Sri Lanka Intelligent Bus Navigation and Passenger Information System

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Project Proposal Report

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Declaration

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does notcontain any material previously published or written by another person except where the acknowledgement is made in the text.

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Abstract

In this research project we aim at enhancing the journey experience with public transport by developing a complete mobile application for such bus tracking system in Sri Lanka. The app also features real-time bus tracking and ETA predictions as well as an interface that can be used by visually impaired users. An AI chatbot incorporated in the bus app which helps users get detailed information on your city about Bus routes, timing or any other logical query they have by just asking it naturally.

The accessibility tab contains a voice guide and supports screen reader compatibility therefore all the important functions can be independently accessed by Visually impaired users. By using GPS data and past traffic patterns, the ETA prediction system predicts arrival times with accuracy, cutting down on waiting times and increasing user comfort. With the goal of bridging the gap between public transport needs and technological innovation, this effort provides a solution that is user-friendly, dependable, and inclusive for all commuters in Sri Lanka.

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Abbreviation	**Full form**
ETA	Estimated Time of Arrival
GPS	Global Positioning System
GPRS	General Packet Radio Service
API	Application Programming Interface
ML	Machine Learning
LSTM	Long Short-Term Memory
NLP	Natural Language Processing
TTS	Text to Speech

1. Introduction

1.1 Background & Literature Survey

Millions of people in Sri Lanka rely on the bus-based public transport system as their main means of everyday commute [1] .There is a vast bus network that covers both urban and rural areas, operated by both state-owned and private companies. Although the system is widely used, there are still several issues that need to be resolved, especially regarding effectiveness, dependability, and accessibility for all users, including those with impairments [2].

Modern public transport systems are built around real-time vehicle tracking, which enables users to track the precise location of buses, trains, and other transit vehicles as they travel their routes [3] .This technology makes use of GPS data, which is updated continuously and sent to a central system. This system interprets and presents the data in an easy-to-understand format, frequently via a mobile application. Real-time tracking lessens the stress of waiting for public transport by letting users see the exact location of their car, especially in erratic traffic situations. By helping transit operators to better manage their fleets, this solution not only improves passenger satisfaction but also maximizes the overall efficiency of the transportation network. Users who depend on timely and accurate information for their regular journeys may find public transport systems more desirable when real-time tracking is implemented, as evidenced by studies [4].

Increasing the effectiveness of public transit now requires the use of predictive analytics, especially when it comes to precise arrival time (ETA) estimation. ETA prediction analyses a ton of past and current data, including vehicle speeds, weather, and traffic patterns, using sophisticated machine learning algorithms [5]. The algorithms can produce extremely precise forecasts of when a car will arrive at a certain stop by analyzing this data. For travelers who need to schedule their trips with the least amount of delay, this information is essential since it lessens the uncertainty surrounding public transportation and cuts down on wait times. High-accuracy ETA prediction helps transport operators by facilitating more efficient scheduling and resource allocation. The application of machine learning models for ETA prediction has shown to be a significant development in transport systems where traffic conditions might change significantly during the day. This has improved both the user experience and the operational efficiency of transit services [6].

A subfield of artificial intelligence called natural language processing, or NLP, gives robots the ability to comprehend, interpret, and react to human language naturally [7]. NLP has been incorporated into mobile applications for public transit to produce interfaces that are easier to use and more accessible. NLP-enabled voice command systems are especially helpful for visually challenged users because they let them utilize spoken language rather than visual cues to interact with transportation apps [8]. This can involve enquiring about the time when the next bus will arrive, getting directions, or asking for help with navigation. Moreover, natural language processing (NLP) makes it possible to create chatbots that converse with consumers in natural language while offering updates on routes, schedules, and transportation. These chatbots can respond to a broad variety of queries, from straightforward ones about bus timetables to trickier ones involving multi-leg travel. By providing a more responsive and intuitive user interface, the incorporation of natural language processing (NLP) into transportation apps not only increases accessibility for visually impaired users but also enhances the entire user experience [9].

The accessibility and user experience of mobile transportation applications have significantly improved with the combined use of real-time tracking, predictive analytics, and natural language processing. By providing voice-based navigation and real-time updates, these technologies offer vital assistance to visually impaired users, enabling them to use public transit more independently and confidently. The integration of chatbot functions and real-time data means that visitors and new residents, who might not be familiar with the local transit system, can simply navigate routes and make educated travel decisions. By simplifying the process of using public transport, this technique increases accessibility for a larger group of people. As a result, by making public transportation more practical, dependable, and user-friendly, these technologies not only enhance the personal travel experience but also help achieve the larger objective of boosting its usage [10].

1.2 Research Gap

Significant progress has been made in the current state of public transport systems, especially in the areas of real-time vehicle tracking and ETA projections. To improve the overall user experience, however, there are still important gaps that must be filled, particularly for visually impaired users and visitors who are unfamiliar with the local roads. The following are the main research gaps that were found.

