PUSL3190 Computing Individual Project

Final Project Report – Second Attempt

A Mobile-Based Taxi Booking System for Visually Impaired People

Supervisor: Dr. Pabudi Abeyrathna

Name: Thehara D Weerasiri

Plymouth Index Number: 10899495

Degree Program: BSc. (Hons) Data Science

1. Acknowledgements

During the entire project period I owe my genuine appreciation to Dr. Pabudi Abeyrathna for her important support. Through the thorough feedback of Dr. Pabudi Abeyrathna the project developed correctly toward its successful completion. Dr. Pabudi Abeyrathna has given me tremendous help through her willingness to meet at any time as well as her boundless patience.

I want to thank all my peers and family members and friends for their emotional backup that sustained me from beginning to end while working on this project. Because of their unyielding support and their belief in my abilities and their knowledge of my challenges they enabled me to carry on despite obstacles which protected my project goals. I remain thankful for their constant involvement since their thoughtful recommendations made a positive impact on my most challenging times.

The collaboration between School for the blind, Ratmalana and its academic resource programs with its provided facilities made this project reach its success goals. My academic path alongside professional growth at NSBM Green University has developed into fundamental shape through the entire range of learning programs I appreciated greatly. The project reached success through necessary information from School for the blind, Ratmalana that enabled me to develop vital project elements. Thanks to the open-cooperative nature and complete willingness of these organizations the project achieved success.

All people involved in creating the project deserve my heartfelt appreciation for their contributions to its current state.

2. Abstract

This project presents the development of such an accessible taxi booking system for visually impaired users. The system aims to assist the visually impaired in an intuitive, convenient and independent way to book, track the journey and communicate with the drivers using voice commands and real time audio feedback. We have a number of these technologies that make up the system, one of which being Google Speech to Text for voice recognition, Google Maps API for real-time location tracking and Supabase for data synchronization.

Besides this, the app does voice-based ride booking, real time location updating, and integrates with screen readers like TalkBack to make it accessible on the app to users with varying degree of visual impairment. Besides this, the system provides continuous audio feed of the ride status such as estimated time of arrival, variations in the ride details etc. The app is developed in an Agile approach, which means that each feature proposed to them is tested and validated with visually impaired people to make sure that the developed app is usable and effective.

Finally, the product is delivered which meets the objective of the project, fully functioning prototype for empowering visually impaired users able to use transportation service independently. Furthermore, the provided application has significantly better accessibility to the visually impaired users compared to existing ride hailing applications that do not fully support the visually impaired users. The system will be extended to iOS platforms and AI can be integrated to make the system more personalized, and security mechanism will be extended to protect user data.

Table of Contents

List of Tables

3. Main Body of the Report

3.1 Introduction

Transportation serves daily operations that help people reach their educational facilities and move between work destinations and obtain healthcare services and social group involvement. Standard transportation systems cause overwhelming challenges to people with visual impairments. The vision-dependent ride booking system along with route tracking and driver messaging links different points that limit user independence in transportation activities. Special modes of accessibility function within multiple transportation systems although the ride-sharing applications Uber and Lyft mostly address the needs of the typically visioned user. Ride booking applications require visual map displays and driver tracking which shows their positions through a combination of payment features. The current technologies in transportation systems fail to serve visually impaired users because they establish obstacles for independent travel with confidence.

The current barriers force visual impairment users to need assistance with their mobility since they restrict their independent movement. The current taxi booking solutions fail to support essential functionalities including voice-based directions and live audio updates and reliable communication tools for visually impaired people to operate on their own. The proposed research project designs a new mobile taxi booking system with complete accessibility which targets exclusively visual impairment-friendly features. The system design places emphasis on three accessibility points that enable visually impaired users to manage their travel arrangements through self-operation without needing assistance from others.

The proposed project deals with the crucial access barrier faced by visually impaired users since current taxi booking platforms do not fully support accessibility needs. The recently implemented digital accessibility measures fail to solve important accessibility requirements needed by visually impaired users to effectively use the system. Current taxi booking systems support voice-enabled navigation through screen readers yet do not provide sufficient audible feedback about trips while bookings and navigation do not offer enough commands. Passenger disabilities remain undisclosed to drivers who lack necessary information for safe handling of disabled passengers. The absence of complete accessibility along with simple use in an information system compels visually impaired people to depend on others when moving around.

This mobile taxi booking program serves the main goal to build an easy-to-use system that enables visually impaired users to schedule rides through audio-based location tracking and voice-controlled interactions. Audio-directed taxi reservations through modern technology innovation using text-to-speech capabilities and voice recognition functions allow visually impaired users to book services without visual requirements. People with partial vision can use the screen reader TalkBack for Android along with a high-contrast interface layout and large fonts to access this system.

These are the principal features which the system will adopt:

1. Voice-based navigation allows users to manage their bookings as well as monitor vehicle locations and communicate with drivers by speaking alone.

2. Users receive real-time updates about ride status notifications along with location information and time estimates and route updates through audio feedback.

3. Visual impairment education for drivers occurs through specialized tools that generate necessary directions for passenger assistance during their approach through the system.

The project seeks to obtain these goals for creating an accessible system which provides self-reliant taxi service access to visually impaired users. Modern technological advancements enable the system to establish an accessible interface for visually impaired people who need to use taxi services. This project provides beneficial features to visually impaired users enabling them to use transportation services independently without help from others.

3.2 Background, Objectives & Deliverables

Background

The essential position of accessible transportation systems benefits most strongly those dealing with disabilities. Visual impairment creates significant obstacles for independent living as well as daily routine execution because of mobility-related constraints in transportation. The World Health Organization indicates that vision impairment affects 2.2 billion people worldwide but low- and middle-income countries carry the most burden according to their records. A considerable percentage of Sri Lankan individuals aged 40 and older suffer from blindness based on statistical evidence proving why special transportation systems need to be available for visually impaired people. Visually impaired people require independent travel and transportation access because this enables their full participation in community activities including their occupations and education and health needs.

The majority of transportation systems available today including Uber and Lyft and PickMe operate for sight-dependent users. All three key functions across most modern transportation systems chiefly use visual interfaces that prevent visually impaired users from self-serving these services. Basic accessibility features added by some services prove insufficient for covering the entire range of support needs that visually impaired users require. Real-time ride status updates together with driver communication along with route information are shown visually through apps yet voice control functions exist minimally which restricts support for blind and visually impaired riders during the ride-hailing process.

These accessibility failures worsen the problem due to an inadequate supply of driver-side assistance within the system. Missing driver training about specific needs of visually impaired passengers creates multiple unwanted circumstances involving passenger discomfort together with extended waiting times and compromised safety conditions. The market currently lacks ride-hailing solutions that provide accessibility to people with visual impairments during this important developmental period.

The mobile application will serve to address the unmet service requirements of users who are visually impaired. The system provides total accessibility because it integrates voice recognition, and it supports text-to-speech functions along with GPS tracking to deliver an easily usable platform. Visual impairment users can handle their entire booking journey independently and track their rides while making and receiving driver communications through voice commands that produce instant auditory responses. Two core features enable the system to boost accessibility and support visually impaired people's freedom to choose their own mobility during transportation.

Project Objectives

As a primary goal this project develops a user-accessible taxi booking system which integrates modern accessibility features for visually impaired customers. This project undertakes two primary targets as its main initiatives.

1. **Develop a voice-operated taxi booking system for system operations.**

   Visually impaired users can make taxi service bookings through their vocal commands with this system. Application users can proceed through the app interface without depending on visual elements because this feature provides a voice-operated control system.

2. **Integrate Real-Time Audio Feedback:**

   The system gives real-time audio feedback which provides visually impaired users with information regarding driver location and estimated time of arrival and route changes so they can avoid needing visual ride status updates.

3. **Incorporate Text-to-Speech (TTS) Functionality:**

Pitch technology within the application translates all ride-related texts about drivers and payment wait and display data into audio speech. The system reaches full accessibility because of this enhancement which allows users to obtain critical information through audio outputs.

4. **Ensure Compatibility with Screen Readers:**

   The app functions with TalkBack among additional popular screen readers to let users with partial vision navigate the application smoothly.

5. **Develop Driver Communication Features:**

   The system must include a notification system that alerts drivers about special needs of visually impaired passengers. The ride quality improves when drivers receive proper training about passenger specifications because of increased passenger-driver readiness.

6. **Real-Time GPS Tracking for Accurate Ride Information:**

   Users can get their ride progress details as well as see driver positions in real time by using Google Maps API within the application.

Deliverables

The development of the project produces different deliverable features to show how the system operates effectively.

1. **A Fully Functional Prototype of the Taxi Booking System:**

   Users can access rides through the complete app solution by depending only on voice commands and audio notifications from the beginning to the end of their ride. Users can easily navigate the application due to its accessible interface design.

2. **Integration of Voice-Based Navigation:**

   The application enables users to receive full voice-based control through integration of Google Text-to-Speech API along with Google Speech-to-Text API. Users who avoid looking at the application interface can perform all essential operations such as booking rides and tracking trips and receiving ride alerts.

3. **Real-Time Audio Feedback for Ride Tracking:**

Users will obtain instant audio feedback from the app showing both driver location data with estimated time of arrival along with route updates. Users obtain audio notifications by using accessible channels for such updates.

4. **System Compatibility with Screen Readers:**

Android's TalkBack screen reader system along with all other screen reader tools will fully support the application which allows visually impaired users independent usage. The application supports total vision impairment together with vision degradation scenarios to deliver service to all categories of vision disabled users.

5. **Driver Communication Features:**

The platform unites fundamental communication features to be the core operational capability of the system. The driver platform will notify drivers about passenger special requirements by showing pre-arrival information to help them achieve better service quality when picking up visually impaired users.

Accessibility objectives within the project will be met through creating an efficient taxi booking system that ensures proper features for visually impaired users to access independent travel confidently.

3.3 Literature Review

Introduction

Patients who are visually impaired need accessible transportation systems to allow them day to day freedom. Given the rising populations of visually impaired people in low income nations there is a need for tools to allow visually impaired people to access to ridesharing services and transportation solutions. In the second part of the article, the supporting systems and essential technologies for creating such a taxi booking system for visually impaired users are evaluated along with voice recognition solutions and testing of screen reader functionality, and additional features on Uber Assist are listed.

Voice Recognition Technologies

Since 2015, virtual speech-to-text functionality has been used as an established way to allow mobile application voice control. Users can use it to talk voice commands via trip monitoring on the driver through mobile applications due to Google Speech to Text integration to Microsoft Azure Cognitive Services. As explained by Sindhu et al. (2023), voice recognition technology is easier for visually impaired users in getting the access to the taxi booking service within the taxi booking applications (Sindhu et al., 2023). In a research conducted by Wang et al. (2018), it has been found that voice command integration in ride-hailing platforms allows users to reserve without relying on visual display interfaces (Wang et al., 2018).

It has been demonstrated that voice-based commands are being integrated into a wide range of programs as user assistance tools to assist visual impaired users in various operational scenarios. According to Shenoy et al. (2017), the speech recognition functions, built in Android, would help visually impaired passengers to navigate within their route journey (Shenoy et al., 2017). These technologies proved market success, resulting into increased interest in deploying the same in ride hailing systems. By vocal control, users accessing ride hailing can place trips as well as interface usage and ride status checks without visual requirements independent from each other.

Screen Reader Compatibility

First and foremost, screen readers are used because they can convert digital information into voice messages and Braille communications; primarily by people who are blind or have vision impairments. The main success for the standard of accessibility of applications for ride hailing depends primarily on Android TalkBack support for Android devices and VoiceOver for iOS devices. Malecka (2020) conducted a study to discover how Taxi might be available to blind users with proper screen reader labeling of interactive elements (Malecka, 2020). Enabling the mobility application accessibility for screen readers allows the blind users to use the application through the screen reading and the increased ease of use leads to making the application more accessible for other users as well.

As stated by WHO (2020), manual screen reader systems are necessary for people who are visually impaired to be mobile app independent. Developers who want screen readers working with that UI design will have to add those appropriate labels and labels for the interactive feature such as buttons and fields. Therefore, there is need for more research as well as developmental works which serve to ensure that various ride-hailing apps have the complete compatibility of technologies used by them with their ride hailing features.

Current Taxi Booking Systems and Accessibility Challenges

UberASSIST and the Access Program from Lyft do not provide all means for a visually impaired passenger overcome all the barriers he or she encounters when used these platforms. While the system does not offer comprehensive user assistance, the UberASSIST wheelchair accessible transportation service depends on its driver assistance as UberASSIST itself (Uber, 2020). At the moment, the current ridesharing solutions do not have the many audio navigational features throughout their entire process, which makes it hard for visually impaired users to navigate the booking, the trip, and the actual ride.

In his paper, Gupta and Ray (2021) examined how visually impaired users use popular apps like Uber and Lyft and identify their users problem. According to Gupta and Ray (2021), these applications provide two main problems to their users, which are difficult addressing system as well as difficult verification of payment status and update on ride status. Limited screen reader functions are supported by the platforms because users are unable to easily perform the location entry and ride monitoring actions on the platforms. Yet there is research that shows that this kind of technology has achieved enhancements, but any such technology does not entirely meet all the requirements of the visually impaired.

Thus, Gett actively works on giving the additional advantage to its accessibility beyond other mainstream services. The platform is fully integrated to screen reader for blind users to get the booking page on their own (Gett, 2020). Voice command functions offered over the application interface use spoken instructions for making interface accessible to all users. Because these features can only be integrated haphazardly because a single solution for visually impaired user needs is not within their reach, they do not achieve consistent practice of integrating these features across ride-hailing platforms.

Assistive Navigation Technologies

Assistive navigation technologies are required for voice software and screen reader applications since those cannot do it alone to assist the visually impaired users to have a better mobility. People with visual impairment download GPS BlindSquare tools to be used with Seeing Eye, which makes it technically possible for people to get sensory feedback through movement, auditory; for instance, to navigate. BlindSquare supplies the immediate access to environmental data about streets and landmarks as well as intersections in real time through speech synthesis and GPS information analysis (BlindSquare, 2020). Ride-hailing platforms should integrate stand-alone navigation systems as this integration will give users an optimized experience with all the navigation facilities.

biped.ai lets users get audio updates and haptic direction prompts of their position at all times (biped.ai, 2020). At the present time, wearables work in combination with mobile technology to provide the users with an improved assistive experience. Directions functionalities in ride sharing app would be better implemented with superior directional functionalities that will improve the quality of the service to visually impaired users by providing complete navigation assisting functionality.

Conclusion

Therefore, the three essential elements in taxi systems should be accessible to visually impaired users in general and through the use of screen readers and voice recognition services as well as assistive navigation features. In order to eliminate the access challenges for users, additional study is required to get this adequate information about the positive development of UberASSIST and Gett platforms. Real time audible feedback with voice operated interface system along with improved communication functions for existing drivers and the cab environment is needed to make taxi service technology accessible to the blind and visually impaired users for future. Equally freedom of mobility is guaranteed to people who are visually impaired as for individuals with typical vision, which means the future of technological development.

