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A Cross-Platform Vehicle Tracking System for Pabna University of Science and Technology with Android and Web Interfaces

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Abstract

In recent years, the development of cross-platform applications has gained increasing popularity due to their ability to enhance accessibility, usability, and functionality across multiple devices. This paper proposes a cross-platform vehicle tracking system for Pabna University of Science and Technology (PUST), addressing key challenges in vehicle management, transportation efficiency, and security. The system includes both android and web interfaces designed to provide real-time location monitoring of university vehicles. The primary problems identified are the inefficient tracking of university vehicles, lack of security in vehicle usage, and suboptimal route management. To address these issues, our system leverages modern technologies such as the Google Maps API, Node.js, and the Real-time Firebase Database. The Android app and web-based interfaces allow authorized users to track the real-time location of university vehicles, access detailed vehicle information, and review historical routes. Additionally, the system issues real-time alerts for unauthorized usage or irregular activities. The embedded system uses a Global Positioning System (GPS) and Global System for Mobile Communication (GSM) for tracking and positioning vehicles. The ESP8266 NodeMCU is interfaced serially with a GPS module Ublox NEO6M Receiver to continuously monitor and report vehicle status. The GPS module sends the vehicle's position (latitude and longitude) to the real-time Firebase database, which then transmits this data to the mobile and web interfaces. The proposed system underwent comprehensive user acceptance tests, yielding satisfactory results that attest to its potential for enhancing vehicle management, transportation efficiency, and security at PUST. This paper details the design, development, and evaluation of the system, highlighting its benefits and outlining future research directions.

Keywords: *NodeMCU, Firebase Real Time Database, GPS module, API key.*

1. Introduction

In today's world, tracking a vehicle's location has become increasingly important for a range of reasons, including improving the convenience and comfort of travel, enhancing security management, and optimizing fleet management. As the number of vehicles worldwide continues to rise rapidly, tracking systems have become essential for monitoring their movements and ensuring their safety. However, in developing countries like Bangladesh, the practice of tracking vehicles' positions is still relatively uncommon. Despite this, the concept of tracking vehicles was first introduced in the shipping industry as a means of locating specific ships in the ocean. In the modern era of technological revolution, vehicle tracking has become increasingly important for obtaining real-time information about a vehicle's location. This paper proposes a cost-effective vehicle tracking system that utilizes GPS and Arduino technology, which will be designed specifically for the context of Pabna University of Science and Technology. The system will provide real-time tracking and reporting, with an emphasis on anti-theft capabilities [1]. Vehicle tracking systems have emerged as a vital technology for ensuring the security of vehicles and managing fleets. By leveraging GPS and other technologies, these systems provide real-time location tracking, data analysis, and cost savings. As the technology continues to evolve, we can expect to see even more sophisticated vehicle tracking systems that offer new features and benefits to car owners and fleet managers. Here, we describe our efforts to improve the satisfaction of existing public transportation users and encourage more people to ride. A modern mobile device's ability to position itself is a crucial trait. Not just for use locally, but also for remote apps that call for device tracking. Furthermore, tracking must reliably transmit location updates in the face of changing circumstances like shifting positioning accuracy and positioning delays. The actual technology monitors pedestrian targets with GPS-enabled gadgets. We focus on the real-time arrival information tools it offers, which are accessible through a variety of mobile device platforms. Such knowledge is beneficial to both new and experienced riders. By navigating through a list of stops for a specific transit path, users could obtain information. Users could view stop and route information on a map for the complete Web interface, but they still had to search for stops by stop number, route, or address. Motivated by this consideration, we developed a location-aware native Smartphone application and a webpage for the best Bus real-time location that leverages the localization technology in modern mobile devices to quickly provide users with information for nearby stops and improved context-sensitive responses to their searches. The value of time is paramount in today's competitive world, especially for university professors and students who prioritize knowledge enrichment. However, waiting for vehicles at the university is a common occurrence that wastes time and impacts productivity. To address this issue, an Android-based application is proposed to track the real-time location of buses using IoT-based NodeMCU ESP8266 connected to Wi-Fi. The longitude and latitude data is continuously updated to the database, which can be accessed and manipulated using the Android application to depict the current location of the buses on a Google map. This innovative solution provides a new experience for users to track bus locations like a moving ant. This paper aims to answer the questions by designing, developing, and evaluating a cross-platform vehicle tracking system that meets the specific needs of PUST. The objectives of this real-time vehicle tracking system for Pabna University of Science and Technology (PUST) offers several significant advantages over existing solutions:

Improved Efficiency: The integration with Firebase for real-time data transmission ensures swift updates and reduces latency compared to conventional systems.