1. **Accuracy of ETA Predictions**

Current systems frequently have trouble estimating arrival times with sufficient accuracy, especially in the face of unpredictable occurrences and fluctuating traffic. Some systems use real-time traffic information, but others only use historical data, which results in ETAs that are less accurate. To provide more precise and dynamic ETA predictions, the trick is to successfully integrate historical data and real-time traffic circumstances. These elements have each been the subject of independent studies in the present literature, but comprehensive approaches that successfully integrate these elements are lacking. This discrepancy highlights the requirement for a more resilient prediction model that can adjust in real time and raise the dependability of ETAs under various conditions.

2. **Accessibility Features**

Accessibility for visually impaired users is a problem in many of the current transportation systems. Although some systems provide basic information through mobile applications, they frequently lack features like voice commands and audible feedback that are intended to improve accessibility. This shortcoming is brought to light in research papers, which demonstrate a notable void in the creation of voice-enhanced features that cater to the requirements of visually impaired users. To enable greater freedom and ease of use for all users, public transport apps must have a more inclusive design that incorporates these accessibility features.

3. **Information Retrieval**

One major flaw in the current public transportation systems is the lack of integrated chatbots that offer quick access to schedules and route information. Most existing solutions need users to navigate through apps by hand to gather information, which can be challenging, especially for users who are unfamiliar with the UI or the local transit routes. The delivery of information through mobile applications has advanced significantly, but chatbot integration for route information is still largely absent. This disparity highlights the need for more interactive and user-friendly technologies that support conversational interfaces, giving users quick and easy access to the data they need.

	Research Paper 1 [11]	Research Paper 2 [12]	Research Paper 3 [13]	Research Paper 4 [14]	Proposed System
ETA prediction with current traffic conditions	✓	✗	✗	✓	✓
ETA prediction with Historical data	✓	✓	✗	✗	✓
Voice enhanced features focusing on visually impaired users	✗	✗	✗	✗	✓
Chatbot for route information	✗	✗	✗	✗	✓

Table 1: Comparison with existing research papers

1.3 Research Problem

The increasing reliance on public transportation necessitates systems that are not only efficient but also accessible to a diverse range of users, including visually impaired individuals and tourists unfamiliar with local transit routes. However, current public transportation applications face significant limitations. Firstly, the accuracy of Estimated Time of Arrival (ETA) predictions remains inconsistent, especially under varying traffic conditions and unforeseen events. Existing systems either rely on real-time traffic data or historical data, but seldom integrate both to provide dynamic and reliable ETA predictions. This leads to passenger dissatisfaction and inefficiencies in transit planning.

Secondly, there is a noticeable lack of accessibility features tailored to visually impaired users. Many applications fail to provide essential features such as voice commands and sound feedback, which are critical for enabling independent navigation. This exclusion limits the usability of public transportation apps for a significant portion of the population, leading to reduced mobility and independence for visually impaired users.

Thirdly, while mobile applications exist to provide route information, they often require users to manually search for details, which can be cumbersome, particularly for tourists or new users who are not familiar with the transit system. The absence of integrated chatbots or similar interactive tools further exacerbates the challenge of accessing route information quickly and intuitively.

Therefore, the research problem centers on the need to develop a comprehensive, user-centric public transportation system that can accurately predict ETAs by integrating both real-time traffic conditions and historical data, while also enhancing accessibility for visually impaired users through voice-enabled features. Additionally, the system should incorporate interactive tools such as chatbots to streamline the retrieval of route information, thereby improving the overall user experience for all passengers.

2. Objectives

2.1 Main Objectives

The primary goal of this research is to create a comprehensive and user-focused mobile application for public transportation that incorporates improved accessibility features designed for visually impaired users, accurate ETA prediction based on past data combined with current traffic conditions, and real-time vehicle tracking. The program will also include interactive features, such chatbots, to give users quick and easy access to route information. This will enhance the entire user experience for all users, even those who are not familiar with the local transit systems.

2.2 Specific Objectives

There are four specific objectives that must be reached to achieve the overall objective described above.

1. **Develop an accurate ETA prediction model**

This mission is to create and implement a complex prediction model that can be used to precisely predict when buses and trains, among other forms of public transit, will arrive. In order to do this, the model will integrate historical data such as previous traffic patterns, vehicle speeds, and typical delays with real-time traffic conditions, such as the traffic jams, accidents, and weather at the moment. The algorithm will constantly adjust to changing conditions by incorporating both real-time and historical data, giving passengers dependable ETAs that will increase the assurance with which they can plan their travels. By reducing the differences between anticipated and actual arrival times, this model seeks to enhance user experience in general.

