DEVELOPMENT OF AN ANDROID-BASED MOBILE APPLICATION FOR FINDING THE NEAREST BUS STOP AND PREDICTING THE ESTIMATED TIME OF ARRIVAL

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ABSTRACT

The researchers developed a mobile android application to help local and tourist passengers to navigate the whole Bonifacio global city (BGC). The application is designed specifically for BGC and provides a helpful feature such as estimated time of arrival of buses for every bus stop and the next along the route. It also shows the estimated time of arrival while you are walking and it highlights the bus stops within the area.

Additionally, passengers can view details of the bus routes, markers on maps widget, their estimated time of arrival to the nearest bus stop, and bus' estimated time of arrival. In drivers, the drivers can use the app to check the estimated time of arrival at the next bus stop and activate their location. The admin oversees the entire application, managing driver details. The BGCBus application makes navigating around BGC easier and convenient for everyone involved.

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CHAPTER I

THE PROBLEM AND ITS SETTING

Introduction

For millions of people globally, public transportation networks are essential to their everyday lives since they provide a practical and environmentally friendly way to get around cities. Due to its low startup and running costs, flexible route network, and proximity to town and city centers, the conventional bus is the primary public transportation mode in most developing country cities. (Verma & Ramanayya, 2014). Buses are a popular mode of transportation since they are typically less expensive than other options. One of the main factors influencing people's decisions to use the bus is its price, particularly for budget-sensitive people. However, some individuals often need clarification when searching for the nearest bus stop, and some are lost. According to Candra et. al, 2021, Finding the nearest bus stop may cause an individual to miss the bus, resulting in being late in their schedules.

All commuters want to experience smooth transportation. According to the Headway Commuters, the most essential part of commuting is finding the nearest bus stop and catching the bus. On the other hand, many of them describe their experience in commuting as "horrendous" and " far too complex and confusing" as it takes time to find a bus stop in the middle of nowhere, especially if the commuters are new to the area. To address these challenges, mobile applications with machine learning capabilities will be developed to search the bus stops on the map. This study aims to create a mobile application aimed to facilitate bus stop locations for urban commuters and generate estimates of the users' arrival times at the bus stops.

Background of the Study

The BGCBus is an essential component of the transportation system at Bonifacio Global City (BGC), Philippines, as it provides a cost-effective and commute-friendly mode of transit for residents. ("BGC Bus to Improve Routes for Faster, Shorter Trips," 2017) However, public transit might be difficult, particularly for demand-responsive bus services such as BGCbus, which still need a set bus schedule (Freiberge et. al, 2021).

One of the challenging problems as a commuter is having to wait for a bus to arrive. However, bus stops in BGC are not always well-marked or easy to find. This can lead to confusion as the commuters need to learn the place, and may frustrate them if they get lost finding the location of the Bus Stop that may lead them to miss their bus.

Another area for improvement with the BGCBus system is the limited service frequency and coverage. One of the main concerns for commuters who use public transportation is the unpredictable nature of bus services, particularly the confusion over bus stop locations and arrival times.

The BGCBus system is also not integrated with other transportation modes, such as the MRT and LRT. This makes it difficult for riders to travel to and from BGC using different modes of transportation. For example, riders who live or work outside of BGC may have to take a taxi or ride a ride-hailing app like Angkas or Grab to get to their work or malls inside the city. This can be expensive and time-consuming.

These problems make the BGCBus transportation system difficult and inconvenient for riders, and they can also harm the city's economy. For example, businesses in BGC may find attracting and retaining employees challenging if there is no reliable and efficient public transportation system. Additionally, traffic congestion in BGC may increase if more people choose to drive instead of taking the bus. This mobile application enables the urban commuters to find out the location of the buses which can be viewed on the google map. The application saves the commuter's time to wait for the buses as they can know their current location of the buses updated every moment in the form of latitude and longitude on Google maps.

Objective of the Study

To create an innovative and user-centric mobile application to locate the shortest bus stop routes based on the user's location to the designated route. It also provides predictions of estimated arrival times of the commuters to the nearby bus stop and ETA of the next bus to the bus stop. The aim is to enhance the urban commuting experience by offering commuters information, ultimately contributing to improved public transportation accessibility and convenience.

The specific objective are as follows:

1. Design a mobile application with the following features:
    a. Driver
        i. Verification system
        ii. Share current location.

iii. Estimated time of arrival to the next bus stop.

iv. View the next bus stop based on the assigned route.

b. Passenger

i. Share current location.

ii. View and select bus routes.

iii. View details of the selected bus route.

iv. Focused on the nearest bus stop.

2. Show in the screen where essential information is listed, such as:
   a. Labels (e.g. bus stop, bus' eta to the bus stop, and travel time) based on selected bus route.
   b. Bus stops are marked in maps widget.
3. Deploy a system using programming tools and libraries for front-end, back-end, version control, debugging, and database functionalities as listed below:
   a. Programming languages

i. Flutter Framework

ii. Dart Programming Language

iii. javaScript Programming Language

iv. JSON Framework

b. GPS Tools

i. Geocoding

ii. Mapping

c. API

i. Google Maps API

4. Create a working mobile application using the following developmental tools.
    a. Visual Studio Code
    b. Android Studio
    c. MongoDB
    d. Postman
5. Test and evaluate the system and determine the developed system using the ISO 25010 criteria.
    a. Functional suitability
    b. Performance efficiency
    c. Reliability
    d. Usability
    e. Maintainability
6. Test and evaluate the system and determine the developed system using the ISO 25010 criteria.

Significance of the Study

- Future Researchers - Future researchers can use this study as a reference in making a study about the nearest bus stop.

- Bonifacio Transport Corporation- The local government of Quezon City can use this paper to further enhance the said application.

- Bonifacio Global City - This application can help the city itself to make BGC Buses more

  accessible to the commuters and community.

- Commuters - They can use this mobile application as a way finder for the nearest bus stop and guide for the bus' estimated arrival time.

Scope and Delimitations

This study focuses on developing an android-based mobile application that provides real-time arrival of BGC Bus in certain stations. The application must access the current location of the user and it can determine the nearest bus stop based on his current location. The application needs a stable internet connection for it to run smoothly because of its GPS feature and ETA. It also shows the minutes and distance between the user's current location and the bus stop; this is solely based on the user's normal walking speed. The study's location is only limited to the BGC area and its bus stops. Additionally, the system will not show the places near to their searched bus stop. Lastly, in the driver's module, the passenger's location is not seen by the drivers.

CHAPTER II

CONCEPTUAL FRAMEWORK

Review of Related Literature

Public Transportation

Public transportation, also known as public transit, offers various transport services to the general public and plays a crucial role in modern transportation systems worldwide (Litman, 2024). And, according to Kumari et al. (2010) and Rehrl et al. (2007), a good transportation network is one of every modernized city's initial priorities because today's modern society needs mobility in every aspect of life. Every day, people need to go to work, children need to go to school, and products need to reach the other end of the supply chain. However, because of the continuous population growth in the world, transportation networks are unceasingly congested.

Public Transportation in the Philippines

The Philippines is dependent on bus services to link cities with each other (Boquet, n.d.). Public Utility Bus is the only practical way to ride for people who do not have cars because public jeepneys cannot travel for more than 30 kilometers (Boquet, n.d.). One of the problems faced by commuters is difficulty in traveling. In the survey made by Social Weather Stations in 2021, 72% of working people expressed their dismay because they found commuting extra challenging due to limited public transportation (CNN Philippines Staff, 2021). Additionally, high volumes of private vehicles are one of the reasons for the traffic crisis faced by the Philippines (Jimenez, 2017). With this, the

Department of Transportation introduced a new idea of transportation system, the Point to Point Bus service system.

According to Statista, there were 7,000 public buses in the Philippines last 2021; it significantly decreased compared to previous year. One type of public bus is a point to point bus, which was launched in the Philippines in 2016. It offers commuters shorter travel time, as buses depart on a fixed schedule and travel directly from terminal to the drop-off point (De La Cruz, 2019). From an initial number of 20 units with 3 routes, it increased to 312 point-to-point buses with 35 routes (TDT, 2018). The main objective of this mass of transportation is to lessen the volume of cars in Epifanio De los Santos Avenue by encouraging private vehicle owners to use public vehicles (Lucero, et. al. 2019). In a survey and article made by Lucero, Fillone, and Habana, they found out that not all routes encourage private car owners to use public transportation but most of the current users are satisfied with the services offered by point-to-point buses.

Using public transportation as a mode of travel has advantages to its users and the environment as well (Global Mblty Call, 2022). Using public transportation is cheaper than owning a private car. Some of the public vehicles do not use fuel, instead they use rechargeable batteries which are helpful to the environment. Lastly, some of the public transportation here in the Philippines have special lanes exclusive for them that make the journey easier and faster.

Location-Based Services

Location-based services (LBS) evolved from mobile services. A mobile service is determined by the interaction of the user, the mobile device, and the mobile provider.

Since the value for the users depends on the context (i.e. environmental factors surrounding them), mobile services can be assigned to different context-aware services which are characterized by integrating information about the user‘s environment into the service delivery process (Gummerus and Pihlström 2011). LBSs can also be defined as services that depend on and are enhanced by the positional information of the mobile device (Dhar and Varshney 2011). Since all users' activities take place in time and space, location and time are the essential elements of context for mobile devices. Because, by definition, a mobile device does not remain stationary, location is a key enabler for this new class of services (Aaltonen et al. 2005). The geographic location information can be ‘‘any type of data that places an individual at a particular location at any given point in time, or at a series of locations over time’’ (Cheung 2014).

Bus Stop

In the research conducted by Singla and Bhatia, focusing on GPS-based bus tracking systems, they describe real-time bus tracking systems as independent systems that display bus arrival times on an LCD screen installed on each bus. An RF transceiver mounted on the bus periodically retrieves signals containing GPS coordinates, including the bus's current location. The researchers addressed significant challenges in public transportation and proposed solutions. They integrate GPS technology into their system and consider historical average speeds for each segment to enhance accuracy by including factors such as traffic volume, road crossings, and time of day. According to the study of Sinn et al. (2012), accurate bus arrival time prediction is crucial for developing an intelligent public transportation system. The researcher proposes a non-parametric algorithm based on real-time GPS measurements to address this challenge. The researchers employed a Kernel regression model to capture the complex relationships between bus location updates and arrival times at bus stops. Their findings demonstrate that the proposed algorithm outperforms parametric methods based on Linear Regression Models and prediction methods based on the K-Nearest Neighbor (KNN) Algorithm.

Google Maps

Google Maps were first announced on Google Blog on Feb. 8, 2005, and the map coverage was extended from the USA, UK, and Canada to the entire world on June 20th of the same year. Google Maps, previously referred to as Google Local, is a global online map service, which includes landmarks, path lines, area shapes, vector maps, satellite maps, topographic maps, etc. There have been a great number of Google map-based studies. For instance, an online map application using Google Maps APIs, SQL database, and ASP.NET was created by (Hu and Dai 2013); a travel guide teaching platform was developed using Google Street View by (Yang and Hsu 2016); an online location-based service was developed using Google Maps for Android mobile by (Ibrahim and Mohsen 2014).