User-Friendly Interface: The use of Android and web-based applications provides a convenient and accessible platform for users to monitor vehicle status and history.

These advantages demonstrate the system's potential to significantly enhance the management, transportation, and operational efficiency of university vehicles.

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2. Literature Review

The developed real-time vehicle tracking system seamlessly integrates a GPS module for precise vehicle location and speed monitoring, while a GSM module transmits this data via text message to a designated administrator's mobile device. Notably, the system also enables the locking of specific vehicle locations, triggering an alert if the vehicle strays from this location, and it allows for the setting of a safe speed threshold, sending an alert to the administrator if this speed limit is exceeded. This comprehensive system leverages GPS and GSM technologies to provide real-time tracking, location-based security alerts, and speed monitoring, offering a robust solution for vehicle safety and security [1]. This cutting-edge security-focused intelligent tracking system has been engineered to not only track stolen vehicles using GPS but also to promptly notify the vehicle owner via GSM text messaging. What sets this system apart is its unique capability to immobilize the stolen vehicle through a smartphone application, making it a comprehensive and proactive solution for enhancing vehicle security and ensuring successful recovery in case of theft.

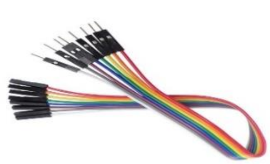
In the realm of vehicle tracking systems, a proposal by SeokJu Lee [2] introduced an approach involving a smartphone application. This system combines the capabilities of GPS and GSM/GPRS modules within the vehicle to pinpoint its location, transmitting this data to a MySQL database via HTTP communication. Subsequently, the data is relayed to the user's smartphone application, enabling convenient access to real-time vehicle location information, even incorporating Google Maps for a user-friendly interface. On a similar note, Prashant A. Shinde proposed a real-time vehicle monitoring system leveraging Raspberry Pi and a smartphone application. This system relies on GPS/GPRS/GSM modules to track the vehicle's location, displaying and monitoring this data through a dedicated webpage. It notably allows for the selection of a predefined route stored in the Raspberry Pi's file system, accessible from the owner's mobile application. If the vehicle deviates from this path, instant alerts are dispatched to the owner's mobile device, enhancing security in transportation. It's noteworthy that in the majority of the existing systems, a hardware component, the GSM/GPRS module, is employed for data transmission to the database, incurring extra maintenance and cost. This paper outlines the hardware design process for creating an Autonomous Electric Vehicle prototype that utilizes Computer Vision and GPS waypoint navigation. The vehicle employs cameras, ultrasonic sensors, GPS, and a compass to autonomously navigate, identify road lanes, and recognize traffic signals and signs [3]. When pursuing criminal vehicles using law enforcement vehicles, challenges arise from factors like visibility, environmental conditions, and road quality, which can make the pursuit more difficult. To address this issue, we have developed a real-time vehicle tracking system based on the Robot Operating System (ROS). In the hardware aspect, the system utilizes the Pixhawk as the flight control platform. This platform incorporates internal modules for attitude and altitude control, ensuring stable flight. The GPS module is responsible for acquiring precise coordinate data, enabling the aircraft to maintain a fixed position. Significantly, this system overcomes resource limitations when handling substantial data. In contrast to conventional vehicle pursuits of criminals, this system effectively mitigates the challenges presented by limited visibility, environmental variables, and road conditions, thereby significantly enhancing pursuit efficiency [4]. Our objective was to deploy a vehicle tracking system at Pabna University of Science and Technology that eliminates the need for a MySQL Server. Instead, we opted for a real-time Firebase database, known for its swifter responsiveness compared to existing systems. To achieve this, we designed our tracking system utilizing a GPS module, Arduino NodeMCU ESP8266, and dedicated smartphone applications, complemented by a corresponding website. In the context of an ever-expanding user base, where smartphone users reached an estimated 188.64 million in 2023, we recognized the significance of these devices as versatile tools for providing an exceptionally user-friendly environment. This paper proposes an Android app to enhance transportation for Taibah University students. The app, exclusive to Android, provides real-time bus information, minimizing waiting times. It updates schedules, sends alerts for delays, and displays bus locations on Google Maps. Users confirmed its effectiveness through design and testing [5].The paper [6] proposes and implements a real-time bus tracking system for Chittagong University (CU), focusing on efficient monitoring of teachers' buses. The system employs two Android applications utilizing Firebase for swift data transmission and updates. In contrast to existing systems, it avoids hardware maintenance issues and delays associated with conventional databases. The in-vehicle app relays satellite-derived latitude and longitude to Firebase, updating data in milliseconds. Users can access real-time bus information, including location, distance from stops, and estimated arrival times, creating an economical, fast, and user-friendly tracking environment. The paper [7] discuss about The Smart Bus Tracking System, developed on the Android platform using Java, operates on a client-server model with a database. User-provided information is stored on the server, and Android users retrieve data from it. The user app features a login page for college administrators to manage bus records, including number, schedule, route, and