2. **Enhance accessibility for visually impaired users**

This goal is to add voice-activated instructions and audible feedback to the mobile application so that visually impaired people may utilize it. Users will be able to request information like the best route to travel, the time when the next bus will arrive, and other pertinent details by using voice commands to engage with the app without having to view or touch the screen. Users will be guided through the app's features by sound feedback, which will also send them aural alerts when things like their bus is coming up. By including these functions, the program will increase the mobility and autonomy of visually impaired users by enabling them to freely traverse public transit systems.

3. **Realtime vehicle tracking**

The mobile application will have a real-time car tracking mechanism as part of this goal. Users will be able to see public transportation vehicles' precise whereabouts on a map in real-time, thanks to this system's continual location updates that utilize GPS data. With the use of this function, travelers will be able to track the whereabouts of their bus or train, which will help them choose when to depart for their stop and reduce uncertainty regarding arrival timings. When there are delays or unforeseen changes in the timetable, real-time tracking will be very helpful because users may modify their plans accordingly.

4. **Chatbot to Provide Route Information**

The goal of this objective is to create and include a chatbot into the mobile application so that it may act as a virtual assistant for users looking up the routes of public transit. Natural language processing (NLP) will be used by the chatbot to comprehend customer enquiries and deliver pertinent, conversational answers. When a user asks, "How do I get from downtown to the airport?" for instance, the chatbot will provide the best routes, along with transfer details and projected travel times. This function is especially useful for visitors, recent arrivals, or anyone who is not familiar with the local transit system because it provides a simple and straightforward method of obtaining route information without requiring the user to input precise details or navigate complicated menus.

3. Methodology

The creation of the mobile application for public transportation is methodically organized around an all-encompassing, methodical, and user-centered approach. This strategy is designed to make sure that the application not only satisfies but also surpasses the wide range of needs of different user groups, such as tourists, frequent commuters, and people with visual impairments. Delivering an application that provides a dependable, easy-to-use, and seamless user experience across all public transit touchpoints is the main goal. The process is meticulously broken down into multiple crucial stages to do this: requirement gathering, system design, implementation, testing, deployment, and post-deployment evaluation. To deliver the application successfully and make sure it is reliable, easy to use, and flexible enough to meet changing requirements, each of these stages is essential.

3.1 Understanding the Key Technologies in the Public Transportation Mobile Application

3.1.1 Google Maps API for Interactive Mapping

An essential part of the program is the interactive mapping feature that lets users see the real-time whereabouts of public transport vehicles thanks to the Google Maps API. To show the movement of buses and trains on a map, the Google Maps API provides a number of functions, such as route planning, geolocation, and map visualization. Users may readily view and track their vehicle's position by integrating Google Maps into the mobile application, which improves their capacity to make well-informed travel decisions. The API is a common tool for location-based applications due of its worldwide familiarity and dependability.

3.1.2 TensorFlow and Keras for ETA Prediction

Two of the most popular frameworks for creating machine learning models are TensorFlow and Keras. These resources are used in this project to create an ETA prediction model that precisely predicts when public transport vehicles will arrive. While Keras offers an intuitive interface for deep learning model design and training, TensorFlow offers a comprehensive machine learning environment. The algorithm predicts ETAs with excellent accuracy by utilizing historical trip data, real-time traffic data, and current vehicle positions. The model can be trained effectively and implemented at scale thanks to the usage of TensorFlow and Keras, giving users accurate ETA forecasts.

3.1.3 Natural Language Toolkit (NLTK) for Voice Command Processing

One of the most popular libraries for handling human language data in Natural Language Processing (NLP) applications is the Natural Language Toolkit (NLTK). The voice command feature in this project is implemented using NLTK, allowing users to communicate with the app by speaking commands. Because of NLTK's extensive collection of text processing libraries, the application can comprehend user requests with accuracy and respond with pertinent information. Due to their reliance on voice commands to browse the app, visually challenged users can benefit greatly from this technology. The program can handle a variety of natural language inputs thanks to the inclusion of NLTK, which improves user engagement.