GPS (Global Positioning System)

GPS tracking systems have the potential to improve public safety and convenience significantly. For example, Whipple et al. (2009) developed a proof-of-concept system that uses GPS data and Google search services to warn drivers about upcoming school zones and speed limits and to sound an alarm if the driver is speeding in a school zone. The system is designed to help drivers keep their eyes on the road while being aware of their speed and surroundings.

In addition to improving safety, GPS tracking systems can make public transportation more convenient for passengers. For example, Nivaan et al. (2021) proposed a mobile application system to track the location and position of buses using sensors embedded in each bus and GPS. The system has two main features: bus tracking and route planning.

Users of the system can see precisely where buses are and how long it will take them to arrive at their destination. This information can help users make more informed travel decisions and avoid unnecessary delays. Additionally, users can plan their trips and track their bus's progress in real-time. This can help users to minimize travel time and to avoid waiting at bus stops.

GPS tracking systems can also improve the efficiency of public transportation services by providing transportation operators with data on bus location and passenger movement. This data can be used to improve route planning and scheduling.

Other studies have combined GPS tracking with mobile applications to get the bus's exact location and provide recommendations on the nearest bus route (Nagadapally et al., 2015). Other studies have developed intelligent ticket devices that contain dynamic routes according to the bus terminal (Shingare et al., 2016) and analyzed the attractiveness of routes to form an optimal bus route network in suburban areas (Vakulenko et al., 2019). Overall, GPS tracking systems have the potential to improve public safety and convenience significantly. By tracking the location of buses and passengers, these systems can help reduce accidents, improve route planning and scheduling, and make it easier for passengers to get around.

Mobile Application

As mobile use dominates the world in today's generation, it is said to be thanks to the help of mobile applications. A mobile app is a tailored software program created explicitly for utilization on compact, wireless computing devices, such as smartphones and tablets. Unlike desktop or laptop computers, these apps are optimized for the unique capabilities and constraints of mobile devices, providing users with a more seamless and user-friendly experience on the go (Hanna and Wigmore, 2023).

Many people use mobile apps for different things like talking to friends, browsing the internet, managing files, making documents, and for entertainment. These apps are easy to use from anywhere. It's not just individuals who benefit – businesses make money from them too. So, mobile apps don't just affect individuals; they also have a big impact on how businesses operate and on society as a whole (Islam et. al., 2010). Mobile application developers are considering certain aspects and taking them into account to determine the best trends. Prominent software firms like Apple and Google are disrupting the previously stable and established players in the mobile application industry (Holzer & Honduras, 2010).

Flutter

Developers can use Google's Flutter open-source mobile application development framework to create natively compiled, high-performing apps for desktop, web, and mobile platforms. Developers have come to love Flutter because of its quick development cycle, customizable widgets, and hot reload feature. Over 500,000 developers have used Flutter globally, and the number of Flutter users is increasing quickly.

Cross-platform mobile app development is the most important thing in today's world. Developers are often forced to build the same software for different operating systems. (Operating System) or accept a similar low-cost solution that trades speed and accuracy for weight gain. Flutter is an open source SDK for creating advanced and more reliable mobile apps. applications for operating systems such as iOS and Android. Important Flutter features are available at the moment compilation that executes computer code that includes compilation during programming and runtime than in the past. Often, this involves the conversion of bytecode, otherwise known as source code, into machine code, which is done manually. Summary of AOT (Progress compiler) compiles to a high-level programming language such as C or C, or an intermediate language Representation as Java bytecode or .NET Framework CIL (Common Intermediate Language) code, in the machine code that depends on the system so that the next two numbers run the bottom. Flutter has a feature called dynamic deployment that helps you test, create user interfaces, add features and fix bugs. Flash deployment works by inserting source code files into a running Dart virtual machine (VM). Once the VM has updated the class, Flutter framework with new fields and functions automatically rebuilds the widget tree, allowing you to quickly view your unique effects change. Flutter targets the best mobile platforms.

Dart

Dart programming language, developed by Google, across various domains in contemporary software development. The literature review highlights Dart's evolution and distinctive features, positioning it within the broader landscape of programming languages. In software development, Dart is prominently used in web development for dynamic user interfaces and mobile app development through the Flutter framework. It also finds application in server-side programming, leveraging its asynchronous model for scalability, and in IoT and embedded systems due to its lightweight nature. This research aims to provide a nuanced understanding of Dart's versatile role in real-world scenarios, emphasizing its significance in modern software engineering.

Microsoft Visual Studio Code

Visual Studio Code is a full-featured developer editor. It includes numerous development, debugging, and collaboration tools. It includes built-in support for Javascript, typescript, Node.js, and other programming languages (Heller, 2023). Visual studio technology is also used to provide smart code completion for variables, methods, and imported modules. This is also a strong code-focused development environment intended to make writing web, mobile, and cloud applications easier (Del Sole, 2021). Visual Studio Code utilizes a folder-based structure for its coding environment, simplifying the management of code files that aren't integrated into projects and facilitating a seamless workflow across multiple programming languages (Uzayr, 2023).

Android Studio

Android Studio is an integrated development environment (IDE) for android application development (TechTarget, n.d.). It is developed by Google and based on IntelliJ IDEA and specifically programmed for android development. Its features are Git integration, libraries, debugging, app inspection, and manifest file (GeekforGeeks, 2023). It was first released in 2013 in a google I/O conference and the stable version was created in December 14, which is known as version 1.0 (Reidt, 2022).

Postman

Postman is a developmental tool where developers can build, test, and modify APIs. It can perform various HTTP requests making it easier to develop and test an API. It was made by software engineer Abhinav Asthana in 2014 as a side project because he found it difficult to test and develop an API (GeeksforGeeks, 2024). Since then, over 30 million developers use Postman. Additionally, Postman is also easy to navigate because of its simplicity and easy to use interface thus making it simple for the users to test the API's functionality (Digitalcrafts, 2017).

Cloud Computing

Cloud computing is the on-demand access of computing resources — physical servers or virtual servers, data storage, networking capabilities, application development tools, software, AI-powered analytic tools and more — over the internet with pay-per-use pricing (Smalley & Susnjara, 2014). It lets the users access these services without requiring them to have physical servers or data centers. The idea of cloud computing was first introduced in the year 1960s by Dr. Joseph Carl Robnett Licklider in his memo that discussed an intergalactic computer network. In the early 2000s, business for cloud emerged and Amazon Web Services is one of the first companies who offers cloud-based storage. Many companies and individuals use cloud computing in their everyday lives. According to Michalowski (2024), there are an estimated 2.3 billion people who use personal clouds like dropbox, google cloud, and iCloud. Additionally, 60% of some business data is now stored in the cloud. This shows the promising future of cloud computing and how it is significant in today's world.

Amazon Web Services

Amazon Web Services or AWS is a company that offers cloud-based products with pay-as-you-go pricing (AWS Whitepaper, 2024). AWS started to offer web services in 2006 and it continuously expands up to this day. Many individuals and companies avail AWS because of its flexibility and low cost infrastructure; the user only pays for the services he uses and easy access to resources offered by Amazon Web Services.

Database

Database is a collection of data that is specially organized for rapid search and retrieval by a computer (Ellison, et. al. 2023). Databases are managed by Database Management System. It is also described as a collection of multiple software that work together to store, compute, maintain, structure, and deliver the data as part of a product (Knight, 2024). In other words, DBMS is typically used to manage databases. Data are also commonly arranged in rows and columns format that are inside the table to make the query of these data organized and controlled. Different types of databases are used depending on how users use their data. One type of database is Not only Structured Query Language or NoSQL.

NoSQL

Not only Structured Query Language, or NoSQL, is used for non-relational databases as it stores data into non-tabular format that is contrast to relational databases. It emerged in the late 2000s as the cost of storage dramatically decreased and it allowed the developers to store huge amounts of unstructured data, giving them a lot of flexibility (MongoDB, n.d.). NoSQL is also commonly used in mobile applications because it provides low latency data retrieval which is crucial for real-time interaction (Tyler, 2023). Additionally, the scalability of NoSQL is impressive which is ideal for mobile application development.

MongoDB

MongoDB is a document database that stores data in a JSON format called BSON (w3schools, n.d.). It is a NoSQL database solution so it allows the developers to store unstructured data and query different data types. Additionally, MongoDB allows the user to store back-end applications seamlessly because of its secondary and geospatial indexing (IBM, n.d.). With this, MongoDB is ideal for mobile applications.

MongoDB Atlas

MongoDB also has a cloud-based platform called MongoDB Atlas. It is a Database-as-a-Service that provides automatic backups, protection controls, and seamless scalability (GeeksforGeeks, 2023). It also provides an API and users will only pay for the resources they consume. Additionally, users can manage the database through MongoDB Atlas without installing the application into the device because it is fully cloud-platform.

MongoDB Compass

MongoDB Compass is a free interactive tool for optimizing, querying, and analyzing the data in MongoDB (MongoDB, n.d.). MongoDB Compass was used as a data visualization with list and table structures (Khana et al., 2021); it offers an option to visualize the collection through a GUI interface (Hamaji & Nakamoto, n.d.).

JSON

JSON stands for JavaScript Object Notation is a text format for storing and transporting data (w3schools, n.d.). It exchanges data that are both understandable for humans and machines. JSON can be used to exchange data across different programming languages and platforms. It is a popular choice for developers because of its simple and easy-to-use format (Oracle, n.d.).

Node.js

Node.js is an open-source, runtime environment created by Ryan Dahl in 2009 (Agu, 2023). Before inventing Node.js, JavaScript could only run on a browser. In 2008, Google created a web browser called Chrome and it has an engine called V8 that can execute JavaScript. Ryan Dahl used V8's engine to understand and execute JavaScript which results in building Node.js. Since then, Node.js is widely used by big organizations such as Netflix, and PayPal. According to the survey made by Stackoverflow, Node.js is the most common web technology that is used by professional developers and people who learn to code. In a total of 58,743 responders, 25,733 people or 47.12% responded to Node.js.

Google Maps Static API

Google Maps API is a robust tool that can be used to create a custom map, a searchable map, check-in functions, display live data synching with location, plan routes, or create a mashup just to name a few (Helen, 2015). It is made by Google to allow developers to integrate the API to their personal projects. According to Built with, over 17 million websites use google maps API and 5,786 websites in the Philippines use the

API. The development of google maps API was discovered when developers hacked google maps to incorporate it to their own website (Svennberg, 2010).

There are different varieties of google maps API and one of them is google maps static API. It lets developers use google maps images in their web page without requiring JavaScript or any dynamic page loading (Google Developers, n.d.). Developers must insert URL parameters through a standard HTTP request so the API can return it as an image. This returned image can be embedded to the user's webpage.

A-star (A) Algorithm*

The A* algorithm is a combination of heuristic methods such as BFS and methods like the Dijkstra algorithm (Srikanth and Thalmann 2000), which was put forward in 1968. However, the traditional A* algorithm has characteristics of slow search speed and can easily fall into the failed search state when trap obstacles are met in unknown environments (Stentz 1994). The algorithm not only runs fast in the path search process but also has good real-time performance so it is widely used in path planning (Liu et al, 2017).

Machine Learning

A particular type of artificial intelligence (AI) called machine learning (ML) focuses on creating computer systems that can learn from data. Over time, software applications can perform better because of the wide range of techniques that machine learning (ML) incorporates. Algorithms used in machine learning are trained to identify patterns and relationships in data. As seen by recent ML-powered applications like ChatGPT, Dall-E 2, and GitHub Copilot, they apply previously collected data as input to make predictions, classify information, cluster data points, reduce dimensionality, and even help develop new material.

