Intelligent Transportation System Real-Time Tracking

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Abstract

Transportation systems, particularly bus networks, face numerous challenges stemming from uncertainty and long waiting times. These problems hinder the efficiency and effectiveness of public transportation, leading to inconveniences for commuters and suboptimal operations for transportation authorities. Uncertainty and long waiting times in transportation systems arise from various factors such as traffic congestion, unforeseen events, and inadequate information. This often leads to unpredictable bus arrival and departure times, leaving passengers waiting for extended periods at bus stops. Long waiting times not only inconvenience passengers but also discourage the use of public transportation, resulting in increased private vehicle usage, congestion, and environmental concerns. To address these issues, our project aims to develop strategies and technologies to reduce uncertainty and minimize waiting times in bus transportation systems. One approach involves leveraging intelligent transportation systems and real-time data to improve passenger experience. By integrating technologies like Global Positioning System tracking, advanced analytics, and mobile application development, passengers will have access to sufficient information to make informed decisions, reducing uncertainty and frustration associated with long waiting times.

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I. Introduction

Intelligent Transportation Systems (ITS) have revolutionized the way we approach transportation challenges, aiming to enhance efficiency, reliability, and user experience. One critical aspect of ITS is the implementation of real-time bus tracking systems, which leverage Global Positioning System (GPS) technology and mobile applications to provide live tracking and information to commuters. This research paper explores the implementation of an intelligent transportation system using GPS and mobile applications to track buses in real-time, addressing the challenges of uncertainty, long waiting times, and improving the overall effectiveness of public transportation [1].

In recent years, urban areas have witnessed an increasing demand for efficient and reliable public transportation systems. However, one of the significant issues faced by commuters is the lack of real-time information about bus arrival times and delays, resulting in frustration and inconvenience. By integrating GPS technology with mobile applications, transportation authorities can provide commuters with accurate and up-to-date information about bus locations, estimated arrival times, and potential delays. This empowers passengers to make informed decisions and plan their journeys accordingly, reducing uncertainty and waiting times.

The implementation of GPS-based bus tracking systems offers several advantages. Firstly, it enables transportation authorities to monitor the real-time location of buses, facilitating efficient resource allocation and optimized scheduling. By analyzing the collected data, authorities can identify areas with high demand and adjust bus frequencies accordingly, ensuring an improved distribution of services. This leads to reduced overcrowding and decreased waiting times for passengers [2].

Secondly, mobile applications equipped with live bus tracking capabilities provide passengers with a convenient and user-friendly interface to access real-time information. Commuters can easily view the location of nearby buses, estimated arrival times, and any service disruptions or route changes. This enhances the overall user experience by reducing uncertainty, increasing confidence in public transportation, and encouraging the use of sustainable modes of travel.

Furthermore, the integration of GPS and mobile applications in intelligent transportation systems enables transportation authorities to collect valuable data for performance analysis and decision-making. The information obtained from GPS tracking and user interactions can be used to evaluate the efficiency of bus routes, identify bottlenecks, and improve overall system operations. Such insights facilitate evidence-based planning, leading to more effective transportation networks.

The system architecture consists of three main components: the on-board bus tracking unit, the central server, and the user interface. The on-board tracking unit utilizes GPS technology to continuously update the location of the bus, which is then transmitted to the central server via wireless communication. The central server processes the incoming data, performs real-time analysis, and stores the information in a database. The user interface, accessible through a mobile application or a web portal, allows passengers to access the live bus tracking information.

II. Objective

The objective of this project is to conduct a pilot experiment on one of our university buses that transports students and staff to the campus in the morning. The experiment aims to evaluate the effectiveness and feasibility of the intelligent transportation system in providing real-time bus tracking, improved passenger experience, and reduced waiting times.

2.1. Evaluate Real-time Bus Tracking

The primary objective is to assess the accuracy and reliability of the real-time bus tracking system implemented using the SIM808 GPS module and Arduino Uno. By monitoring the bus's location in real-time, the experiment will determine the system's ability to provide accurate information on bus routes and estimated time of arrival, enabling passengers to make informed decisions about their travel.

