IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 2, November 2024

Real-Time Tracking System for City Bus Location And Passenger Count

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Abstract: *This survey paper reviews the advancements in real-time tracking and passenger counting systems for city buses, emphasizing the growing need for efficient, data-driven public transit solutions. As urban populations rise, city transport systems face challenges in managing demand, reducing congestion, and improving service reliability. Real-time tracking systems using GPS, GIS, and IoT-enabled sensors enable passengers and transit authorities to monitor bus locations and optimize travel times. Additionally, passenger counting systems—utilizing infrared, AI-based vision models, and pressure sensors—provide data on bus occupancy levels, allowing commuters to make informed travel decisions and helping transit agencies manage resources efficiently.*

This paper examines existing technologies, compares various tracking and counting methods based on accuracy, cost, and scalability, and explores recent trends in artificial intelligence, big data analytics, and smart city integration. Furthermore, it identifies critical challenges, including data privacy, accuracy in urban environments, and energy consumption, proposing future research directions for enhancing the reliability, sustainability, and user-friendliness of these systems. Our findings underscore the transformative potential of real-time bus tracking and passenger counting in advancing public transportation infrastructure and enhancing urban mobility.

Keywords: real-time tracking

I. INTRODUCTION

Efficient public transportation is a cornerstone of urban mobility, essential for reducing traffic congestion, lowering pollution levels, and providing accessible travel options for city residents. As urbanization intensifies globally, city transit systems are under pressure to handle increasing passenger volumes while maintaining high standards of reliability and convenience. However, challenges such as overcrowded buses, unexpected delays, and inconsistent scheduling can hinder the effectiveness of traditional public transit systems

To address these issues, real-time tracking and passenger counting technologies are emerging as vital tools. Real-time tracking systems enable commuters, city authorities, and transit operators to monitor bus locations, predict arrival times, and assess service delays in real-time, providing timely information to passengers and aiding transit agencies in better route management. Passenger counting technologies, meanwhile, offer valuable data on bus occupancy levels, helping to avoid overcrowded conditions and improve service planning. Together, these technologies enhance public transit services by giving passengers accurate information about bus locations and occupancy levels, enabling them to make informed travel decisions

The integration of GPS and GIS technologies, IoT-enabled sensors, and AI-powered data analytics has significantly advanced the capabilities of tracking and counting systems. By employing these technologies, transit agencies can optimize routes, enhance scheduling, and manage resources based on real-time demand patterns. Despite their advantages, however, implementing these systems presents challenges in terms of cost, accuracy, and data privacy. Data security protocols, sensor reliability, and energy efficiency must be carefully considered to ensure the successful deployment and sustainability of these systems in urban environments.

This survey paper reviews current technologies for real-time bus tracking and passenger counting, comparing methods based on key criteria such as cost-effectiveness, accuracy, scalability, and implementation challenges. Additionally, we

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explore recent advances in IoT, machine learning, and big data analytics that are shaping the future of public transit. By providing an overview of existing solutions and identifying future research directions, this paper aims to contribute to the development of efficient, data-driven public transportation systems that meet the evolving needs of modern cities.

II. RELATED WORK

Research on real-time tracking and passenger counting in public transportation has gained considerable momentum in recent years, with advancements in GPS, IoT, sensor technology, and data analytics leading the way. In this section, we review key studies and approaches, examining how they contribute to the development of effective public transit systems.

1. GPS-Based Tracking Systems

One of the foundational technologies for real-time bus tracking is GPS, which provides continuous location updates. Studies such as Wang et al. (2020) and Gupta et al. (2019) demonstrated the use of GPS and Geographic Information Systems (GIS) to enable real-time tracking, improving route efficiency and reliability. Many systems combine GPS data with other data sources, such as historical traffic patterns, to predict bus arrival times more accurately. Additionally, mobile applications like Google Transit and Citymapper have integrated GPS-based real-time data to deliver arrival estimates to users, a model that has become widely adopted by transit agencies globally.