Although machine learning is an effective tool for problem-solving, enhancing company operations, and automating chores, it's a difficult technology that calls for substantial resources and in-depth knowledge. Selecting the appropriate algorithm for a task requires a solid understanding of statistics and mathematics. Large volumes of high-quality data are frequently needed for machine learning algorithm training in order to get correct results. The results themselves can be hard to interpret, especially when they come from complicated algorithms like deep learning neural networks that are designed to resemble the human brain. Furthermore, tuning and running ML models can be expensive.

According to The "2023 AI and Machine Learning Research Report" from Rackspace Technology states that 69% of the companies debated considered AI/ML to be the most important technology, and 72% of firms reported that these technologies are a component of their business and IT plans. Businesses that have used it have stated that they have used it to lower risk (53%), forecast business performance and industry trends (60%), and enhance current procedures (67%).

Haversine Formula

The Haversine formula is important in navigation; it calculates and determines the distance between two points, the latitude and longitude, on a sphere (Nitin et al., 2013). Haversine formula commonly used in real-world cases such as calculating the shortest distance of the map, (e.g.) the flight routes, marine navigation and GPS navigation for the routes for drivers. Haversine formula follows from the terms of haversin (θ) $sin^2\left(\frac{\theta}{2}\right)$.

The central angle between the latitude and longitude on a sphere can be calculated by the formula $\theta = \frac{d}{r}$ where d is the distance between two points of the sphere and r is the radius. To calculate the distance between two points, the haversine formula is

$$d = 2r\, sin^{-1}\left(\sqrt{sin^2\left(\frac{\phi 2-\phi 1}{2}\right) + cos(\phi 1)cos(\phi 2)sin^2\left(\frac{\varphi 2-\varphi 1}{2}\right)}\right)$$

Figure 1. *Haversine Formula*

where

- φ_1, φ_2 are the latitude of point 1 and latitude of point 2,
- λ_1, λ_2 are the longitudes of point 1 and longitude of point 2.

ETA Prediction

Estimated Time of Arrival (ETA) refers to the amount of time taken by a vehicle to reach its destination. It is a transportation concept that refers to the length of time it takes for any vehicle like a bus, ship, helicopter, or emergency service to arrive at its destination (Priya et al. 2021). ETA is commonly used to inform travelers about the remaining time available before a certain mode of transportation reaches a particular destination.

Google Maps ETA

The most basic and important criterion for Google Maps to estimate the time taken to reach a particular destination is based on the route taken to reach the given destination from the source. This is calculated using the A-star (A*) algorithm, which helps in obtaining the shortest route from the starting point to the desired destination. This would be the shortest path recommended by Google Maps without taking into consideration the real-time traffic, which was a major drawback. To overcome this drawback, Google collects continuous data from all cellular devices in that particular way and other routes possible. Manipulating this data, the average speed of any user can be determined and the shortest path can then be decided. A user can find a route by adding a few halts, avoid freeways, avoid bridges, and choose a location according to their desire, despite the shortest path recommended by Google Maps.

Before 2007, Google Maps was only able to calculate the estimated time of arrival (ETA) by taking into consideration the distance between two given points and the average speed of the object or person between the source and destination. The flaw with this was that a very important criterion of traffic was overlooked. Today, Google Maps considers the current traffic condition on the selected route, which often proves to increase the commute time. It provides the user with two ETAs – one is at the average optimal conditions and the other is under current traffic conditions, which helps the user estimate the time required to reach any particular destination. (Kay, 2019).

Geocoding

Geocoding is a powerful tool that can be used to improve the accuracy and efficiency of a variety of applications related to location or geography. Geocoding refers to the procedure of transforming an address or location description into geographical coordinates, specifically latitude and longitude (Ramella, 2019). These coordinates are essential for mapping applications, facilitating the placement of markers on maps and enabling the calculation of distances between different geographical points. According to the *Berkeley Library*, geocoding typically starts with data cleaning, which means preprocessing and standardizing the format of the data that will be geocoded. This is important because it helps to ensure that the geocoder can accurately match the addresses to their corresponding geographic coordinates. It is also a standard feature in commercial Geographic Information Systems (GIS), and boosts spatial capabilities by efficiently processing tasks like batch and reverse geocoding. The accuracy and efficiency of spatial data analysis and display in commercial GIS applications are improved by this integration (Bichler and Balchak, 2007).

Mapping

Mapping services are essential tools for a variety of applications, including navigation, transportation, and location-based services. Google Maps is a popular online mapping platform and consumer application that provides satellite images, aerial images, street maps, 360° interactive Street View, real-time traffic conditions, and route planning for walking, driving, cycling, and flying. (beta) and public transport. Google Maps also provides an API for embedding maps on third-party websites and provides location tracking for businesses and other organizations in a number of countries around the world. Other mapping services include Yahoo Maps, Mapquest, Ask Maps, and Microsoft Windows Live Local. These mapping services offer similar features such as satellite imagery, street maps, and route planning. However, each service has its own unique features and performance.

Mapping services can be used in colorful fields, including transportation, civic planning, and position-grounded services. For illustration, mapping services can be used to dissect business patterns, identify traffic hotspots, and optimize transportation routes in transportation planning. Also, mapping services can be used to dissect land use patterns, identify areas of high population viscosity, and plan for unborn development in civic planning.

Functional Testing

According to Evans et. al. (2006), functional testing focuses on the stability, interoperability, security, accuracy, and compliance of software. Functional testing can be done from two distinct perspectives: requirements-based or business process-based. Requirements-based testing uses a parametric specification of functional testing for software as its basis for system design. Risk criteria are prioritized in requirements-based testing to ensure that the most critical tests are included in the testing process. Requirements-based testing also tries to fulfill the requirements that are set before the development of the system. This checks if it meets the specifications listed in the requirements.

Business-processed-based testing describes the knowledge used in daily business use of the software. This testing checks the use cases for business transactions and applications that the system vowed to do. It usually starts with testing user test cases and then to business processes.

Non-Functional Testing

According to Evans et. al. (2006), non-functional tests how the system works in terms of performance, efficiency, load, stress, and duress. This includes measurements in RAM consumption, CPU utilization, and other parameters. The 49 International Organization for Standardization (ISO) created a parametric test that reflects the software quality in terms of non-functional specifications. This is called ISO 25010.

The specifications under this test that can be considered for the project are:

1. Functional Suitability
2. Performance Efficiency
3. Usability
4. Reliability
5. Maintainability

Review of Related Studies

MongoDB, and MongoDB Atlas

It is very important to consider the reliability of public transportation nowadays, as millions of people use public transportation to travel. Addressing this concern, a study by Lohokare et al. (2017) proposes the development of an application designed to track the real-time location of buses that use MongoDB for storing data and for enabling load balancing, which thereby enhances the reliability of public transportation systems. In the research conducted by Martin Tran in 2019, titled "A Tracking Mobile Application for School Buses," MongoDB, an open-source database, was employed for storing and retrieving the collected data. MongoDB, which ranked fifth among the most popular document-type databases in 2019, offers a distinct architecture characterized by collections and documents, diverging from traditional tabular structures. Tran suggested that MongoDB's unique structure helps keep data organized. He also highlighted MongoDB's ability to store all data in one place, which was important for the project. MongoDB is praised for being lightweight, reliable, and fast, making it a great option for NoSQL database applications (Zhou et al., 2017).

In the study conducted by Mashayamombe et al. (n.d.), MongoDB Atlas was utilized as a data storage solution. The said study found that MongoDB Atlas offers flexibility in managing large volumes of data and boasts robust security features. This makes it an excellent choice for organizing and managing data, particularly advantageous for the proposed study, where developers anticipate dealing with substantial amounts of data.

Estimated Time of Arrival Prediction

According to Padmanabanl et al. (2010), the development of a real-time bus arrival prediction system for Indian traffic conditions was explored. The study focused on using GPS data as the primary resource for predicting bus travel time. The authors conducted their research using data collected on a specific bus route in Jinan, China and analyzed the potential impact factors of bus travel time. They selected a set of input variables and developed two artificial neural network (ANN) models to predict bus arrival times. The study concluded that the hierarchical ANN (HANN) model provided the most accurate predictions for short-distance routes, while the ANN model was more suitable for long-distance routes. The study by Lin and Zeng (1999, pp. 1-2,7-8,13-17) focuses on developing algorithms for predicting bus arrival times using GPS data. The document discusses developing arrival time estimation algorithms, including route representation, GPS data screening, algorithm formulation, and the development of performance measures. It also compares the performance of different algorithms based on criteria such as overall precision, robustness, and stability. The document provides valuable insights and findings that contribute to the study of predicting bus arrival times using GPS data.

Developmental Tools

The developmental tools that will be used in this research are:

- Integrated Development Environment (IDE): Visual Studio Code (VSCode), Android Studio
- Programming Language: Dart, Flutter Framework, JavaScript, JSON Framework, NoSQL
- Database: MongoDB
- API Testing: Postman

Conceptual Model of the Study

Based upon the research findings, related literature, presented studies, and valuable insights, a conceptual model, depicted in Figure 2, was constructed. This model illustrates and elaborates on the essential elements necessary for system development. The components encompass input, processing, output, and evaluation.

