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Where is My City Bus Tracking Application Using Wi-fi Strengths

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Abstract - The increasing demand for efficient and real-time public transportation tracking systems has led to the widespread adoption of GPS-based solutions. However, GPS systems often face limitations such as high implementation cost, signal unavailability in indoor or dense environments, and reduced accuracy in controlled areas like campuses. To address these challenges, this paper proposes a **Wi-Fi Based Bus Tracking System** titled *"Where Is My city Bus Tracking Application using Wi-fi Strengths"*, which utilizes nearby Wi-Fi signals for location detection instead of relying on GPS.

The proposed system operates by scanning available Wi-Fi networks and analyzing their **SSID (Service Set Identifier)** and **RSSI (Received Signal Strength Indicator)** values to determine the bus's current location. Each Wi-Fi access point is pre-mapped to specific bus stops, enabling the system to identify the nearest location based on signal strength. The bus device continuously performs Wi-Fi scanning, selects the strongest known network, and updates the current location dynamically.

To ensure real-time data availability, the system integrates with **Firebase Realtime Database**, which synchronizes location updates between the bus device and the passenger mobile application developed using Flutter. Users can track the live bus location, while the system also incorporates offline detection using timestamp monitoring to identify inactive or disconnected devices.

The system leverages **Wi-Fi positioning techniques** such as proximity-based detection and RSSI-based estimation, providing a low-cost and energy-efficient alternative to traditional tracking systems. However, challenges such as signal fluctuations, environmental interference, and overlapping Wi-Fi networks are considered and addressed through optimized threshold logic and network filtering mechanisms.

Experimental observations demonstrate that the proposed system performs effectively in controlled environments such as campuses or predefined routes, offering reliable tracking with minimal infrastructure requirements. Although the accuracy is lower compared to GPS in open outdoor environments, the system proves to be a practical and scalable solution for localized transportation tracking.

In conclusion, the proposed Wi-Fi-based tracking system combines **IoT, real-time cloud synchronization, and mobile application development** to deliver an innovative, cost-effective, and efficient alternative to conventional GPS-based tracking systems.

***Key Words*:**
Wi-Fi Based Tracking, RSSI (Received Signal Strength Indicator), SSID Mapping, Indoor Positioning System, Firebase Realtime Database, Flutter Mobile Application, IoT-Based Tracking, Proximity Detection, Real-Time Location Tracking, Signal Strength Analysis

1. INTRODUCTION

In recent years, the need for efficient and real-time transportation tracking systems has increased significantly, especially in environments such as college campuses, private transport systems, and controlled route services. Passengers often face uncertainty regarding bus arrival times and current locations, leading to inconvenience, time wastage, and poor travel planning. To overcome these challenges, tracking technologies such as Global Positioning System (GPS) are widely used. However, GPS-based systems have several limitations, including high implementation cost, dependency on satellite signals, reduced accuracy in dense or indoor environments, and increased power consumption.

In many scenarios, particularly within campuses or predefined routes, GPS signals may become unreliable due to obstructions such as buildings, trees, or network issues. Additionally, implementing GPS hardware in every vehicle increases the overall cost of deployment and maintenance. These challenges create the need for an alternative solution that is cost-effective, reliable, and suitable for controlled environments.

To address these issues, this project proposes a **Wi-Fi-Based Bus Tracking System** titled *"Where Is My city Bus Tracking Application using Wi-fi Strengths"*. Instead of relying on GPS, the system utilizes nearby Wi-Fi networks to determine the location of the bus. Every location or bus stop is mapped with a unique **SSID (Service Set Identifier)** of a Wi-Fi access point. The system scans available Wi-Fi signals and uses the **Received Signal Strength Indicator (RSSI)** to estimate proximity and identify the current location of the bus.

The core idea of this system is based on the principle that the strength of a Wi-Fi signal decreases as the distance from the access point increases. By continuously scanning and selecting the strongest known Wi-Fi signal, the system can approximate the bus location with reasonable accuracy. This approach makes the system highly suitable for environments where Wi-Fi infrastructure is already available, such as educational institutions or urban areas.