2. IoT and Sensor Integration for Real-Time Tracking

Recent studies have emphasized IoT-enabled systems that offer scalable, low-cost solutions for public transit tracking. For example, Liu et al. (2021) introduced an IoT-based architecture where each bus is equipped with sensors that send location data to a central server through cellular or Wi-Fi networks. This setup reduces latency and allows for near-instantaneous location updates. Similarly, Banerjee and Roy (2020) proposed a smart bus tracking system that uses an integrated IoT and cloud computing framework, which processes data in real-time, making the system efficient and responsive even in peak traffic hours.

3. Passenger Counting Technologies

Passenger counting is crucial for managing occupancy levels, ensuring safety, and enhancing the commuter experience. Researchers have explored various counting technologies, including infrared and ultrasonic sensors, camera-based AI systems, and smart card readers. Studies like those by Park et al. (2019) and Choi et al. (2020) evaluated infrared sensor-based counting, which is affordable and effective for tracking boarding and alighting passengers. However, infrared sensors can sometimes be affected by environmental conditions, leading to inaccuracies.

Camera-based AI models, as presented by Zhang et al. (2022), use computer vision algorithms to count passengers based on video data, with high accuracy even in crowded conditions. Although effective, these systems require more processing power and storage, making them a costlier option for transit agencies. To address this, researchers are exploring lightweight AI models and edge computing to reduce bandwidth and processing demands

4. Machine Learning and Predictive Analytics for Arrival Times

Several studies leverage machine learning to improve ETA (Estimated Time of Arrival) predictions by analyzing historical data on travel times, passenger counts, and traffic conditions. For instance, Kumar et al. (2021) developed a predictive model that utilizes machine learning algorithms to estimate arrival times dynamically.

III. SYSTEM ARCHITECTURE AND PROPOSED SYSTEM

The proposed Real-Time Tracking System for City Bus Location and Passenger Count aims to overcome the limitations of existing transit solutions by providing a comprehensive, user-centered platform that integrates GPS tracking, IoT-based passenger counting, and data-driven analytics. This system is designed to deliver real-time bus locations, estimated arrival times, and live passenger occupancy data to both commuters and transit authorities. By enhancing information accuracy, accessibility, and operational efficiency, the proposed system aims to improve the urban transit experience for passengers while enabling better resource management for transit operators.

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Key Features of the Proposed System

Real-Time GPS-Based Bus Location Tracking

Each bus in the transit system will be equipped with a GPS module to provide real-time location data. This data will be transmitted continuously to a central server and made available to users through a mobile or web application.

The real-time tracking feature will allow passengers to view live bus locations on a map, along with estimated times of arrival (ETA) at each stop. This reduces uncertainty, allowing passengers to plan their commutes more effectively.

IoT-Enabled Passenger Counting System

The system will employ IoT-based passenger counting sensors, such as infrared sensors or camera-based solutions, at bus doors to count the number of passengers boarding and exiting in real-time.

This data will be aggregated and updated on the app to provide passengers with occupancy information for each bus, helping them avoid overcrowded buses and choose alternative routes if needed.

Data Aggregation and Processing on a Centralized Server

The proposed system includes a centralized server that aggregates location and passenger data from all buses, processing it to generate real-time insights. The server will also analyse historical data to identify patterns and peak travel times.

This infrastructure supports efficient data management and storage, enabling transit authorities to make data-driven decisions regarding schedules, route optimization, and resource allocation.