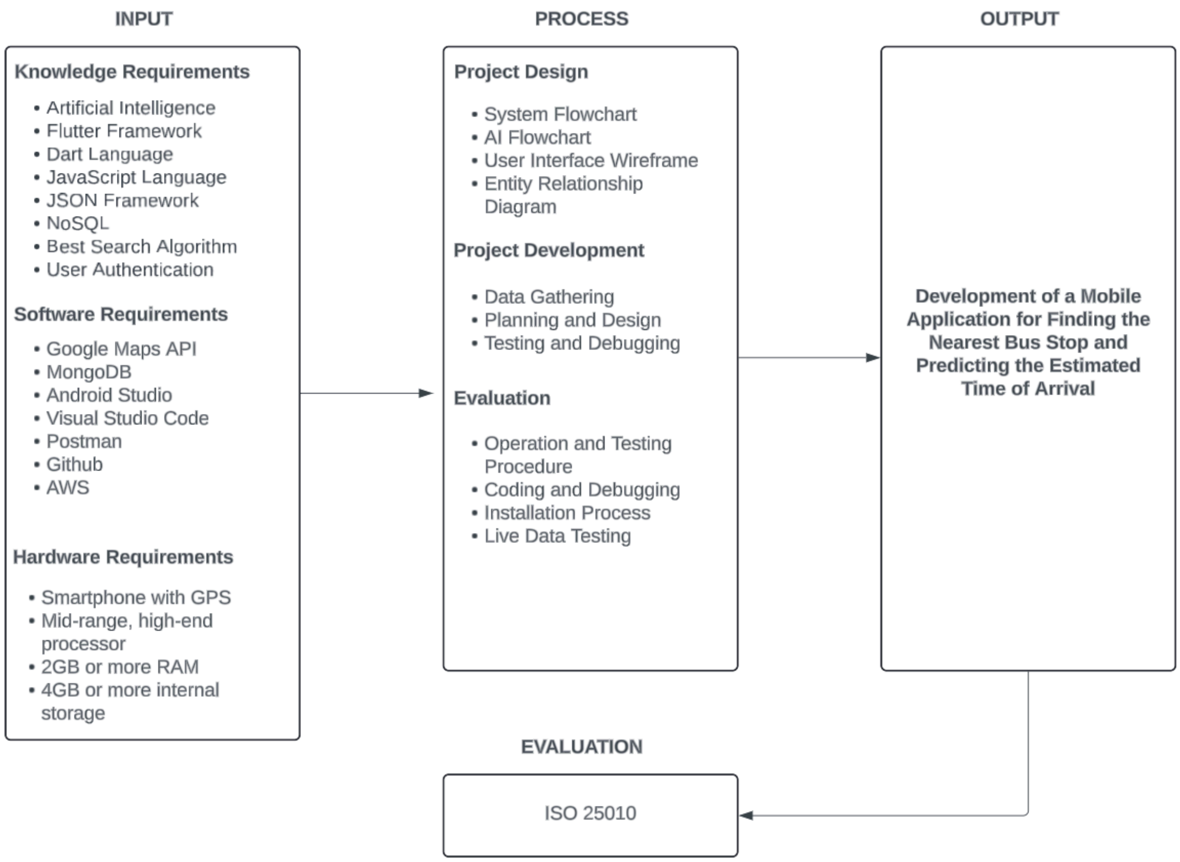


Figure 2. *Conceptual Model of the Study using IPO Model*

Input

In the input block, three different requirements are needed to develop the mobile application. In knowledge requirements, Familiarity with flutter framework, dart programming language, JSON framework, Javascript programming language, and NoSQL is essential in programming the front-end and back-end of the mobile application and the database as well. Also, knowledge in artificial intelligence, user authentication, and best search algorithm is also crucial as it is featured in the application. In software requirements, the following software tools are needed to build the application. This includes the IDE, API tester, and cloud services for the mobile application. Lastly, the hardware requirements are also indicated in the input block which are needed to test and build the entire mobile application. These combined knowledge and resource prerequisites lay the foundation for a comprehensive and effective development process.

Process

The process of developing a mobile application involves several key steps that ensure a systematic and practical approach. The requirement analysis, which involves a crucial phase aimed at comprehending user needs and meticulously defining the application's functionalities. System Development marks the implementation phase, where code is crafted using Dart and Flutter to actualize the envisioned features. Subsequently, the Software Testing phase ensues, dedicated to the identification and resolution of bugs, thereby ensuring the final product attains a high standard of quality. The concluding phase, System Improvement, emphasizes an iterative approach to refining the application based on user feedback and testing results, allowing for continuous enhancement and optimization. This structured process is designed to deliver a robust and user-friendly mobile application.

Output

The output part explains what we expect to achieve with the conceptual framework. The primary production is “Development of Mobile Application for Finding Bus Stops and Predicting Estimated Arrival Time”.

Evaluation

The 8 characteristics of ISO 25010 will be used as criteria if the mobile application is developed accurately.

Operational Definition of Terms

Bus Arrival - refers to when a bus arrives at a particular stop or station. It is the time when passengers can board or alight from the bus.

Tracking - Process of following something to see where it goes or what it does. It involves collecting and analyzing data to gain insights into behavior or patterns.

Location - A location is where a particular point or object exists.

ETA Prediction - ETA stands for estimated time of arrival. An ETA prediction is a forecast of the time it will take for a person or vehicle to reach a destination. ETA predictions are often used in navigation and transportation applications to help users plan their trips and arrive on time.

Bus Route - the route regularly followed by a passenger bus.

Bus Stop - a place on a bus route, usually marked by a sign, at which buses stop for passengers to alight and board.

CHAPTER III

METHODOLOGY

This chapter reveals the methods of research to be employed by the researcher in conducting the study, including the research design, study population, research instrument, and its development, establishing its validity and reliability, data gathering procedures, and the appropriate statistical treatment of data.

Project Design

This project aims to develop a mobile application that helps the commuters to navigate the only transportation available in Bonifacio Global City, the BGC Bus. The application will utilize the GPS of the user by accessing his current location and show a list of bus routes. Once the passenger chooses, the details of the bus routes will be generated by the application and the nearest bus stop will be highlighted and the bus' estimated time of arrival (ETA) to the selected bus route. Additionally, a role for the driver is added to the application and will be given an email address and password to ensure that BGC Bus drivers are the ones who are accessing the driver's role.

The project's success will enhance commuters' travel experiences by offering a convenient and reliable tool for navigating the transportation system. To ensure scalability and sustainability, the project will implement a robust backend infrastructure for seamless data processing and storage. The development process will follow industry best practices, including rigorous testing phases and iterative improvements based on user testing and feedback. This is a comprehensive approach aimed to deliver a reliable, user-friendly, and intelligent mobile application for efficient navigation within public transportation systems.

Architectural Diagram

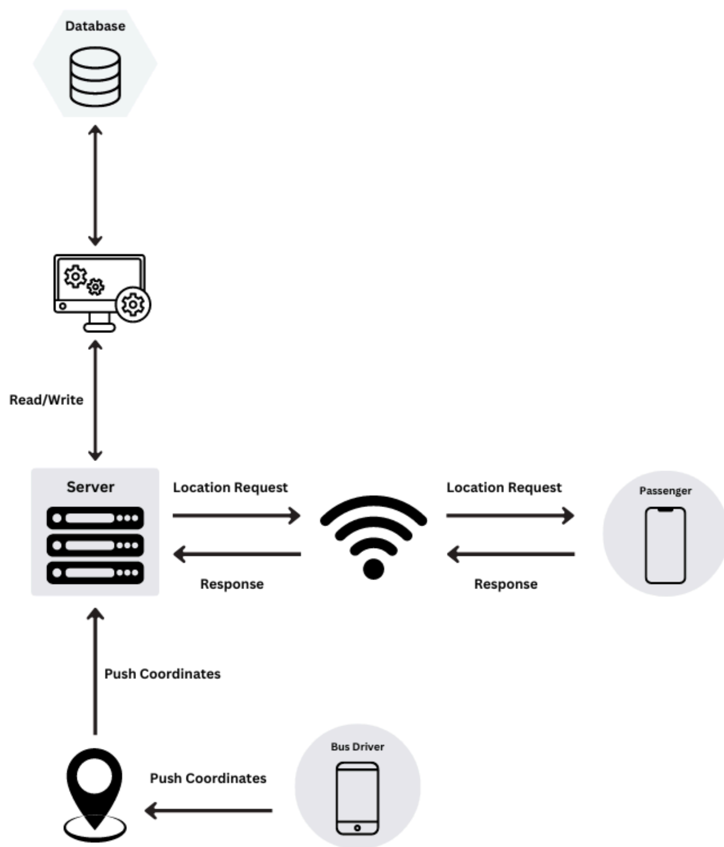


Figure 3. *System Architecture*

This figure represents a client-server system architecture that manages location requests in this system. When passengers initiate location requests, it will be received by a central server that stores and manages location data in a database. The server then fulfills the request by sending a response, which is the location data, back to the passenger's application.

Client - The client-side can be any device that initiates a location request, such as a passenger's smartphone app.

Server - The server is a central computer system that stores and manages data. In this system, the server stores a database of user locations or travel data.

Location Request - The location request represents the data sent from the client to the server. It refers to a request for a location update from the passenger's app.

Response - The response refers to the data or message sent from the server back to the client. It refers to the location data sent by the server to the passenger's app.

Database - The database is a structured collection of data stored on the server. In this system, it stores location data of users or points of interest.

Push Coordinates - This refers to how location data is sent from a passenger's device to the server.

The system works by, first, the passenger will initiate a location request by turning on GPS using their mobile device, then the application location request to the server, after that, the server retrieves relevant location data from the database, and lastly, the server will send the location data (response) back to the passenger's application.

Flowchart Diagram

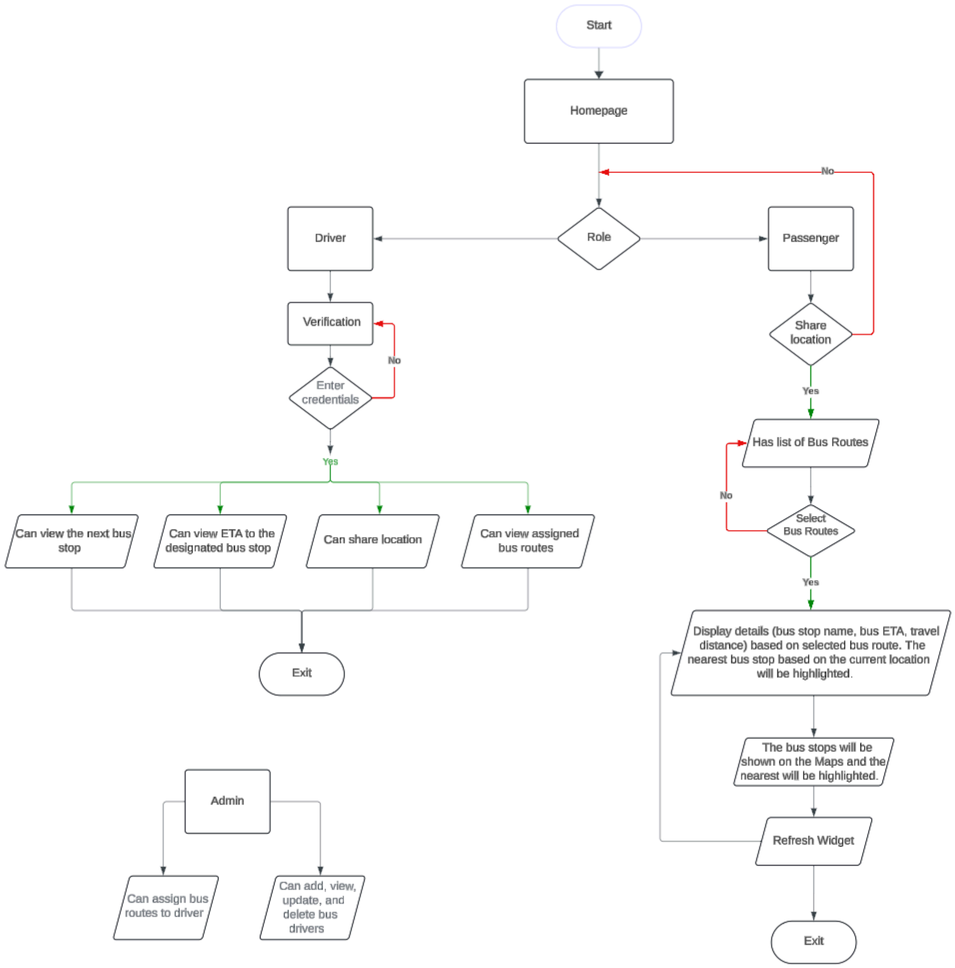


Figure 4. *Program Flowchart of the System*

The system's program flowchart, as depicted in Figure 4, provides a clear and concise representation of the logical sequence and flow of the system. Beginning on the application's homepage, the user will select if his role is driver or passenger. If the user selects driver, he is required to verify by entering valid email address and password made by the admin, once successful, he can access the features that are exclusive to driver's side such as sharing location, viewing assigned bus routes, viewing of ETA to the designated bus stop, viewing of the next bus stop, and editing bus details. Once the driver ends his shift or on his break, he can exit the application. On the other hand, if the user is a passenger, he must share his current location so he can use the application. With permitted location sharing, the application will show a drop-down list of bus routes and the passenger can select a certain bus route. After selecting, the application will display the details such as bus: stop, route, plate number, ETA, and the travel distance. The nearest bus stop widget will show 1 nearest bus stop within the passenger's current location, and will show its ETA walking distance in minutes. Additionally, the selected bus route will also be shown on the maps and the nearest stop will also be highlighted. The widget will be refreshed every 3 minutes to change the positioning, and travel distance of the passenger and the accuracy of bus' ETA as well. The endpoint of the flowchart is marked by the "Exit" symbol, which indicates the termination of the program. In the backend of the application, the admin can assign bus routes to the driver. He can also do the CRUD method into bus drivers through a web page.