3.2 System architecture

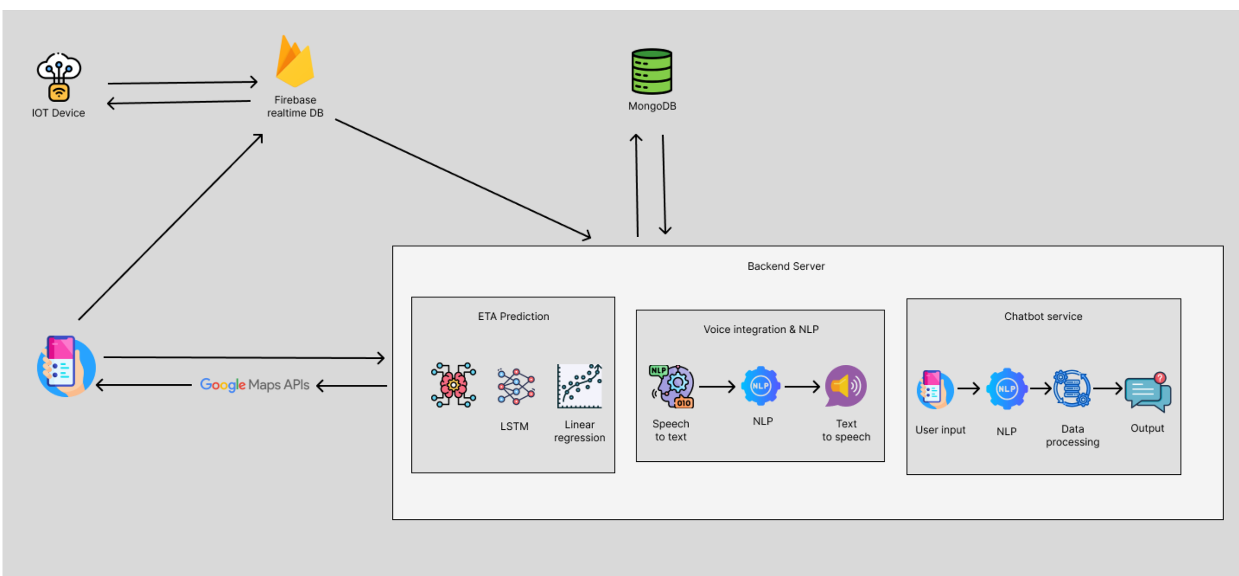

Figure 1: Component system diagram

The system architecture, as shown in the picture, is made to effectively handle and process real-time data in order to improve the public transit user experience. The system is made up of a number of interconnected parts that cooperate to deliver interactive features, real-time updates, and predictive insights suited to different user requirements.

The system starts with IoT devices mounted on public transit vehicles. These devices constantly gather and transmit position data in real time to Firebase, a real-time database. This data is retrieved from Firebase by the backend server, which then processes it to keep the vehicle's location up to date. The Google Maps API is then used to display the processed data in the mobile application. Users may track their bus or train in real time by using the app's integration with Google Maps, which shows the location of the vehicle visually on an interactive map. For users that need to plan their trips using the most up-to-date information, this function is essential.

On the server side of the system, an ETA prediction model determines the ETA of public transport vehicles. This model uses advanced machine learning techniques such as LSTM networks and Linear Regression to assess historical traffic data, current traffic circumstances, and real-time location data from Firebase. Using these multiple data sources, the program produces incredibly accurate ETA estimates, which are then communicated to customers through the mobile application. Thanks to this predictive feature, users may plan their trips more efficiently, which is especially useful in instances where precise timing is critical, as during peak travel hours or in areas with unpredictable traffic patterns.

Additionally, the mobile application has voice command capabilities, which opens it up to a larger user base, including individuals who prefer hands-free use or are visually challenged. Speak commands to the app to interact with it, such finding out when the next bus is arriving. A Natural Language Processing (NLP) module in the system is used to process these voice inputs. It translates spoken words into text, decodes their meaning, and retrieves pertinent data. After that, the system sounds a message, like "The next bus will arrive in 5 minutes." By enabling users to obtain timely information without requiring manual app interaction, this feature greatly improves usability.

The smartphone application has a chatbot feature to help users even more, especially visitors and locals who might not be familiar with the public transport system. Based on user enquiries, this chatbot is intended to offer comprehensive route information. For instance, when a user enters in "I want to go from Colombo to Kandy," the chatbot uses natural language processing (NLP) to interpret the input, collect the relevant route information, and provide the user detailed advice on which buses to take, where to transfer, and how long the trip would take. Users who want quick and simple access to route information without having to go through numerous menus or maps will find this service extremely helpful.

Summary of technologies, techniques, architectures and algorithms used for the classification of Coconut Caterpillar Infestation is shown in the table below.

Technologies	Firebase, Google Maps API, Python, Flask, TensorFlow, Keras, MongoDB, React Native, Expo, Node.js, Natural Language Toolkit (NLTK)
Techniques	Machine Learning (Supervised Learning), Natural Language Processing (NLP), Speech Recognition, Data Retrieval, API Integration
Algorithms	Long Short-Term Memory (LSTM), Linear Regression
Architectures	Client-Server Architecture, RESTful API, Microservices

Table 2 : Technologies and techniques

3.2.1 Software solution

The Software Development Life Cycle (SDLC) is a methodical approach to software development that ensures code accuracy and consistency. When requirements shift, in the conventional approach software developers are unable to go back to earlier steps therefore, they are compelled to carry out all of the steps in the correct order. However, if agile methodology is used in SDLC developers are not required to do so. Being agile is all about adapting to changes. With compared to several agile frameworks scrum is the most effective agile framework as compared to the others mentioned. Scrum is an agile project management framework that is lightweight and can be used to manage and solve complex adaptive problems. Figure 2 illustrates the six core processes of agile methodology.

