Advancements in Public Transport: Design and Implementation of an Android-Based Real-Time Bus Tracking System

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Abstract— In cities, bus transportation is becoming a vital form of transportation. Most people in cities and villages use this form of public transportation. But since nothing in life is flawless, there is one shortcoming with buses as well: passengers must wait too long for the bus to arrive without having knowledge of where the bus is. This shortcoming encourages the use of private vehicles, which leads to an increase in fuel consumption and pollution. People move from one city to another for a variety of reasons, such as education, employment, travel, and so forth; therefore, they may not be familiar with all the locations in the new city. They encounter challenges when trying to visit some of the city's new locations. The Indian Government has initiated the Smart Cities Mission to improve people's living quality in cities and towns by using best practices, information, digital technology, etc. Such people migrating from one city to another face the major problem of finding city buses. As they are new to the city, they are unaware of the city's bus timings and bus numbers. To solve these difficulties, this proposed system of bus app was created. The passengers would benefit from knowing the buses' approximate arrival times so they may schedule their travel accordingly rather than waiting for them. This app provides information on the arrival and departure times of metropolitan city buses and tracks them. Since most people have smartphones, the bus driver's phone was used to track all of the buses along the route and was embedded with the Google Maps API. Users may log in and see all the buses that are close by with live tracking. This smart bus app may help in solving locality identification problems for passengers.

Keywords—Smart Bus, Digital Technology, Google Maps API, Smart Cities

I. INTRODUCTION

Buses play a crucial role in day-to-day life by providing an affordable, reliable, and convenient mode of transportation for millions of people worldwide. Buses offer a more accessible mode of transportation for people who may not have access to personal vehicles or other forms of transportation. They operate on schedules and routes, making them a convenient choice for commuting to work, school, or other destinations. They also often have multiple stops, allowing passengers to get on and off at various locations along the route. Moreover, buses are typically more affordable than other modes of transportation such as cars, taxis, or ride-sharing services, making them a popular choice for budget-conscious travelers. There are buses available for passengers travelling to different locations, but not all passengers are aware of the bus information.

People don't know where public transit is currently located or when one will arrive at a specific bus stop. On finding a solution to this issue, public transportation will become more convenient and well-liked. Public moving to a different city also faces the lack of knowledge on public transport. There is a dependency needed on native people to know about public transport. Complete information, including the number of buses that travel to the desired location, bus numbers, bus timings, the routes that the bus would travel, and the time it would take for the vehicle to arrive at the location, would help passengers with various routes, track the bus's current location, and provide the accurate time for the bus to arrive.

Passengers can identify their buses and plan their journeys more effectively by being aware of bus information such as bus numbers, timings, routes, arrival and departure times, and live bus location. Every traveler should be aware of some essential information, and thanks to modern technology, doing so has gotten simpler. Through engaging apps, smartphones may offer a rich user experience. To avoid being late or missing the stop, passengers can use this real-time Android app to find the actual location of the bus.

There are many methods that attempt to address this issue, but the predictability and accuracy of these systems are not particularly trustworthy. Only the arrival and departure times of buses at their source and destination were supplied by certain applications. Such applications provide the estimated time of arrival considering parameters such as congestion time, signal time and time required for a passenger to get up and down from the bus [1]. Internet of Things (IoT) devices plays a major role in tracking the bus arrival time. Using an internet-based tracking web application [2], buses in Nagpur were tracked more accurately and effectively than they do now. This system will provide information on routes, bus status, bus schedules and the position of a bus without the need of GPS with the help of IoT device. According to Verma and Bhatia's research [3], GPS has a wide range of uses and may be used to track the routes and positions of moving vehicles. They create a web-based system that shows the user where the vehicles are

II. LITERATURE SURVEY

A real-time tracking system for public transport was created by Jerrin George [4] and employs LoRa wireless transmission to connect base stations and bus stops. The buses have RF transmitters that continually communicate information about the identify of the bus. When the bus enters range, RF receivers installed in the bus stop immediately transmit this information to the base station through LoRa communication. The base station's LoRa receiver gathers transit data from each of these bus stops within its coverage area, updates it as needed, and records all pertinent data in a database.