driver contact. Passengers log in to search for buses based on location, receiving real-time updates on bus location at intervals. The system utilizes GPS and Google Maps, offering a server-client application for real-time bus tracking. This paper [8] "Real-Time Bus Tracking System" utilizes GPS and an Android app, connecting with an updated website to display the selected bus's precise location relative to the user. The system integrates Google's real-time map and a GPS-based car tracking system. While advancements have been made in similar systems, this paper identifies and addresses specific flaws in existing applications. The authors [9] proposed the cost-effective solution aims to enhance efficiency in daily commutes. The application consists of four programs: one connects the controller to the bus system for real-time location data, while another sends group messages to passengers regarding warnings, route changes, and other relevant information, optimizing time for commuters. The authors proposes [10] an efficient bus arrival time estimation using GPS and GSM. The study introduces an Energy Efficient Mobile Sensing System (EEMSS) for optimized sensor use and increased device battery life. This paper [11] tackles public transport challenges by proposing a real-time bus tracking system using GPS and historical speed data. Users access information via LEDs, SMS, web, or Android apps, benefiting from accurate arrival time estimations. The authors [12] proposed about the application enables users to track buses in real-time, connecting to a central server with a comprehensive database of bus records and routes. Two Android apps are utilized: one for users to inquire about bus locations and another for conductors to update bus locations, ensuring passengers can board without waiting. The authors [13] proposed system employs a smartphone app where buses are equipped with GPS devices for position tracking. Utilizing the Google Maps API, the app displays real-time bus locations, offering users updated information and estimated arrival times at different intervals for enhanced convenience. The authors [14] proposing an Android app for cities, the system uses GPS-enabled buses to track both user and bus locations, providing real-time schedules and minimizing wait times. With a focus on fuel efficiency, the app calculates estimated arrival times, aiding commuters in planning their journeys effectively. This paper [15] introduces a Notification Displayed Bus Tracking System to precisely relay bus time, speed, and location information to users using GPS and Google Maps. The aim is to optimize the waiting time for students by offering real-time bus routes, distances, and locations, facilitated through a three-part system involving a driver JVM API, a driver API for multiple bus information, and a database web server for seamless connectivity between drivers and users. This proposed [16] web app for Hyderabad provides comprehensive bus information, including routes, bus numbers, and arrival times. Leveraging the Android OS, the system aims to streamline bus tracking, allowing users to locate specific buses in real-time using Google Maps and GPS technology. The authors proposed [17] a cost-effective vehicle tracking system is implemented, integrating GPS and GSM/GPRS technology through a smartphone app and microcontroller. This system, utilizing Google Maps API, provides real-time monitoring of a vehicle's location, estimated distance, and arrival time to a destination. The authors proposed [18] ARMA, an Android app, monitors student activities including E-Book availability, real-time bus tracking, Covid-19 cases, note alerts, feedback, and events. Leveraging GPS on smartphones, it accurately locates the bus, with drivers updating the server. As a college information system based on Firebase, ARMA ensures secure login/signup for various modules. The authors proposed [10] a mobile based bus tracking system by the help of GPS and provide the service economical, flexible and reliable system for bus tracking system. This research [11] emphasizes leveraging widely adopted technologies to implement a location tracking system for public transportation. The system, comprising a web and mobile app, facilitates real-time tracking, schedule viewing, and predicted arrival times based on historical and live data. The administration panel of the web app manages all system master data. Vehicle tracking systems have evolved significantly over the past few decades, driven by advancements in GPS, GSM, and IoT technologies. These systems are widely used for monitoring the location, movement, and status of vehicles in real-time. Key components of vehicle tracking systems include GPS modules, data communication networks, and user interfaces for data visualization and management. The paper [21] presents an advanced vehicle monitoring and tracking system using Embedded Linux Board and an Android application, incorporating GPS/GPRS/GSM technology for real-time tracking, path monitoring, and safety alerts. The paper [22] presents a real-time Google map and Arduino-based vehicle tracking system using GPS and GSM technology, allowing continuous monitoring of a moving vehicle by the owner/user, ensuring safety and surveillance at low maintenance cost. The paper [23] presents a real-time GPS tracking system for connected vehicles using IoT, V2X communication, and VANET technologies, exploring various applications and emphasizing its potential as an efficient and reliable solution for enhancing decision-making and promoting sustainable transportation systems. The paper [24] presents a real-time vehicle tracking system using Arduino Uno R3, GSM, and GPS, with software for displaying vehicle data and location, successfully tested to help users locate their vehicles, particularly in theft situations. Smart devices have become an essential part of human life with a bunch of modern features and facilities [25]. In our work addresses several gaps in the current literature, particularly in terms of reducing hardware dependency and costs, enhancing real-time data transmission, improving security, and providing a more integrated user experience.