2.2. Assess Passenger Experience

The experiment seeks to gauge the impact of the intelligent transportation system on the overall passenger experience. By providing passengers with up-to-date information on bus locations and arrival times, the system aims to reduce uncertainty and waiting periods. The objective is to evaluate passengers' satisfaction levels, perception of waiting times, and their overall experience using the system.

2.3. Test System Feasibility

The prototype pilot experiment will assess the feasibility of implementing the intelligent transportation system on a university bus. It will examine the system's compatibility with existing bus infrastructure, such as power supply and communication networks. Additionally, the experiment aims to identify any technical challenges or limitations that need to be addressed for successful system implementation.

2.4. Identify Potential Enhancements

The prototype pilot experiment will provide an opportunity to identify potential enhancements or additional features that could further improve the intelligent transportation system. This could include features like notifications for bus delays or changes in routes, integration with other campus services, or the inclusion of accessibility features to cater to diverse user needs.

III. Components

3.1. Arduino Uno

The Arduino Uno is a microcontroller board that serves as a crucial component in the intelligent transportation system. It acts as the main control unit responsible for collecting and processing data from various sensors and modules. In this project, the Arduino Uno is utilized to interface with the SIM808 GPS module, receive location coordinates, and transmit the data to the server. It plays a vital role in ensuring seamless communication between the SIM808 GPS/GPRS module and the central server.

3.2. SIM808 GPS/GPRS Module

The SIM808 GPS module is an essential hardware component utilized to obtain accurate real-time location coordinates of the buses in the intelligent transportation system. It integrates both GPS and Global System for Mobile Communications (GSM) functionalities, allowing for precise positioning and wireless communication capabilities. By connecting to multiple satellites, the SIM808 module retrieves latitude and longitude data, which is then transmitted to the Arduino Uno. This module ensures the reliable tracking of buses, forming the foundation of the real-time bus tracking system.

3.3. ThingSpeak Server

The ThingSpeak server is a cloud-based Internet of Things (IOT) platform that acts as the central hub for storing and managing the data collected from the buses. It provides an efficient and scalable solution for data storage, analysis, and visualization. In this project, the ThingSpeak server receives the location coordinates transmitted by the SIM808 GPS/GPRS module, processes the incoming data in real-time, and stores it in a database. Additionally, it enables the retrieval of the stored data for further analysis and presentation through the user interface [3].

3.4. Flutter Based Mobile Application

The Flutter-based mobile application serves as the user interface in the intelligent transportation system. It provides a platform for passengers to access real-time bus tracking information and enhances their overall user experience. The Flutter framework, known for its cross-platform capabilities, allows for the development of mobile applications compatible with both Android and iOS devices. Through the mobile application, users can view the locations of nearby buses, obtain estimated arrival times, and receive notifications about any service disruptions or route changes. It acts as a user-friendly and intuitive tool to empower commuters with up-to-date information, reducing uncertainty and improving their journey planning [4].

IV. System Architecture

The intelligent transportation system comprises three main components which are: the bus unit, the server, and the Flutter based mobile application which is our passenger interface unit. These components are going to be integrated together seamlessly to provide real-time bus tracking information to passengers [5].

4.1. Bus Unit

The bus unit consists of the SIM808 GPS/GPRS module and Arduino Uno, which are connected to the power supply of the bus. The SIM808 module utilizes GPS technology to acquire accurate latitude and longitude coordinates of the bus's current location. The Arduino Uno acts as the control unit, responsible for receiving the location data from the GPS module and transmitting it to the server. The communication between the Arduino Uno and SIM808 module is established through appropriate serial communication protocols. The module is also equipped with a SIM card that provides General Packet Radio Service (GPRS) internet connectivity.

To send the location data to the server, the Arduino Uno sends AT commands to the SIM808 module, instructing it to establish a GPRS connection with the server. The SIM card enables data transmission over the internet, allowing the bus unit to send the collected location data to the server in real-time. This data transmission process ensures that the server has up-to-date information about the bus's location [6].