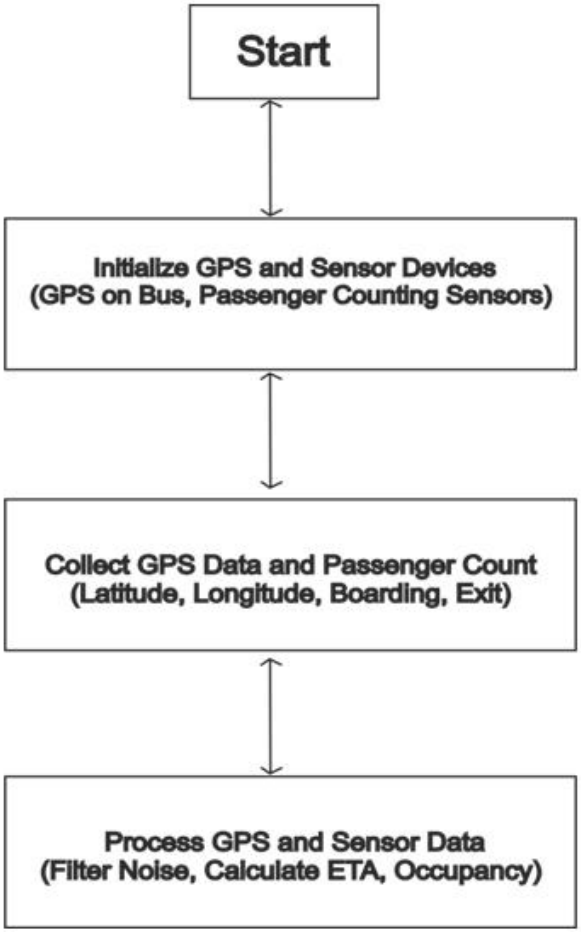

Fig. Activity Diagram

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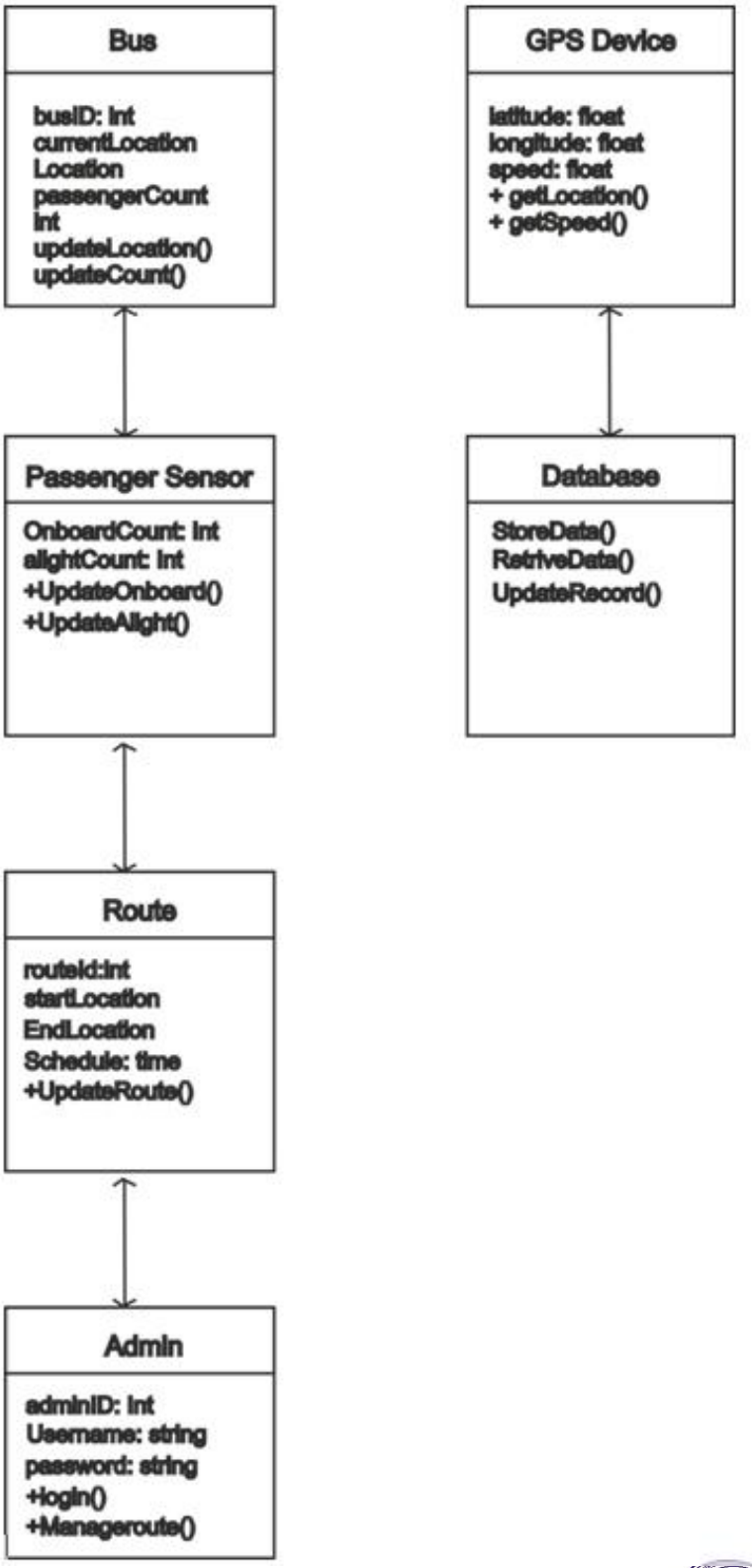