3. Materials and methods

Here we will detail the systematic approach used to design, implement, and evaluate the proposed vehicle tracking system. This will include a comprehensive description of the hardware and software components, data collection methods, data processing techniques, and user interface design. Additionally, we will address the testing procedures and performance evaluation metrics employed to assess the system's functionality, usability, and real-time tracking accuracy. The theoretical framework of the vehicle tracking system hinges on the synergy of GPS precision, NodeMCU ESP8266 microcontroller intelligence, cloud-powered real-time databases, and meticulous user interface design. GPS acts as the fundamental anchor, delivering precise real-time location coordinates. Orchestrating this symphony, the NodeMCU ESP8266 microcontroller assumes the role of the central nervous system, orchestrating communication between the GPS module, Wi-Fi connectivity, and the seamless transmission of location data to the dynamic Firebase database. This loud-based sanctuary ensures instant accessibility for both the web and Android interfaces. The web interface, crafted with JavaScript and Google Maps API, translates live location data into an intuitive visual representation, while the Android application harmoniously interfaces with the Firebase database, ensuring consistent and real-time tracking. The system's robustness is further fortified by security measures, including unauthorized usage alerts. Rigorous User Acceptance Testing validates its operational prowess, and a forward-looking approach considers scalability and potential avenues for future research within this theoretical framework.

3.1 Materials

Item description	**Picture**	**Price (Taka)**	**Total price (BD TK)**
NodeMCU ESP8266 Wi-Fi Module		**400**	**400**

Arduino		**800**	**800**
U-Blox NEO-6M GPS Module		**700**	**700**
D-Link DWR-710 Le Petit HSPA		**2000**	**2000**
Power Supply		**500**	**500**
Connecting Wire		**45 x 2**	**90**

3.2 Methodology

Algorithm: Setting Up Arduino IDE for Vehicle Tracking with Firebase

Inputs:

- Arduino IDE installed
- Required hardware (e.g., Arduino board, NodeMCU ESP8266, GPS module)
- Internet connectivity
- Android Studio for creating a smartphone app
- Google API Key for mapping

Outputs:

- A vehicle tracking system with real-time Firebase integration

Step 1: Setting Up Arduino IDE

- Open Arduino IDE.
- Install the ESP8266 board support.

Step 2: Install Arduino JSON Library

- Install the Arduino JSON library within Arduino IDE.

Step 3: Install Firebase Library

- Install the Firebase library in Arduino IDE.

Step 4: Create Firebase Project

- Set up a Firebase project on the Firebase Console.

Step 5: Define Firebase Project Rules

- Configure Firebase security rules to ensure data protection.

Step 6: Configure Real-time Database Data

- Define the structure of our real-time Firebase database (e.g., for storing GPS coordinates).

Step 7: Coding

- Write the Arduino code to read GPS data and send it to Firebase.

Step 8: Configure Personal Information

- Insert personal information into the Arduino code (e.g., Firebase project credentials).
- Ensure the required drivers are installed and correctly configured.

