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Smart Public Transport Real-Time Location and Occupancy Monitoring for Buses

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Abstract: The current public transportation booking systems exhibit significant limitations in flexibility and real- time information delivery, leading to in efficient seat utilization and suboptimal user experience. Predominantly, these systems only permit passengers to book seats from the initial departure point of a bus to its final destination, disregarding intermediate stops. This constraint not only results in underutilized capacity and increased operational costs but also reduces system productivity. Moreover, existing platforms generally lack real- time occupancy data, preventing passengers from assessing whether a bus is full, overcrowded, or underutilized, thus further impacting travel decisions and satisfaction. This paper proposes a smart public transport solution that integrates real-time location referencing and manual occupancy monitoring for buses through a mobile application and a web-based administrative dash board. Unlike traditional systems, this approach allows passengers to book seats from any intermediate stop, thereby enhancing seat allocation efficiency. Instead of relying on automated sensors, the system adopts a manual headcount strategy by integrating with existing conductor-operated ticketing machines. When a ticket is issued, booking information is synchronized with the application, allowing it to infer passenger load dynamically for each route segment. The mobile application features dual authentication, supporting both passenger access and administrative control, enabling real-time updates of bus status and occupancy. The admin dashboard provides a comprehensive view of fleet activity and operational insights. This integrated system aims to improve operational productivity, enhance commuter experience, and support the development of more responsive and intelligent public transport services.

1. INTRODUCTION:

In the modern era of rapid technological advancement, digitalization has become a cornerstone across all sectors, including transportation. The integration of digital technologies in public transport systems plays a pivotal role in improving commuter convenience, operational efficiency, and service transparency. While metropolitan cities have adopted various digital platforms for transport management, many district-level and intra city bus services still rely on traditional, non-digital methods for ticketing and passenger tracking. A significant limitation in existing bus booking platforms is their inability to support ticket reservations from intermediate stations. Most systems only allow bookings from the initial departure point to the final destination, excluding passengers waiting at intermediary stops. Additionally, intra city buses operating within smaller districts often do not employ any form of real-time occupancy tracking. As a result, passengers at bus stops remain unaware of the bus's crowd level, which may lead to discomfort, overcrowding, or missed opportunities to board. To address these shortcomings, this paper presents a smart public transport solution designed specifically to cater to intermediate stop bookings and provide real-time bus occupancy status.

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The proposed system includes a mobile application that enables passengers to book tickets between any two stops along a route, not just the endpoints. Furthermore, it offers live occupancy indicators such as "less crowded", "moderately crowded", or "overcrowded" to help passengers make informed travel decisions. Unlike systems that rely on automated sensors, our approach integrates with the ticketing machines used by conductors in intra city buses. When a ticket is issued, the application updates the current head count, providing real-time insight into bus occupancy. This manual-yet-digital hybrid approach ensures minimal infrastructure changes while achieving reliable data capture. The mobile application features dual authentication modes: one for passengers to book and view bus status, and another for transport department personnel to update bus details and occupancy. This ensures both user accessibility and administrative control within a unified platform. By bridging the gap between traditional and smart transport systems, the proposed solution aims to enhance accessibility, reduce inconvenience at intermediate stops, and improve the overall efficiency of intra city public transportation services.

2. METHODOLOGY

Existing System:

The existing bus ticketing infrastructure mainly employs centralized web and mobile-based solutions that enable end-to-end online booking of tickets from the departure station to the destination station. The systems are also coupled with GPS modules to offer real-time tracking of buses along with seat availability to the end consumers. Nevertheless, the architecture is restrictive in nature, as it does not provide for dynamic ticket assignment to boarding passengers from intermediate stops. For intra-city bus operations, current platforms are not equipped with sophisticated functionalities like real-time crowd intensity estimation and passenger headcount monitoring at bus stops, which limits their efficiency and scalability in handling high-frequency urban transit operations.

Proposed System Overview:

The solution under consideration implements an integrated intelligent transport management system with the aim of optimizing intra-city and inter-district bus operations by virtue of real-time monitoring, dynamic seat management, and automated service updates. In city-to-city operations, the software program is integrated with the electronic ticketing machine (ETM), where transaction data in real time is updated to compute seat occupancy levels. In inter-district operations, the model adds functionality where users can check for seat availability, pre-book seats, and view live route information so that their long-distance travel experiences are seamless and hassle-free. The system also provides twin authentication, giving the commuters access for booking, live status updates, and occupancy surveillance, while transport agencies have access to manage arrivals, delays, departures, and incidents.