To provide real-time updates to users, the system is integrated with **Firebase Realtime Database**, which enables instant synchronization of location data between the bus device and the passenger mobile application. The frontend of the system is developed using Flutter, allowing passengers to view live bus locations, track movement along predefined routes, and receive updates efficiently. Additionally, the system includes features such as offline detection using timestamps, route management, and local data storage for improved performance.

This project combines concepts from **Internet of Things (IoT), mobile application development, and indoor positioning systems** to create an innovative tracking solution. While Wi-Fi-based positioning may not achieve the same level of accuracy as GPS in open environments, it offers a low-cost, energy-efficient, and practical alternative for controlled and semi-indoor environments.

Overall, the proposed system aims to improve passenger convenience, reduce uncertainty in transportation, and demonstrate the feasibility of Wi-Fi-based tracking as a viable alternative to traditional GPS-based systems.

2. LITERATURE SURVEY

In recent years, several approaches have been developed for vehicle tracking and indoor positioning, primarily focusing on technologies such as GPS, GSM, and Wi-Fi-based systems. Traditional bus tracking systems predominantly rely on **Global Positioning System (GPS)** technology to determine real-time location. These systems provide high accuracy in open outdoor environments; however, they suffer from significant limitations such as signal loss in indoor or dense urban areas, high power consumption, and increased implementation cost. Additionally, GPS-based systems require dedicated hardware, making them less suitable for low-cost or campus-level deployments.

To overcome these limitations, researchers have explored **Wi-Fi-based positioning systems**, which utilize existing wireless infrastructure for location detection. One of the simplest techniques is the **Proximity-Based Method**, where the location is determined based on the nearest Wi-Fi access point. In this approach, when a device detects a particular SSID, it is assumed to be within the coverage area of that access point. While this method is easy to implement and cost-effective, it provides only coarse-grained location accuracy. Compared to the existing approaches, the proposed system adopts a **simplified and practical Wi-Fi-based tracking method** that combines proximity detection with RSSI analysis. Instead of complex fingerprinting, the system uses **predefined SSID-to-location mapping** and selects the strongest available Wi-Fi signal to determine the current bus location. This approach reduces implementation complexity while still providing acceptable accuracy for controlled environments such as campuses or fixed routes.

Furthermore, the integration of **Firebase Realtime Database** enables instant synchronization of location data, which is not commonly addressed in traditional Wi-Fi positioning research. The use of a **Flutter-based mobile application** enhances user accessibility by providing real-time tracking information to passengers.

In summary, while existing systems provide various solutions for location tracking, they often involve trade-offs between accuracy, cost, and complexity. The proposed system focuses on achieving a balance by offering a **low-cost, easy-to-implement, and real-time Wi-Fi-based tracking solution**, making it suitable for practical deployment in controlled environments.

3. PROPOSED SYSTEM

The proposed system, titled *"Where Is My city Bus Tracking Application using Wi-fi Strengths – Wi-Fi-Based Bus Tracking System"*, introduces a cost-effective and practical solution for real-time bus tracking using Wi-Fi signals instead of conventional GPS technology. The system is specifically designed for controlled environments such as college campuses or predefined routes, where Wi-Fi infrastructure is readily available and GPS performance may be unreliable.

The architecture of the system consists of three major components: the **Bus Device (Wi-Fi scanning unit)**, the **Firebase Realtime Database**, and the **Passenger Mobile Application (Flutter-based UI)**. The bus device continuously scans nearby Wi-Fi networks, processes signal strength information, and determines the current location. This data is then transmitted to the Firebase database, which synchronizes updates in real time with the passenger application, allowing users to track the bus location instantly.