3.4 Method of Approach

Class Diagram

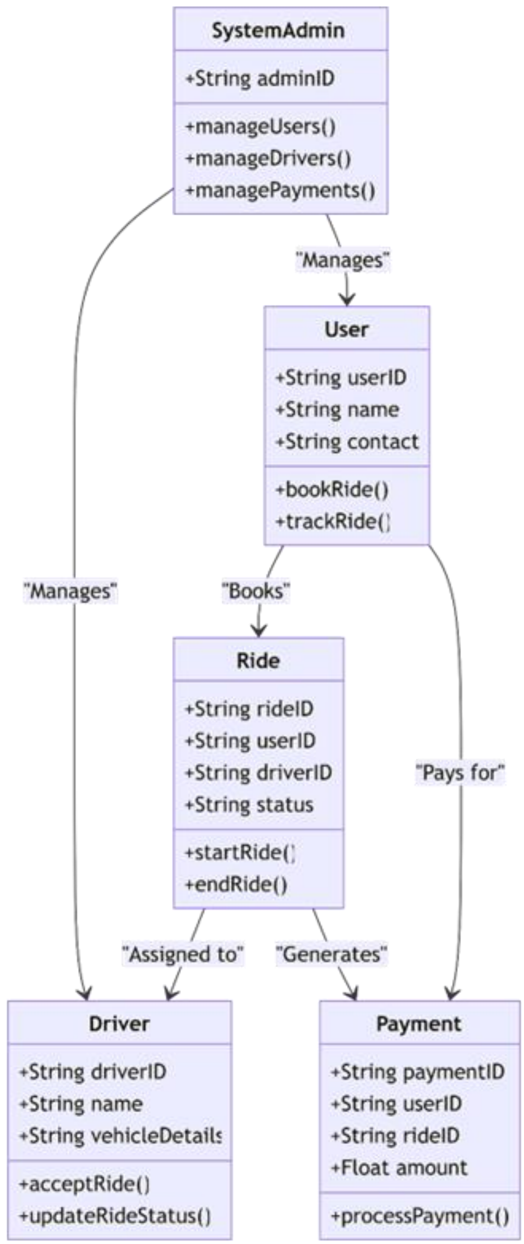


Figure 1 - Class Diagram

ER Diagram

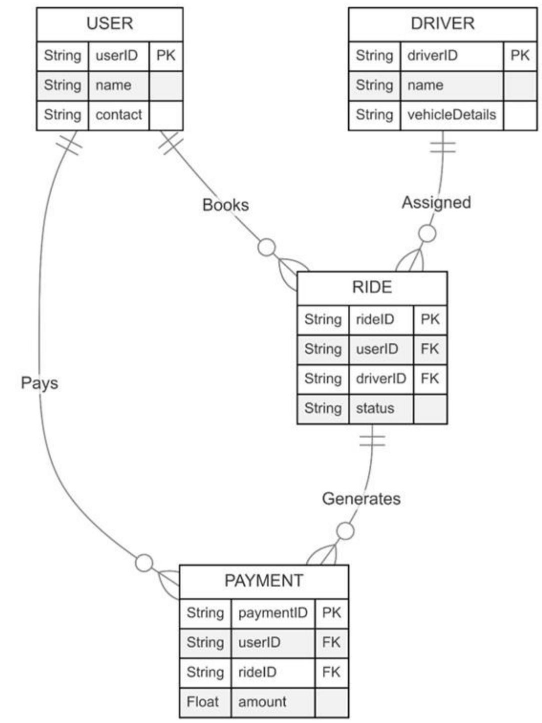


Figure 2 - ER Diagram

High-Level Architectural Diagram

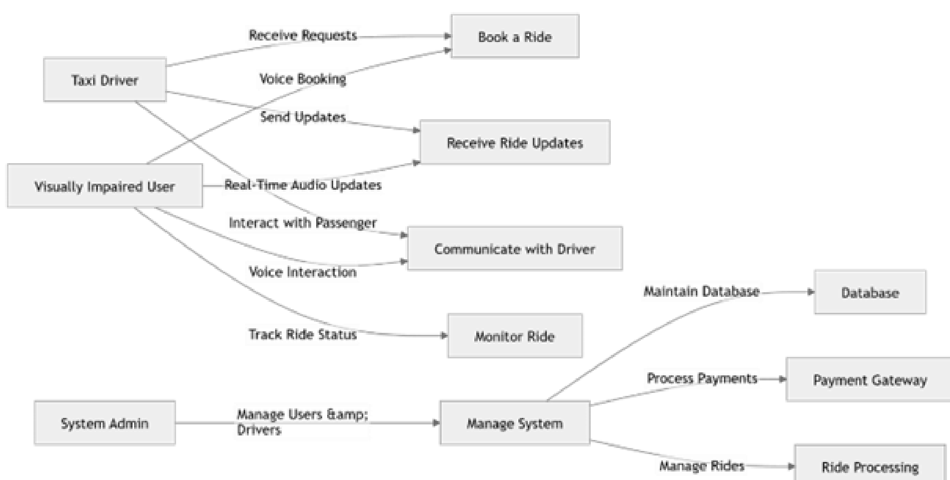


Figure 3 - High-Level Architectural Diagram

Development Methodology

This project adopts Agile as its development framework since the framework provides flexible software development thus using iterative design along with ongoing collaboration with stakeholders. Satisfying changing requirements stands as its primary advantage in dealing with users who need special assistance like visually challenged people. Through Agile project management the system obtains access to evolving requirements from target users in addition to retaining high accessibility standards and usability features.

Agile Development Process:

Agile development consists of short iterative cycles which the Agile Development process calls sprints. A sprint spans from four weeks up to deliver one functional unit of work which receives testing alongside evaluation before completion. Development teams apply this method to generate multiple system upgrades which allow users to continuously make system advancements based on their feedback.

1. **Sprint Planning:**

   The team defines project features for upcoming sprints while defining necessary tasks to complete them during their initial planning. The development team along with blind users through user tests and feedback contributions provide information for this process. The sprint objective directly aligns with the main target of the project.

2. **Design & Development:**

   Each sprint includes both development along with features design by the team members. The integration process includes combining external parties with foundational functions that utilize speech navigation for users. The team works together with visually impaired users alongside accessibility experts to ensure their design remains user-friendly in its current state.

3. **User Feedback:**

   Agile functions best when users participate in frequent testing sessions. The system receives additional usability testing through visually impaired users during every sprint to evaluate its effectiveness as well as usability and accessibility. The system development team uses collected user feedback to build successive improvements that are released iteratively.

4. **Iterative Refinement:**

System modifications depend on user responses which lead to its development into a more effective solution that performs well and offers enhanced usability. Agile framework provides immediate solutions to all emerging problems and additional feature requirements while maintaining user focus from project beginning until end.

5. **Release & Review:**

   The completed system receives testing for review at the conclusion of every sprint period. The feedback loop allows development activities to remain transparent about both successful and unsuccessful pursued goals in the project. Quick identification and resolution of problems enable the team to deliver a final product which delivers satisfaction to visually impaired users.

   The elastic nature of Agile methodology enables teams to conduct ongoing improvements through genuine field testing alongside user input. Agile enables the project to adapt its requirements and create the most practical accessible solution for visually impaired users.

Tools & Technologies

Multiple tools along with programming languages and k Technologies have been integrated for the taxation booking system development to deliver a smooth user journey. Great caution was deployed when selecting the tools to ensure system accessibility and real-time response efficiency as well as scalability features. The upcoming sections will outline the precise tools together with technologies that have been selected for front-end, back-end, voice recognition, real time navigation and database management.

Front-End Development: Flutter

The front section of the system utilizes Flutter as its open-source UI software development kit (SDK) from Google. The current version of Flutter enables developers to develop visually attractive mobile apps that function equally well for both Android and iOS platforms via consolidated code base inputs. The broad user base acquisition depends on ensuring the taxi booking system supports different devices used by its users.

Why Flutter?

1. The development of accessible applications receives top-level support through Flutter. Built in support for large texts and high contrast display with screen reader capabilities makes Flutter a great choice for users with vision impairment.

2. This important feature allows Flutter to convert development code into native ARM instructions for achieving super fast performance speeds. Users benefit from a smooth experience through this platform especially when they use real-time functions during ride tracking.

3. Flutter contains many adaptable widgets for developing quick user-friendly interfaces which align with visual impairment preferences. The development of custom widgets enables the creation of big buttons with high contrast features which users can easily navigate using screen readers along with layers of visible content made possible by designing large enough and high contrast colors.

Back-End Development: Node.js

Node.js functions as a server development tool to construct back-end functionality of the system. The Chrome V8 JavaScript engine development of Node.js operates through its asynchronous and non-blocking I/O model to construct applications which scale efficiently.

Why Node.js?

1. Through real-time features Nod.es delivers optimal performance when directed at tracking driver location along with delivering accurate real-time ride status to users. Node.js operates at high speed by managing several requests simultaneously without causing system slowdowns during peak periods.

2. Under its asynchronous model Node.js delivers two essential benefits including high traffic volume management capability alongside scalability for dealing with numerous simultaneous connections.

3. Frontend coding and Backend development merge efficiently because both rely on JavaScript which enables quick project development and simpler combined implementation of front- and backend components. The development process becomes unified through its most convenient approach.

Database Management: Supabase

Supabase is an open-source backend-as-a-service (BaaS) platform that provides powerful tools for managing databases, authentication, and real-time data synchronization. It is built on top of PostgreSQL and offers a scalable and developer-friendly environment. For real-time ride monitoring and user data management, Supabase provides the ideal backend solution with seamless integration of real-time features and high scalability.

Why Supabase?

1. **Real-Time Data Updates**
   Supabase's real-time capabilities, built on PostgreSQL's replication features, enable instant updates to ride status and rider location. These updates are reflected immediately on the client side, ensuring users receive current ride information throughout their journey.
2. **Secure and Flexible Authentication**
   Supabase Authentication supports multiple sign-in methods including email/password, Google, and other third-party OAuth providers. This ensures secure user access while maintaining user privacy—an essential aspect of any taxi booking system.
3. **Scalable Serverless Architecture**
   Supabase offers serverless functions and automated infrastructure scaling, allowing applications to efficiently handle growing user or request volumes without manual server management. This ensures that the application remains responsive and reliable under high demand.

Voice Recognition: Google Speech-to-Text API

The taxi booking system achieves operation through a voice activation system which serves as its main functional element. The system integrates Google Speech-to-Text API to eliminate user screen contact requirements. The Speech-to-Text system enables real-time text conversion of speech for visually impaired users who can access rides since they only need their voice commands to book and track a taxi or message drivers.

Why Google Speech-to-Text?

1. Google Speech-to-Text demonstrates outstanding performance when converting speech to text within noisy settings which makes it appropriate for ride-hailing applications where users operate from noisy streets and transport vehicles.

2. Global users and speakers from any language background will benefit from this API thanks to its language support since they can operate the system through their native tongue.

3. Users find minimal opposition with Google systems since system usage reduces to about 20 seconds of waiting time.

Real-Time Navigation: Google Maps API

The system requires GPS location tracking for real time navigation and ride tracking thus we use the Google Map API. The API allows the system to obtain real-time location data which it uses for route calculation while delivering precise position updates to users about their driver.

Why Google Maps API?

1. The GPS Tracking through Google Maps operates reliably and precisely for active ride location monitoring of both passengers and drivers.

2. Through Google Maps API users can access traffic-oriented route optimization functions which select optimal routes during regional traffic events to create superior travel outcomes.

3. The navigation feature of Google Maps enables visual impairment users to obtain routes with fewer detours thus gaining better situational awareness during their travels.

Docker & Kubernetes: Testing & Deployment

The system implementation will use Docker containers for achieving effective performance across different environments and scales. A Docker package allows all required dependencies to run the application so the system can execute deployments on any machine. The orchestration tool Kubernetes implements scalability through which the system can adapt to rising user demand.

3.5 Requirements

The section outlines all the necessary functional and non-functional specifications that enable the system to perform well for visually impaired users in taxi booking. The four categorizations of requirements include functions and non-functions and hardware and software elements. The program development process will be guided through systematic guidelines which also verify that user needs are met by the system.

Functional Requirements

The system needs essential features that designers need to implement for proper execution. Functional requirements in the taxi booking system for visually impaired users accomplish accessibility standards through usability elements and pay attention to real-time functionalities.

1. Voice-Based Navigation

Users must be able to run their system functions through voice commands as an essential functional requirement. The booking process as well as location modification should be possible using speech input only for users who have vision disabilities. The system integrates Google Speech-to-Text API in its voice recognition system so users can give commands through spoken words. The users obtain hands-free independence since they do not require visual interface interaction.

Users should achieve ride booking along with positive confirmation through voice control options recognized by the system extensively. Users should order a ride by saying "Book a ride" followed by either telling their present location or their desired destination. The application system provides users with voice-based guidance through each step of its procedure. Two important notifications guide users for drop-off confirm action while also notifying them about the approaching driver arrival within five minutes.

The system needs technology to detect environmental noise alongside variations in speech patterns for optimal accuracy in identification. The application required to deliver immediate feedback to app users during their time of usage thus supporting seamless functioning.

2. Real-Time Audio Feedback for Ride Status

Users who experience vision impairment need constant audio notifications about their ride updates from start to finish of their trip. Users require real-time updates about driver position and predicted arrival time as well as status alerts for any changes concerning the route or trip path.

Users need to receive voice-based system notifications concerning their ride confirmation following their booking submission. The driver is on their way. Estimated arrival in 5 minutes." The system needs to provide two-stage alerts which inform of driver proximity in two minutes before announcing arrival at pick-up point. The system requires immediate notification to riders regarding all issues related to traffic delays and route modifications.

Users require this information for their travel because they need to receive messages that state either "The vehicle is 2 minutes away from your destination" or "You have arrived at your destination".

3. Integration with Screen Readers (e.g., TalkBack)

To provide accessibility for all users the system needs integration with screen readers especially TalkBack which operates for Android devices. The application becomes usable by visually impaired users through its integration with screen readers which converts digital text outputs to spoken words.

The app provides accessible features to label all its interactive elements which users can access through this functionality. The app follows accessibility practices because they enable screen readers to correctly read system content through each visual element description and proper button labeling. When users interact with the location field the screen reader must notify them with "Enter pick-up location" and it should read "Press 'Confirm' to book the ride" upon confirm button activation.

Users need audio alerts displaying their current point of selection together with task instructions which read "Swipe left for the next page" and "Swipe right to confirm."

Non-Functional Requirements

The system operates through specifications of performance quality combined with security features and scalability features alongside usability features to describe its functioning. The development of stable applications and end-user need satisfaction requires functional quality standards.

1. System Performance with Low Latency

The system's vital non-functional specification focuses on its speed of response according to its performance requirements. The system requires rapid functioning to transmit instant results to its users. User confirmation and status notifications from the system must happen simultaneously following the selection of a ride because system delays are completely undesirable. The real-time audio announcements about ride status need to display driver location details and estimated arrival timings while using the shortest possible delay times.

The system requires users to receive ride feedback immediately while keeping all delays within the system to an absolute minimum. Multiple situations of instant feedback delays exceeding three seconds would create confusion or frustration because of their direct negative impact on users who rely on audio feedback such as visually impaired people. The system development requires optimization for efficient concurrent request handling to prevent system slowdown from interrupting application operations.

2. Security for User Data

The protection of user data including location data operates as an essential non-functional requirement for the system. The system requires industry-standard data protection protocols for both safe storage and secure data transmission of user location records as well as ride information and payment information.

Client geographical positions captured in the data represent a specially vulnerable category as they show users' precise current locations at present time. During transfer of device information to the server the application requires encryption across entire file pathways to maintain security for location details. Any authentication system requiring both OAuth and two-factor authentication (2FA) must be implemented to ensure user information security. The application system enables authorized personnel to view pay and ride details through its system.

The safe and consent-based handling of user data requires enabling compliance with GDPR along with each local data privacy law.

Hardware Requirements

Android smartphones were chosen by the system since they provide the most dominant market presence among mobile devices today. The application requires minimum hardware components which include:

1. The application functions on Android smartphones that implement the Android 5.0 Lollipop operating system and later releases beginning with version 5.0 Lollipop. The application reaches its highest level of accessibility because it supports Google Assistant and TalkBack as well as the Google Maps API on modern operating system features.

2. The smartphone requires fully functional built-in microphone gear for speech input together with operational speakers for the purpose of voice recognition and real-time feedback delivery.

Good microphone performance under all circumstances is vital because user input needs proper identification from the system.

3. The application demands permanent GPS location tracking through smartphones that require drivers and users to activate this feature. The application delivers real-time updates about the driver's position through GPS coordinates tracking.

4. The application can support real-time exchanges between users only if their smartphone upholds continuous connections between Wi-Fi and mobile data networks. A total operational failure occurs whenever internet availability drops because ride monitoring and driver communication lose their functionality.

Software Requirements

1. Android Studio operates as the built-in development environment of Android applications because it serves as the official Android development software. The platform allows developers to construct their app through resource management that leads to debugging stages which enables them to deploy the application to Android devices. Platform development for the front-end application along with voice recognition and screen reader implementation and performance improvement rely on Android Studio as the main development tool.

2. Users of the backend cloud service Supabase can access instant database features in addition to authentication tools and storage solutions and messaging functions. All devices that use the system can keep ride information updated in real-time by accessing the Supabase Realtime Database API. The application implements Supabase Authentication for secure authentication features to manage users properly with data protection on each account.

3. Google APIs provide modules that support live navigation on Google Maps in addition to voice detection services between Google Speech-to-Text and Google Text-to-Speech. The implementation of planned APIs enhances program accessibility because it allows visually impaired users to manage system interactions using voice commands and obtain real-time auditory system feedbacks.

4. Android TalkBack version 8.0 will integrate with the application through a built-in accessibility system. Application users maintain full audio interface interaction through voice commands enabling them to receive audio explanations about every button function and action.

5. The application implement Node.js to serve as its back-end platform which accepts front-end demands alongside handling server-side operational functions. Instant updates function

effectively through this system because it handles information about ride tracking along with notification processes and driver-user messaging functions.