Fig 1: Block diagram of proposed solution

Mobile Application for reservation the mobile application is developed using Flutter with the integration of the Google Maps API for live bus tracking and geo location capabilities. It has a two-factor authentication system in place, with role-based access control: passengers are granted access to features like ticket reservations, route choice, and real-time occupancy information, while drivers and transport authorities are provisioned with administrative rights to update operational information such as arrivals, departures, delays, or incident reports (e.g., break downs, accidents).This design guarantees secure data transfer, real-time synchronism, and enhanced transport management system reliability.

Mobile Application for intracity buses:

The mobile app includes a real-time intra-city bus tracking module connected to the Electronic Ticketing Machine (ETM) used by conductors. The ETM feeds transactional and passenger volume data in real-time through secure APIs to the backend server, which synchronizes with the mobile app. This integration facilitates automatic occupancy detection, crowd-level estimation in real-time, and real-time updates for commuters, improving transparency and operational efficiency.

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3. LITERATURE SURVEY:

Real-time passenger count system for smart transportation Public transportation systems often face challenges such as ticketing processes and lack of real-time information on seat availability. In response to these issues, this research proposes the implementation of a Real-Time Passenger Count System (RTPCS) to enhance the efficiency, transparency, and passenger experience in smart transportation networks. The RTPCS utilizes advanced computer vision technology, specifically YOLO Version 8, to detect and count passengers entering and exiting from buses in real-time. By integrating this system into buses and displaying the information on screens at bus stops, passengers can access up-to-date information on seat availability, enabling them to make informed decisions about boarding. This research contributes to the field by addressing practical challenges in public transportation and proposing an innovative technological solution. Through a comprehensive review of existing literature, detailed system design, and rigorous evaluation, the effectiveness and feasibility of the RTPCS are demonstrated. The proposed system improves passenger satisfaction by providing real-time seat availability information.

Video-based automatic people counting for public transport:

Interest in Automatic People Counting (APC) for crowd detection and management is rapidly growing. While arrange of Internet of Things (IoT) sensors and systems exist, video analytics is emerging as a particularly attractive option especially for applications where more traditional methods of people counting are not available, unreliable or expensive. In this paper we focus on automatic people counting in the public transport context specifically, rail replacement bus services in which bus companies are typically contracted to provide bus.

Advance Public Bus Transport Management System:

The Advanced Public Bus Transport Management System (APBTMS) addresses in efficiencies in public transport by integrating IoT, GPS, and Computer Vision (CV) for real-time monitoring and data- driven operations. It enables live bus tracking, automated passenger density estimation, object detection, and safety monitoring of environmental factors such as accidents, fire, and road quality. A mobile app provides passengers with live updates, while transport authorities manage operations through a web plat form. Future enhancements like speed detection and extended safety features make the system scalable to school buses and other public transport services, ensuring smarter, safer, and more efficient transportation.

Design of an IOT-Based seat occupancy monitoring system for public transport:

With the rise in public transport users, managing revenue and ensuring transparency remain major challenges, particularly in Rwanda's bus sector, where unfair practices by drivers reduce reported income. Interviews with 20 bus owners and 18 company managers revealed that most drivers under report earnings, with 98% of owners and 90% of managers confirming significant losses. To address this, an IoT-based seat occupancy monitoring system has been designed to detect passenger seating, calculate distance traveled, and compute fares in real time, ensuring accurate revenue tracking without reliance on supervisors. The prototype enables companies to cut supervision costs, improve return on investment, and enhance operational transparency. Future extensions include vehicle condition monitoring, integration with mobile apps for passengers to view seat availability, and the application of AI to optimize system intelligence over time.