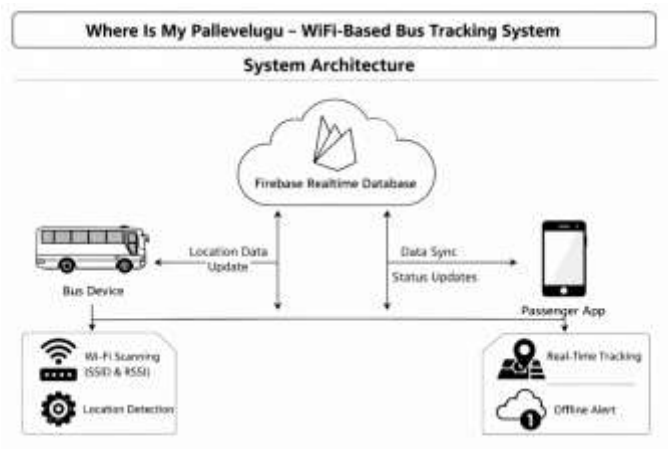

Fig -1: System Architecture

4. RESEARCH METHODOLOGY

the proposed system is developed to provide a practical and low-cost solution for bus tracking using Wi-Fi signals. The methodology focuses on collecting Wi-Fi data, processing signal strength, identifying location, and updating it in real time using cloud technology. The system is implemented using a combination of mobile application development and cloud database integration.

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4.1 System approach

The proposed system follows a simple approach where the bus device scans nearby Wi-Fi networks and determines location using SSID and RSSI values. Each Wi-Fi network is pre-mapped to a bus stop. The system selects the strongest signal to identify the current location of the bus.

4.2 Data collection

The system collects Wi-Fi data using Flutter plugins. During scanning, the following details are captured:

- SSID (Wi-Fi network name)
- RSSI (signal strength)

Only known Wi-Fi networks (pre-mapped) are considered for location detection.

4.3 Location Identification

After scanning, the system compares RSSI values of all detected known networks.

- The Wi-Fi with the highest RSSI is selected
- This indicates the nearest access point

Since each SSID is linked to a bus stop, the system identifies the current location.

4.4 Data Transmission using Firebase

Once the location is identified, the system updates the data to Firebase Realtime Database. The stored data includes:

- Current bus stop
- Timestamp (last updated time)

Firebase ensures real-time synchronization between the bus device and passenger application.

4.5 System Integration

The Flutter mobile application retrieves data from Firebase. It continuously listens for updates and displays:

- Current bus location
- Live updates

This allows passengers to track the bus in real time.

5. RESULTS AND DISCUSSIONS

The proposed Wi-Fi-Based Bus Tracking System was tested in a controlled environment to evaluate its functionality, performance, and accuracy. The system was able to successfully detect the bus location when known Wi-Fi networks were available. By selecting the Wi-Fi network with the strongest RSSI value, the system correctly identified the nearest bus stop in most cases. When multiple Wi-Fi signals were present, the system effectively chose the strongest signal, ensuring proper location detection.

5.1 Functional Testing

The proposed Wi-Fi-Based Bus Tracking System was tested in a controlled environment to verify its functionality. The system successfully detected the bus location when known Wi-Fi networks were available. By selecting the Wi-Fi network with the strongest RSSI value, it correctly identified the nearest bus stop in most cases.

Table 5.1: Test Cases

Test Case	Input Condition	Output
Test Case 1	Known Wi-Fi detected	Correct
Test Case 2	Weak Mapping	Correct
Test Case 3	No update from device	Offline

Table 5.1 shows the outputs for different test cases. The corresponding results are shown in the Fig 5.1.1, Fig 5.1.2, Fig 5.1.3. The functional testing demonstrates the reliability and accuracy of the system.