Context Level Diagram

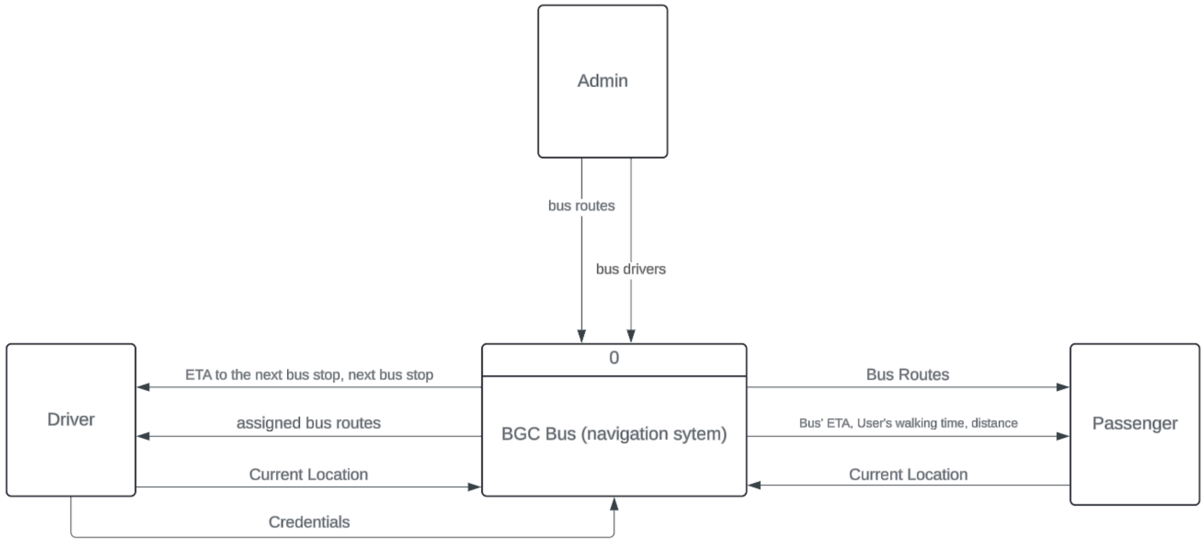


Figure 5.1 *Context Level 0 Diagram*

In Figure 5.1, The context-level diagram illustrates the key features of the BGC App, a mobile application designed to enhance the commuting experience within the Bonifacio Global City area. The application comprises a User Interface with several critical components tailored for both passengers and drivers. For passengers, the BGC App provides real-time Bus ETA and ETA to the nearest bus stop, detailed bus route information, and a shared location option to enhance communication and safety. On the driver's side, the application allows drivers to view their assigned routes, receive ETA updates to the next designated bus stop, edit bus details, and share their location strictly to ensure efficient route management and passenger coordination. Additionally, the admin can view, add, update, and delete necessary information such as bus routes, bus drivers, and bus details. This can be done through an API. The primary system feature is to deliver timely and accurate bus-related information, thereby optimizing the commuting experience within BGC through enhanced connectivity and reliability.

Data Flow Diagram

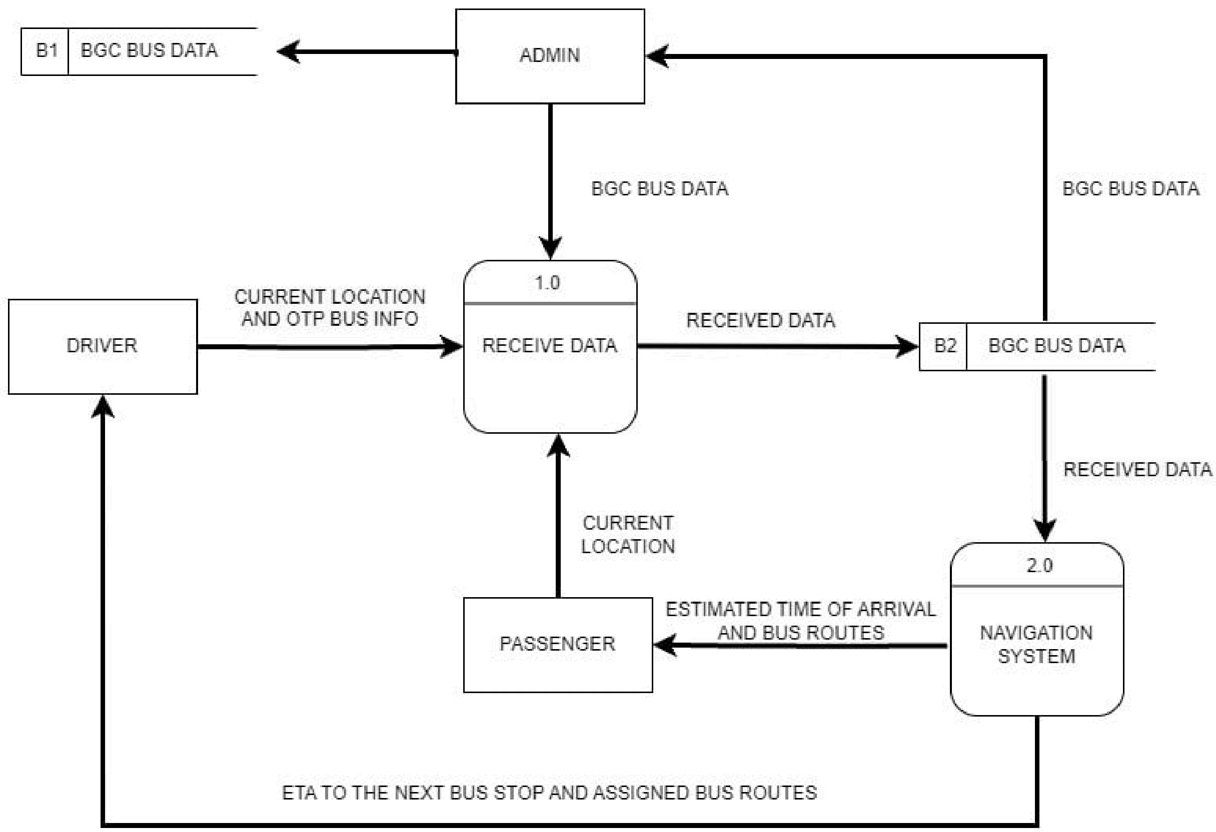


Figure 5.2 *Level 1 Data Flow Diagram*

Figure 5.2 presents the context-level 1 data flow diagram, illustrating the key features of our mobile application and its processes. Primarily, the admin receives all the incoming data, which is first stored in a data repository. This data is then processed by the system to fulfill the needs of passengers, such as providing the estimated time of arrival and bus routes. Simultaneously, the system also calculates and displays the estimated next bus stop and the assigned routes for the driver.

Entity Relationship Diagram

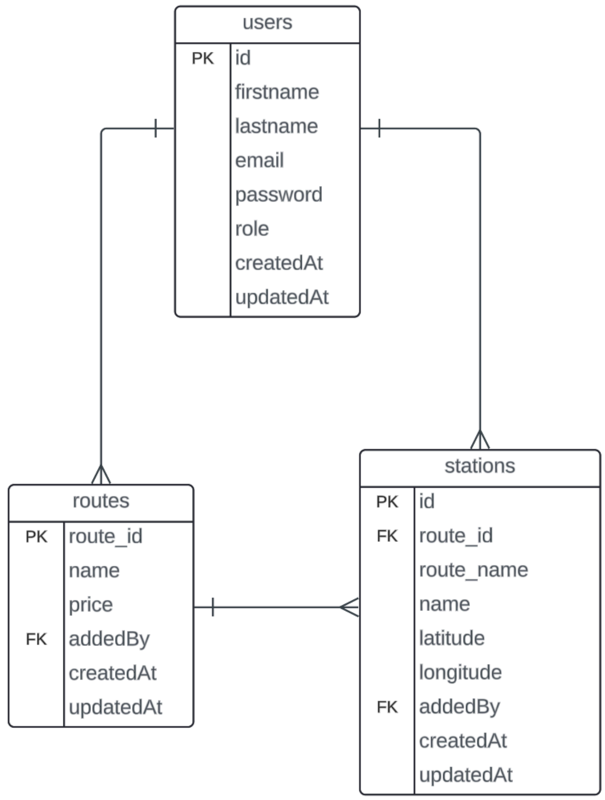


Figure 6. *Entity Relationship Diagram of the System*

The figure above shows the three tables in the database and their fields as well. Additionally, it is also shown which are the Primary Key and the Foreign Key in each table. The cardinality between *users table* and *routes table* is one to many. In the users *table* and *stations table* it is also one to many. Lastly, the *routes table* and *stations table* is also one to many.