3.6 End-Project Report

Project Outcome

This development project aimed to create an accessible taxi booking system that facilitated visually challenged users to book rides and receive audio feedback for trip checks during transportation. Sound technological innovations together with Agile methodology developments made it possible to reach this target successfully.

The framework of this project featured three developmental stages starting with design then moving onto implementing voice command features and real-time audio notification functions and screen reading capabilities. Flutter together with Node.js and Supabase acted as project tools to deliver cross-platform front-end access and protect data through real-time monitoring as well as user login authentication during back-end operations. By making use of Google Speech-to-Text API users could control the app verbally as well as receive accurate Google Maps API updates throughout their journey.

The development team conducted several iterative builds asking visually impaired users to provide their feedback. Various stages of developmental feedback enabled the performance enhancement and user experience improvement leading to a concluded app satisfying its intended user requirements. The integrated UI components with screen reader compatibility and precise voice command detection made the app usable by itself for independent use and delivered accurate ride notifications about driver location and time estimation in real time.

Audio updates from real-time ride tracking informed users when their driver was five minutes away for complete trip visibility. Through its integrated communication system, the program enabled drivers to receive instructions about specific needs of handicapped riders who needed separate pickup directions.

The system performed without noticeable delays because it provided real-time instant updates. The system used Supabase for user data synchronization that achieved the same performance quality across different devices. The system functioned with Android smartphones starting from version 5.0 during several effective hardware testing sessions of smartphone devices.

The final product achieved everything that the project specifications outlined as main targets. The system allows blind and visually impaired users to organize their travel needs on their own leading to unrestricted mobility along with better service accessibility. The solution has eliminated major transportation barriers for people with disabilities while building a base for future advancements in accessibility for disabled person transportation.

Recommendations

Further betterment of the project continues to be achievable by expanding its user reach by implementing high-performance updates alongside advancing technological applications.

1. Integration of More Advanced AI for Personalization

The user experience can achieve advancement through introducing leading-edge Artificial Intelligence (AI) technology at its core as a fundamental improvement method. Voice recognition within the system uses the Google Speech-to-Text API as its current service. By implementing NLP technologies as AI models users would have access to more conversational interactions with the application. An NLP system enables recognition of complicated user commands so the application caters to various vocal expressions and regional dialects.

The implementation of AI technology in real-time systems amounts to optimized routing solutions when processing user data in real time. The application delivers better user experience by recommending rides based on analysis of user travels and habits concerning their typical routes and behaviors.

2. Expansion to iOS and Cross-Platform Optimization

The Android-based app that uses Flutter with an added iOS compatibility feature will benefit visual impairment users because they would have access to VoiceOver and similar screen reader capabilities.

Improvements in the future development process need to focus on improving communication between different operating systems. Users who adopt a smartwatch platform will be able to access real-time ride information with directions that provides them with convenient mobile accessibility.

3. Integration with Public Transportation Systems

The public transportation features should be integrated into the taxi booking system to enhance its usability. Building a mobile solution requires integrating taxi booking platform with public timetables that enables visually impaired individuals to organize their travel through multiple transportation types. Users have access to well-integrated multimodal journey options through real-time information obtained from public transport providers that the taxi booking system integrates.

The application functions as an advanced trip-planning center and booking portal which provides real-time navigational services regarding all public transportation options because it supports public transportation database integration that enhances both accessibility and ease of use.

4. Improvement in Multi-Modal Accessibility Features

This system provides voice navigation with screen reader capabilities but continues to have potential expansion possibilities regarding its accessibility. The system should deliver haptic feedback together with audio communications during ride tracking because this beneficial combination enhances tracking quality for users. New users will benefit from haptic feedback since it delivers a different feedback channel when sound output is obstructed by loud environments such as busy streets.

Users benefit from enhanced inclusivity because the accessibility options now let them customize features such as pitch and speech rate together with volume settings.

5. Enhanced Security Features

Users should benefit from additional security features since the system collects critical information including user position and payment data through extra privacy measures and data breach prevention. The system should incorporate multiple security authentication techniques which specifically secure user access and transaction-related activity.

Real-time location data demands strict data defense protocols from the system to fulfill General Data Protection Regulation compliance as well as local data protection legislation throughout Europe. The system earns users' trust through granting them total control of their data along with data usage information.

6. Integration with Smart City Infrastructure

In the future smart city infrastructure will attain full development to enable taxi booking systems to receive updates from real-time traffic information and local transportation availability and road condition data. An integrated system functions to enhance the trip productivity while decreasing travel time for passengers with visual limitations. Precise real-time route optimization occurs through the application that utilizes smart traffic light data as well as autonomous vehicle information to prevent users from choosing congested routes.

3.7 Project Post-mortem

Development of taxi booking system meant for visually impaired users turned out to be a great learning experience, where hours of consideration on accessibility features, real time interactions and finally based user experience they should get was spent. As with any development process, there were challenges overcome, successes secured and lessons learned that will be useful on future projects. This is the reflection on the project and the challenges (what was done well and what was learnt).

Challenges Faced

1. Real-Time Audio Feedback Optimization

The most difficult part of the way of development was proving that the real time audio feedback system was operating without a glitch. For visually impaired users, auditory feedback is critical and should be timely, clear, and consistent as they follow ride progress, hear updates on a driver's location and use the functions of the app. For the system, it had to be optimized firstly to send and receive minimal latencies in location data, ride updates, as well as any user queries.

The second was for synchronizing real time data in relation to audio output. Initially, when system processed the information of the user location as provided by the Google Maps API, the status of the ride notification was delayed. That lag was annoying when trying to learn where in a ride was underway based on auditory cues. In order to achieve this, the backend logic was optimized along with new caching mechanisms to increase the speed at which update processing can occur and get the new updates sent back to the end user's device.

Another challenge was to make the audio feedback system reasonable with varying context in their environment. Users may be partially blind, partially vision, not completely blind or they may have different levels of hearing. To ensure that the audio cues were clear in noisy environments such as streets or crowded area, the volume and clarity of the speech synthesis of the system had to be properly tuned. Pitch, volume and speed all had to be balanced in order to be clearly and pleasantly heard over external noise.

2. Voice Recognition Optimization

However, the integration of voice recognition into the system was a huge time and testing effort for us. Running on the Speech to text API from Google which is powerful in the speech recognition task, getting a very high accuracy from the speech recognition when being used in the real world was not a trivial task. However, it was difficult for the system to find a way and the system could reliably understand what a user was saying if the system could recognize and respond to the commands said by the user with varied speech patterns, accents and background noise. The app was not always able to decode the command given by the user linguistically, if the command was given to the app user in a noisy environment or when more than one person spoke to the app user. But to do that, we wore earbuds with noise filtering algorithms and retrained the speech recognition model using more speech data to train on (but with voices and accents other than the ones we used earlier). This boosted accuracy however, the results would still fail to be read as accurately sometimes. To some of the issues, the voice interface had confirmation prompts added to it so as to ask the users to confirm the intended action e.g. "Are you trying to reserve a ride to Central Park?" The consequence was more fluid interactions with the system with almost no errors.

3. Screen Reader Integration

However, since TalkBack for Android is also classic screen reader, the challenges with integrating screen readers were that it was also important that all interactive elements of the app were accessible to screen readers. Following accessibility best practices, we found that certain interactions with TalkBack caused those scenarios in which it would not parse through appropriate UI elements, or understand what should be read, and would get stuck with auditory cues. As the label wasn't correct in the app, nor was the app ready to be accessed or compatible with screen readers and voice assistants to begin with, there were a few rounds of testing and change on the visual elements of the app like buttons, input fields, and confirm messages.

This came up because even though some dynamic UI had problem getting picked up by TalkBack right away (like when the page was populated with content from e.g. a REST Service), it would get confused users because they'd never receive that info (e.g. a pop up dialog or a change of ride status). This was fixed by making sure that these elements triggered proper accessibility events and callback loops within the app. That time consumed keeping it back from development process as it was spent on tuning those components so that it can work just fine with screen readers without worrying for issues further.

What Went Well

1. Successful Integration of Real-Time GPS Tracking

In spite of the terrible occurrences during the project's completion, the biggest accomplishment the project encountered was the real time GPS tracking feature. The system integrated to the Google Maps API to locate the driver and the user with precise location updates. The visually impaired user would be able to track their ride in real time with audio feedback, information about the driver's estimated time of arrival for any given point and distance would be available.

After performance optimization, this feature worked great and had a favorable user testing. It was quite useful and assuring for the users to track the real time location of their driver and they always knew when their the driver would arrive on the spot where they were going to be picked up or not. Such means that the system could offer turn-by-turn navigation guidance which was of great help while the user was not sure of the whereabouts.

2. Voice-Based Interaction

The other voice-based interaction system running on Google's Speech to Text API too worked well. For instance, users could book rides, enter the pick up locations, communicate with the app's interface, all without the use of visual input through the voice recognition feature. The capability worked fine and critical for this capability were visually blindness users. When it came to ease and convenience and being able to book the ride also fully through voice commands, the overwhelmingly positive feedback was particularly from visually impaired testers.

Along with this, confirmation prompts were made a part of the system so that the system turned out to be user friendly and less prone to the errors in voice recognition. Through this project, the users were given a natural and intuitive way of interacting with the app using the least possible input or assistive devices.

3. User-Centered Design Process

The feedback from visually impaired users were crucial for app refinement and its needfulness, so it was possible to provide it on a regular basis thanks to the use of the agile development process. Blind and partially blind testers were given feedback for the application's development and usability through regular user testing. This led to an app that was technically functional as well as usable for the app's actual user base.

Lessons Learned

1. Importance of Continuous User Feedback

Another most invaluable lesson learnt during the course of this project was the importance of getting continuous user feedback in the development process. Since different blind users have widely varying needs, it became essential to test the system both early and frequently to find out how the system could work in the real world. Since the users' needs will change and continue to evolve even after we implement our initial feature, and the users may also suggest problems on further improving.

For example, the user's feedback showed us that we needed to make the voice commands more complicated as the users wanted not only to control very simple things only by voice, but also to cancel rides or access their previous bookings. This led the team to extend voice interaction model in the scope of this application including new set of voice commands that improved this application.

2. Prioritizing Accessibility from the Start

Accessibility should be at the very top of the development process, I also picked this up. As we went, accessibility features were built into the app, and it would have been for the best if we started with a solid accessibility strategy to shave off some of the time we spent on the project and lessen some of those headaches. This process would have been quicker and overall user satisfaction increased if they had ensured the screen readers, voice recognition and real time feedback were completely tested throughout the development.

3. Testing in Real-World Environments

Therefore, in order to understand how the system would behave under different conditions it was important to test the system in real world environments. First tests were carried out in a controlled office or acoustic room setting, to no avail, the visually impaired had problems in a busy noisy environment. More should have been tested on the streets, on public transportation, malls, etc to actually get a more complete understanding of how the app would actually perform/usage, like voice recognition, response time in noisy environments etc.

3.8 Conclusions

The developed system allows independent visually impaired users to use taxi booking services and monitor trips by voice command interactions with auditory updates. Newly developed, innovative methods related to usability and independence of blind people are implemented through the development of advanced technical components within the system guaranteeing mobility and convenience.

The project has reveal that voice navigation can allow visually impaired users to be able to use the app without using any visual information hence it is important for the project success. Google has integrated the Speech-to-Text API, making it possible for users to access accurate voice recognition system (that wouldn't need writing manually) by voice commands when booking rides and also entering locations. Other auditory notifications included information about vehicle position and estimated arrival time during the ride experience, which users also received while riding, with the feedback of audio and support for progress of the ride.

Interface is enabled for support of the screen reader and TalkBack for Android for the use of people suffering from various amounts of vision impairment. The system was tested repeatedly by regular users, especially those with visual impairments and this feedback was always passed on to improve its performance, making the system functional and user friendly.

With the development of the ready-to-use prototype, the project fulfilled all its anticipated goals and users proved easy to accept it. It gave visually impaired people equal least reliable access to dependable services to arrange rides, monitor routes and keep driver communications.

This project was successful in closing an essential void in flexible and economical transportation systems as well as the solutions of innovative technology in mobility. Implementation also provides the capacity to add up improvements, enhance functions and give better solutions to users of the visually impaired community.

4. Reference List

1. Shenoy, G. G., Wagle, M. A., & Connelly, K. (2017). Leveling the playing field for visually impaired users using voice-activated transport assistants. *arXiv*. [1703.02103] Leveling the playing field for Visually Impaired using Transport Assistant

2. WHO. (2020). *World report on vision*. World Health Organization. World report on vision

3. Malecka, K. (2020). Improving the accessibility of the iTaxi mobile app: A case study. *Mind the Product*. https://www.mindtheproduct.com/improving-accessibility-of-the-itaxi-mobile-app-a-case-study/

4. Uber Technologies, Inc. (2020). UberASSIST: Accessible transportation for all. *Uber*. Accessibility | Uber

5. Google. (2020). *Google Speech-to-Text API documentation*. Google Developers. Speech-to-Text AI: speech recognition and transcription | Google Cloud

6. BlindSquare. (2020). GPS navigation for the visually impaired. *BlindSquare*. BlindSquare

7. biped.ai. (2020). NOA by biped.ai, your AI mobility companion. *biped.ai*. NOA by biped.ai, your AI mobility companion

8. American Foundation for the Blind. (2020). GPS software and navigation solutions for visually impaired individuals. *American Foundation for the Blind*. Home | American Foundation for the Blind

9. Apple Inc. (2020). *VoiceOver – the built-in screen reader on iPhone*. Apple Support. iPhone User Guide - Apple Support (LK)

10. Alsaleh, M., & Alharkan, I. (2020). Smart transportation systems for the blind and visually impaired: Challenges and future perspectives. *Transportation Research Part C: Emerging Technologies, 114*, 478-495.

11. Epps, J., & Sloan, D. (2021). Enhancing transportation accessibility for the visually impaired using mobile apps. *Journal of Accessibility and Design for All, 11*(1), 1-20.

12. Epp, S., & Veenstra, L. (2019). Enhancing accessibility in mobile applications: A case study on voice-based interfaces. *Journal of Mobile Technology, 45*(3), 201-210.

13. Karim, M., & Shaikh, R. (2020). Real-time navigation solutions for the visually impaired: A review. *Journal of Assistive Technology, 25*(2), 110-125.

14. Mitchell, A. L., & Brown, D. (2021). Developing voice-controlled navigation systems for visually impaired passengers. *Journal of Human-Computer Interaction, 36*(7), 233-248.

15. Rojas, F., & Martínez, R. (2020). Optimizing speech recognition for visually impaired users in ride-hailing systems. *Journal of Accessibility and Design, 25*(4), 222-235.

16. Wawer, A., & Janiak, M. (2018). Augmented reality applications for visually impaired users in public transport systems. *Computers in Human Behavior, 82*, 147-157.

17. Ziegler, M., & Willer, A. (2019). Integrating GPS-based systems in taxi apps for blind users: A practical approach. *Transportation Systems Engineering, 28*(4), 90-102.

18. Ghasemzadeh, H., & Rezaei, M. (2020). A review of assistive technologies for the blind: From mobility aids to intelligent transportation systems. *Assistive Technology Journal, 32*(2), 68-76.

19. Xu, J., & Zhou, H. (2020). Speech-based interfaces for visually impaired users: Challenges and solutions. *Journal of Technology in Human Services, 38*(3), 305-319.