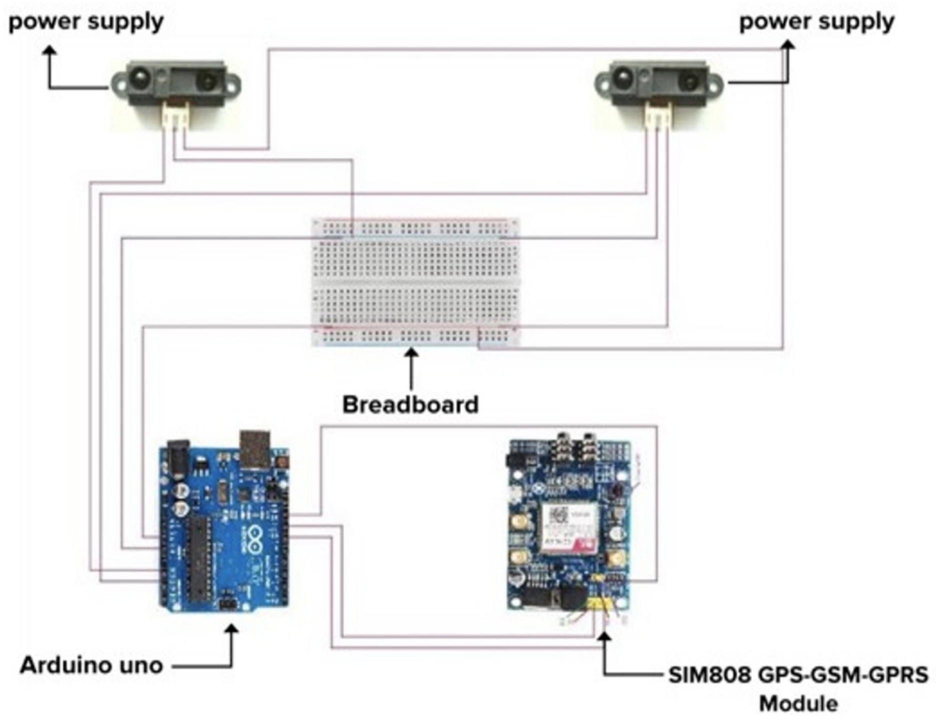

Figure 1. Bus Unit Circuit Diagram

4.2. Server

The server unit in this system architecture is implemented using the ThingSpeak platform. ThingSpeak serves as the central hub for receiving, storing, and processing the location data sent by the bus unit. The server is responsible for handling the incoming data and performing real-time analysis.

When the bus unit transmits the location data to the server, ThingSpeak receives and stores this data in a database. The server processes the incoming data to extract meaningful information, such as bus coordinates, timestamps, and any additional relevant details. And now the data is stored, analyzed, and ready to be fetched by the mobile application which is the next step.

4.3. Mobile application

The passenger interface consists of a Flutter-based mobile application that interacts with the server to provide real-time bus tracking information to the users. The mobile application serves as the user interface for passengers to access the system's features and functionalities.

Through the mobile application, users can retrieve bus location information from the server. The application establishes a connection with the server using appropriate APIs or protocols to fetch the real-time location data and in this case HTTP protocol is used. It retrieves the stored location data from the server and displays it on the user's mobile device. The application may include additional features such as displaying estimated arrival times, indicating any service disruptions or route changes, and providing notifications to the users [7].

The mobile application acts as an intuitive and user-friendly platform, empowering passengers to access the real-time bus tracking information effortlessly. By utilizing the Flutter framework, the mobile application can be developed to be compatible with both Android and iOS devices, ensuring wider accessibility for users.

V. Workflow of the System

The workflow of this system proceeds as follows.

5.1. Bus Unit

The SIM808 module in the bus unit utilizes AT commands to gather location data and send it to the server using the HTTP protocol. Here's an overview of the process:

5.1.1. Establishing Communication

The Arduino Uno, acting as the control unit, communicates with the SIM808 module through a serial connection. AT commands are sent from the Arduino to the SIM808 module using this communication channel [6].

5.1.2. Retrieving Location Data

To gather location data, the Arduino sends the appropriate AT commands to the SIM808 module. The SIM808 module, equipped with GPS functionality, communicates with GPS satellites to determine the latitude and longitude coordinates of its current location. The module then retrieves this location data and makes it available for transmission.

5.1.3. Preparing the HTTP Request

Once the location data is obtained, the Arduino prepares an HTTP request using AT commands. The request typically includes the server's URL or IP address, the specific endpoint or resource to which the data should be sent, and the necessary headers.