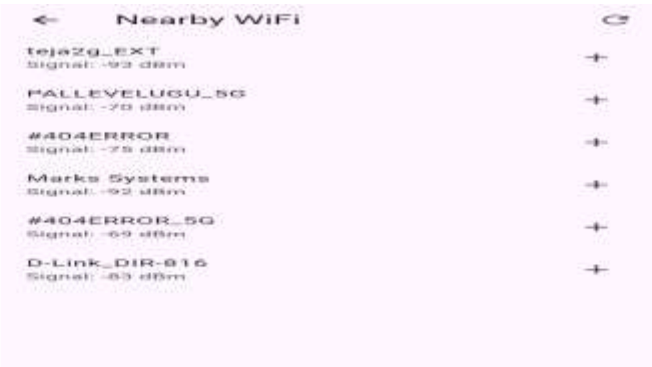

Fig 5.1.1: Test Case 1

Fig 5.1.2: Test Case 2

Fig 5.1.3: Test Case 3

5.2 Performance Evaluation

The system demonstrated good performance with near real-time updates. Wi-Fi scanning and location detection were completed within a few seconds. The integration with Firebase Realtime Database ensured instant synchronization of data, and the passenger mobile application was able to display updates without noticeable delay

Table 5.2: Performance

Operation	Time Taken
Wi-fi scan	1–2 seconds
Firebase update	Instant

5.3 Accuracy Analysis

The accuracy of the system mainly depends on the strength of the Wi-Fi signal. When the RSSI value is strong, the system provides accurate location detection. However, when the signal is weak or fluctuates due to environmental factors such as obstacles or interference, the accuracy may decrease. The system performs best in environments where Wi-Fi networks are stable and properly mapped.

5.4 Discussion

The system proves to be a cost-effective and simple alternative to GPS-based tracking systems. It works efficiently in controlled environments and uses existing Wi-Fi infrastructure, reducing the need for additional hardware. However, some limitations were observed, such as signal fluctuations, interference from multiple networks, and reduced accuracy in open environments.

6. CONCLUSION

The proposed project, *"Where Is My city Bus Tracking Application using Wi-fi Strengths – Wi-Fi-Based Bus Tracking System"*, presents a simple and cost-effective solution for real-time bus tracking using Wi-Fi signals instead of traditional GPS technology. The system successfully demonstrates how **SSID mapping and RSSI-based signal strength analysis** can be used to estimate the location of a bus in controlled environments.

By integrating the system with **Firebase Realtime Database** and a **Flutter mobile application**, real-time synchronization of location data is achieved, allowing passengers to track the bus efficiently. The system performs well in environments such as campuses or predefined routes where Wi-Fi networks are available and properly mapped.

However, the system also has certain limitations. The accuracy depends on Wi-Fi signal strength, which can fluctuate due to obstacles, interference, and environmental conditions. Compared to GPS, the system provides lower accuracy in open outdoor environments and is highly dependent on the availability of mapped Wi-Fi networks.

Despite these limitations, the project proves to be a practical and innovative alternative for localized tracking. It reduces implementation cost, avoids dependency on satellite signals, and utilizes existing infrastructure effectively.

7. FUTURE ENHANCEMENTS

Although the proposed Wi-Fi-Based Bus Tracking System works effectively in controlled environments, there are several improvements that can be made to enhance its performance, accuracy, and usability in real-world .One of the major enhancements would be the development of a hybrid tracking system by combining Wi-Fi with GPS. This would allow the system to use GPS in outdoor environments and switch to Wi-Fi-based tracking in indoor or signal-restricted areas, thereby improving overall accuracy and reliability.

Another important improvement is the use of advanced filtering techniques or machine learning algorithms to handle RSSI fluctuations. Since Wi-Fi signals are affected by noise and interference, applying intelligent filtering methods can help in making more accurate location predictions and reducing errors caused by unstable signals.

The system can also be enhanced by implementing Wi-Fi fingerprinting techniques, where a database of signal patterns is created for different locations. This would provide higher accuracy compared to simple RSSI-based methods, although it requires additional setup and maintenance.

From a user perspective, the mobile application can be improved by adding features such as:

- Estimated arrival time (ETA) of the bus
- Push notifications for bus arrival
- Route visualization using maps
- Multiple bus tracking support

Finally, the system can be extended by integrating other technologies like Bluetooth beacons or IoT sensors to further improve location accuracy and coverage in complex environments.

In conclusion, with these enhancements, the system can be transformed into a more accurate, scalable, and user-friendly solution suitable for real-world public transportation systems**.**

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