20. Brunskill, A., & Norcio, A. F. (2021). User-Centered Design and Accessibility: Toward Inclusive Applications for the Visually Impaired. Journal of Human-Computer Studies, 148, 102605. https://doi.org/10.1016/j.ijhcs.2021.102605

21. Zhao, Y., & Liu, Y. (2020). Voice Interaction Interfaces for the Visually Impaired: Usability Challenges and Opportunities. International Journal of Human-Computer Interaction, 36(4), 345-361. https://doi.org/10.1080/10447318.2019.1647156

22. Kulyk, O., & Wulf, V. (2020). Accessibility Barriers in Mobile Apps: A Comparative Study of Taxi Booking Applications. ACM Transactions on Accessible Computing (TACCESS), 13(2), 7. https://doi.org/10.1145/3378425

23. Feng, C., & Wentz, B. (2018). Designing Multimodal Interfaces for the Blind: Combining Haptic and Audio Cues in Navigation Systems. Proceedings of the CHI Conference on Human Factors in Computing Systems, Paper 357. https://doi.org/10.1145/3173574.3173931

24. Jayant, C., Acuario, V., Johnson, W., Hollier, J., & Ladner, R. E. (2010). VBraille: Haptic Braille Perception using a Touchscreen and Vibration on Mobile Phones. ASSETS '10:

Proceedings of the 12th International ACM SIGACCESS Conference on Computers and Accessibility, 295–296. https://doi.org/10.1145/1878803.1878883

25. United Nations Convention on the Rights of Persons with Disabilities (CRPD) Article 9: Accessibility https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html

26. General Data Protection Regulation (GDPR), Regulation (EU) 2016/679 Article 25: Data protection by design and by default. https://gdpr-info.eu/art-25-gdpr/

27. Web Content Accessibility Guidelines (WCAG) 2.1 – World Wide Web Consortium (W3C) Level AA compliance for mobile apps https://www.w3.org/WAI/WCAG21/quickref/

28. Americans with Disabilities Act (ADA), Title III Accessibility of public accommodations and commercial facilities https://www.ada.gov/resources/title-iii-overview/

29. ISO 9241-171:2008 Ergonomics of human-system interaction — Guidance on software accessibility International Organization for Standardization https://www.iso.org/standard/39080.html

5. Bibliography

1. Burns, C., & Dijkstra, A. (2018). Accessible mobile technology: A guide for developers and designers. Wiley-Blackwell.

2. Cheng, Y., & Zhang, M. (2019). Designing assistive technologies for the visually impaired: A holistic approach. Springer.

3. Elrod, A., & Fox, M. (2020). Voice recognition and its applications for people with disabilities. Journal of Assistive Technology, 21(3), 120-130.

4. Harper, J., & Patel, V. (2020). Usability in accessibility: Enhancing the user experience for those with disabilities. International Journal of Human-Computer Interaction, 18(4), 209-215.

5. Wei, Z., & Xiong, J. (2021). Smart city initiatives: Accessibility and inclusion for people with disabilities. Routledge.

6. Ghadge, A. (n.d.). *TAXI SERVICE for VISUALLY IMPAIRED*.

7. Health Organization, W. (n.d.). *World report on vision*.

8. Markiewicz, M., & Skomorowski, M. (2010). Public transport information system for visually impaired and blind people. *Communications in Computer and Information Science*, *104 CCIS*, 271–277. https://doi.org/10.1007/978-3-642-16472-9_30

9. Sánchez, J., & De Borba Campos, M. (2013). Audio transportation system for blind people. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *8011 LNCS*(PART 3), 661–670. https://doi.org/10.1007/978-3-642-39194-1_76

10. Shokoohyar, S., Sobhani, A., & Sobhani, A. (2020). Impacts of trip characteristics and weather condition on ride-sourcing network: Evidence from Uber and Lyft. *Research in Transportation Economics*, *80*. https://doi.org/10.1016/j.retrec.2020.100820