5.1.4. Establishing GPRS Connection

To send the HTTP request to the server, the SIM808 module needs to establish a GPRS connection. The Arduino instructs the module to initiate the GPRS connection using the appropriate AT commands. The SIM808 module establishes a connection to the internet via the inserted SIM card, allowing for data transmission [6].

5.1.5. Sending the HTTP Request

After the GPRS connection is established, the Arduino sends the prepared HTTP request to the server using AT commands. The request contains the location data collected by the SIM808 module. The Arduino transmits the request through the SIM808 module's serial interface, which then forwards the data over the established GPRS connection.

5.1.6. Processing the HTTP Response

Once the server receives the HTTP request, it processes the data and generates an HTTP response. The response may include a status code, indicating the success or failure of the request, along with any additional data or instructions.

5.1.7. Handling the HTTP Response

The Arduino, through the SIM808 module, listens for the HTTP response from the server. The response is received as a series of data packets via the serial communication channel. The Arduino parses and interprets the response using AT commands, extracting any relevant information or instructions [6].

Figure 2. Bus unit after implementation

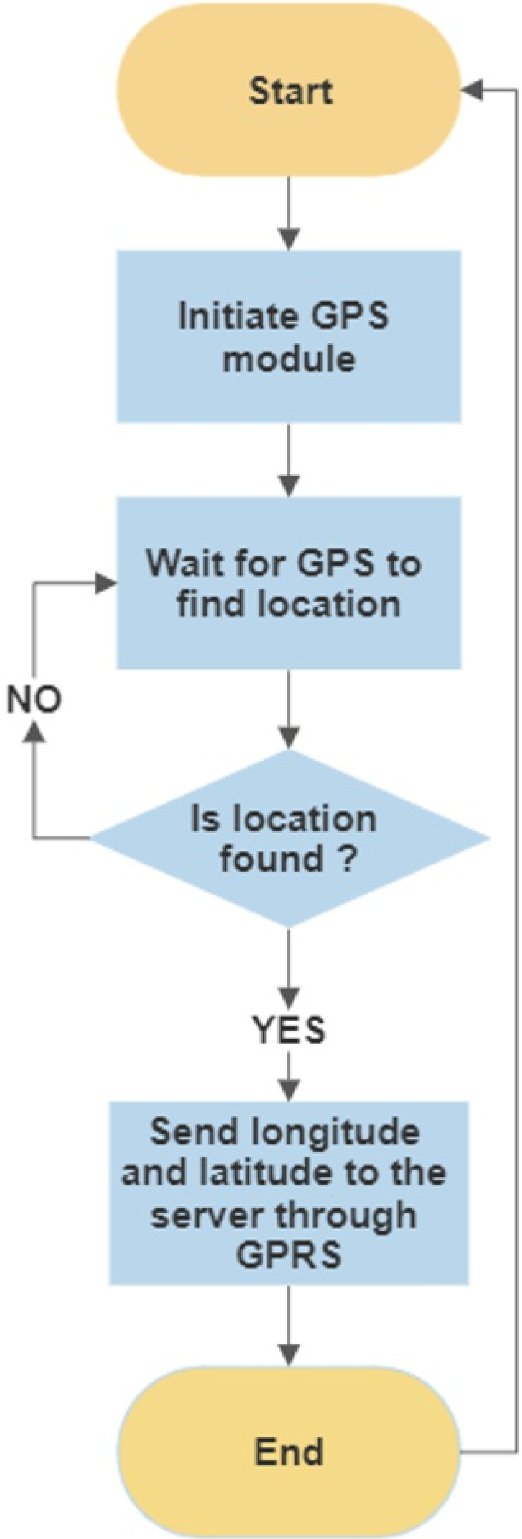

Figure 3. Bus Unit Workflow

5.2. ThingSpeak Server

5.2.1. HTTP Request Reception

The server unit, implemented using the ThingSpeak platform, receives the HTTP request sent by the bus unit. The server listens for incoming requests and identifies the specific endpoint or resource associated with the received request.

5.2.2. Data Processing and Storage

Upon receiving the request, the server extracts the location data from the request payload. It processes and validates the received data, performing any necessary data transformations or conversions. The server then stores the processed location data in a database for further analysis and retrieval.