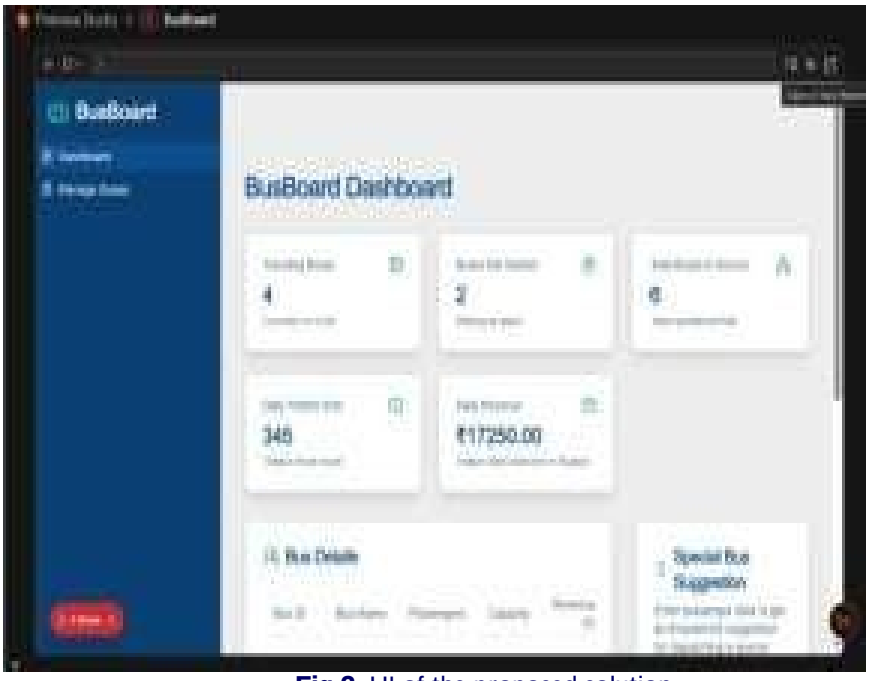

Fig 2: UI of the proposed solution

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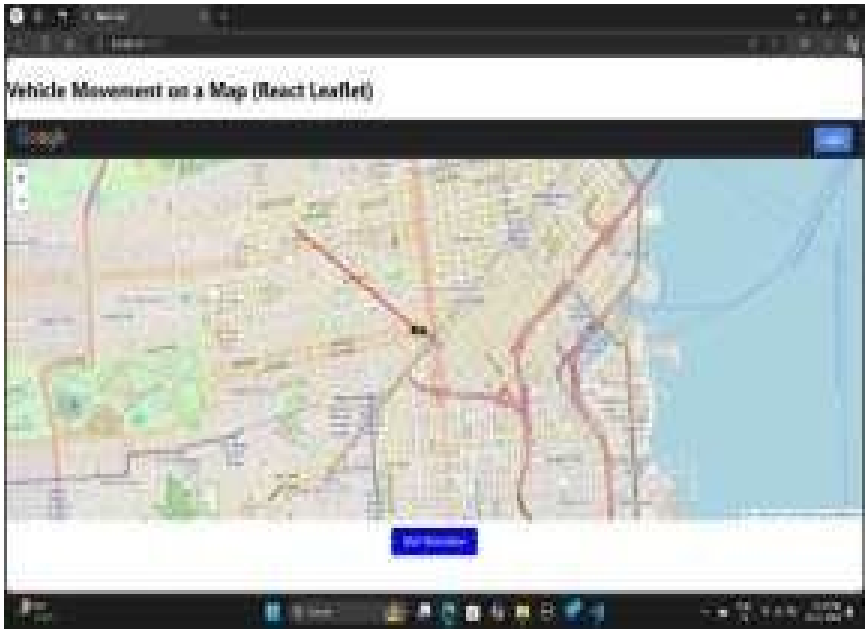

Fig 3: Vehicle track

4. CONCLUSION:

In the light of rising urban mobility needs, traditional reservation and bus tracking systems have limitations including the lack of support for dynamic ticket reservation and poor real-time passenger information. This paper addresses these issues through proposing a mobile app architecture that allows booking tickets from intermediate stops along the journey and integrating real-time bus location with occupancy detection to enhance situational awareness for passengers. The system takes advantage of a web- based management console that allows for transport authorities to conduct schedule management, route modification, and data synchronization in a simplified and effective way.

Through the combination of user-oriented mobile capability and operator-centric management platform, the solution improves scalability, maximizes resource use, and helps build a more intelligent and responsive public transportation system.

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