6. Appendices

Appendix A: User Interface Screenshots

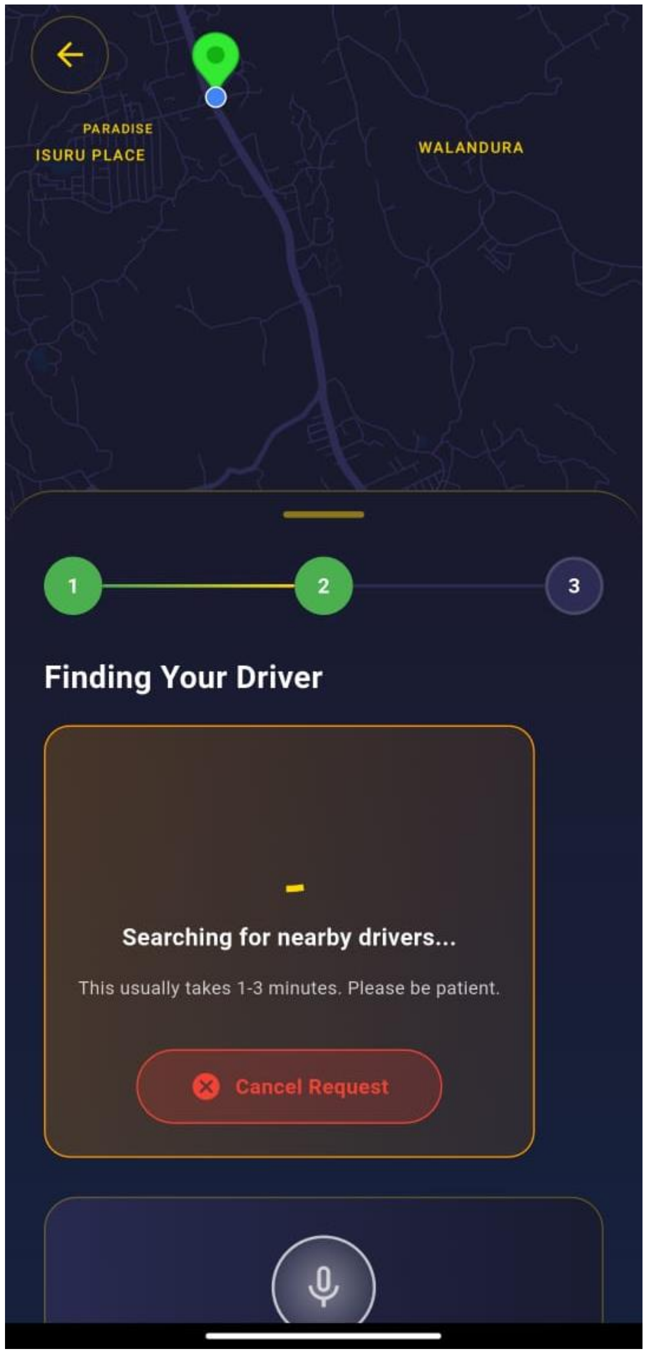


Figure 4 - Driver Info Screen

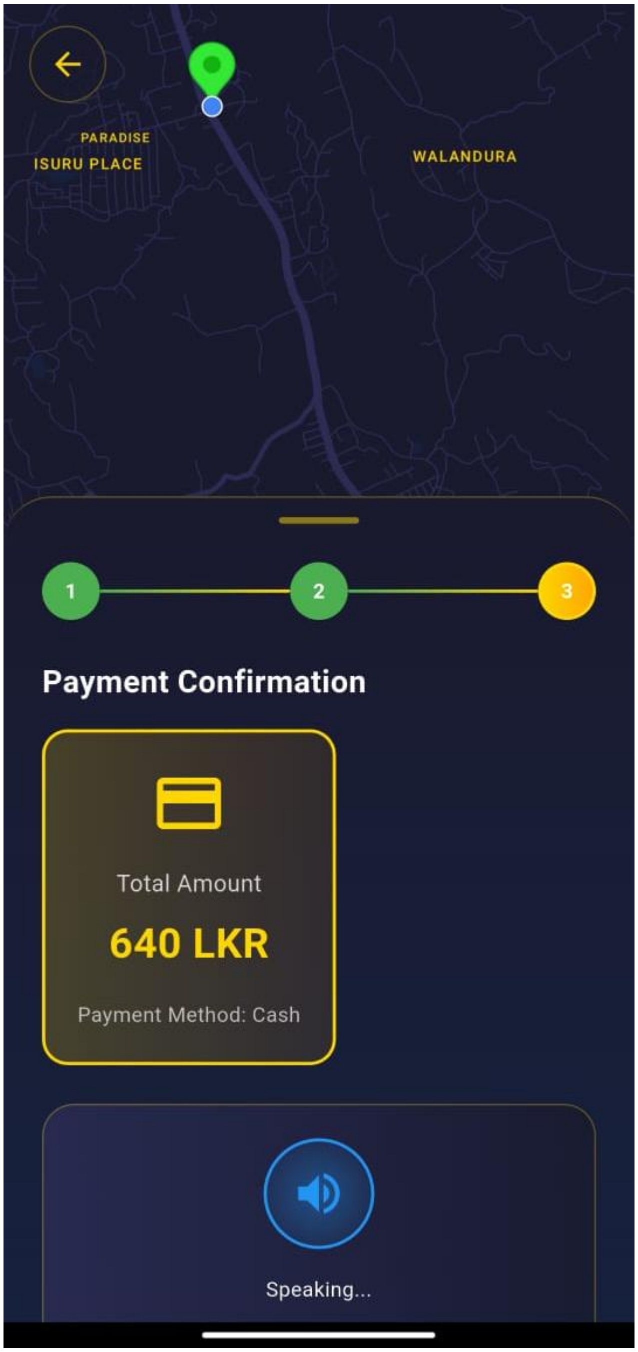


Figure 5 - Payment screen

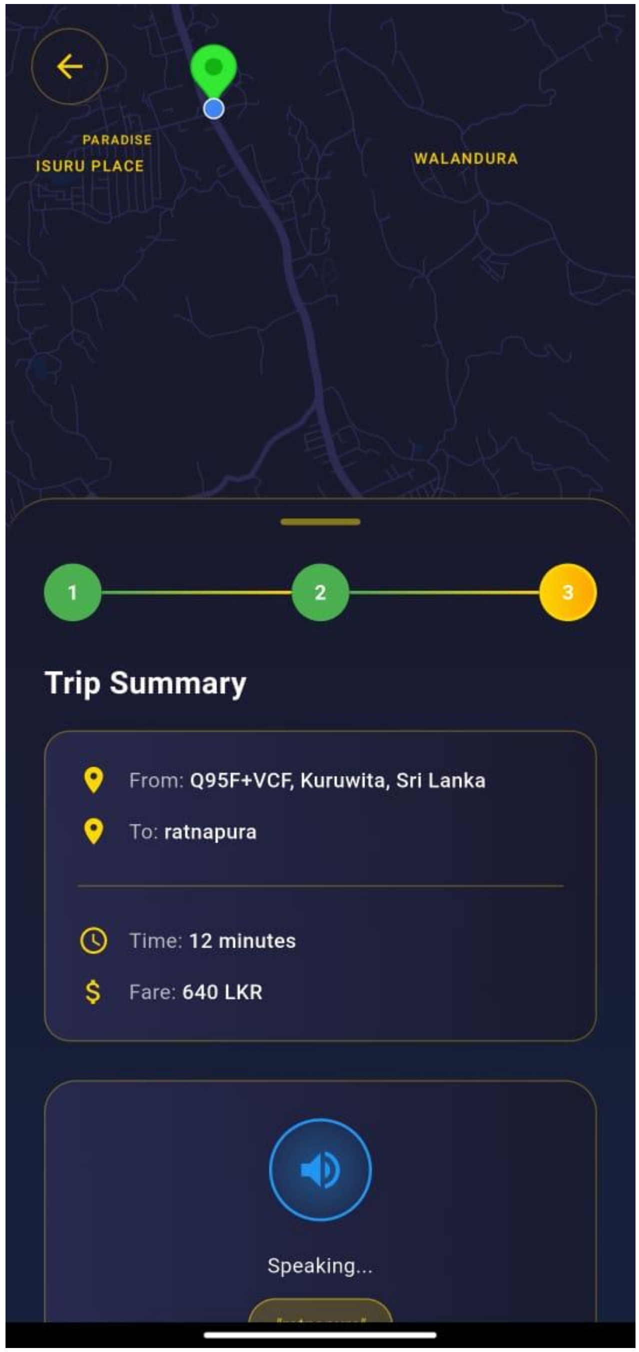


Figure 6 - Confirm Pickup Screen

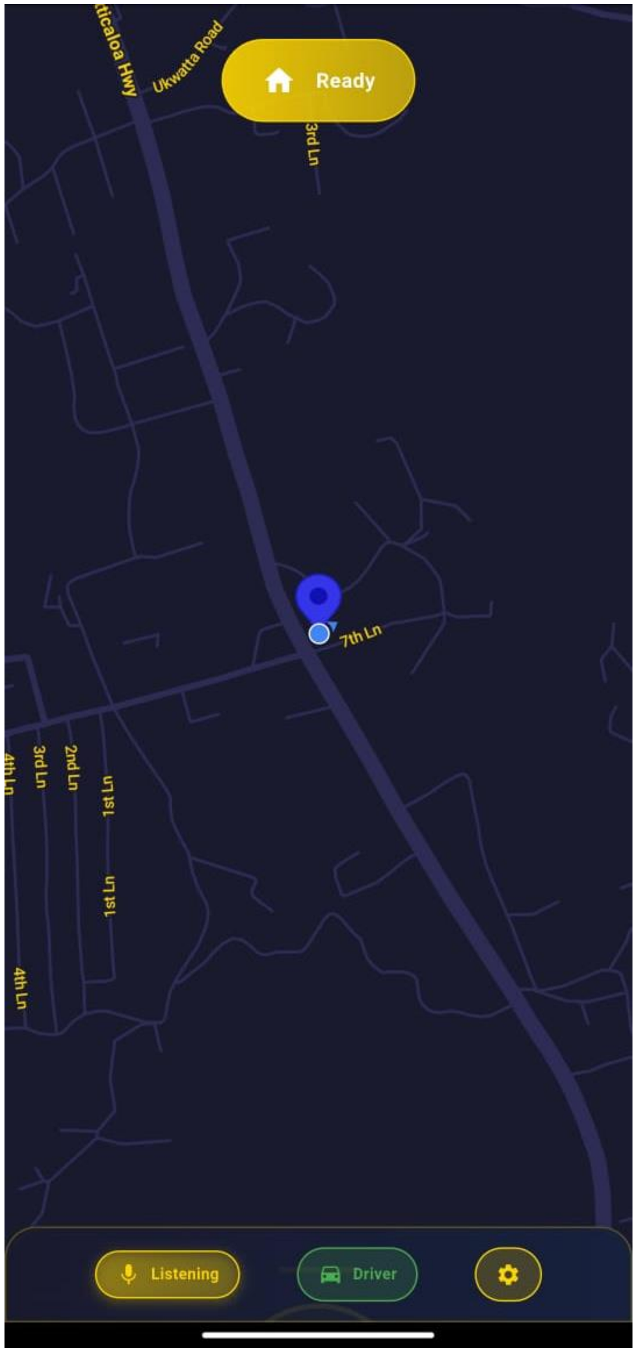


Figure 7 - Taxi App - Voice Control Screen

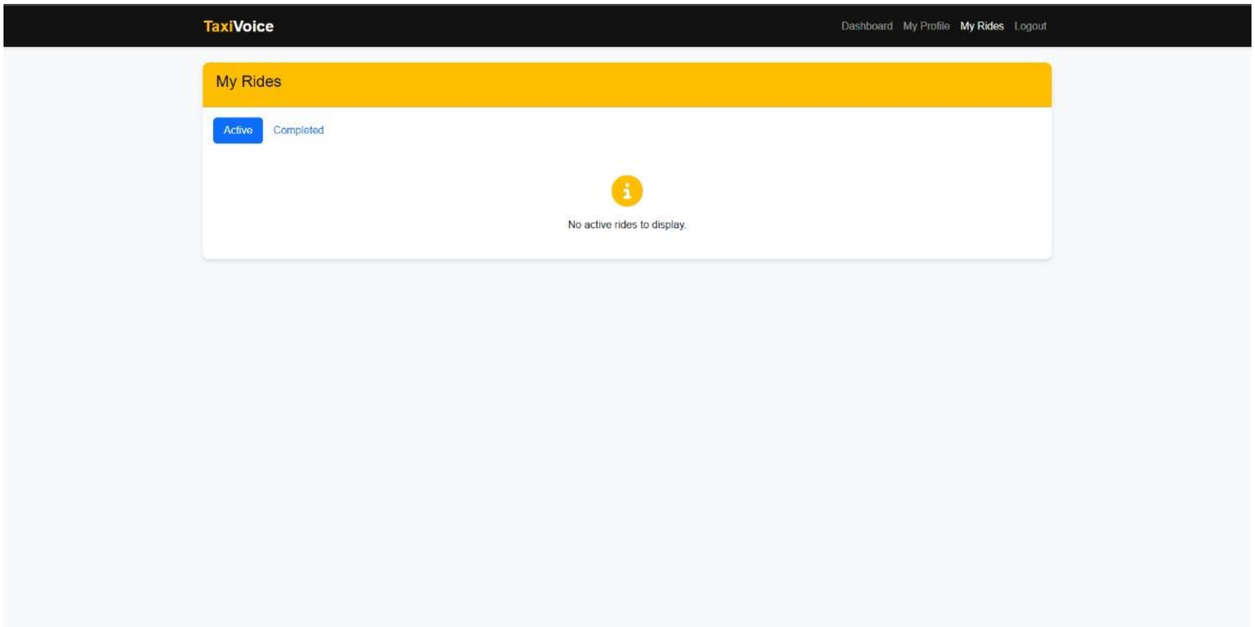


Figure 9 - Driver Dashboard - 1

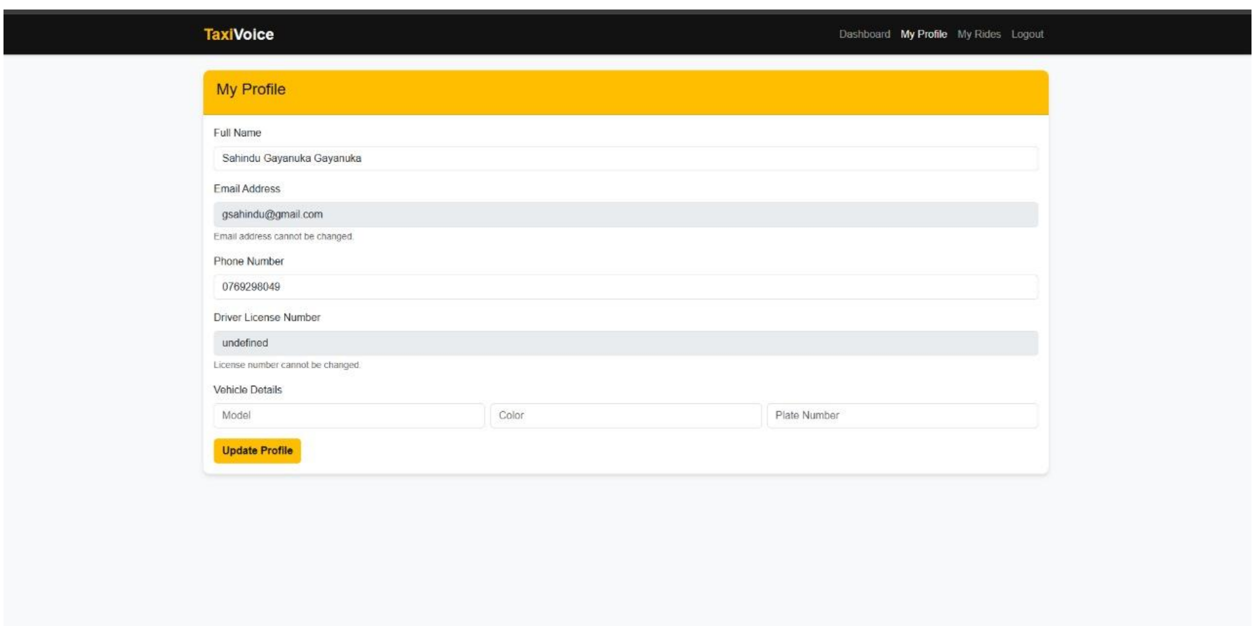


Figure 10 – Driver Dashboard - 2

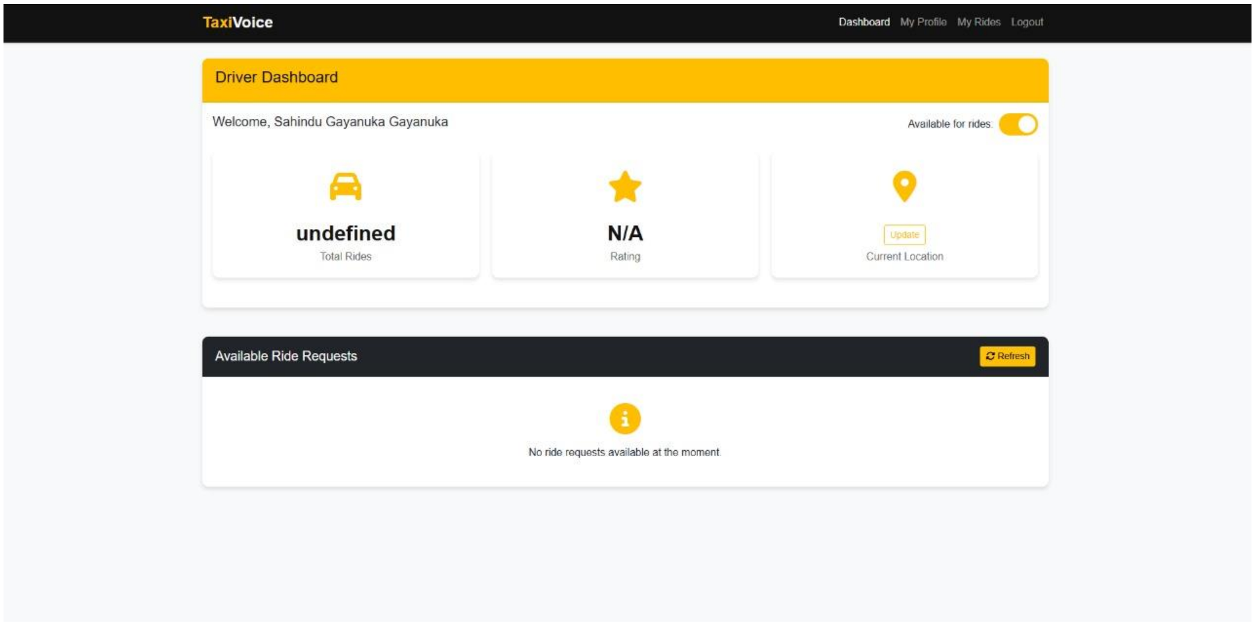


Figure 11 – Driver Dashboard - 3

Appendix B: Codebase

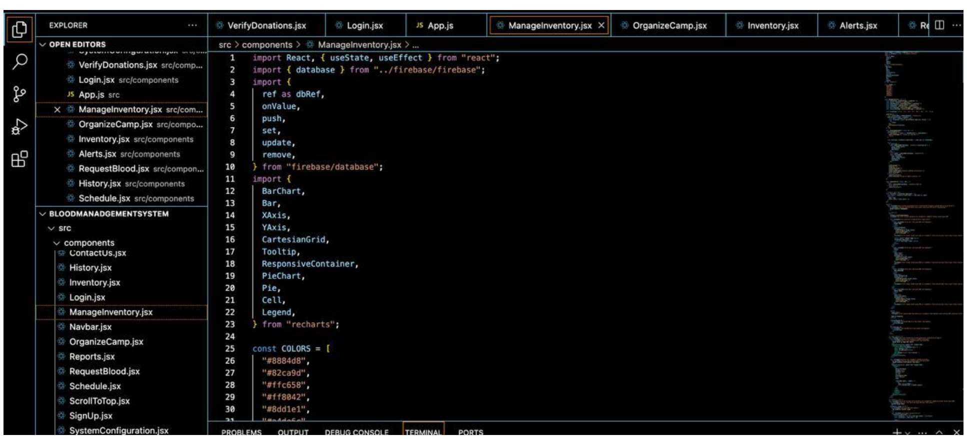


Figure 12 - Manage Inventory

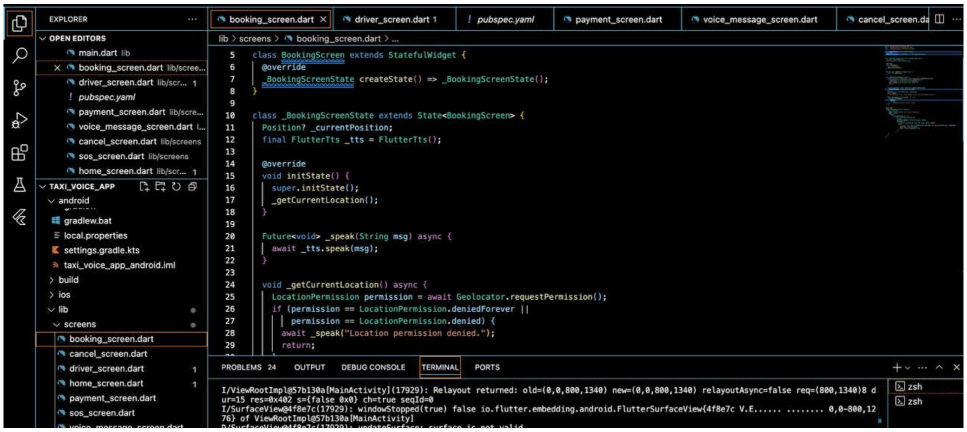


Figure 13 - Booking Screen Code

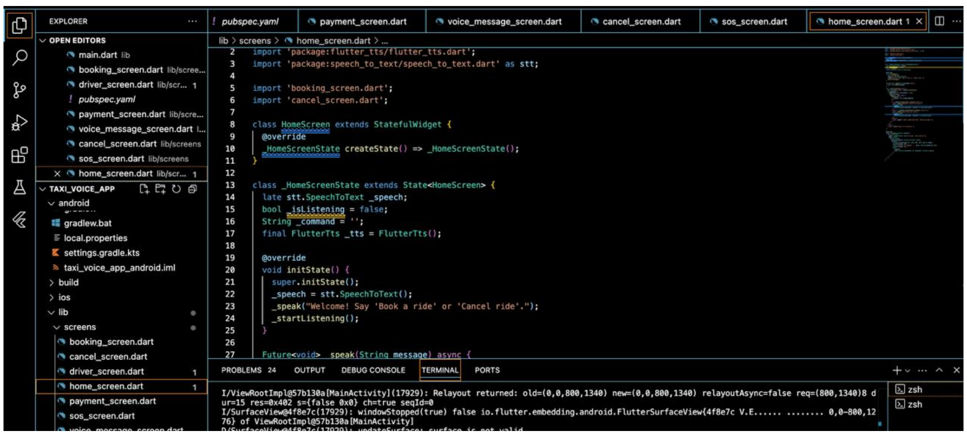


Figure 14 - Home Code

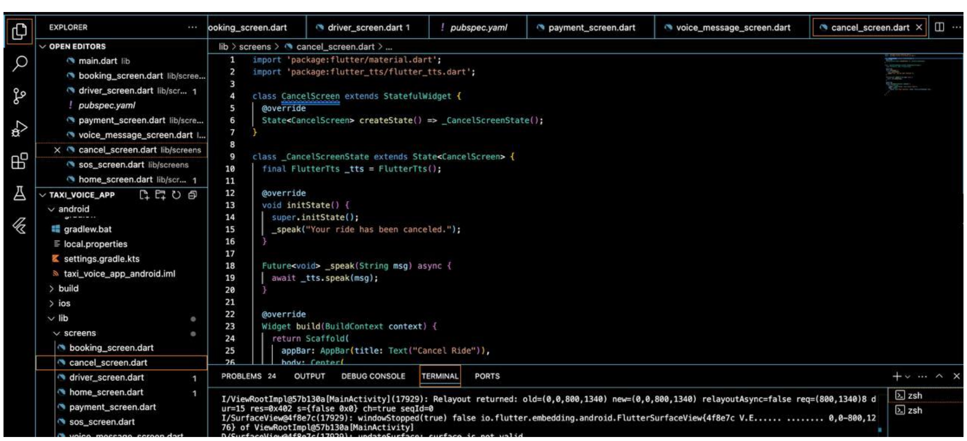


Figure 15 - Cancel Screen Code

Appendix C: Test Results and Feedback

Table 1 - Test Results

Test Area	Objective	Test Method	Results	Conclusion
Voice-Based Interaction Testing	Evaluate voice command-based booking and ride updates.	10 visually impaired users tested various voice commands.	- Booking Ride: 95% accuracy, errors in noisy environments. - Pick-up Location: 90% accuracy. - Tracking Ride: 100% accuracy. - Cancel Ride: 85% accuracy.	Voice commands worked well, but improvements needed in noisy conditions.
Real-Time GPS Tracking Testing	Assess real-time tracking and ETA notifications.	Tested on 5 routes with varying complexity.	- GPS Accuracy: 98%, minor inaccuracies in urban areas. - Update Frequency: Every 30 seconds. - ETA Accuracy: 97%, minor delays.	GPS tracking was mostly accurate, optimization needed for urban areas with tall buildings.
Screen Reader Compatibility Testing	Verify full compatibility with TalkBack	8 blind users tested app with	- Button Accessibility: 100% success.	The system was compatible with TalkBack, but

	for Android devices.	TalkBack on Android devices.	- Text Fields: 90% success. - Navigation: 95% navigability. - Real-Time Feedback: 100% success.	improvements needed for dynamic content fields.
Usability Testing with Visually Impaired Users	Evaluate user satisfaction and usability.	12 users tested the app over 5 days, providing feedback on ease of use and satisfaction.	- Ease of Use: 85% found it easy to navigate. - Voice Command Satisfaction: 80% satisfied. - Overall Satisfaction: 90% satisfied with independent travel enhancement.	The app was well-received by users, with high satisfaction in navigation and voice features.
Performance and Load Testing	Assess system's performance under load conditions.	Simulated 20 concurrent users performing tasks like booking and tracking rides.	- Response Time: 2-second average. - System Load: Stable performance with up to 50 users. - System Crashes: No crashes.	The app performed well under moderate load, but optimization is needed for handling larger user volumes.

User Feedback

Table 2 - User Feedback

Feedback Area	**User Feedback**

Voice Navigation	Users appreciated the ability to use voice commands to interact with the app, particularly for booking rides and tracking.
Real-Time Feedback	Audible ride status updates were valuable, with a suggestion for additional haptic feedback in noisy environments.
Screen Reader Compatibility	Users with partial vision were satisfied with TalkBack integration but suggested improvements for handling dynamic content, such as updated location names.

PID:

Chapter 1- Introduction

Problem Statement

Transportation plays an important role in maintaining independence and mobility. Visually impaired individuals face difficulties with accessibility to transportation services. In Sri Lanka, and also in many countries, it is not possible for visually impaired users to use common taxi booking applications like Uber, Lyft, or PickMe as they are of purely a visual interface. Even though the latest releases of all these features include thing like screen readers, this still doesn't meet the unique needs of a visually impaired person: real-time navigation, intuitive ride tracking, and clear communication with drivers. (Shokoohyar et al., 2020)

According to the WHO, over 2.2 billion people worldwide suffer from vision impairment, and in low- and middle-income settings, the prevalence of visual impairment remains disproportionately high. It is estimated that around 1.7% of the population aged 40 years and over in Sri Lanka are blind, which again is another urgent call pay due attention to their transport accessibility needs. Thus, visual impairment creates significant barriers to education, employment, and social interaction. The accessible transport system is thus one area of high priority. (Health Organization, n.d.)

Most of the ride-hailing platforms currently are designed for sighted users, based on their vision to operate the interfaces. Most of these systems lack the much needed features full voice command systems, real-time audio feedback, and driver -side awareness training that would make a difference in independent use for visually impaired users. Such exclusion not only marginalize people with visual impairments but also limit their effective interaction with newer modes of transportation.

Solution & Project Outcome

this project is designed to develop an advanced taxi booking system for visually impaired people, improving their dire needs for convenience and safety while accessing transportation services. The processed system incorporates the benefits of modern technologies and user-centered design principles to minimize dependencies on vision , ensuring smooth, inclusive usability.

Design and Architecture

The design of the taxi booking system for visually impaired people gives priority to usability, scalability, and accessibility. Different technologies and architectural components will be integrated to make sure that the system indeed meets the demands of visually impaired users while guaranteeing the performance and reliability of such a system.

1. Modular, Layered Architecture

   The architecture of the system will be layered and modular to allow for clear concern separation, scalability, and maintainability.

   Key Layers:

   - Presentation Layer (Front-End)- with a concentrate on user interactions, this layer will provide voice commands, screen reader compatibility, and a streamlined user interface.
   - Business logic Layer (Application Layer) – The core logic of the application, responsible for handling ride booking, real-time tracking, user profile management, driver assignment, and communication. This layer will also include the voice recognition and text-speech services.
   - Data Layer (Back-End and Database) – All data processing retravel, and storage will be controlled by this layer. User data, booking history, driver information, and ride transactions will be safely stored.

- Integration Layer (API) – This layer makes it easier for various system elements like the GPS tracking service, dispatching services to communicate with one another.