Min-Ki Kim et al [5] presents a comprehensive study on a smart bus tracking and routing system that uses GPS and GSM technology to provide real-time bus tracking and schedule information to passengers. Abdullah Alsamhi et al [6] and D. Dharshini et al [7] proposes a smart bus system that utilizes Internet of Things (IoT) and cloud computing technologies to optimize bus routes, monitor bus operations, and provide real-time information to passengers.

The Study by Marta Campos Ferreira et al [8] provides an overview of mobile ticketing systems for public transportation, including technologies such as NFC, QR codes, and mobile apps. G V Nivaan et al [9] examines the impact of a real-time bus information system on transit ridership and user satisfaction. This study found that providing real-time bus information through a mobile app led to a significant increase in transit ridership and improved user satisfaction.

K.Irene Monica et al [10] evaluates the impact of a smartphone app on commuter behavior and travel patterns. The study found that the app led to a significant reduction in travel time, improved trip planning, and increased use of public transportation. They suggested Google Maps, GPRS, and GPS (Global Positioning System) provides location-based services which moves increasingly vital in Smartphone.

Anjali Jain et al [11] developed a bus monitoring mobile phone app that allows users to precisely track the bus location and time of arrival at the bus stop. This employs high frequency RFID tags on the buses and RFID readers at the bus stops. Real-time RIFD tagging data is captured and transmitted to the cloud using a NodeMCU. Users may obtain real-time bus operating and status information through a cloud-based mobile app.

Damilola Oladimeji [12] discussed about the challenges, technologies and applications of smart transportation system. They provide a thorough grasp of the advancements in the aforementioned applications and look at the current research that bases its applications on these fields. Cell phones are likely the best options for developing IoT applications because to the invasion of these devices and their steadily increasing limit at a completely modest pricing. In [13], a methodology focused on the fusion of technological advancements, such as GPS and Android, is catered to that may assist travellers using a mobile phone to navigate through the present region of nearest transportation heading towards the bus station. The study in [14] creates an integrated framework model for the delivery of public services in SCs, which entails a public business model in addition to the technological underpinnings of service operations via hardware and software, as well as the regulation and monitoring of these functions. The difficulties with network design, operational planning, scheduling, and management of intelligent public transportation systems will be covered in this article [15].

III. PROPOSED FRAMEWORK

The current public transit system includes employing IoT devices, GPs trackers, or RFID tags to know when a bus will arrive. The usage of these technologies results in significant financial outlays. Many cities also have some kind of public transport scheduling system that informs passengers of the routes, timetables, and anticipated bus arrivals. Riders may have to rely on printed timetables or manually updated information at bus stops because these systems are frequently not real-time.

The Smart Bus App project aims to provide a comprehensive solution for commuters using public transportation, by providing real-time bus schedules and allowing users to purchase tickets and passes directly from their mobile devices. This mobile application will help users to plan their trips efficiently, navigate their journey, and track bus arrival times. The Smart Bus App is designed to be user-friendly and intuitive, ensuring that it can be easily used by a wide range of passengers. The project is motivated by the need to improve the experience for bus riders, by reducing the time and effort required to use public transportation even in non-familiar surroundings or cities. By providing real-time updates on bus locations and arrival times, the app aims to make bus travel more convenient and reliable. Additionally, by allowing users to purchase tickets and passes directly from their mobile device, the app will eliminate the need for paper tickets and reduce the time required to board the bus.

Smart Bus App project is aligned with the growing trend towards mobile technology and the increasing use of smartphones in daily life. By providing a mobile app that can be easily downloaded and used on iOS and Android devices, the Smart Bus App aims to reach the widest possible audience and encourage more people to choose public transportation as their preferred mode of travel. Overall, the Smart Bus App project has the potential to significantly improve the bus commuting experience, making it more efficient, convenient, and enjoyable for riders.

In this mobile app for public transportation, the features provided are real-time updates on bus schedules, routes and arrival times, as well as the ability to purchase tickets or passes directly from their mobile devices.