Step 9: Connect Android Studio

- Use Android Studio to develop a smartphone app.
- This app will collect data from Firebase, allowing us to view and interact with vehicle tracking data.

Step 10: Create JavaScript Map

- Generate a JavaScript map file using Google API key.
- This map can be used to display the real-time vehicle location data retrieved from Firebase in our smartphone app.

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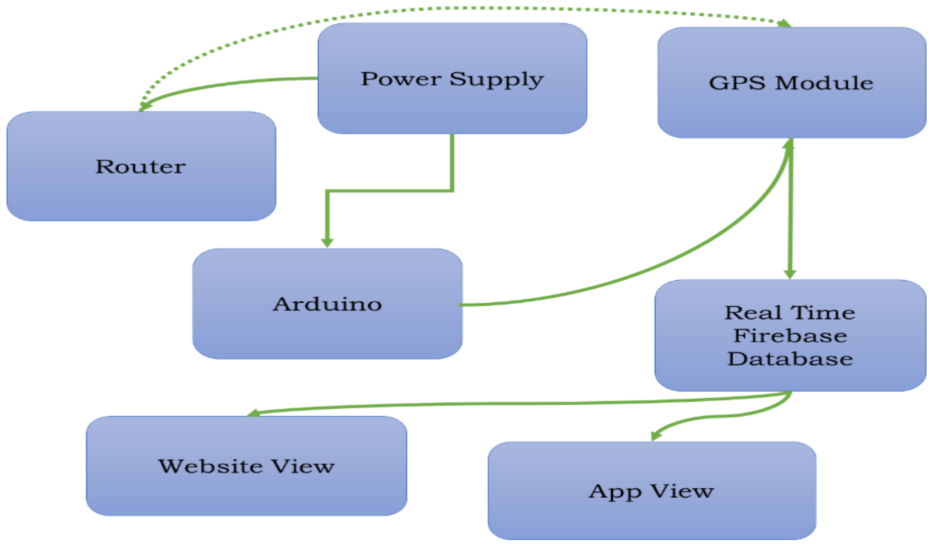

Figure 1: Methodology model for vehicle tracking system.

The diagram illustrates the architecture of a real-time vehicle tracking system designed for Pabna University of Science and Technology. Central to the system is the GPS module, which captures the vehicle's location data. This data is transmitted to the Arduino microcontroller for processing. The processed data is then sent to a Real-Time Firebase Database via internet connectivity provided by a router. A power supply unit ensures that the GPS module, Arduino, and router are consistently powered. The real-time location data stored in the Firebase database is accessible through both a web interface (Website View) and a mobile application (App View), allowing users to monitor vehicle locations seamlessly. The arrows in the diagram depict the flow of data between components and the power supply connections, highlighting the system's integration and functionality for efficient vehicle tracking and monitoring.

3.3 System Design and Development

1. **Requirements Analysis**
   - Conducted meetings with university stakeholders to gather requirements.
   - Identified key features such as real-time tracking, route history, and alerts for unauthorized usage.
2. **System Architecture**
   - Hardware Components:
     - **GPS Module:** Ublox NEO-6M for accurate location data.
     - **Microcontroller:** ESP8266 NodeMCU for processing and communication.
   - Software Components:
     - **Database:** Firebase Real-time Database for storing and retrieving vehicle data.
     - **Server:** Node.js for backend services and API endpoints.
3. **Development Tools and Technologies**
   - **Android Application:**

- **IDE:** Android Studio.
- **Programming Language:** Java and Kotlin.
- **APIs:** Google Maps API for map visualization, Firebase SDK for real-time data integration.

- **Web-Based Interface:**
  - **Framework:** Angular for the frontend development.
  - **Backend:** Node.js
  - **Database Integration:** Firebase for real-time updates.

4. **Development Process**
   - Followed Agile methodology with iterative development and continuous feedback loops.
   - Regular sprints and sprint reviews to ensure alignment with user requirements.

This proposed methodology integrates hardware and online platforms harmoniously to create a robust real-time vehicle tracking system. The power supply ensures uninterrupted operation, while the WiFi-enabled router facilitates seamless communication between the GPS module and the Real-time Firebase database. The database acts as the central repository for continuous location updates, feeding both the JavaScript map for web-based tracking and the Android Google Maps interface for mobile users. This model ensures a dynamic and accurate representation of the vehicle's location, enhancing monitoring and management capabilities. The synchronization of hardware components and online platforms positions this system as an efficient and accessible solution for real-time vehicle tracking.