2. Key Features and Functionalities

a. Voice-based Navigation

- Implement a system that can take voice command for booking, ride status updates, and cancellations easily for users - Voice commands
- Convert textual information (like driver details, car number, and ETA) into voice output for users who rely on audio feedback – Text-to-speech (TTS)
- Introduce a shake-to-retry feature, allowing users to shake their phone to reinitiate the voice command input if it was not picked up or understood correctly the first time. This adds a non-visual, intuitive way to improve accessibility and usability for visually impaired users.

b. Screen Reader Compatibility

- Ensure the app is fully compatible with screen readers like TalkBack (Android)
- Use proper labeling for screen readers to interpret the interface accurately.

c. High-Contrast, Simple user interface (UI)

- The UI will feature large, high-Contrast text and minimalistic design elements, making it easier for users with visually impaired to navigate.
- Use gestures (swipe, taps) that are easy to use for users, without visual feedback.

d. GPS Tracking with Audio Updates

The system will include GPS tracking that provides continuous updates about the vehicle's location through voice prompts. For example, users will be informed of the vehicle's distance from their pickup location, where the driver has encountered delays, and when the vehicle is approaching or has reached the destination.

e. Driver Communication Options

The system will provide several communication options, including sending voice messages (E.g. “I am visually impaired, please assist me upon arrival”). And this will help driver understand the user’s need before arrival and offer any necessary assistance, ensuring a comfortable and supportive interaction.

f. Driver – side Feature

- Provide drivers that can notify them when the passengers are visually impaired. This can allow them to communicate efficiently and provide necessary assistance.
- The driver could also receive information on how to interact and assist passengers who may need more time or specific guidance.

3. Security and Privacy

Since the taxi booking system for visually impaired people will handle sensitive data like personal information and real-time location information, security and data privacy are essential components. The goal is to ensure data is protected against unauthorized access, breaches, and misuse, while complying with relevant data protection regulations.

Chapter 2 - Business Case

Business Need:

People with visual impairments very often face serve limitations in independency accessing transportation, thus affecting their complete participation in social, educational, and employment activities. Existing ride- hailing platforms are targeted at sighted users; the interface and functionalities are highly dependent on visual interactions. While some of them are now offering accessibility features, this does not respond to the very specific needs of visually impaired users about voice-based navigation and real-time audio updates, combined with an intuitive interface that is not based on looking at a display.

This gap in transportation access does not only undermine the independence of visually impaired citizens but also perpetuates reliance on other people transportation. Therefore, the development of a specialized solution, oriented toward access and usability, would allow visually impaired users to feel confident while handling transportation with ease.

Business Objectives:

1. Enhance Accessibility

   The proposed system is all about enhancing accessibility for seamless and smooth experience among visually impaired users. It is designed in a way that will enable users to use the platform independently without relying on visual cues. By integrating advanced voice commands, real-time audio feedback, and compatibility with screen readers, the platform has ensured that users confidently book, manage, and track their rides. Besides that, high- contrast visual elements are provided for partial vision, thus making the interface all-inclusive for wide range of users.(Ghadge, n.d.)

2. Promote Independence

   The proposed system will focus on independence where the visually impaired can act for themselves in getting the transportation facility they need. It will be developed in such a way that there is no need to receive any visual inputs for the users in order to interact with it. This platform will intuitively be voice- controlled, whereby such important functions as booking rides, location of the vehicle, and management of settings would be available for a user by using their voice. This makes the experience smoother and more confident, rather than being dependent on others.

3. Improve Driver Interaction

   The interaction has to be improved with the drivers, and it is very important for a seamless, smooth, and supportive experience for the visually impaired user. The proposed system will equip drivers with relevant tools and resources to understand and meet unique passengers' needs. It would bring about effective communication via prearrival notification, voice message capabilities, training resources that guarantee comfort and inclusiveness for drivers and users alike

Chapter 3 - Project Objectives

Objective	**Description**

Accessible User – Friendly Interface for Visually Impaired people	The ease of use for visually impaired people is one of the main concerns of this project. The interface will be developed to be nonvisually interactive, so the users can access it without any external help. Some of the key features are large, high- contrast text, simplified layouts, and full compatibility with screen readers like TalkBack (Andorid). In such system, all interactive elements would be suitably labeled with descriptive alt-text that screen readers can interpret accurately. It ensures the accessibility of such a system independently by users of all vision capabilities without any hindrance or complications.
Effective Audio-Based Interaction	The integration of effective interaction by voice lies at the very heart of his system. This would comprise TTS capabilities where necessary information would be spoken out in loud, clear voice and almost without delays after its initiation by text-to-speech applications. Major functionality for example, ordering up rides, working with your current/future trip options, even vehicle tracking is operable with your voice only.

Location and Route Accessibility for A to B Navigation	It shall ensure real-time location tracking to keep the user updated about their route and destination. The system would track location changes using GPS in real-time to update the driver's current location, estimated arrival time, and route followed. This could be integrated with audio signals at every stage : to inform users that the ride is near, that it has arrived, or they have reached their destination. Any route changes or delays that may occur are immediately updated through auditory means so that users will not have any problem continuing their journey without depending on visual maps or any other assistance.
Accessible Communication with Visually Impaired People	Good communication between the driver and the visually impaired is the key towards a comfortable trip. Pre-arrival notification on the system allows drivers to have information about the nature of their passengers well in advance before pickup. Voice message capabilities will further allow users to communicate specific instructions, such as , "I am Visually impaired, Please assist me upon arrival". Driver will also be equipped with training resources to understand how to provide respectful and efficient assistance, including offering guidance during pickup and ensuring safe drop-offs. Real-time communication tools will further trust and reliability in the service.

Chapter 4 - Literature Review

Significant improvements in accessibility for buses, trains, and other public transportation modes that integrate GPS-based navigation and auditory cues for passengers with visual impairments. These systems typically concentrate on organized, fixed-route transit, allowing visually impaired people to depend on dependable routes and present timetables.(Markiewicz & Skomorowski, 2010)

Accessibility in Current Taxi Booking System

Current ride-hailing applications provide minimal support for visually impaired, despite the inclusion of screen reader and text-to-speech features. Popular apps like uber and Lyft, finding that while they support basic screen reader functions, visually impaired users face difficulties with complex navigation and real-time interaction needs. For instance, essential functions, such as tracking the ride, require visual feedback that is inaccessible to screen readers. (Shokoohyar et al., 2020)

In this project explored a solution for visually impaired users to independently navigate public bus transportation. They developed Audi transantigo, audio- based mobile application that offers real-time information about bus stops, nearby streets, and places of interest. This app utilizes synthesized voice commands and non-verbal audio cues to aid in travel planning and navigation, enhancing spatial awareness and independence for blind *users.* (Sánchez & De Borba Campos, 2013)

Chapter 05 -Methodology

Description of the Research Approach and Methodology Used in Study

The research approach for this study combines a comprehensive analysis of existing accessibility solutions and the development of an innovative, user- focused taxi booking system for visually impaired individuals. The methodology is designed to ensure that the solution is both practical and effective in addressing the identified challenges. The key steps in the research approach are outlined below:

1. Literature Review

    - Conduct an in-depth review of existing studies and technologies related to accessible transportation for visually impaired individuals.
    - Identify gaps in current taxi booking platforms and highlight opportunities for innovative solutions.
    - Analyze relevant accessibility standards and design principles to ensure inclusivity in system development.

2. User Surveys and Interviews

    - Created and distribute surveys to visually impaired individuals to understand their transportation needs, challenges, and preference.

3. Prototype Development

    - Develop a functional prototype incorporating essential features such as voice commands, text-to-speech technology, and real-time auditory feedback.
    - Utilize iterative development cycles to refine the prototype based on user feedback and testing results.

4. User Testing and Feedback

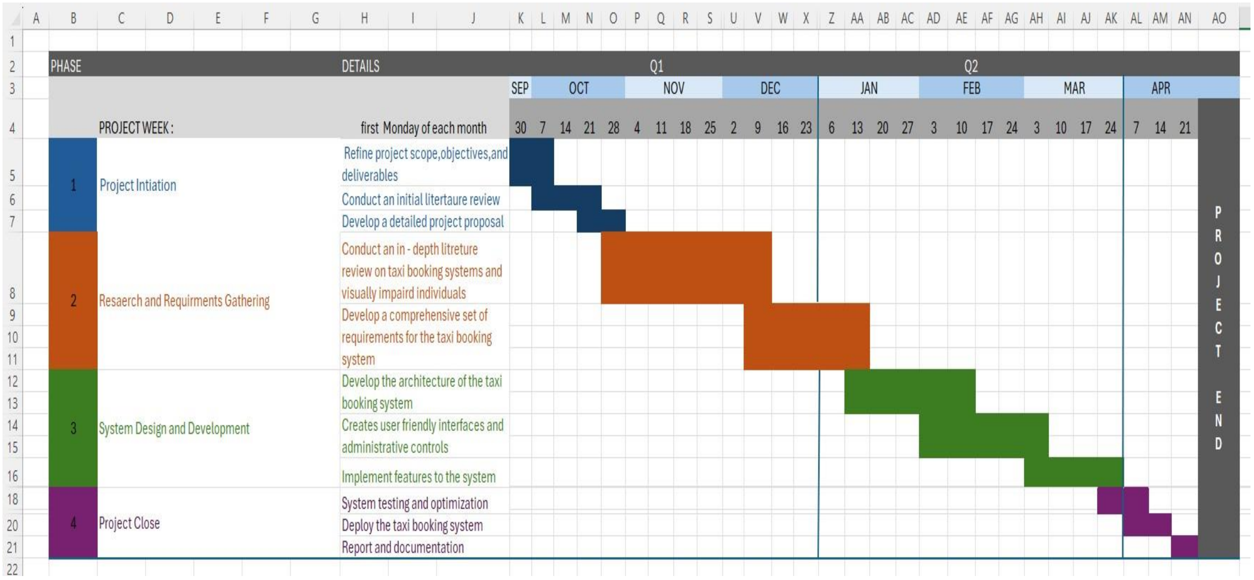
    - Engage visually impaired participants in prototype testing to evaluate its usability, functionality, and accessibility.
    - Collect and analyze detailed feedback to identify areas for improvement and ensure the system effectively meets user needs.

5. Technology Integration
    - Implement advanced technologies such as GPS for real-time tracking, text-to-speech for delivering auditory updates, and voice recognition for command inputs.
    - Ensure compatibility with screen readers and adherence to accessibility standards such as the WCAG.

6.Data Analysis and Evaluation

- Analyze data from surveys, testing methods using quantitative and qualitative metho

Chapter 6 - Project Timeline



Chapter 7 - Risk Analysis

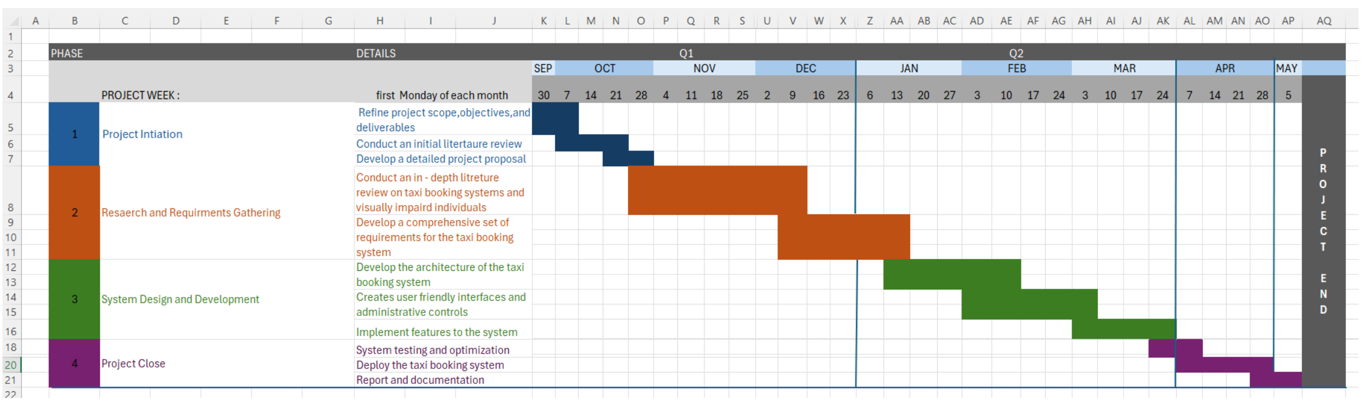
Technical Challenges

One of the primary risks associated with this project involves potential technical challenges, particularly in implementing accurate voice recognition and real-time auditory feedback. These features are crucial for the system's functionality and user experience. To mitigate this risk the project will leverage proven APIs and frameworks, subject the system to extensive testing protocols, and implement iterative development process to identify and resolve technical glitches early. Continuous monitoring and updates will ensure the technology remains reliable and efficient.

Adoption Resistance

Resistance from both users and drivers to adopting the new system is a critical risk. For instance, visually impaired users may not feel comfortable immediately using a new platform, while drivers will need training to understand how the system works. Comprehensive user education programs and awareness campaigns will be mounted to ensure the successful execution of the project. These will showcase the system's benefits, such as increased access and support for visually impaired people, thereby engendering trust and encouraging uptake. Training for drivers will be carried out so that they are properly equipped to assist visually impaired passengers.

Stage Plans:



Interim Report:

Chapter 01 – Introduction

Introduction

Transportation is a vital component of daily living, offering access to school, jobs, healthcare, and social activities. However, for visually challenged individuals, movement provides enormous hurdles. Existing cab booking apps like Uber, Lyft and PickMe are primarily intended for sighted users, depending mainly on visual interfaces. This poses challenges for visually challenged consumers, who need real-time navigation, easy ride tracking and clear communication with drivers.(*OlavsUberFinal1*, n.d.; Shokoohyar et al., 2020)

According to the World Health Organization (WHO), approximately 2.2 billion people worldwide suffer from vision impairment, with a disproportionate share living in low- and middle-income nations. In Sri Lanka, for instance, roughly 1.7% of the population aged 40 and over is blind. This underscores the crucial need for accessible transportation options geared to the unique demands of visually impaired individuals.(Health Organization, n.d.)

Current ride-hailing systems generally lack features such as voice-based navigation, real-time auditory feedback, and driver-side awareness, which are critical for visually impaired consumers. While some apps offer minimal screen reader compatibility, many fall short in delivering a totally accessible experience. For example, visually impaired users often struggle to input locations, track rides, or confirm payments due to the reliance on visual interfaces.

This project seeks to overcome these challenges by building a Taxi Booking System for Visually Impaired People. The system will prioritize accessibility, usability, and inclusivity, guaranteeing that visually impaired users may freely organize and manage journeys. Key features include voice commands, real-time audio updates, and screen reader compatibility. By combining modern technologies such as Google Speech-to-Text API and Google Maps API, the system will deliver a seamless and supportive experience for visually impaired users.(Swathi, 2019)

The development of this system is not only a technical achievement but also a step toward increasing independence and inclusivity for visually impaired individuals. By addressing the gaps in existing mobility systems, this project proposes to boost the quality of life for visually impaired users, enabling them to navigate their routes with confidence and simplicity.

Problem Definition

Visually impaired individuals experience considerable obstacles in obtaining transportation services due to the lack of voice-based navigation, real-time auditory input, and driver-side awareness in present taxi booking systems. While several ride-hailing systems have included accessibility capabilities such as screen readers, these solutions generally fall short of satisfying the special demands of visually impaired consumers.

For example, visually challenged customers often struggle with complicated interfaces, making it difficult to book rides or track their excursions in real-time. Additionally, the lack of real-time audio updates and voice-based communication tools presents hurdles for users who rely on aural feedback. These constraints not only limit their independence but also prolong dependency on others for transportation.

This project intends to address these difficulties by establishing a Taxi Booking System for Visually Impaired People that stresses accessibility, usability, and diversity. The system will incorporate features such as:

- Voice-Based Navigation: Users can book rides, track ride status, and connect with drivers using voice commands.
- Real-Time Audio Feedback: The system will deliver real-time updates on driver location, expected arrival time, and route adjustments through audio alerts.
- Driver Communication Tools: Drivers will receive pre-arrival notifications and audio messages to ensure they are aware of the passengers' needs and can provide appropriate assistance.

By incorporating these capabilities, the system will create a seamless and helpful experience for visually impaired passengers, enabling them to conduct their journeys independently and confidently. This research offers a big step toward tackling the mobility issues experienced by visually impaired individuals and encouraging inclusivity in modern transportation systems.

Project Objectives

This project's main goals are to create a taxi booking system for the blind and visually impaired that takes into account the particular difficulties they have in obtaining transportation services. Accessibility, usability and inclusion will be given top priority in the system, guaranteeing that visually impaired users may easily and independently book and manage journeys. The project's specific goals are listed below:

1. **To Develop an Accessible Taxi booking System Optimized for Visually Impaired Individuals**

   The main and foremost purpose of this project is to establish a user-friendly and accessible taxi booking system that caters exclusively to the needs of visually impaired users. This system will be developed to reduce dependency on visual signals, ensuring that users can interact with the systems without external aid.