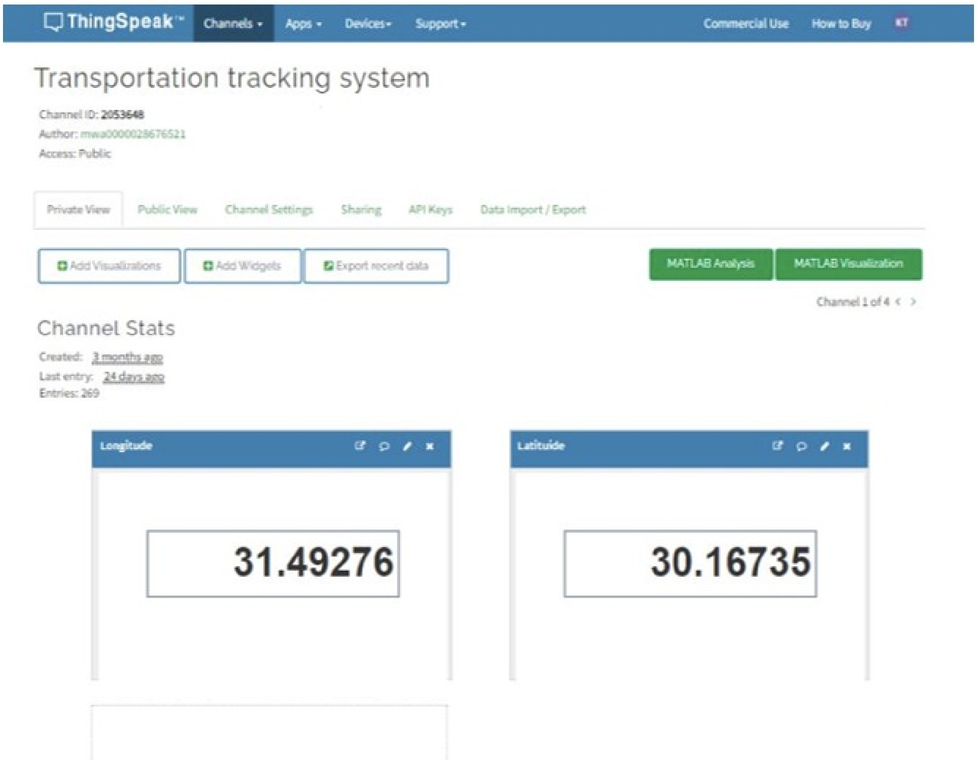

Figure 4. Location data on ThingSpeak Server

5.2.3. Real-time Analysis and Insights

The server unit can perform real-time analysis on the received location data. It may calculate bus arrival times, identify patterns or anomalies, and generate meaningful insights. The server can generate alerts or notifications for any service disruptions or route changes based on the analyzed data.

5.3. Flutter based Mobile Application

5.3.1. User Interaction

The passenger interface comprises a Flutter-based mobile application, acting as the user interface. Passengers can access the application on their mobile devices to interact with the intelligent transportation system.

5.3.2. Retrieval of Bus Tracking Information

The mobile application utilizes appropriate APIs or protocols to establish a connection with the ThingSpeak server. It sends requests to fetch the real-time bus tracking information. The application includes user-specific preferences, such as selecting a specific bus route or setting notifications for preferred bus arrivals.

5.3.3. Display of Real-time Information

Upon receiving the response from the server, the mobile application processes and parses the data using Flutter's programming capabilities. It then displays the retrieved bus tracking information to the user. This information typically includes the location of the bus, estimated arrival times, and any service disruptions or route changes.

5.3.4. Enhanced Features

The mobile application can also provide additional features to enhance the user experience. For example, it can send push notifications to users regarding bus delays or changes in routes. The application may also allow users to provide feedback, access historical bus tracking data, or enable personalized journey planning.

By following this workflow, the bus unit collects and transmits real-time location data to the server, which processes and stores the data. The passenger interface unit retrieves this information from the server and presents it to the users, providing an efficient and user-friendly intelligent transportation system.