Fig. Class Diagram

DOI: 10.48175/IJARSCT-22155

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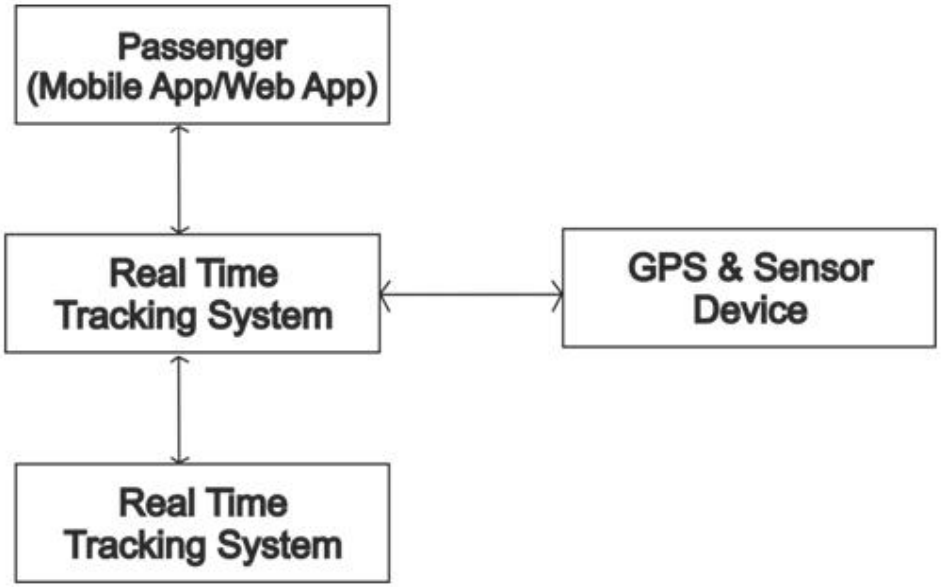

Fig. DFD Level 0

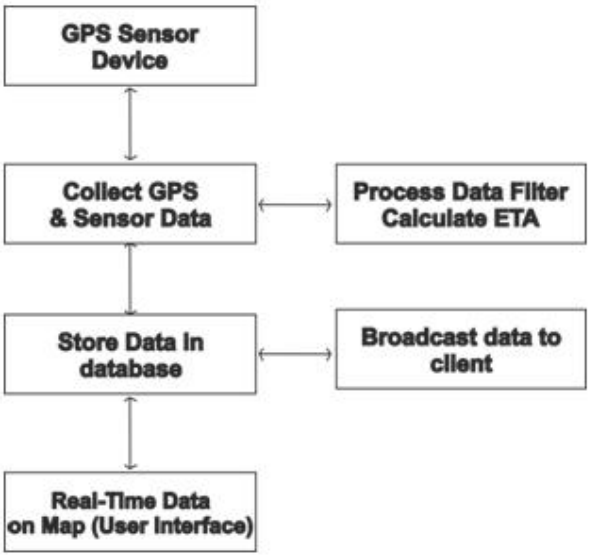

Fig. DFD Level 1

IV. ADVANTAGES AND DISADVANTAGES

Advantages

- Enhanced Passenger Experience
- Operational Efficiency for Transit Agencies
- Data-Driven Planning and Urban Development
- Safety and Security