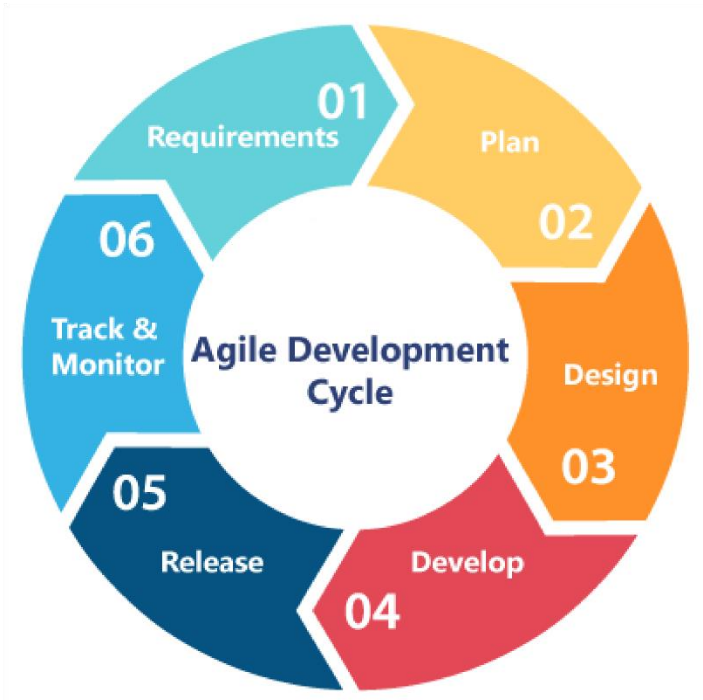

Figure 2 : Agile development phases

Requirement gathering

- **Stakeholder Identification and Engagement**

Determine and interact with important parties, such as transit operators, public transportation authorities, and possible end users like commuters, those with visual impairments, and tourists. Their feedback is essential to comprehending the difficulties and demands of the application in the context of Sri Lanka. To obtain in-depth understanding of the precise features and functionalities that are most required, such as real-time tracking, ETA projections, and route information, arrange workshops and focus groups with key stakeholders.

- **Data Collection and Analysis**

In order to facilitate the creation of the predictive models within the program, pertinent datasets are gathered from online resources like Kaggle. These datasets could contain statistics on the use of public transportation, traffic patterns, weather, and historical transportation data. Following collection, the data is transformed and modified to take into account the particular circumstances and factors that are pertinent to Sri Lanka's public transport system. This entails adjusting data to take into consideration regional differences in transportation infrastructure as well as common traffic congestion patterns in large cities like Colombo and public holidays.

- **Analysis of Existing Systems**

Examine the present applications for public transit that are offered both domestically and abroad to find any holes in the market. This analysis aids in comparing the new application's features and functionalities to those of the current ones and in identifying areas for improvement. Think about the demands of the market and the competitive environment, concentrating on how the application may provide distinctive value propositions like more precise ETA projections adapted to local conditions or an easier-to-use user interface for non-technical customers.

Feasibility study

- **Economic Feasibility**

The project to produce a mobile application for public transport has been evaluated economically to make sure that the expenses incurred in its development, implementation, and upkeep outweigh the possible returns. Software development, cloud services (Firebase, Google Maps API), and machine learning infrastructure are the main costs. High user uptake is anticipated to yield large profits on the initiative, especially in urban regions with high public transit usage. Partnerships with transportation authorities, in-app advertising, and premium features are examples of potential revenue streams. The project is financially feasible since the total budget is within the organization's means and the anticipated return on investment (ROI) is positive.

- **Scheduled Feasibility**

The project schedule has been meticulously designed to guarantee that all significant benchmarks may be accomplished within the necessary duration. Agile technique is used in the development process, with distinct sprints for requirement collecting, design, programming, testing, and deployment. Taking into account the resources available and the complexity of the tasks at hand, a realistic length has been assigned to each phase. Regular sprint reviews and the team's experience with Agile methodologies will help to keep the project on schedule. The project timeline has taken into consideration potential risks, like integration difficulties or delays in data collecting, to guarantee that the project can be finished on schedule.

- **Technical Feasibility**

The project's technical viability has been assessed through an analysis of the selected technology stack and the competencies of the development team. React Native for mobile development, Firebase for real-time data management, Google Maps API for mapping services, and TensorFlow for machine learning are just a few of the well-known technologies used in this project. These scalable and dependable technologies guarantee that the application can accommodate growing user loads and data volumes. Technical difficulties are less likely because the development team has the requisite knowledge of these technologies. Technical viability has been established for the integration of NLP for voice commands and machine learning for ETA forecasts, with the necessary frameworks and tools in place.

Design (system and software design documents)

After the planning phase, system and software design documents are created which contributes to the overall system diagram.