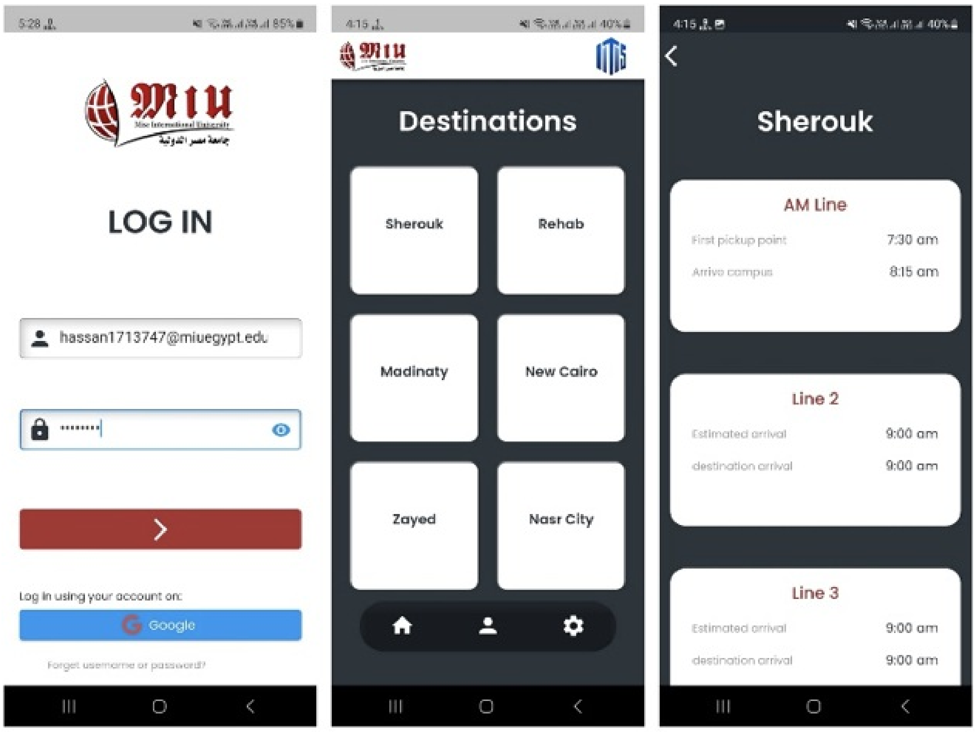

Figure 5. mobile app registration and route selection

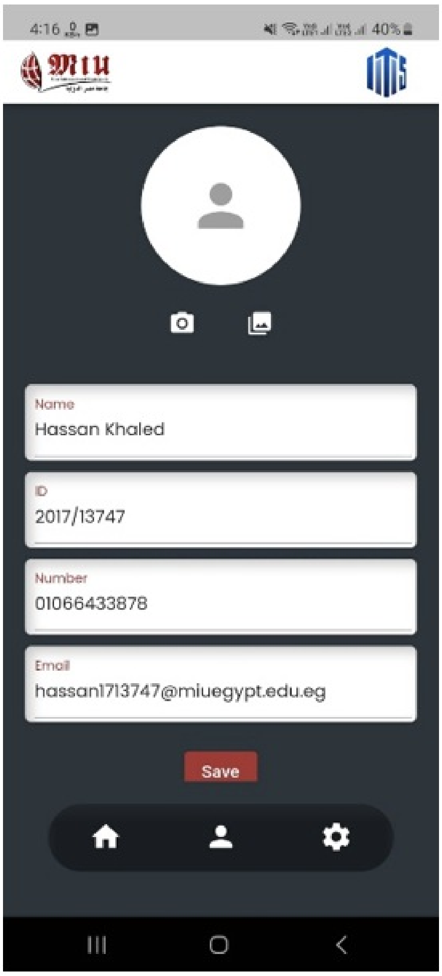

Figure 6. Student account information

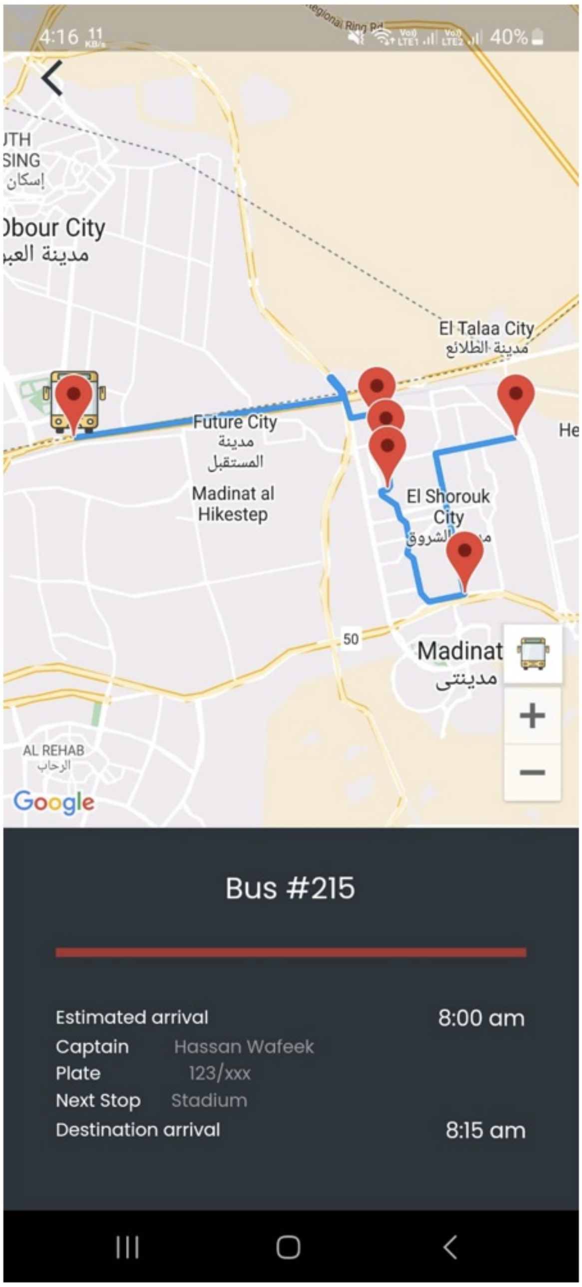

Figure 7. Mobile Application bus location and route view

VI. Conclusion

In conclusion, this research paper presented the implementation of an intelligent transportation system (ITS) using GPS technology, mobile applications development, and server infrastructure. The objective was to enhance the efficiency, reliability, and user experience of public transportation through real-time bus tracking, reducing waiting times, and providing accurate information to passengers.

Through the successful pilot experiment conducted on one of our university buses, we demonstrated the feasibility and effectiveness of the proposed system. The integration of the SIM808 GPS module, Arduino Uno, ThingSpeak server, and Flutter-based mobile application showcased a robust architecture that enables real-time bus tracking and data dissemination.

During the pilot experiment, the bus unit attached to the university bus, consisting of the SIM808 GPS module and Arduino Uno, effectively collected and transmitted location data to the server unit. The server, implemented using ThingSpeak, processed and stored the data, providing real-time analysis and insights. The passenger interface unit, represented by the Flutter-based mobile application, seamlessly retrieved and displayed the bus tracking information to users, enhancing their overall travel experience.

The results of the pilot experiment demonstrated several notable benefits. Passengers gained access to accurate and up-to-date bus location information, allowing them to plan their journeys more efficiently, reducing uncertainty, and minimizing waiting times. Furthermore, the integration of GPS technology and mobile applications enabled transportation authorities to make informed decisions regarding resource allocation, optimized scheduling, and improved overall system operations.

The successful pilot experiment validates the potential of intelligent transportation systems in addressing the challenges faced by commuters and improving the effectiveness of public transportation. The implementation of real-time bus tracking not only reduces passenger frustration and inconvenience but also encourages the use of sustainable modes of travel. By leveraging GPS technology, server infrastructure, and mobile applications, transportation authorities can enhance the reliability and user experience of public transportation systems.

Future work in this field could involve scaling up the system to cover a larger fleet of buses, integrating additional features such as predictive analytics for bus arrival times, and incorporating feedback mechanisms to further enhance the system's functionality. Continuous monitoring and evaluation of the system's performance would contribute to further optimization and refinement.

Overall, the successful pilot experiment conducted on one of our university buses highlights the potential of intelligent transportation systems in revolutionizing public transportation, improving passenger experience, and reducing waiting times. This research provides a solid foundation for future developments and advancements in the field of intelligent transportation systems.

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