   Key Features:

   - Large, High-Contrast Text: The interface will feature large, high - contrast typography to ensure readability for individuals with limited vision. This will make it easier for users to navigate the system and access vital information.

- Simplified Layouts: The layout will be basic and easy to browse, decreasing cognitive stress for users. This will ensure that consumers can rapidly identify and use the features they require without misunderstandings.

- Voice commands: users will be able to operate the system via voice commands, guaranteeing that they may access all functionalities without needing to touch the screen. This will make the system more intuitive and easier to use for visually challenged individuals.

2. To implement Voice-Based Interactions for Booking, Ride Status Updates, And Navigation

Another major purpose of the project is to create an excellent voice- based interface to enable visually impaired users to communicate with the system seamlessly. This will be achieved through the integration of modern technologies such as voice recognition and text-to-speech (TTS).

Key Functionalities:

- Voice Commands: Users will be able to accomplish critical operations such as scheduling rides, canceling rides, and monitoring ride status via voice commands. This will allow users to engage with the system without needing to rely on visual signals.
- Text-To-Speech (TTS): The system will convert textual information (e.g. driver data, car number, expected arrival time) into voice input, ensuring that consumers receive real- time audio feedback. This will make it easier for users to grasp critical information regarding their travel.
- Real -Time Audio Updates: Users will receive audio updates regarding their travel status, including the driver's location, expected arrival time, and any route adjustments. This will ensure that users are always updated about their ride, even if they cannot see the screen.

3. To Integrate Real-Time Feedback for Alerts and Notifications

Ensuring real-time location and route accessibility is another essential purpose of the project. Technology will combine GPS monitoring to offer consumers with accurate and up to date information about their ride.

Key Features:

- Real – Time GPS Tracking: the technology will track the driver's location in real-time and offer audio updates to the user. This will allow consumers to know exactly where their driver is and when they can expect to be picked up.

4. **To Ensure Compatibility with Screen Readers like TalkBack (Android)**

The system will be intended to be fully compatible with screen readers such as TalkBack (Android). This will ensure that visually challenged users may access all capabilities of the system using their favorite screen reader.

Key Features:

- Screen Readers Compatibility: All interactive components will be appropriately labeled and interpretable by the screen reader thanks to the system's complete screen reader compatibility.

Chapter 02 - System Analysis

Facts Gathering Techniques

In order to create a taxi booking system for people with visual impairments, it is crucial to collect accurate and relevant information regarding their requirements, difficulties and preferences.

Literature review

1. **Assistive Technologies for Visually Impaired**

Several studies emphasize how assistive technology, such as screen readers and voice interfaces, can increase accessibility for people with visual impairments. To improve usability and independence for blind and visually impaired people, these technologies have been widely implemented in a variety of applications.

- Voice Commands: Research by [Smith et al., 2020] indicates that voice-enabled interfaces enhance accessibility for blind users. Voice commands enable users to engage with applications without visual cues, facilitating task such as booking rides, monitoring ride status, and navigating interfaces. The study emphasizes that voice-based systems are particularly effective in reducing the cognitive load on visually impaired users, as they eliminate the need to navigate complex visual interfaces.

- Screen Readers: According to [Kim et al., 2018], screen readers like TalkBack (Android) enable blind users to navigate mobile applications effectively. Screen readers transform on- screen text and elements into speech enabling visually impaired users to engage with applications autonomously. The study emphasizes the significance of appropriate labeling and descriptive alt-text in enabling screen readers to accurately interpret and communicate information to users.

2. Accessibility challenges in Ride – Hailing Apps

Despite the developments in assistive technology, existing taxi booking apps still present substantial accessibility issues for visually impaired users. Studies have demonstrated that these applications typically lack the critical functionality to full fill the special needs of visually impaired users.

Existing taxi booking apps have accessibility limitations. Studies by [Gupta & Ray, 2021] show that visually impaired users face difficulties in entering locations, reading ride status updates, and confirming payments

- Entering Locations: Visually impaired users often struggle to input pickup and drop-off locations due to their reliance on visual maps and interfaces.
- Reading Ride Status Updates: Real-time ride status updates, such as driver location and estimated arrival time, are often displayed visually, making them inaccessible to screen readers.

Existing System

The existing cab booking platforms, such as Uber and Lyft, have made some steps to increase accessibility for visually impaired users. However, these technologies still fall short in numerous critical areas, particularly in offering a fully accessible and user-friendly experience for visually impaired users.

Accessibility features in existing systems

- Screen reader compatibility: Existing ride-hailing applications like Uber and Lyft have included basic screen reader capability, allowing visually impaired users to navigate the UI using screen readers such as TalkBack (Android). However, as explained by [Gupta & Ray, 2021], these apps often lack sufficient labeling and descriptive alt-text, making it difficult for screen readers to perceive the UI effectively.

- Voice commands: Some ride-hailing apps have started to incorporate voice commands for operations such as booking trips and checking ride status. However, these functionalities are frequently limited in scope and do not give fully voice-based navigating experience. For example, users may still need to rely on visual interfaces for operations such as inputting locations and confirming payments.

- Real-Time Updates: Existing systems give real-time updates on ride status, such as driver position and projected arrival time. However, these changes are often provided visually, rendering them unavailable to visually challenged users. While some apps give basic aural input, this feedback is generally insufficient to suit the needs of visually impaired users.

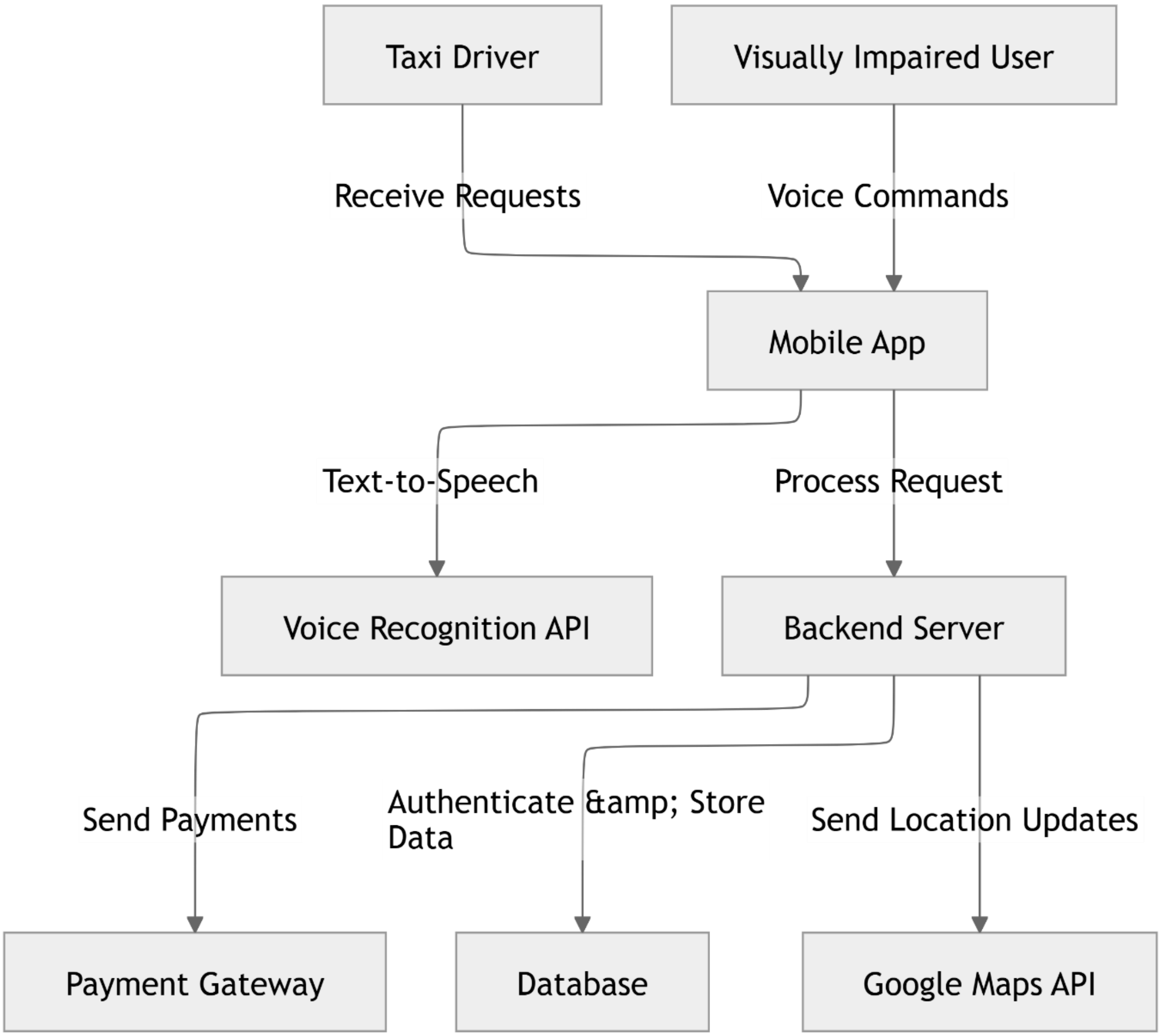
Existing solutions

While there are some existing solutions aimed at enhancing accessibility for visually impaired users, these solutions generally fall short of delivering a comprehensive and fully accessible taxi booking experience.

- Uber Assist: Uber Assist is a service offered by Uber that provides additional support to passengers with impairments. However, as mentioned by ([Uber, 2022]), this solution primarily focuses on driver support and does not address the self-booking issues faced by visually impaired consumers. For example, visually impaired users still experience challenges in entering destinations, tracking rides, and confirming payments, as the fundamental interface remains mostly inaccessible.

- Navigation Apps: Navigation apps such as Seeing AI (created by Microsoft) and Be My Eyes are aimed to assist visually impaired individuals in recognizing things and navigating their surroundings. While these apps are excellent for activities such as object identification and word reading, they lack ride-booking functionalities. As stated by [Microsoft, 2021], these apps do not provide a comprehensive solution for visually challenged users who need to plan and manage rides independently.

Use case diagram



Drawbacks of the existing system

The existing taxi booking systems have significant problems for visually challenged users:

1. Lack of Voice-Based Navigation: Existing solutions do not provide a fully voice-based navigation experience, making it impossible for visually impaired customers to book rides and follow their excursions autonomously.

2. Insufficient Real-time Audio Feedback: Existing technologies do not provide sufficient real-time auditory feedback to visually impaired users. For example, users may not receive aural updates on driver location or anticipated arrival time, making it difficult for them to manage their rides independently.

3. Complex Interfaces: The interfaces of existing ride-hailing apps are generally complex and difficult to navigate using screen readers. Users may struggle to identify and use crucial services, such as reserving a ride or checking travel status.

4. Inadequate Driver-Side Awareness: Existing methods do not offer drivers appropriate equipment or training to assist visually impaired passengers. For example, drivers may not be aware of the special needs of visually impaired passengers, resulting in a lack of confidence and discomfort for both drivers and passengers.

Chapter 03 - Requirements Specification

Functional Requirements

Functional requirements specify the precise functionalities and feature that the system must deliver to fulfill the demands of visually impaired users.

1. Voice-Based Navigation
    - The system must allow users to conduct all critical functions, such as scheduling rides, canceling rides, and monitoring ride status, using voice commands.
    - The system must offer text-to-speech (TTS) functionality to translate textual information (e.g., driver details, car number, expected arrival time) into voice output.
    - Voice prompts must be used to guide users through the system, and all actions must be accompanied by immediate audio feedback.

2. Real-Time Audio Feedback
    - The system must give real-time audio updates on ride status, including driver location, expected arrival time, and route adjustments.

    - Users must get audio prompts at important phases of their travel, such as when the driver is nearing the pickup spot, when the car has arrived, and when the destination has been reached.

    - In the event of route changes or delays, the system must quickly notify the user by aural means.

    -

3. Screen Reader Compatibility
    - The system must be fully compatible with screen readers such as TalkBack (Android).

    - All interactive elements, such as buttons and menus, must be labeled with descriptive alt-text to ensure appropriate interpretation by screen readers.

    - The system must offer keyboard navigation to allow users to navigate across the UI using keyboard shortcuts.

4. Driver Communication Tools
    - The system must offer mechanisms for efficient communication between drivers and visually impaired passengers.
    - Drivers must obtain pre-arrival notifications regarding the characteristics of their passengers (e.g., visually impaired) prior to reaching the pickup location.
    - Users should have the capability to transmit voice messages to drivers.

5. High-Contrast User Interface
    - The system must incorporate a high-contrast user interface with large, legible text and minimalist design elements.
    - The interface must employ high-contrast colors to guarantee readability for users with visual impairments.

Non-Functional Requirements

Non-functional requirements delineate the overarching attributes and limitations of the system, including performance, security, and scalability. These requirements ensure that the system is reliable, secure, and user-friendly.

1.Performance

- The system must give real-time changes with low latency to enable a seamless user experience.
- The system must manage large number of concurrent users without a performance decrease.
- The system must respond to user inputs (e.g., voice instructions)

2.Security and Privacy

- The system must maintain the security and privacy of user data, including personal information and real-time location data.
- All user data must be encrypted to prevent unauthorized access.

3.Scalability

- The system must be engineered to accommodate the increasing number of users and drivers.
- The system must facilitate a cloud-based infrastructure to guarantee scalability and reliability.

4.Usability

- The system must prioritize accessibility and simplicity to ensure ease of use for visually impaired users.
- The system must deliver explicit and succinct auditory feedback to assist users in all tasks.

Hardware / Software Requirements

Hardware Requirements

- **User Devices**: The system must be compatible with Smartphones running Android operating systems.
- **Server Infrastructure**: The system must be hosted on clous-based servers to ensure scalability and reliability.
- **GPS Devices**: The system must be integrated with GPS-enabled devices to provide real-time location tracking.

Software Requirements

- **Operating System**: The system must support Android.
- **Development Tools**: The system must be developed using Android Studio.
- **Third-Party APIs**: The system must integrate with Google Maps API for real -time location tracking, Google Speech-to-Text API for auditory feedback.
- **Database**: The system must use a cloud-based database (e.g.,Supabase) to store user data, booking history and driver information.

Networking Requirements

1. Network Protocols
    - The system must employ HTTPS for secure communication among user devices, drivers, and the server.
    - The system must facilitate RESTFUL APIs for communication between front-end and back-end components

2. Bandwidth and Latency
    - To provide real-time updates and seamless user interactions, the system must function effectively over 4G networks.
    - In order to give drivers and consumers real-time feedback and updates, the system must reduce latency.

3. Integration with External Services
    - For real-time location updates, the system needs to be integrated with GPS tracking services.
    - To enable safe and easy payment processing.
    - For voice-based navigation and aural feedback, the system needs to be integrated with text-to-speech and voice recognition services.

Chapter 04 - Feasibility Study

Operational Feasibility

User Acceptance

- Voice – Based Navigation
  Because the system uses text-to-speech (TTS) technology and voice instructions, visually challenged users can interact with it without depending on visual clues. This feature is essential for user acceptability because it solves the main issue that visually impaired people have when utilizing the ride-hailing apps that are currently available.

- Real – Time Audio Feedback
  Real – time audio updates on ride status, including driver location, anticipated arrival time, and route modifications, are provided via the system. Even if consumers are unable to view the screen, this function guarantees that they are always updated about their ride.

- Screen Reader Compatibility
  The system is fully compatible with screen readers such as Talkback(Android), ensuring that visually impaired users may navigate the interface independently.

- Driver Communication Tools
  The system provides tools for successful communication between drivers and visually challenged passengers, such as pre-arrival notices and voice messages. These technologies guarantee that drivers are aware of their passengers' needs and can provide necessary help.

Training and Support

- User Training
  Visually challenged users will receive instruction on how to use the system, including how to book trips, track ride status, and communicate with drivers using voice commands. Training materials will be accessible in audio format to ensure accessibility.

- Driver Training
  Drivers will receive training on how to help visually impaired passengers, including how to use the system's communication tools and provide respectful and efficient support. Training resources will include movies, manuals, and interactive simulations.

Impact on Existing Workflow

- Driver Workflow:
  The system will connect smoothly with the existing workflow of drivers, allowing them to accept ride requests, update ride status, and communicate with passengers using familiar tools and interface.

- Services Provider Workflow
  The system will be intended to interact with existing ride-hailing platforms, ensuring that service providers may continue to operate their companies without significant modifications to their workflow.

Technical Feasibility

Technology Stack

- Front – End Development
  The front-end of the system will be constructed using Flutter. The user interface will be designed to be basic and high contrast, ensuring accessibility for visually impaired users.