Flowchart of Algorithm

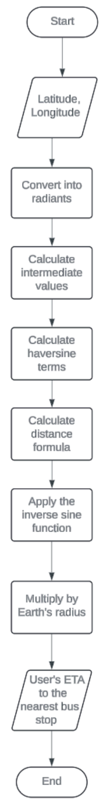
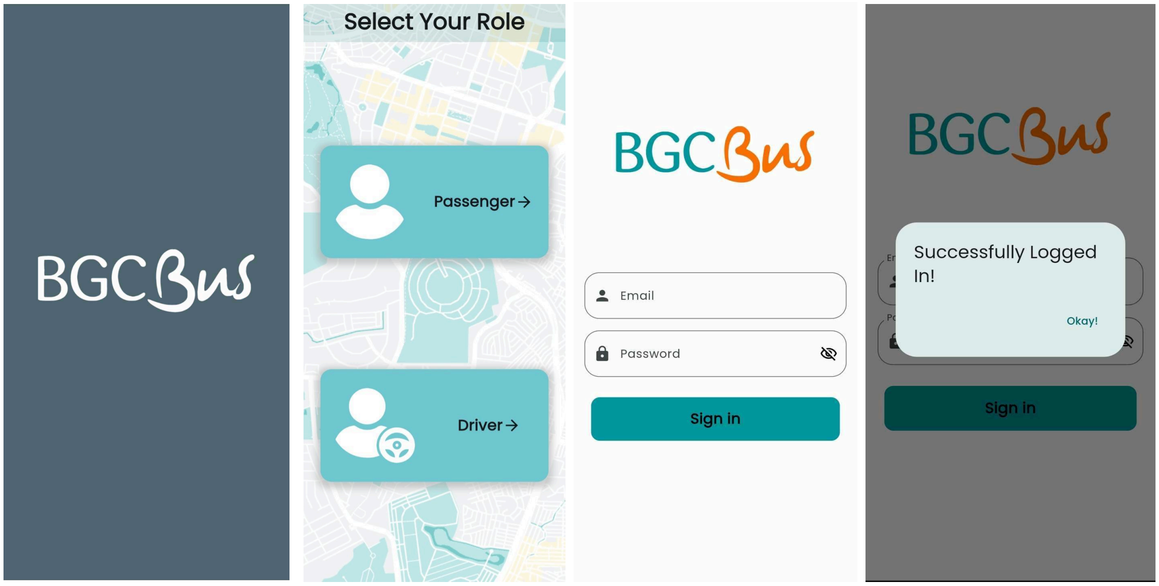
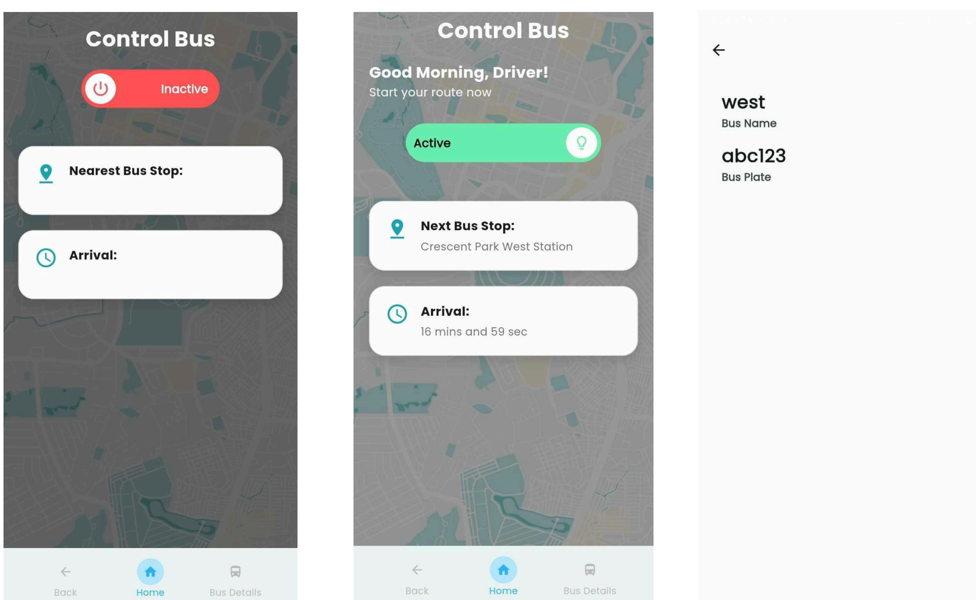


Figure 7. *Algorithm flowchart of Haversine*

Wireframe



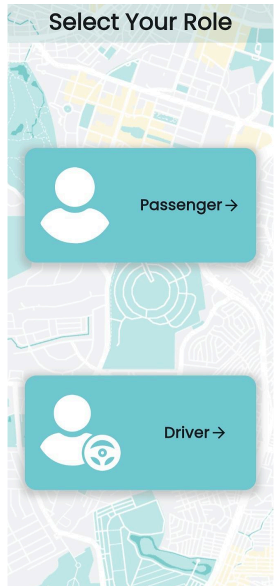
Title Page Home Page Verification Page



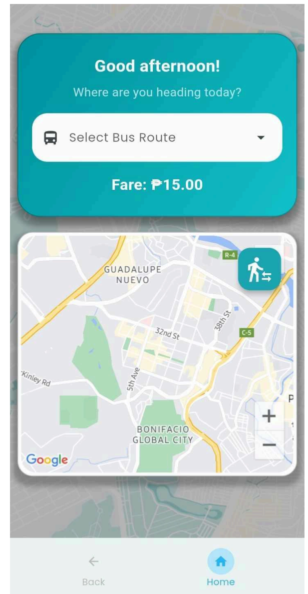
Share location Bus Information

Figure 8.1 *Wireframe (driver page)*

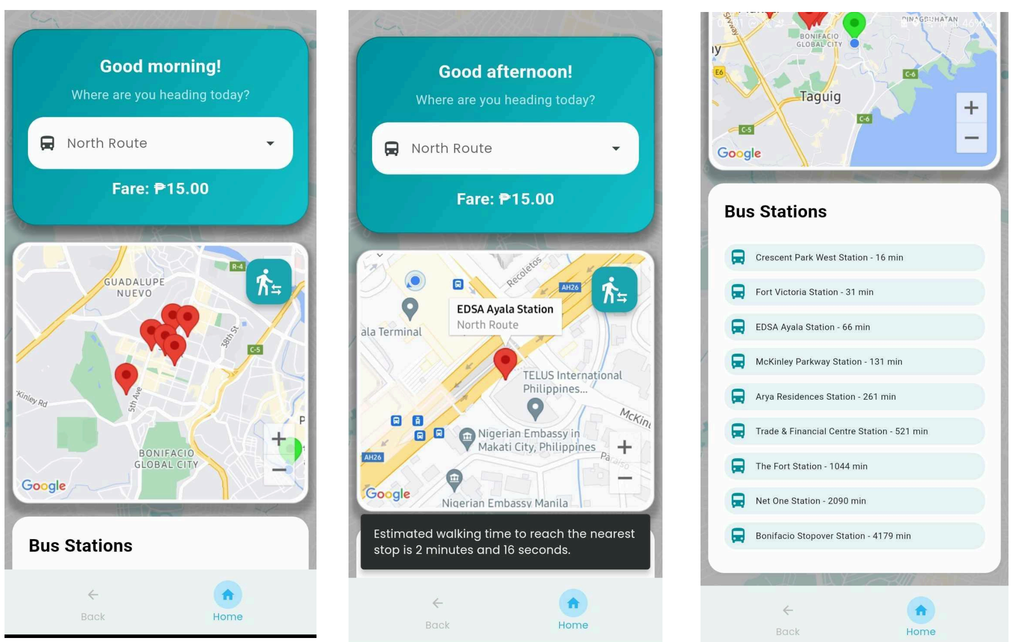
Title Page



Home Page



Landing Page



Page with bus details and ETA

Figure 8.2 *Wireframe (Passenger)*

Project Development

The project development process for the Development of a Mobile Application for Finding the Nearest Bus Stop and Predicting the Estimated Time of Arrival followed the agile software development life cycle. The agile development life cycle is designed to be iterative and adaptive, which is well-suited for projects that involve new technologies and complex requirements.

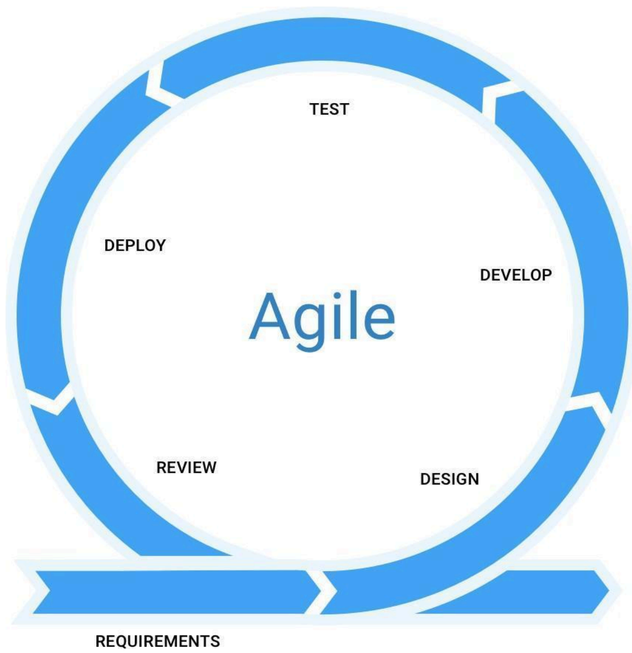


Figure 9. Agile Diagram

Requirements: This phase involves identifying the needs, scope, limitations, and general systemic requirements of the application.

Design: In this phase, the researchers will focus on developing the user interface (UI) of the system. Designing the UI will be the primary objective, aligning it with the study's specifications, such as:

- The ability to view bus routes of BGC buses.

- The ability to choose the bus routes.
- The ability to view bus stop, bus' ETA, and travel distance based on selected bus route.
- The ability to show a passenger's selected route in the maps widget.
- The ability to show the nearest bus stop upon clicking the widget.

Develop: Actual coding takes place in this phase, and the application is produced according to accepted specifications. Researchers are responsible for addressing and fixing potential issues, making this phase pivotal to the entire project.

Test: During this phase, the researchers will rigorously test the programme to ensure the system is free of bugs.

Deploy: Clients gain access to the application for beta testing. Users receive instructions on proper usage and provide initial feedback during this phase.

Review: A comprehensive review is conducted to assess the application's performance. Any concerns or problems are addressed to ensure the project objectives are met.

Pseudocode

Haversine import necessary Dart libraries ('dart:collection' for data structures and 'package:collection/collection.dart for additional collection utilities).

```
import 'package:bgc_bus/models/busRoute.dart';
import 'package:geolocator/geolocator.dart';
import
'package:google_maps_flutter/google_maps_flutt
er.dart';
import '../models/busStop.dart';
class Utils {
  static Future<LatLng> getUserPosition({bool
isTest = false}) async {
  double? lat;
  double? lng;
  if (isTest) {
    lat = 14.550471110714515;
    lng = 121.05142854599926;
```

```
    }
    else {
      await Geolocator.checkPermission();
      await Geolocator.requestPermission();
                    Position?   position   =   await
Geolocator.getCurrentPosition(
          desiredAccuracy: LocationAccuracy.high);
      lat = position.latitude;
      lng = position.longitude;
    }
    return LatLng(lat, lng);
  }
      static   int   getNearestStopIndex(busRoute
selectedRoute, LatLng userPosition) {
    List<busStop> _stops = selectedRoute.stops!;
    Map<int, double> gScore = {};
    Map<int, double> fScore = {};
    Map<int, int?> cameFrom = {};
    Map<int, double> hScore = {};
    for (int i = 0; i < _stops.length; i++) {
      busStop stop = _stops[i];
      gScore[i] = double.infinity;
      fScore[i] = double.infinity;
                                  hScore[i]       =
Geolocator.distanceBetween(userPosition.latitud
e,
                              userPosition.longitude,
stop.location.latitude, stop.location.longitude);
    }
    int? current = null;
    gScore[0] = 0;
    fScore[0] = hScore[0]!;
    while (current != null) {
      int? minIndex;
      double minFScore = double.infinity;
      for (int i = 0; i < _stops.length; i++) {
        if (fScore[i]! < minFScore) {
          minFScore = fScore[i]!;
          minIndex = i;
        }
      }
      current = minIndex;
      fScore[current!] = double.infinity;
      for (int i = 0; i < _stops.length; i++) {
        if (current == i) continue;
          double tentativeGScore = gScore[current]!
+

Geolocator.distanceBetween(_stops[current].loca
tion.latitude,
                _stops[current].location.longitude,
                _stops[i].location.latitude,
                _stops[i].location.longitude);
        if (tentativeGScore < gScore[i]!) {
          cameFrom[i] = current;
          gScore[i] = tentativeGScore;
```

```
        fScore[i] = gScore[i]! + hScore[i]!;
      }
    }
  }
  final Map<int, double> scores = {};
  var stops = selectedRoute.stops;
  for (int i = 0; i < stops!.length; i++) {
    var stop = stops[i];
    double distance = Geolocator.distanceBetween(
      userPosition.latitude,
      userPosition.longitude,
      stop.location.latitude,
      stop.location.longitude
    );
    scores[i] = distance;
  }
  var sortedScores = Map.fromEntries(
      scores.entries.toList()..sort((e1, e2) => e1.value.compareTo(e2.value)));
  return sortedScores.keys.first;
 }
}
```

The class called ‘Utils’ is to determine the user's current location and finding the nearest bus stop on a specified route. It uses the ‘Geolocator’ package for geolocation services and ‘google_maps_flutter’ for mapping functionalities. The ‘getUserPosition’ method returns the user's position as a ‘LatLng’ object, either using real-time data or a preset location for testing. The ‘getNearestStopIndex’ method identifies the closest bus stop using an A* search algorithm, which calculates distances and scores to find the optimal path. This method initializes various maps to track scores and estimates, updating them iteratively to find the shortest path. Finally, it simplifies the process by directly calculating and sorting the distances from the user's position to each bus stop.