This app have been successful in reducing the time and effort required to use public transportation, as riders can access all the necessary information and services in one place. transportation. By offering real-time updates, a route planner, and the ability to purchase tickets or passes directly from a mobile device, the Smart Bus App will make the bus commuting experience more convenient, efficient and enjoyable for riders. Fig 1 presents an innovative approach to improve real-time bus tracking in public transport systems using Android-based technology.
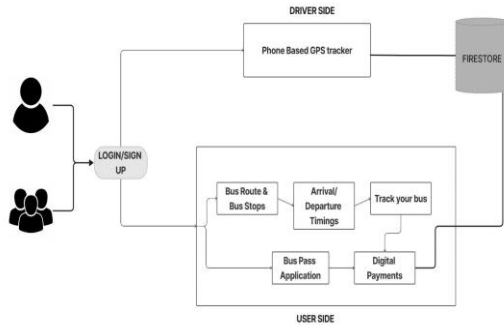

Fig. 1.   Block Diagram of Proposed Methodology

This smart bus app is implemented in Flutter for UI design with Firebase for backend process. Firestore to store and retrieve data for the app. Real-time tracking was implemented using the Firebase Realtime Database or Cloud Firestore to track the location of buses in real-time. Flutter's geolocator package is used to get the user's location. Google offers a wide range of APIs, including Maps API, YouTube API, Gmail API, and many others, that developers can use to integrate Google functionalities into their own applications, websites, or services.

IV.   WORKING PRINCIPLE

The working principle of Smart Bus covers the module implementation such as
- Driver Login
- Updating the Bus details
- Passenger Login
- Find My Location
- Bus Info/Route Info
- Integration of Payment Gateways

A. Driver Login

Flutter is used to create a role-based login page where authentication is dependent on the role. Both the driver and the passenger have unique IDs, and the screen is browsed in accordance with each one's function.

The system enables drivers to register their vehicles effortlessly through a dedicated sign-up button, as depicted in Fig 2. Leveraging the ubiquity of smartphones among the population, our solution utilizes these devices for live tracking purposes. Additionally, to address privacy concerns for drivers, we propose an alternative solution in the context of government-

owned buses, where low-cost smartphones can be installed onboard by the government. This paper explores the benefits and feasibility of both approaches, highlighting their potential to enhance efficiency, reliability, and passenger satisfaction in public transport systems.
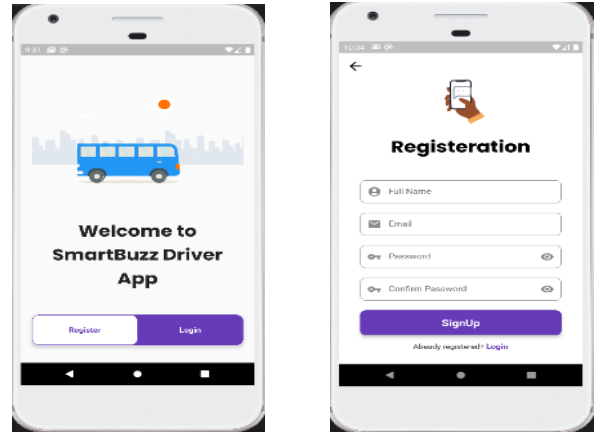

Fig. 2.   Driver Login and Sign Up Page

B. Updating the Bus Details

Upon logging in, the driver initiates the process by enabling location services on their smartphone. This action triggers the update of the bus's information, which is promptly reflected on the passenger side. The module focuses on the integration of mobile-based tracking technology, ensuring accurate and up-to-date bus tracking information.