- **Sequence diagram**

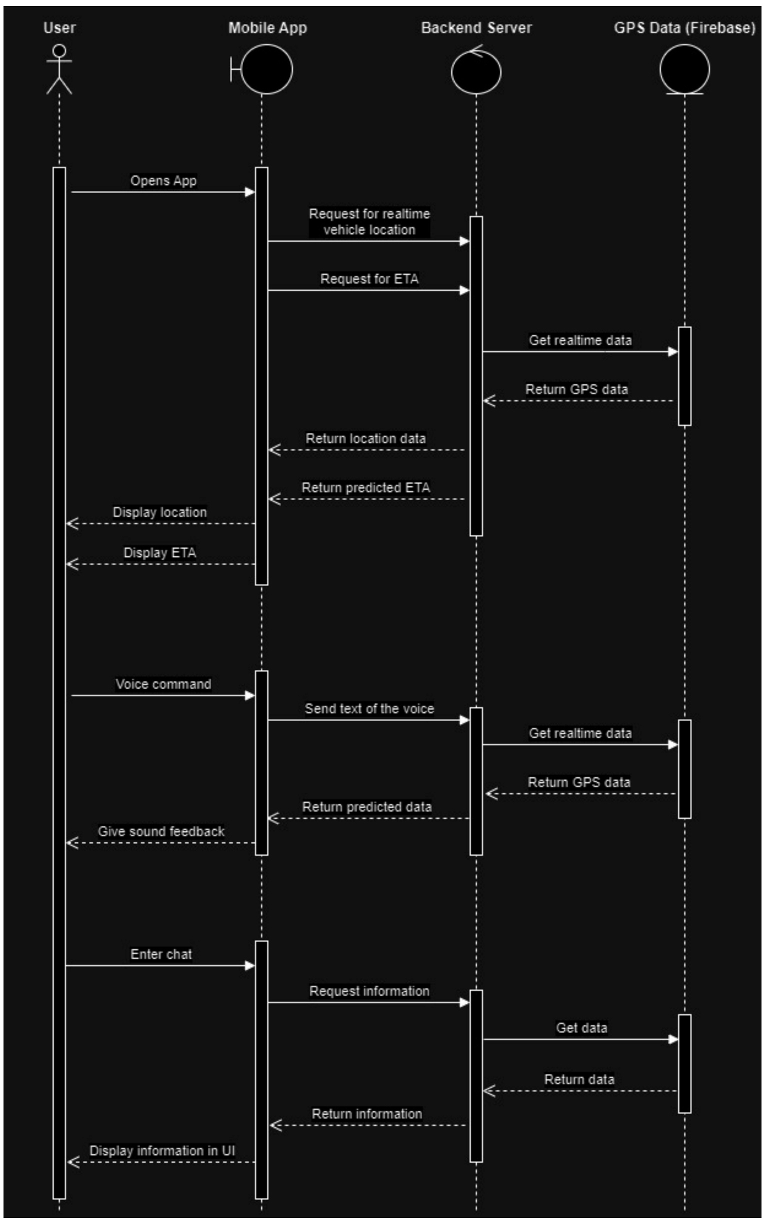

Figure 3 : Sequence diagram for component

Implementation (Development)

The development of essential features that satisfy the determined user needs is the main goal of the implementation phase, which makes sure the program provides precise and trustworthy answers. The main elements created in this stage are as follows:

- **Cross-Platform Mobile Application Development:**

React Native and Expo are used in the development of the mobile application to provide cross-platform compatibility, including iOS and Android. Whichever device is being utilised, this method offers a smooth user experience.

- **Real-Time Vehicle Tracking:**

By integrating Firebase as the real-time data source, the application may use the Google Maps API to retrieve and show real-time location updates of public transport vehicles on an interactive map.

- **ETA Prediction:**

TensorFlow is being used to implement an ETA prediction model that blends historical data unique to Sri Lanka with real-time traffic data. The model makes it easier for users to plan their trips by giving them precise arrival time estimations.

- **Voice Command Processing and Feedback:**

NLP techniques are being used to develop voice command capabilities, which will enable users to interact with the app by speaking commands. By processing these orders and producing aural feedback, the system enhances accessibility, particularly for users who are visually challenged.

- **Chatbot Integration for Route Information:**

incorporation of a chatbot service into the smartphone application to help residents and visitors navigate the public transit network. In order to help customers identify the bus routes that best suit their needs, the chatbot answers their enquiries about bus routes and delivers comprehensive, context-specific information.

Testing (Track and Monitor)

The application is thoroughly validated during the testing phase to make sure it satisfies all functional and performance criteria. Accuracy and dependability tests are conducted on critical aspects like as voice commands, ETA prediction, and real-time tracking. Integration testing guarantees the seamless operation of all components, such as the backend server, Firebase, Google Maps API, and mobile application. To ensure that the program satisfies their needs, real users participate in User Acceptance Testing (UAT). The program is constantly checked after deployment to track performance and promptly fix any problems, guaranteeing a dependable and user-friendly experience.