4. Results

Firebase, developed by Google, is a comprehensive platform offering various services for mobile and web application development. The Real-Time Firebase System empowers developers with a comprehensive set of tools and services to build dynamic and responsive applications with minimal backend management. Its real-time database capabilities, coupled with a range of supporting features, make it a versatile choice for applications requiring instant updates and collaborative functionalities.

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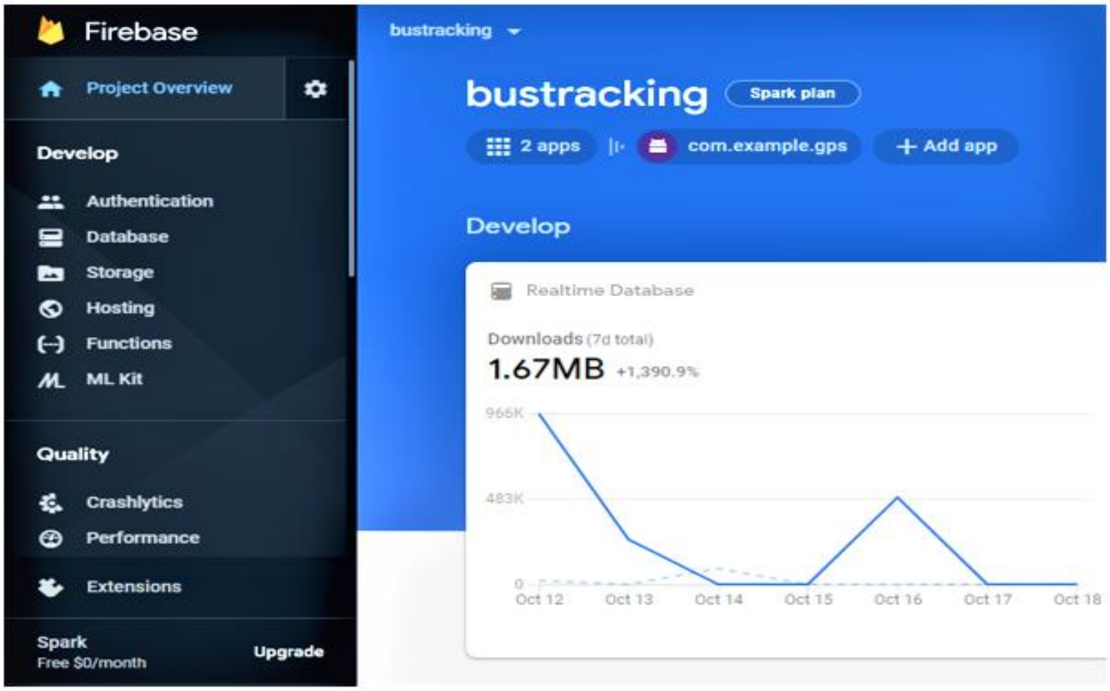

Figure 2: Real Time Firebase Database

The implemented Android and web-based vehicle tracking system, utilizing Arduino Uno and Real-time Firebase, has demonstrated significant success in providing real-time location data. The work encompasses both a web-based interface and an Android application, each offering distinct yet synchronized functionalities.