Through this innovative approach, drivers can effortlessly contribute to the system while passengers benefit from reliable and synchronized real-time updates. Fig 3 delves into the technical details and implementation of this GPS-based bus tracking solution, highlighting its potential to enhance efficiency, convenience, and overall user experience in public transport.
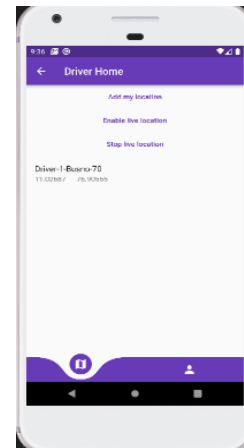

Fig. 3.   Enabling Driver Location to update Bus Details

C. Passenger Login

This module introduces a role-based authentication mechanism implemented in a real-time bus tracking system. The login page is designed to cater to different user roles, with a particular focus on passenger authentication. To log in,

passengers are required to provide their name, phone number, email address, and password, ensuring secure access to the system. This approach enables personalized tracking and communication features, enhancing the overall user experience. Fig 4 examines the implementation of role-based authentication, highlighting its significance in ensuring data privacy, security, and seamless user engagement within the bus tracking system.
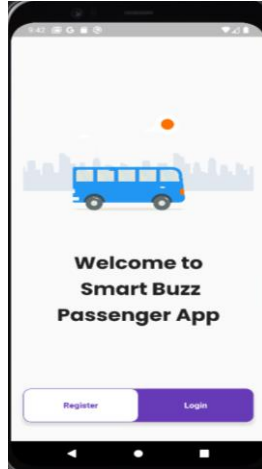

Fig. 4.   Passenger Login

D. Find My Location

The accompanying mobile app utilizes the GPS technology to track the passenger's location in real-time. Based on the user's location, the app provides relevant information about nearby buses, ensuring timely and convenient access to public transportation. Fig 5 shows the location identification of passenger.
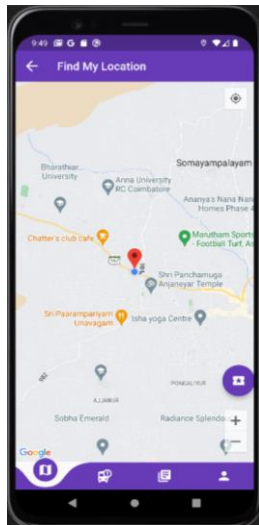

Fig. 5.   Location finding

E. Bus Info/Route Info

The system utilizes the knowledge of passengers' locations to retrieve relevant information such as bus numbers, routes, and timings from the database. By dynamically accessing this information, the system ensures that passengers receive accurate and up-to-date details about nearby buses, enabling them to

make informed decisions and plan their journeys more effectively. Fig 6 shows the available buses and their route.
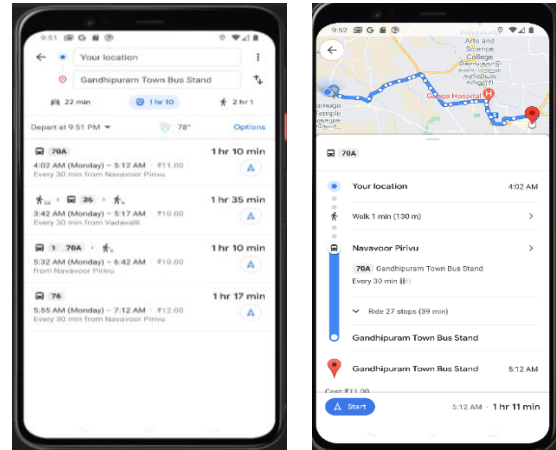

Fig. 6.   Bus Stop and Route View

Through a user-friendly interface, passengers can select the desired bus and initiate the tracking process. By clicking the "Track Me" button, the system promptly displays the bus's current location, providing real-time updates to the passengers. Fig 7 depicts the live tracking of the bus as per passengers needed route.
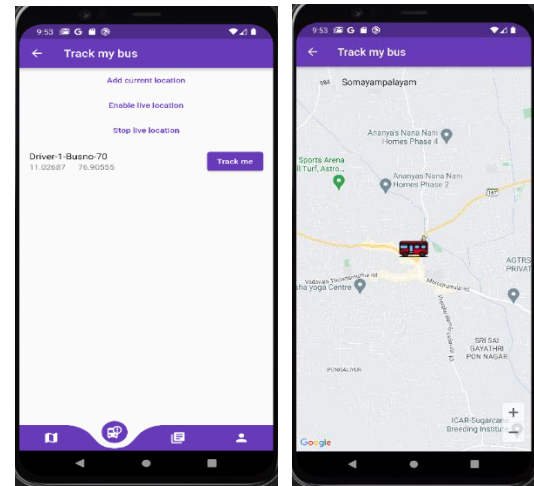