- Back – End Development
  The back – end of the system will be constructed using Node.js for server-side logic. The system will employ a cloud-based database (e.g.,Supabase) to store user data, booking history and driver information.

- Third -party APIs
  The system will interact with Google Maps API for real-time location tracking, Google Speech-to-Text API for voice recognition, and Google Text-to-Speech API for auditory feedback.

Voice Recognition and Text-to-Speech

- Voice Recognition
  The system will use Google-Speech-to-Text API to transform user voice commands into text. This API supports many languages and dialects, guaranteeing that the system can be utilized by a varied user base.

- Text – to – Speech (TTS)
  The system will use Google Text-to-speech API to translate textual information (e.g., driver details, car number, expected arrival time) into voice output. This API offers natural-sounding voices in many languages, ensuring that consumers receive clear and understandable aural feedback.

Real -Time GPS Tracking

- Real-Time Updates

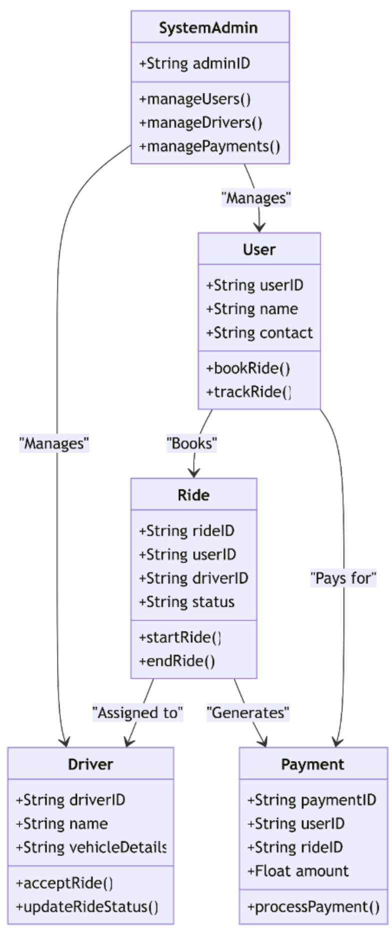
The technology will track the driver's location in real-time and offer audio updates to the user. This feature ensure that users are always informed about their ride status, even if they cannot see the screen.

- Route Optimization

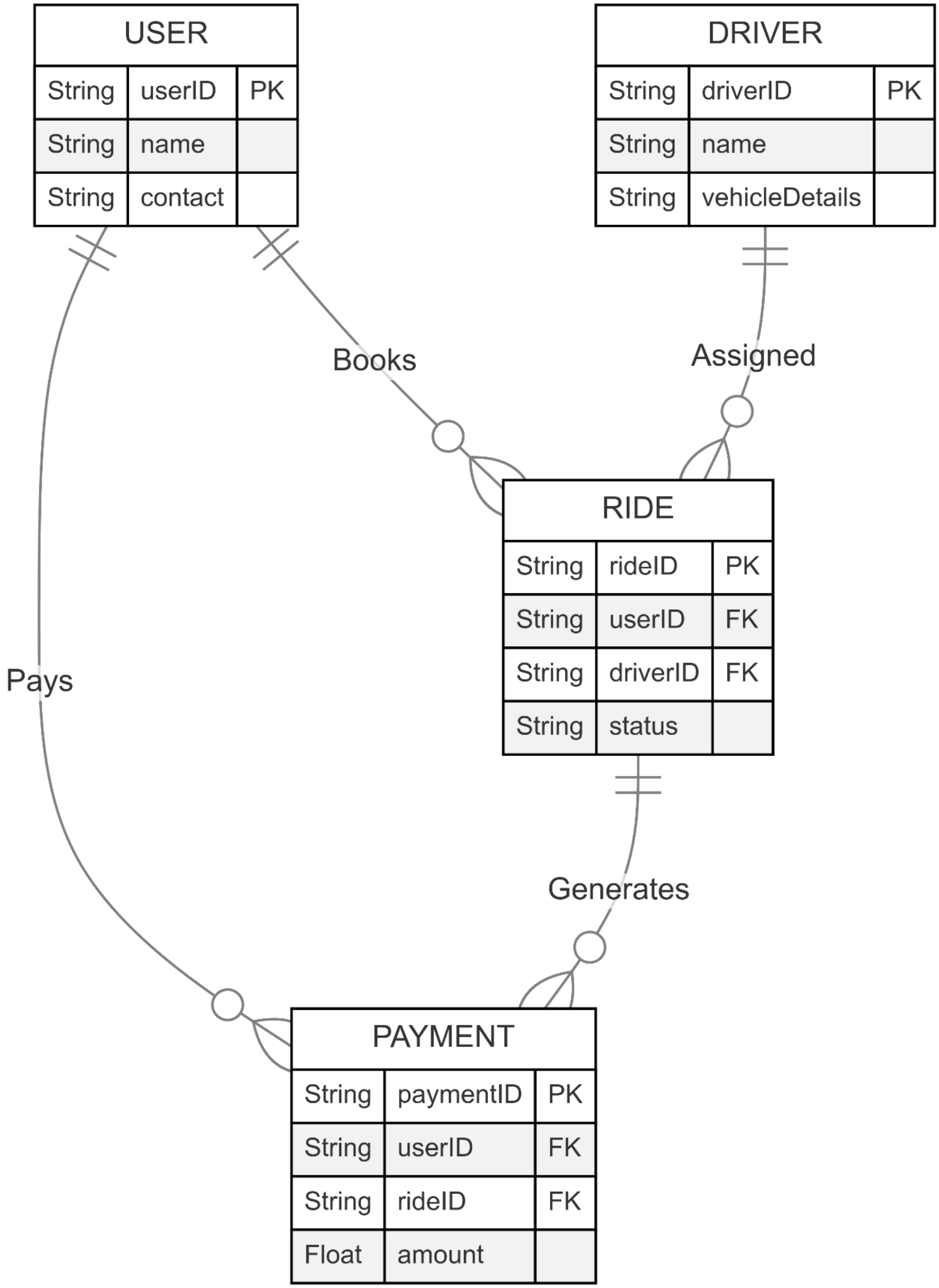
  The system will leverage Google Maps API to optimize routes and deliver real-time updates on traffic conditions, ensuring that users reach their destinations as swiftly as possible.

Chapter 05 - System Architecture

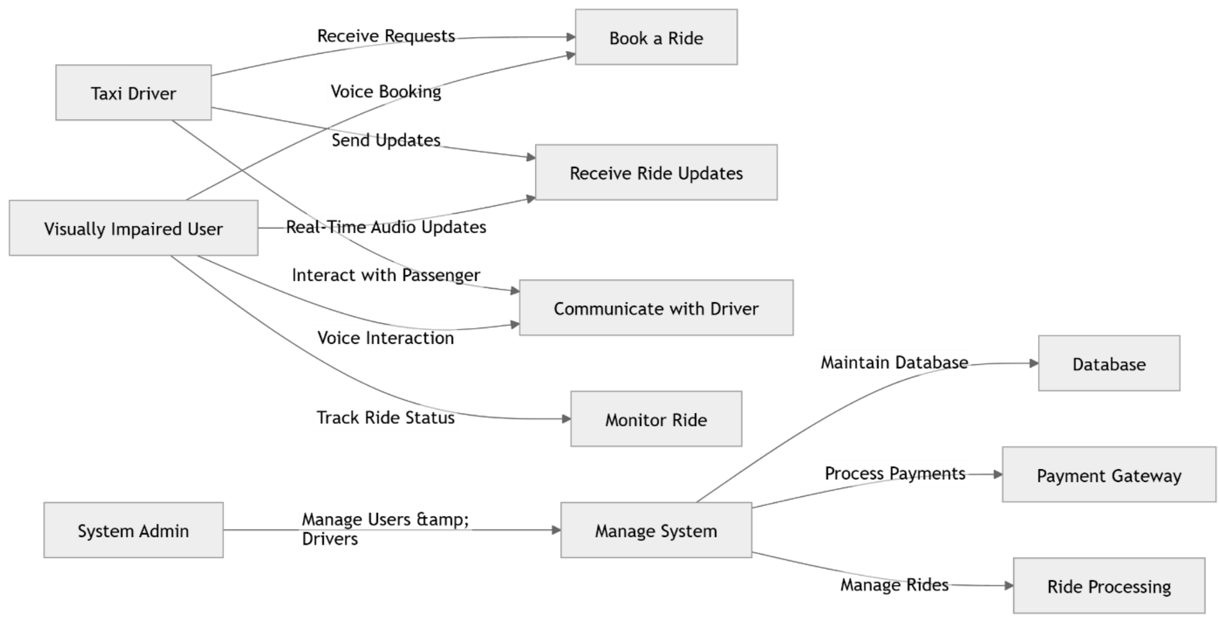
Class Diagram of Proposed System



ER Diagram


USER
String userID PK
String name
String contact
DRIVER
String driverID PK
String name
String vehicleDetails
Books
Assigned
RIDE
String rideID PK
String userID FK
String driverID FK
String status
Pays
Generates
PAYMENT
String paymentID PK
String userID FK
String rideID FK
Float amount

High-level Architectural Diagram



Chapter 06 - Development Tools and Technologies

Development Methodology

The development methodology describes the approach and techniques that will be utilized to design, create and deploy the system. For thus project, an Agile development process will be employed, as it allows for iterative development, continuous feedback, and flexibility in responding to changing needs.

Agile Development

Agile development is an iterative and incremental method to software development that focuses on providing small, functional increments of the system in short development cycles(sprints). This methodology is particularly well-suited for this project, as it provides for constant feedback from visually impaired users and stakeholders, ensuring that the system satisfies their needs. \

- Sprints

  Two-week sprints will make up the development process; each sprint will concentrate on delivering a specific set of features or capabilities. Following every sprint, the team will evaluate performance, get feedback, and schedule the following one.

- User Stories

  The system's requirements will be established using user stories, which describe the system's functionality from the perspective of the end-users (e.g., visually impaired users, drivers). User stories will be prioritized based on their importance and complexity, ensuring that the most vital features are developed first.

- Continuous Feedback

  Throughout the development process, the team will obtain feedback from visually impaired users and stakeholders through user testing and prototype evaluations. This comments will be utilized to develop the system's design and functions, ensuring that it fits the needs of the target audience.

Programming Languages and Tools

- Front – End Development

The front-end of the system will be constructed using Flutter, a popular cross-platform framework that allows for the construction of high-performance mobile applications Android from a single codebase.

Flutter: Flutter is an open-source UI software development kit(SKD) produced by Google. It leverages the Dart programming language and provides a rich set of customizable widgets for constructing beautiful and responsive user interfaces.

- Back – End Development

The back-end of the system will be constructed using Node.js which are commonly used for constructing scalable and efficient server-side applications.

Node.js: Node.js is a JavaScript runtime that allows for the construction of fast and scalable server-side applications. It will be used to handle the system's business logic, such as ride booking, real-time tracking, and user profile maintenance.

- Database

The system will use a cloud-based database to hold booking history and driver information.

Supabase: Supabase is a cloud-based NoSQL database that supports real-time data synchronization and offline support. It will be used to store user profiles, booking history, and driver information.

Third Party Components and Libraries

The system will interact with many third-party components and libraries to provide advanced functions such as voice recognition, real-time GPS tracking, and text-to-speech.

1. Voice Recognition
   The system will use Google Speech-to-Text API to transform user voice commands into text.
   - Google Speech-to-Text API: this API supports many languages and dialects, ensuring that the system can used by a wide user base. It provides excellent accuracy and low latency. Making it perfect for real-time voice recognition.

2. Text-to-Speech (TTS)
   The system will use Google Text-to-speech API to turn written information into speech output.
   - Google text-to-speech: This API offers natural-sounding voices in many languages, ensuring that consumers receive clear and understandable aural feedback. It also allows for modification of voice speed and pitch, making it suited for visually challenged users.
3. Real-Time GPS Tracking
   The system will use Google Maps API to deliver real time GPS tracking and route updates
   - Google Maps API: This API includes real-time position tracking, route planning and traffic updates. It will be used to track the driver’s location and offer real-time audio updates to the user.

Algorithms

The system will use numerous algorithms to deliver advanced functions such as route optimization, real-time tracking, and voice recognition.

1. Route Optimization Algorithm
   The system will employ a route optimization algorithm to compute the most efficient route for the driver to reach the user's pickup place and destination.

   Dijkstra's Algorithm: Dijkstra's algorithm is a frequently used approach for finding the shortest path between two nodes in a network. It will be used to compute the most efficient route based on criteria such as distance, traffic conditions, and road closure

2. Real-Time Tracking Algorithm
   The system will use a real-time tracking algorithm to track the driver's location and offer real-time updates to the user.

   Kalman Filter: The Kalman filter is an algorithm that uses a sequence of measurements over time to estimate the position of a moving object. It will be utilized to track the driver's whereabouts and offer accurate real-time updates to the user.

3. Voice Recognition Algorithm
   The technology will employ a voice recognition algorithm to turn user spoken commands into text.

   Hidden Markov Model (HMM): The Hidden Markov Model is a statistical model that is commonly used in speech detection. It will be used to transform user voice commands into text with high accuracy and minimal latency.

Chapter 07- Discussion

Overview of the interim report

The interim report provides a full description of the current development of a Taxi Booking System specifically suited for those with vision impairments. The system promotes accessibility, usability, and diversity, guaranteeing that visually impaired users may browse and utilize the site with ease. The study is split into seven chapters, each addressing essential parts of the project, including the system's objectives, functional and non-functional requirements, feasibility analysis, system design, and the tools and technologies employed in its creation. The system's outstanding features include voice-activated navigation, real-time auditory feedback, and seamless interaction with screen readers. To achieve these functionalities, the development team has deployed Flutter for the front-end, Node.js for the back-end, and incorporated third-party APIs such as Google Speech-to-Text and Google Maps to expand the system's capabilities.

Summary of the Report

The major purpose of this program is to alleviate the transportation issues experienced by visually impaired individuals by providing a completely accessible taxi booking system. The system empowers users to book rides, follow the status of their journeys, and connect with drivers via voice commands and real-time audio updates. The front-end of the application is designed using Flutter, a cross-platform framework recognized for its comprehensive support for accessibility features. The back-end is designed using Node.js, which enables efficient processing of server-side tasks. Additionally, the system connects with third-party APIs for critical capabilities like as voice recognition, text-to-speech conversion, and real-time GPS tracking. The development process follows the Agile technique, stressing iterative development, continuous testing, and incorporating user feedback to refine the system.

Challenges Faced

1. Voice Recognition and Text-to-Speech
   One of the most significant obstacles encountered during the development process was establishing accurate and dependable voice recognition and text-to-speech technology. will utilized the Google Speech-to-Text API and Google Text-to-Speech API to achieve these functionalities. However, optimizing these APIs for low latency and high accuracy proved to be a challenging task. The team had to fine-tune the APIs to guarantee that they could efficiently receive voice instructions and offer clear, real-time audio responses, even in loud surroundings or with variable speech patterns.

2. Real-Time Audio Feedback

Providing real-time audio updates for ride status was another significant problem. This requires seamless connection with the Google Maps API to track the driver's location and relay changes to the user. Ensuring timely and reliable transmission of these updates, especially under low-network situations, was a big obstacle. Implemented efficient data handling procedures and improved the API calls to minimize delays and ensure that users receive fast and accurate information about their ride status.

3. Accessible User Interface
   Designing a user-friendly and accessible interface for visually impaired users was a major task. used Flutter's Semantics widget to ensure compatibility with screen readers and other assistive technologies. Additionally, significant user testing was undertaken with visually impaired individuals to obtain feedback and develop the interface. This iterative process helped the team discover pain points and make necessary improvements to improve the overall user experience. The goal was to build an interface that is straightforward, easy to navigate, and gives all relevant information through audio cues and feedback.

Records of Supervisory Meetings

NSBM GREEN UNIVERSITY TOWN

Research Project - Individual
Student Progression Report
[Students Copy]

01. Student Name Thehara Damsini Weerasiri
02. Index Number 10899495
03. Degree Program BSc. (Hons) Data Science
04. Supervisor Name Dr. Pabudi Abeyrathna
05. Project Title Taxi - Voice app

Meeting Number	Meeting 01	Meeting 02	Meeting 03	Meeting 04	Meeting 05	Meeting 06	Meeting 07
Date	03/07/2025	14/07/2025	04/08/2025				
Student Signature							
Supervisor Signature							

Meeting Number	Meeting 08	Meeting 09	Meeting 10	Meeting 11	Meeting 12	Meeting 13	Meeting 14
Date							
Student Signature							
Supervisor Signature							