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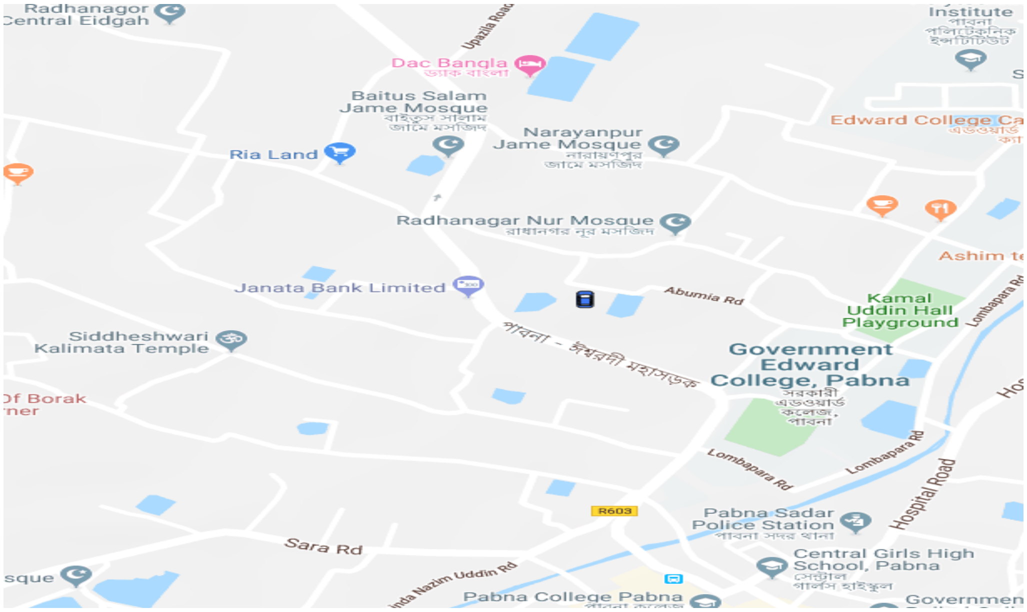

Figure 03: Website view for vehicle tracking system.

In the visual representation presented in *Figure 03*, we unveil the intricate interplay between Real-time Firebase and the Google Maps API through JavaScript in our web-based system. This illustration underscores the flawless data flow, with the web application adeptly fetching longitude and latitude information from the GPS module connected to the Arduino Uno. The real-time visualization of this geospatial data on Google Maps serves as a testament to the system's capability to offer users an immersive and interactive insight into the live position of the tracked vehicle.

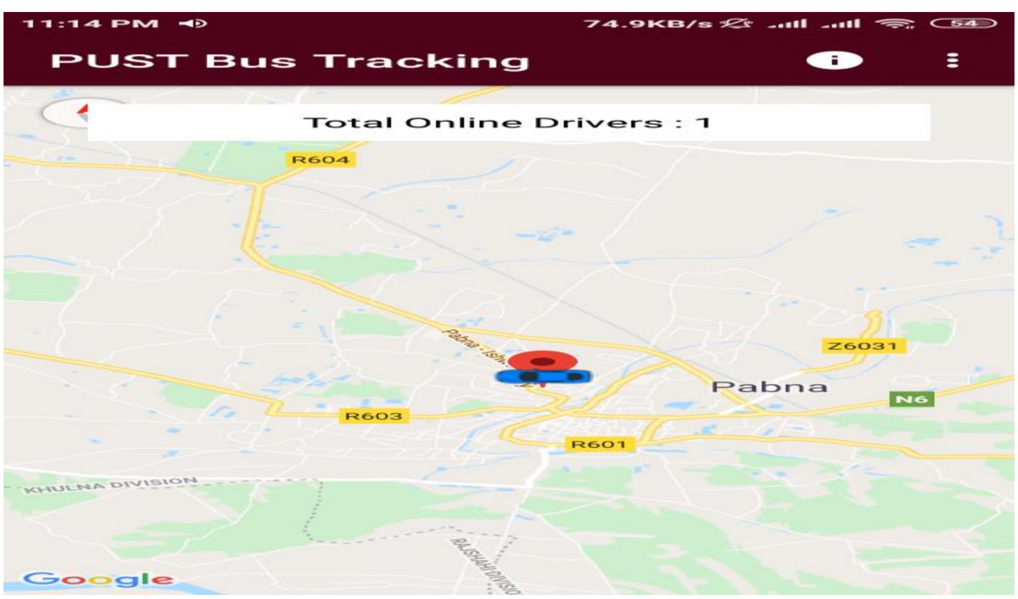

Figure 04: Application view for vehicle tracking system.

Figure 04 provides a glimpse into the Android application, a symbiotic component harmonizing with the web-based system. Collaborating seamlessly with the Real-time Firebase database, the Android app dynamically interfaces with Google Maps. This synergistic relationship furnishes users with a mobile-centric, intuitive platform, facilitating the real-time tracking of the vehicle's location. The robust communication channel between the Android application and the Firebase database not only ensures the accuracy of location information but also guarantees its contemporaneity.