Disadvantages

- High Implementation and Maintenance Costs
- Data Privacy and Security Concerns

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- Technical Challenges and Reliability Issues
- Power Consumption and Sustainability
- Dependency on Network Connectivity

Application

Passenger Convenience and Experience

- Real-Time Bus Tracking: Passengers can track the location of their bus in real time via mobile apps or websites. This ensures they can make informed decisions on when to leave for the bus stop, reducing waiting times.
- Estimated Time of Arrival (ETA): Passengers can view the exact ETA of the bus at their desired stops, making their commute more predictable.
- Occupancy Information: Passengers can see how full a bus is, enabling them to make decisions on whether to board or wait for a less crowded bus. This helps manage overcrowding, especially during peak hours.

Operational Efficiency for Transit Authorities

- Route Optimization: By tracking buses in real time, transit authorities can optimize bus routes, avoid congestion, and provide better service to underserved areas. The system can also recommend the best routes based on live traffic data.
- Schedule Adherence: The system can help ensure that buses adhere to their schedules by tracking delays and adjusting routes dynamically to accommodate traffic conditions.
- Real-Time Monitoring: Administrators can monitor the health of the entire bus fleet in real time, receiving alerts for delays, route deviations, or system malfunctions. This allows quick intervention and better management.
- Performance Analytics: Historical data on bus performance, passenger counts, and route efficiency can be analyzed to improve future service offerings, helping transit authorities make data-driven decisions.

Passenger Safety and Comfort

- Reduced Crowding: Real-time occupancy tracking enables the identification of overcrowded buses. Passengers can choose to wait for less crowded buses, which reduces the chances of uncomfortable or unsafe situations.
- Alerts for Service Disruptions: In case of service disruptions, accidents, or emergencies, passengers can be quickly informed via the app, helping them adjust their plans.
- Improved Security: Tracking buses in real time enhances the overall safety of passengers and drivers. Authorities can quickly locate buses in case of an emergency.

V. CONCLUSION

The Real-Time Tracking System for City Bus Location and Passenger Count represents a significant advancement in the management of public transportation systems. By integrating real-time GPS tracking, passenger counting sensors, and a centralized data system, the solution enhances operational efficiency, passenger convenience, and safety. The system enables passengers to track bus locations, estimate arrival times, and monitor bus occupancy, significantly improving the overall commuting experience.

For transit authorities, the system provides powerful tools for route optimization, schedule management, and performance monitoring. It also allows for real-time decision-making, making it easier to manage issues such as delays, overcrowding, and service disruptions. Furthermore, data collected through the system can drive valuable insights, leading to improved planning, resource allocation, and long-term infrastructure development.

The environmental benefits are also notable, as the system helps reduce fuel consumption, cut emissions, and alleviate traffic congestion by optimizing bus routes. The integration of dynamic pricing and seamless cashless payment options further contributes to enhancing the sustainability and user experience.

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In conclusion, the implementation of a real-time tracking system for buses not only improves the day-to-day operations of public transportation but also contributes to the overall goal of creating more efficient, accessible, and environmentally friendly urban mobility solutions. As cities continue to grow and urban transit demands increase, such technologies will play a pivotal role in shaping the future of public transport.

VI. FUTURE WORK

Real-time tracking and passenger counting systems for city buses continue to evolve, with many promising directions for future research and development. Below are key areas where further advancements could address current challenges and enhance the capabilities of these systems.

1. Enhanced Data Privacy and Security Protocols

Anonymization Techniques: Future research should focus on more sophisticated data Anonymization techniques that allow for effective passenger tracking without compromising individual privacy. Privacy-preserving models, such as differential privacy, could be explored to safeguard sensitive data.

