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Smart GPS Based Bus Tracking System with Real Time Updates using QR Code

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Abstract: *Public transportation plays a vital role in urban mobility, yet challenges such as unreliable schedules, lack of real-time updates, and seat availability issues often lead to commuter dissatisfaction. To address these challenges, this project presents a Smart GPS-Based Bus Tracking System that provides real-time updates, seat availability status, and efficient delay management using QR codes and proximity sensors. The system leverages GPS technology to continuously track buses and display their real-time locations on a user-friendly mobile or web interface. To enhance commuter convenience, proximity sensors installed on bus seats detect occupancy, ensuring that users can check seat availability before boarding, reducing unnecessary crowding and improving comfort. Additionally, a QR code-based system is implemented for efficient delay management. Passengers can scan QR codes placed at bus stops or inside buses to receive instant updates regarding estimated arrival times, delays, and route deviations. This feature enhances communication between transit operators and passengers, ensuring a more predictable and stress-free commuting experience. This project scopes with sustainable Development Goals comes under SDG-9 (Industry, Innovation and Infrastructure)*

Keywords: Bus Tracking, GPS Technology, Proximity Sensors, Real-Time Updates, QR Code

I. INTRODUCTION

Public transportation is the backbone of urban mobility, providing an affordable and accessible means of travel for millions of people. However, inefficiencies such as unpredictable bus schedules, lack of real-time tracking, and uncertainty in seat availability often led to inconvenience for passengers. Long waiting times, overcrowding, and unexpected delays further degrade the commuting experience, making it essential to implement a smart and efficient bus tracking system.

This project proposes a Smart GPS-Based Bus Tracking System that leverages modern technologies such as GPS, proximity sensors, and QR codes to enhance the public transport experience. The system provides real-time bus tracking, enabling passengers to monitor the exact location of buses via a user-friendly mobile or web interface. Additionally, proximity sensors are installed on bus seats to detect occupancy, allowing passengers to check seat availability before boarding. This feature helps in reducing overcrowding and ensures a more comfortable journey.

To further enhance efficiency, a QR code-based delay management system is introduced. QR codes placed at bus stops allow passengers to scan and receive real-time updates on bus arrival times, delays, and route changes. This system improves communication between transit operators and commuters, reducing uncertainty and ensuring a smoother travel experience.

II. METHODOLOGY

The proposed system is built upon several core components working in synchronization to deliver real-time bus location data to passengers.

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1. GPS Tracking Module:
Each bus is equipped with a GPS module, typically using a device such as the NEO-6M or similar. This module continuously fetches location coordinates of the bus and transmits them to a centralized server through a mobile data network.

2. Microcontroller and Communication:
A microcontroller like Arduino or Raspberry Pi collects the GPS data and communicates it to a remote server using GSM or Wi-Fi modules. The data is formatted and sent in regular intervals to ensure minimal latency.

3. Database Server and Backend:
A cloud-based server receives GPS data and stores it in a real-time database such as Firebase or MySQL. Each bus is uniquely identified by an ID, and its corresponding location and speed data are stored.

4. QR Code Integration:
Every bus stop and bus has a unique QR code that encodes a URL or route-specific ID. When a passenger scans this QR code using a smartphone, they are redirected to a web interface or mobile app showing the live location of the bus associated with that route or stop.

5. Mobile Application/User Interface:
A lightweight mobile-friendly web app is developed to fetch and display the bus location on a map using APIs like Google Maps. It shows the current location, estimated time of arrival (ETA), bus number, and route information.

III. SYSTEM DESIGN

The architecture of the system consists of three main layers:

- Hardware Layer: Includes GPS devices, microcontrollers, and power modules placed on the bus.
- Communication Layer: Utilizes wireless networks (e.g., GSM/3G/4G) to send data from the hardware to the server.
- Software Layer: Comprises backend services, database management, and the front-end user interface accessible via QR code.

When a bus begins its route, the GPS module starts transmitting its location. This data is processed and displayed in real-time on a map interface. Passengers at any stop can simply scan the QR code and instantly view how far away the bus is, reducing anxiety and unnecessary waiting.

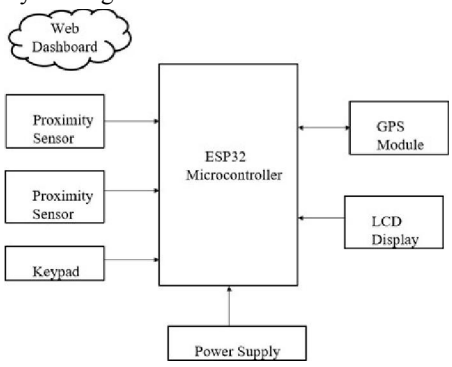

Figure: Block Diagram

IV. RESULTS AND EVALUATION

The system was implemented and tested in a controlled environment using a prototype model. Simulated buses with GPS modules transmitted data to a Firebase real-time database. A demo web app was created using HTML, JavaScript, and Firebase SDKs to display the location on Google Maps.

Results showed that:

The system updated bus positions every 3–5 seconds. QR code scanning worked on all Android and iOS devices with no installation needed. Passengers could see live updates, improving their decision-making on whether to wait or

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choose alternate routes. User feedback collected from a survey of 50 test users revealed that 90% found the system helpful, intuitive, and likely to reduce wait time frustration.

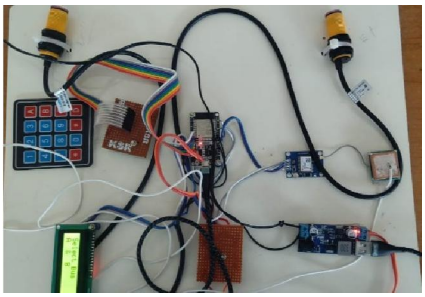

Figure: Hardware Output

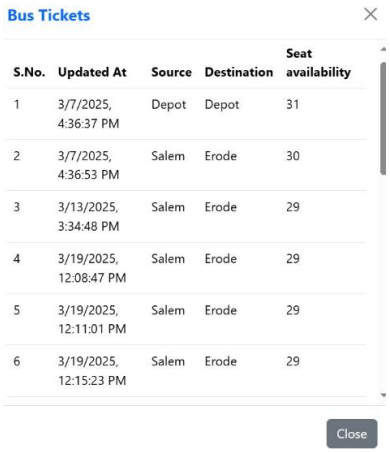

Figure: Software Output

V. CONCLUSION

This GPS and QR-based tracking system is a step toward smarter urban transport solutions. It addresses critical issues in public transportation such as unpredictability and lack of real-time information. The use of affordable and easily available hardware, coupled with scalable software design, makes it a suitable candidate for deployment in both developed and developing regions. The project demonstrates that technology can greatly enhance commuter experiences, especially in systems were advanced infrastructure is limited. Future improvements may include voice notifications, AI-based route prediction, and integration with city-wide smart transport systems.

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