Operation and Testing Procedure

The system needs to be free of any glitches or issues that could impact the user's experience or potentially cause the software to malfunction. Software testing was carried out to eliminate any instances that could negatively affect both user experience and the software's functionality.

1. The mobile application system should have internet access and the GPS location should be turned on.
2. On the *landing page*, the user must select if he is a driver or a passenger.
3. For drivers, a verification must be done to ensure if the user is an accredited driver at BGC Bus.
4. Once authenticated, a *homepage intended for drivers* will be accessed—where features will only be available to drivers such as: ETA to the next bus stop, next bus stop and bus details.
5. For passengers, the screen will be redirected to the *homepage* where he can view the lists of the bus routes.
6. Once the passenger chooses a route, the details such as: bus stop, ETA of bus, and travel distance will be shown. Whereas, it is shown in the maps widget as well.
7. The nearest bus stop widget once clicked, will suggest 1 nearest bus stop based on the passenger's current location and its ETA heading to the stop.
8. After using the application, the user can terminate the application.

The system will be tested using the test procedure shown in Appendix A which consists of different test cases that are needed to be taken for every process module and the expected output. The desired output from every function will be compared to the actual output to see the difference between the two.

Evaluation Procedure

The success of the machine learning-based mobile application for finding the nearest bus stop and predicting ETA can be evaluated by various stakeholders, including projected end-users, experts, and bus operators. The ISO 25010 software quality metrics will be used as a basis to determine the system quality. The research will conduct a survey that consists of Information Technology/Computer Science students, Information Technology/Computer Science professionals, and BGC bus drivers and operators. The respondents must be knowledgeable in their respective fields. The appendix C will be used as an evaluation questionnaire that can be used as a guide to rate the overall quality of the mobile application.

The following are some of the evaluation criteria that can be used:

- Accuracy of ETA Predictions: The accuracy of the ETA predictions is a critical factor in evaluating the success of the application. The application should be able to provide accurate ETA predictions based on real-time data on bus routes, stops, and traffic conditions.
- Ease of Use: The application should be user-friendly and easy to use. The interface should be intuitive, and the application should provide clear and concise information on the nearest bus stop and ETA predictions.
- Reliability: The application should be reliable and provide real-time updates on the ETA of the bus and travel distance of the passenger.
- Scalability: The application should be scalable and able to handle a large number of users. The application should be able to handle peak usage times, such as rush hour, without any performance issues.

- Feedback from End-Users: The feedback from end-users is essential in evaluating the success of the application. The application should collect feedback from end-users on the accuracy of the ETA predictions, ease of use, and reliability.
- Feedback from Experts: Experts in the field of machine learning and public transportation can provide valuable feedback on the accuracy and effectiveness of the machine learning algorithms used in the application.
- Feedback from Bus Operators: Bus operators can provide feedback on the effectiveness of the application in improving the efficiency of bus routes and reducing delays.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter contains the project description, project structure, project capabilities and limitations, test results, and project evaluation. It also includes the results and discussion of the study.

Project Description

The study developed a mobile application called "BGC Bus," which provides commuters with the Nearest Bus Stop based on their current location. The application is believed to benefit commuters to easily find the Nearest Bus Stop as they travel, enhancing their travel experiences by offering convenience and a reliable navigation tool. Access to the internet is necessary for the application to work. It was developed using Flutter as its Framework, and Dart programming language, and for GPS tools, it uses Geocoding and Mapping. The application will use Google Maps API to provide the maps widget and bus ETA.

Before starting the application, it will ask for the user's permission to access The BGC Bus mobile application which has two different modules based on the user's chosen role. Its modules are the *passenger module and the driver module*. The *passenger module* is accessible to any users without requiring them to create or verify their account. The *passenger module* has three features. First, the passenger can select a route in the dropdown option. The second feature is the maps widget where the markers of bus stops are shown and the user's current location. Lastly, it shows the ETA of the user and the bus at the nearest bus stop. On the other hand, the *driver module* has a verification system wherein the driver must input their credentials given by the admin so they can access the said module. Once the system verifies the credentials, the driver can access the features that are available to the drivers. With this application, it was believed to deliver a smooth and reliable guide that will be an efficient guide for navigation for commuters in BGC.

Project Structure

Role page

This page will serve as the starting point for the users, it allows them to select either passenger or driver roles.

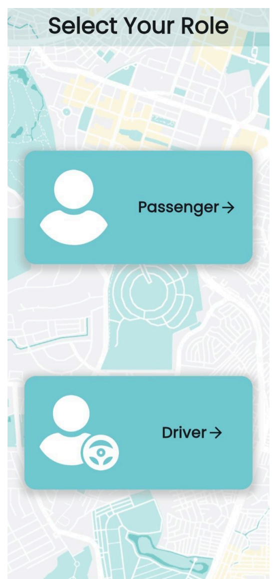


Figure 10. *BGC Bus Home Screen*

Passenger Module

In this section of the system, once a user selects the passenger role, the user will be granted access to choose bus routes and determine the estimated times of arrival (ETAs) for each incoming bus to the bus stop, as well as the nearest bus stop locator based on the user's location.

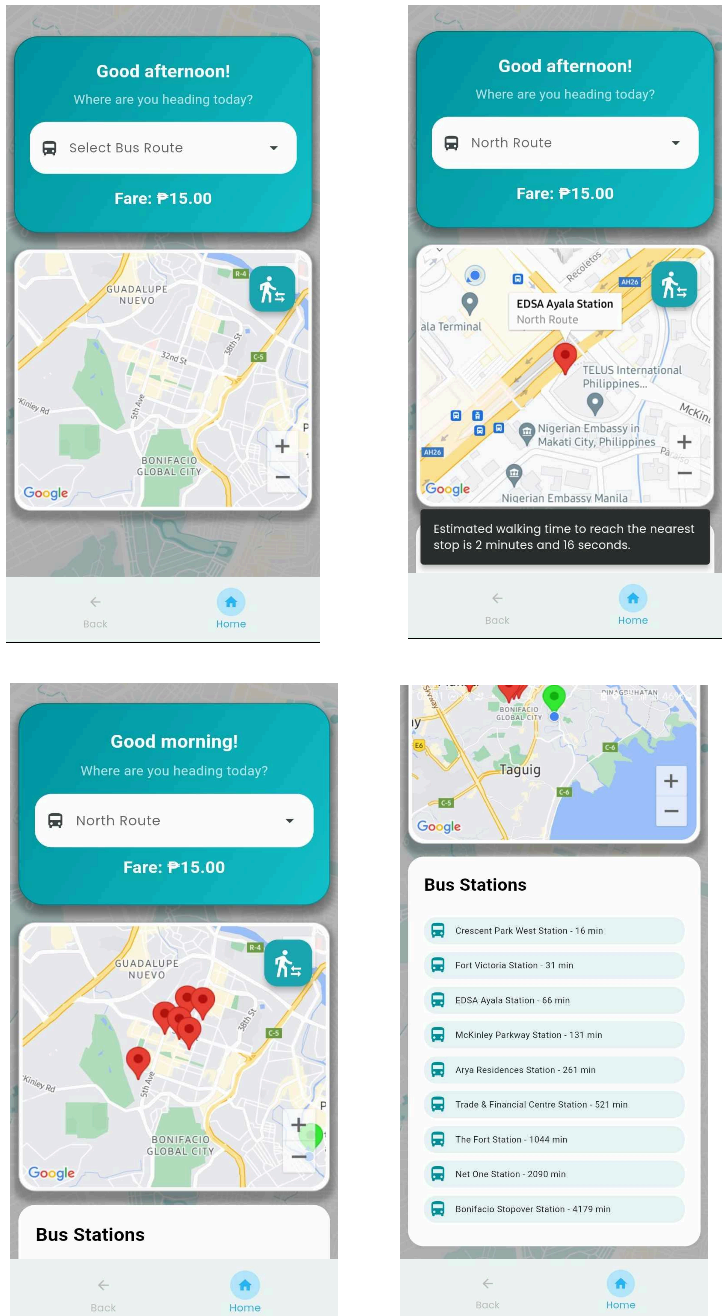


Figure 11. *Passenger Module*

Driver Module

This section of the system displays the driver's login details.

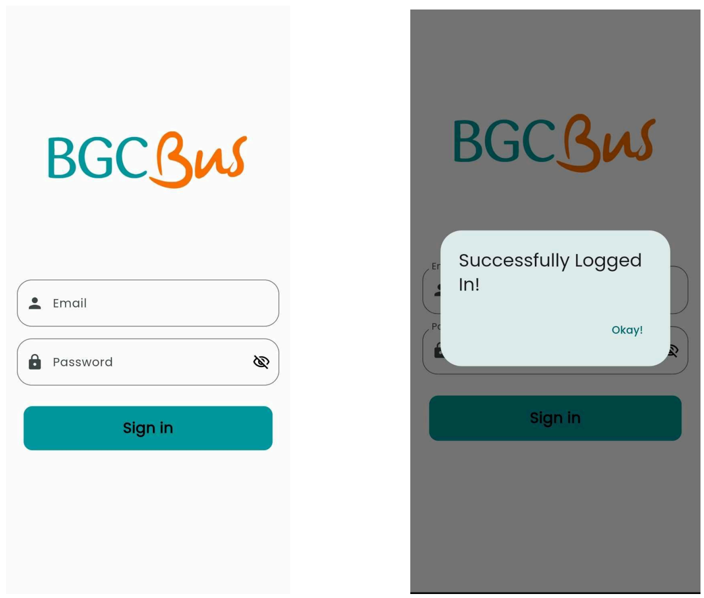


Figure 12. *Driver Module*

Driver Module Verified

In this final section of the system, once the driver has verified their login credentials, they will automatically be logged in to their designated route. After that, the driver will now have access to activate their location, which will be visible to passengers once the route begins.