Secure Data Transmission: Developing secure communication protocols to protect data transmitted over public networks is crucial. This includes encryption strategies and blockchain-based solutions to ensure data integrity and prevent unauthorized access.

2. Improved Accuracy and Reliability of Tracking in Urban Environments

Multi-Modal Location Tracking: Combining GPS with alternative tracking methods, such as Wi-Fi, Bluetooth, or cellular triangulation, can enhance accuracy, especially in areas with poor GPS signal reception.

Advanced Sensor Fusion: Research into integrating various sensors (e.g., cameras, infrared, and ultrasonic) can improve the accuracy of passenger counting, even under crowded or variable lighting conditions.

Environmental Adaptability: Developing algorithms that adjust for environmental factors (e.g., weather, signal interference) will help enhance system reliability in diverse urban settings.

3. Energy-Efficient and Sustainable Solutions

Low-Power Sensors and Devices: Designing power-efficient hardware, such as energy-saving GPS modules and low-power sensors, can reduce the energy consumption of these systems, making them more sustainable for large-scale deployment.

Battery Optimization and Renewable Power: Research on optimized battery management and alternative energy sources, such as solar power, can support continuous operation of tracking systems, particularly on electric buses with limited battery capacity.

Edge Computing: Implementing edge computing techniques to process data locally, rather than continuously sending data to a central server, can reduce energy consumption and network load, improving system efficiency.

4. Integration with Smart City Ecosystems

Interoperability with Other Transit Systems: Future work should focus on the interoperability of real-time bus tracking with other forms of public transit, such as trains and metros, to create a seamless city-wide transportation network.

Collaboration with Smart Infrastructure: Integrating real-time data with traffic signals, road sensors, and weather monitoring systems can enable dynamic traffic management, improving bus travel times and reducing congestion.

Data-Driven Urban Planning: More sophisticated data analytics platforms could allow city planners to use real-time tracking data to optimize routes, build infrastructure in high-demand areas, and enhance city-wide mobility.

REFERENCES

[1]. Namitha Devi N N, Hirabai, Lavanya, Ruchitha BT, Sukrutha R, "Real Time Bus Tracking System," International Journal of Advanced Research in Science, Communication, and Technology (IJARSCT), vol. 3, issue 10, May 2023

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[2]. MenziSkhosana, Absalom E. Ezugwu, "A Real-Time Machine Learning-Based Public Transport Bus-Passenger Information System," International Journal of Sustainable Development and Planning , vol. 16, no. 7, pp. 1221-1238, Nov 2021.

[3]. Jayaraam S P, Jayakumar D, M. Vanathi, B. Sandhiya, J. Karthika. "Bus Tracking System using Mobile GPS Technology." International Conference on Inventive Computation Technologies (ICICT 2024), doi : 10.1109/ICICT60155.2024.10544750, April 2024

[4]. Kute, S.V., Chothave, R.V., Khandre, K.S., Gorde, P.G., &Butkar, U.D. (2022). Bus Tracking System Using Mobile Application. International Journal of Advance Research and Innovative Ideas in Education, , 330-335. IJARIIE-ISSN(O)-2395-4396. vol-8 issue-3 (2022)

[5]. J. NavyaSree, C. Mounika, T. Mamatha, B. Sreekanth, N. Diwakar, Noor Mohammed, "Integrated College Bus Tracking System," Sanskrithi School of Engineering, Department of Computer Science and Engineering, Puttaparthi, Andhra Pradesh, India - May 2023.

[6]. A concise study on college bus tracking systems focusing on GPS-based real-time location monitoring, route management, and arrival predictions.

[7]. Thakur, M., & Agarwal, A. (2019). "Smart Public Transport System using IoT: A Review." International Journal of Advanced Computer Science and Applications (IJACSA), 10(4), 497-502.

[8]. A comprehensive review on IoT-based public transportation systems, including real-time tracking, occupancy monitoring, and automated reporting systems, which can be applied to city buses.