3.1.2 Commercialization

The target audience for the public transport mobile application's commercialization approach includes Sri Lankan tourists, visually impaired users, and regular commuters. Major software stores including Google Play, and the Apple software Store will host the introduction of the app, with gradual distribution starting in crowded cities. Using the app's distinctive features—such as real-time tracking, precise ETA forecasts, and voice command accessibility—to draw and keep users, revenue generation will be fueled by in-app advertising, premium services, and collaborations with regional transportation authorities.

Future scope

The smartphone application for public transport will eventually cover more ground and incorporate features like AI-driven route optimization and new transport modes like trains. Future developments could bring a comprehensive and environmentally sustainable transportation option, such as bilingual support, customized travel recommendations, and alliances with ride-sharing services.

4. Project requirements

4.1 Functional requirements

- **Real-Time Vehicle Tracking**

Using an interactive map, the application must give users up-to-date information on the whereabouts of public transport vehicles in real time.

- **ETA Prediction**

Using a machine learning model that analyses both historical and real-time traffic data, the system must precisely forecast the estimated time of arrival (ETA).

- **Voice & sound integration**

Especially for users who are blind or visually handicapped, the program must enable voice commands and offer audible responses.

- **Chatbot integration**

A chatbot that responds to user enquiries and gives route information must be included in the application.

4.2 Non-functional requirements

- **Performance**

Within two seconds, the program must display real-time data and react to user actions.

- **Scalability**

Without sacrificing performance, the system must be able to accommodate growing user and data volumes.

- **Security**

Encryption must be used to safeguard user data while it is in transit and at rest, notably location data.

- **Usability**

The program needs to be easy to use, have an easy-to-understand interface, and be accessible to users who are blind or visually impaired.

4.3 System requirements

- **Backend Server**

A Flask-based server that communicates with the Firebase database and Google Maps API in addition to handling requests and processing data.

- **Database**

MongoDB is used to store user preferences and historical data, while Firebase is used for real-time data management.

- **Machine Learning Models**

TensorFlow and Keras are machine learning models that are used to develop and execute the ETA prediction model.

- **Mobile Application**

React Native was used in its development to guarantee platform compatibility for both iOS and Android.

4.4 User requirements

- **commuters**

To efficiently plan their trips, they must be able to see the whereabouts of public transport vehicles in real time and get precise ETA estimates information via the mobile app.

- **Visually impaired users**

To utilize the application without using the touch interface, voice command functionality must be available.

- **Tourists & locals**

Need to be able to navigate unfamiliar public transit systems and get thorough route information via the chatbot feature.