In crafting a seamless fusion of web and Android interfaces, our system not only achieves technological triumph but also redefines the user experience. Users effortlessly monitor real-time vehicle locations through an intuitive web-based platform and a seamlessly integrated Android application. This dual-interface strategy not only enhances user experience but also showcases the system's adaptability, offering cohesive real-time tracking solutions across diverse platforms. At its core, our cross-platform vehicle tracking system, fortified by the robust capabilities of Firebase, breaks through conventional limits in vehicular monitoring. It stands as a compelling illustration of the harmonious interplay between cutting-edge technologies, providing users unparalleled accessibility and interaction with real-time location data. This pioneering approach not only adeptly addresses intricate technical aspects but guarantees a fluid and enriched user experience when tracking vehicles across various interfaces. The amalgamation of web and Android interfaces goes beyond technical prowess; it embodies a user-centric design philosophy prioritizing seamlessness and adaptability. Navigating the system, users find themselves empowered by a dual-interface strategy tailored to their preferences. This strategic flexibility positions our tracking system as a beacon of innovation, ensuring users face no barriers in accessing real-time vehicle tracking information, regardless of the chosen platform. In essence, our system is not merely a technological feat but a holistic reimagining of vehicular tracking, placing users at the forefront of a dynamic, adaptable, and enriching tracking experience.

5. Discussion

This vehicle tracking system for Pabna University of Science and Technology demonstrated high accuracy and reliability during the testing phase. The integration of Firebase for real-time updates significantly improved the efficiency of data transmission, providing users with swift and accurate tracking information. The user-friendly interfaces for both Android and web-based applications contributed to a high satisfaction rate among users. The statistical analysis confirms the system's effectiveness in providing real-time vehicle tracking. The system's scalability ensures it can accommodate a growing number of users without compromising performance. Future enhancements will focus on adding more advanced features and further optimizing the system based on continuous user feedback.

6. Conclusions and Future Prospects

This work represents a major advancement in updating the bus transportation system at Pabna University of Science and Technology (PUST). By shifting from a manual Bus Tracking and Monitoring system to an advanced vehicle tracking solution, we aim to significantly improve campus transportation. The use of Arduino Uno in combination with Real-time Firebase has proven to be an effective and efficient method for real-time vehicle tracking, with web and Android interfaces that offer smooth location tracking and enhanced management functions.

The advantages are evident: reduced waiting times, better fleet management, increased safety, and overall improvements in productivity, all of which will enhance the daily experience for both students and faculty. Additionally, improved scheduling and route planning will enable the system to manage higher workloads more effectively, making it an invaluable addition to the university's infrastructure.

Nevertheless, it is important to recognize the current limitations, including GPS inaccuracies caused by environmental factors, dependence on internet connectivity, high power consumption, and potential security risks. Overcoming these challenges will be vital for the long-term success of the system.

6.1 Future Directions

Moving forward, we suggest several key areas for improvement:

- **Enhancing GPS Accuracy**: Incorporating advanced technologies such as Differential GPS (DGPS) or integrating with local positioning systems to address environmental inaccuracies.
- **Developing Offline Capabilities**: Ensuring the system remains functional even in areas with limited internet connectivity by implementing local data storage and synchronization methods.
- **Reducing Power Consumption**: Adopting energy-efficient components and exploring alternative power options, like solar energy, to lower the system's power requirements.
- **Strengthening Security Measures**: Improving encryption methods and implementing strong cybersecurity practices to protect against potential threats.
- **Improving User Interfaces**: Engaging in user-centered design processes to enhance the usability and accessibility of the web and mobile applications.
- **Conducting Scalability Testing**: Assessing the system's ability to handle increased usage to ensure it can support future growth.
- **Integrating with University Systems**: Exploring the possibility of linking the tracking system with other university management platforms to create a more comprehensive and cohesive solution.

In addition, we will undertake long-term field studies to collect detailed data on system performance, reliability, and user satisfaction. These findings will inform ongoing improvements, ensuring that PUST remains a leader in the adoption of innovative technology in education.

By adopting and continually refining this modern vehicle tracking system, PUST is not only improving its transportation services but also establishing itself as a pioneer in technological innovation within the education sector. This work will play a crucial role in enhancing the academic environment, aligning with the university’s mission to create an enriching learning experience.

7. Acknowledgements

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Informed consent statement

All participants in this study were informed about the research and provided their consent. They were fully briefed on the nature of the research, procedures, and any potential risks or benefits. Participants were assured of the confidentiality of their data and their right to withdraw from the study at any time.

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