Fig. 7.   Live Tracking of the bus

F. Integration of Payment Gateways

Additionally, and optionally, Payment for bus ticket can be done through the App. The system utilizes Flutter, a versatile framework powered by the Dart programming language, to create a unified mobile app for both Android and iOS platforms.

The payment processing is facilitated by Razor pay, ensuring secure and convenient transactions. By leveraging Flutter's capabilities, business owners can efficiently transform their ideas into reality, overcoming resource limitations.

The proposed module as shown in Fig 8 streamlines the ticket purchasing process, providing a robust and efficient platform for business owners and enhancing the overall user experience.
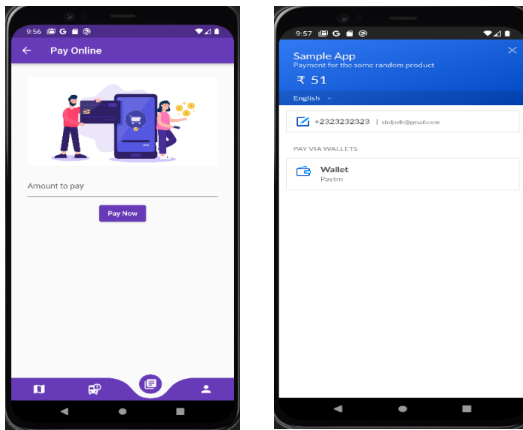
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Fig. 8.   Payment of Bus Fare

G. Merits

- **Convenience**: A smart bus app can give users access to real-time bus monitoring and schedule data, which can improve the convenience and effectiveness of commuting.
- **Increased ridership**: A smart bus app might boost ridership and improve traffic congestion by making it simpler for people to utilize public transit.
- **Cost savings**: By simplifying operations and lowering the requirement for physical infrastructure, smart bus applications can lower the operational expenses of public transportation networks.
- **Improved customer satisfaction**: A smart bus app can improve user experience by streamlining and streamlining the process of using the public transport system.
- **Environmental benefits**: Decreased carbon emissions and other environmental advantages can result from increased usage of public transit.

H. Demerits

- **Regular Updation**: To guarantee that they continue to work effectively and satisfy user expectations, smart bus applications need constant maintenance and upgrading, which may be expensive and time-consuming.
- **Privacy concerns**: Smart bus apps need to access private data, such as location information, which might cause privacy issues if handled improperly.

V.   CONCLUSION

A smart bus app can provide various benefits such as convenience, increased ridership, cost savings, improved safety, environmental benefits, improved customer satisfaction. However, there are also potential demerits such as a privacy concerns, technical difficulties, maintenance and updating costs, security risks, cost, and reliance on technology this app can track the location of buses in real-time and provide riders with up-to-date information on the bus's arrival time and location. It enables users to purchase and store their bus fare electronically,

reducing the need for cash transactions and making payment more convenient. It can show the bus routes and bus stops through which the bus is travelling. By knowing this people can plan their journey accordingly. Overall, a smart bus app has the potential to significantly improve public transportation systems, making them more efficient, convenient, and accessible for passengers. This can also be implemented in buses of educational institutions and corporates for the benefits of students and other people.

VI.   FUTURE SCOPE

- By notifying users when buses are at capacity and pointing them towards less congested buses or other transportation choices, the app can assist in managing the capacity of buses.
- Features like audio announcements and visual signals can be included in the app to help users who have vision or hearing problems.
- To give customers a smooth travel experience, the app may link with various forms of transportation like bike-sharing or car-sharing services.
- Safety and security features like panic buttons and real-time warnings in case of emergency can be offered by smart bus applications.
- Riders' feedback on their experiences may be collected via the app, allowing public transit organisations to immediately address problems and improve services.

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