5. Gantt chart

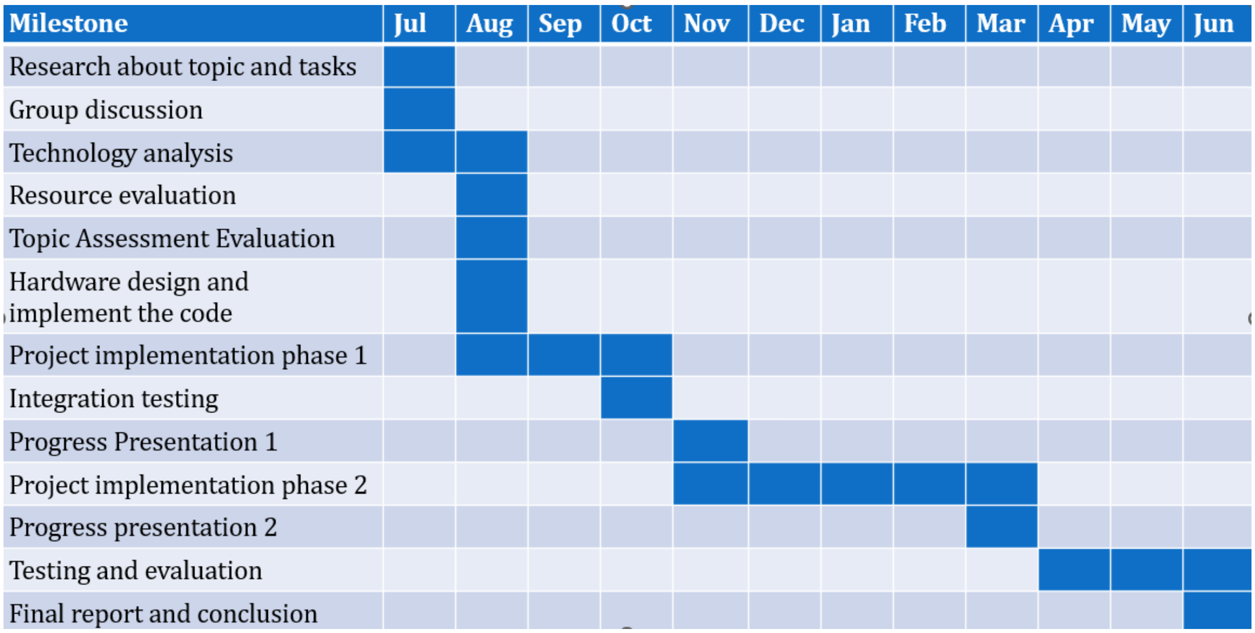

Figure 4 : Gantt chart

5.1 Work breakdown structure

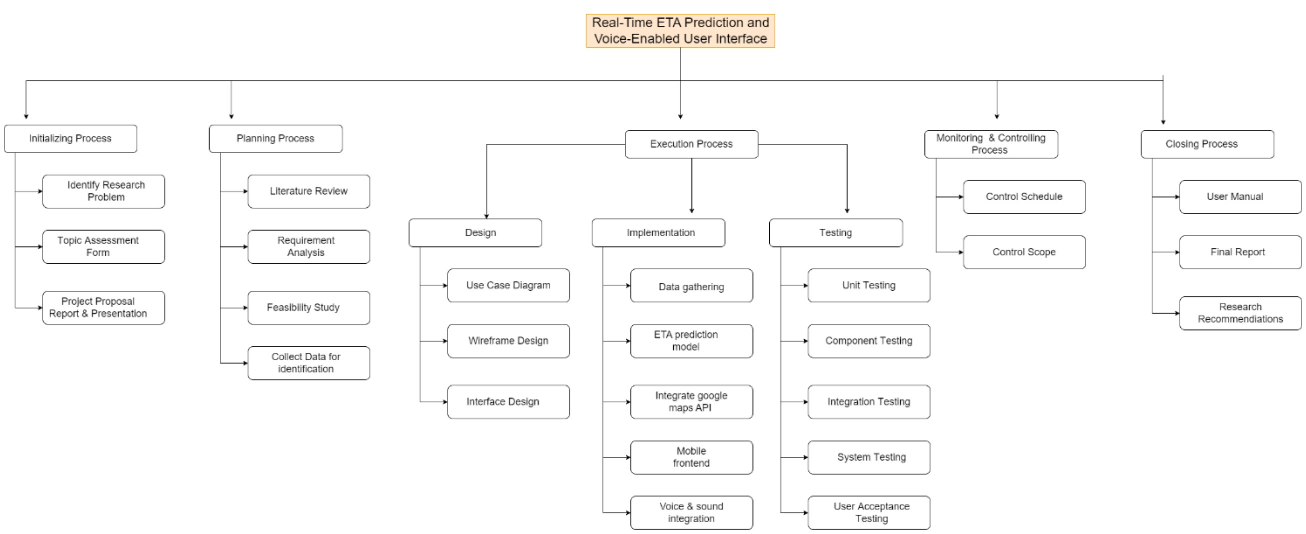

Figure 5 : Work breakdown structure

6. Budget and justification

Expenses	Cost (Rs)
Google maps API	3000
Cost of deployment	5000
Cost of Hosting on Google Play Store	5000
Total cost	**13000**

Table 3 : Budget justification

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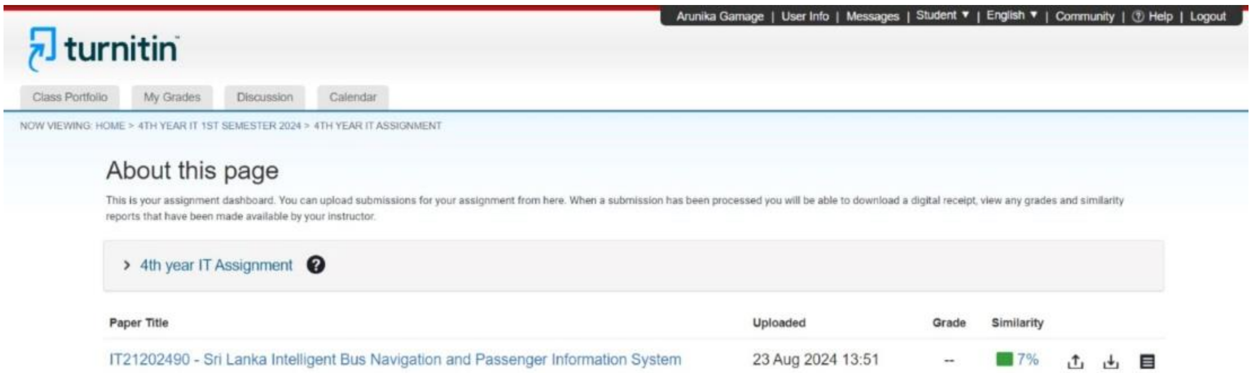
Appendices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