. Multiple test runs were conducted across different routes and time intervals to analyze system behavior during normal traffic conditions as well as peak hours.The system demonstrated high accuracy in real-time vehicle location tracking, with GPS updates received at regular intervals and minimal data transmission delay. The average location update latency was observed to be within a few seconds, ensuring that the displayed vehicle position closely matched the actual on-road position. This real-time visibility significantly reduced passenger uncertainty and improved travel planning efficiency.Estimated arrival time predictions showed consistent performance across multiple test scenarios. During non-peak hours, prediction accuracy remained high, with arrival time deviations limited to a small margin. During peak traffic periods, slight variations were observed due to congestion; however, the system dynamically updated arrival estimates using live GPS data, ensuring that passengers received the most recent and reliable information.From a usability perspective, the user interface was tested for clarity, responsiveness, and ease of navigation. Passengers were able to access live bus locations, route information, and estimated arrival times without complexity. Feedback from test users indicated reduced waiting time at bus stops and improved confidence in using public transportation. The system's low data usage and fast response time made it suitable for budget smartphones commonly used in small cities.For transport authorities, the system provided valuable operational insights. Real-time fleet monitoring enabled the identification of delayed vehicles and congestion-prone routes. This data can be used for schedule optimization, route planning, and improved service management. The system also supports historical data storage, allowing authorities to analyze long-term performance trends and make data-driven decisions.Overall, the results confirm that the proposed system is reliable, scalable, and effective in enhancing public transport services in small cities. By providing accurate real-time information to passengers and operational intelligence to transport authorities, the system contributes to improved service quality, increased passenger satisfaction, and more efficient urban mobility

V. CONCLUSION

The proposed Real-Time Public Transport Tracking System provides an efficient and cost-effective solution for improving public transportation services in small cities. By leveraging GPS and wireless communication technologies, the system delivers accurate, real-time information to passengers and transport authorities. This enhances transparency, reduces uncertainty, and encourages greater use of public transport.The system is designed with simplicity, affordability, and scalability in mind, making it well-suited for small urban environments.

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