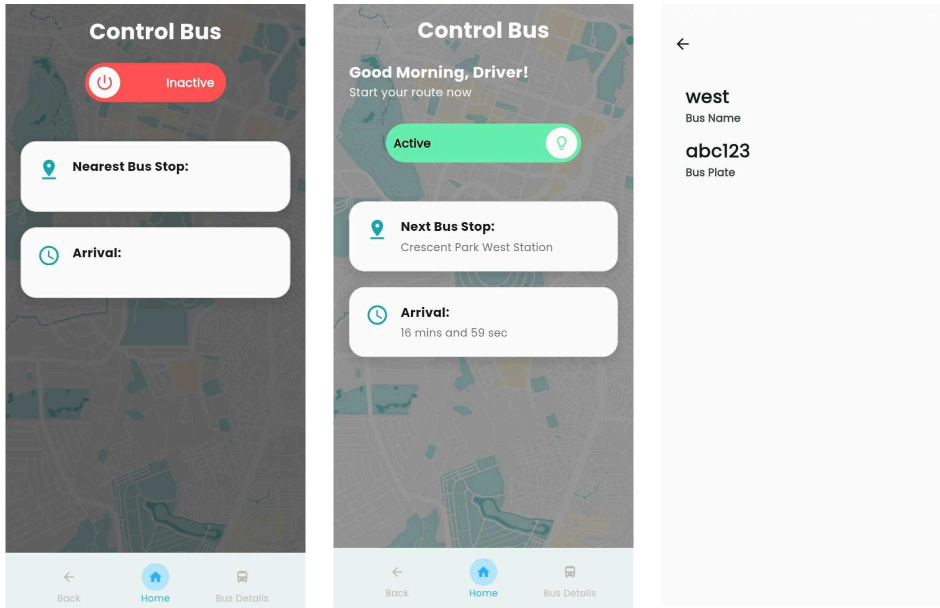


Figure 13. *Driver Module Verified*

Project Capabilities and Limitations

The following are the capabilities of the system:

Passenger Module

1. Display lists of bus routes.
2. Show markers on the map widget of bus stops based on the selected route.
3. Show the user's current location on the map widget.
4. Shows the user's estimated time of arrival to the nearest bus stop.
5. Show the bus' estimated time of arrival at the bus station.

Driver Module

1. Verify credentials given by the admin.
2. Share current location.
3. Show assigned bus routes.

4. Show the next bus stop.
5. Show the estimated time of arrival at the next bus stop.

Passenger Module

The following are the limitations of the system:

1. The system is limited to Android devices
2. The system is limited to ‘walking’ as the mode of travel, with the estimated travel time calculated using an average walking speed of 1.4 meters per second.
3. The system is limited to selecting a passenger’s desired route from a predefined list in a dropdown menu and does not recommend a bus stop based on the passenger’s current and desired location.
4. The system is limited to places that are nearby within the current location at each bus stop are not shown.
5. The system is limited to showing bus details such as (plate number, bus driver name, and etc.) to the passengers.

Driver Module

The following are the limitations of the system:

1. The system is limited to Android devices
2. The map feature is currently restricted to passenger use only, and passenger locations are not visible on the driver’s map.
3. The map is currently limited to passengers only, and passengers are not visible on the driver's map.

Test Results

The tables below show the steps done during the test procedure and the actual result. The actual results are compared to the expected results found in Appendix A.

Steps Undertaken	Actual Result
1. Tap "driver" on homepage 2. Input email address and password. 3.Display the 'active' and 'inactive' driving mode GPS locator	1. Redirected to the Driver Module 2. Driver successfully logged in the credentials provided by the admin 3. GPS can be turned off and on depending if the driver is in driving mode

Table 1. *Driver Profile Module Test Result*

The table shows that the driver profile module can log in to an account. The expected results for the driver should be aligned with the actual results.

Steps Undertaken	Actual Result
1. Tap “passenger” on homepage 2. Click on the dropdown list and select your desired bus route 3. Click the nearest bus stop widget on the upper right side 4. Check the estimated time of arrival of bus	1. Redirected to the passenger module 2. Successfully choose a desired bus route 3. ETA of the passenger into the nearest bus stop in terms of walking will show 4. ETA of bus will show

Table 2. *Passenger Profile Module Test Result*

Project Evaluation

A total of 48 respondents evaluated the system. Respondents were composed of 10 drivers of BGCBus, 5 CS/IT Professionals, and 32 passengers of BGC Bus. The system was evaluated according to the respondent's answers from sets of questions based on its functionality, performance efficiency, usability, reliability, and ISO 25010.

	Mean	Interpretation
Functional Completeness	3.62	Highly Acceptable
Functional Correctness	3.60	Highly Acceptable
Functional Appropriateness	3.52	Highly Acceptable

Table 3. *Responses to Functional Suitability*

The table evaluates the system's functional suitability based on responses from 48 participants, including BGCBus drivers, CS/IT professionals, and passengers. The system was rated on functional completeness, correctness, and appropriateness, with mean scores of 3.62, 3.60, and 3.52, respectively. All aspects were interpreted as "Highly Acceptable," indicating that respondents find the system comprehensive, accurate, and well-suited for its intended tasks. Overall, the system received a positive evaluation for its functional suitability.

	Mean	**Interpretation**
Resource Utilization	3.25	Highly Acceptable
Capacity	3.37	Highly Acceptable

Table 4. *Responses to Performance Efficiency*

The table evaluates the system's performance efficiency based on responses from the participants. Two aspects were measured: resource utilization and capacity. Resource utilization received a mean score of 3.25, and capacity received a mean score of 3.37. Both scores are interpreted as "Highly Acceptable," indicating that respondents find the system efficient in its use of resources and capable of handling the required load effectively. Overall, the system is perceived as performing efficiently according to these metrics.

	Mean	**Interpretation**
Learnability	3.47	Highly Acceptable
Operability	3.41	Highly Acceptable

Table 5. *Responses to Usability*

The system's usability was evaluated based on learning and operability. The mean score for learnability was 3.47, interpreted as "Highly Acceptable," indicating that users find the system easy to learn and quickly become proficient in its use. The operability aspect received a mean score of 3.41, also interpreted as "Highly Acceptable," suggesting that the system is user-friendly and allows for efficient and effective user operation. Overall, the system's usability is highly acceptable, facilitating a positive user experience.

	Mean	**Interpretation**
Availability	3.5	Highly Acceptable
Fault Tolerance	3.31	Highly Acceptable

Table 6. *Responses to Reliability*

Reliability was assessed through the system's availability and fault tolerance. Availability received a mean score of 3.50, interpreted as "Highly Acceptable," showing that the system is consistently available and dependable for users. Fault tolerance had a mean score of 3.31, also "Highly Acceptable," indicating that the system can handle errors gracefully and continue to operate without significant issues. This high level of reliability ensures that users can trust the system to function correctly and continuously.

	Mean	**Interpretation**
Reusability	3.52	Highly Acceptable
Modifiability	3.27	Highly Acceptable
Testability	3.18	Highly Acceptable

Table 7. *Responses to Maintainability*

The system's maintainability was evaluated based on reusability, modifiability, and testability. Reusability scored 3.52, interpreted as "Highly Acceptable," indicating that system components can be reused effectively, enhancing efficiency in development and updates. Modifiability received a mean score of 3.27, also "Highly Acceptable," suggesting that the system can be easily modified to accommodate changes or improvements. Testability had a mean score of 3.18, "Highly Acceptable," reflecting that the system can be tested thoroughly to ensure its proper functionality. The system is highly maintainable, allowing for ongoing improvements and adaptability.

	Mean	**Interpretation**
Functional Suitability	3.58	Highly Acceptable
Performance Efficiency	3.31	Highly Acceptable
Usability	3.44	Highly Acceptable
Reliability	3.40	Highly Acceptable
Maintainability	3.23	Highly Acceptable

Table 8. *Overall Summary of Responses*

The overall summary of responses shows that the system is rated as "Highly Acceptable" across all categories: functional suitability (3.58), performance efficiency (3.31), usability (3.44), reliability (3.40), and maintainability (3.23). These ratings indicate a well-rounded and robust system that meets users' needs in terms of functionality, performance, ease of use, reliability, and maintenance.

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

This chapter recaps and concludes the results of the research from previous chapters. Included in this chapter is the summary of findings, final conclusions, and further recommendations for people who may want to pursue related studies to the study.

Summary of Findings

Based on the results of testing and evaluation of the project, the application achieved the goal of developing a Mobile Application for Finding the Nearest Bus Stop and Predicting the Estimated Time of Arrival. Testing and Evaluation shows and confirms that the mobile application was able to show the estimated time of arrival of the bus to the bus stop as well as the passenger's ETA to the bus stop. This accomplishment highlights the positive impact of having a mobile application that helps commuters from BGC to have an efficient and hassle free rides around the area, especially individuals who are not yet familiar with the transportation system and the bus stop in BGC. The project received a positive response from the users but there is still room for improvements. The feedback and insights of the users will be used to enhance the system.

Conclusions

The study successfully achieved its objective of creating an innovative and user-centric mobile application designed to enhance the urban commuting experience. The application allows users to locate the shortest bus stop routes based on their current location and provides predictions for the estimated arrival times (ETA) of both passengers to the nearby bus stop and the next bus to the bus stop. By meeting the following specific objectives, the project has contributed significantly to improving public transportation accessibility and convenience:

1. Mobile Application Design Features:
    a. For Drivers:

        i. Verification system

        ii. Share current location.

        iii. Estimated time of arrival to the next bus stop.

        iv. Viewing the next bus stop based on the assigned route

    b. For Passengers:

        i. Sharing of current location.

        ii. Viewing and selecting bus routes.

        iii. Viewing of details of the selected bus route.

        iv. Focused on the nearest bus stop.

    Essential information such as bus stops, bus ETA to the bus stop, and travel time are clearly displayed on the screen. Bus stops are marked on a map widget for easy visualization.

2. Show in the screen where essential information is listed, such as:
    a. Labels (e.g. bus stop, bus' eta to the bus stop, and travel time) based on selected bus route.

    b. Bus stops are marked in maps widget.

3. Deploy a system using programming tools and libraries for front-end, back-end, version control, debugging, and database functionalities as listed below:
    a. Programming languages
        i. Flutter Framework
        ii. Dart Programming Language
        iii. JavaScript Programming Language
        iv. JSON Framework
    b. GPS Tools
        i. Geocoding
        ii. Mapping
    c. API
        i. Google Maps API
4. The application 'BGC Bus' was successfully developed using the following tools
    a. Visual Studio Code
    b. Android Studio
    c. MongoDB
    d. Postman
5. The application was evaluated successfully based on ISO/IEC 25010 in terms of:

a. Functional suitability

b. Performance efficiency

c. Reliability

d. Usability

e. Maintainability

6. Test and evaluate the system and determine the developed system using the ISO 25010 criteria.

Recommendations

This mobile application aims to help the commuters of BGC and the drivers to ease their experience when riding BGC buses by providing machine learning tools that give accurate results. Based on researcher's experience while developing the application, the following are their suggestions and recommendations:

1. **Future Developers -** It would be beneficial to include additional features, such as allowing passengers to search for their destination within the BGC area. It is also advisable to develop a separate admin application that enables the admin to manage information related to the BGC bus without relying on Postman. Furthermore, a polyline should be incorporated to assist users in navigating to the nearest bus stop.
2. **BGC Bus Administrators** - This study can be helpful for the administrators of BGC Bus, particularly concerning the continuation of their mobile application. Ensuring that the application features catering to passengers and drivers are fully operational will significantly enhance the accessibility and convenience of the

BGCBus experience. Therefore, implementing these enhancements is essential for improving user experience and minimizing operational complexities.

3. **Future Researchers** - This study serves as a comprehensive reference for future researchers interested in conducting studies related to the BGC Bus. This study includes algorithms and technologies that are related to Estimated Time of Arrival and finding the Nearest Bus Stop, that will help the future researchers to further explore and enhance the functionalities.

APPENDIX A

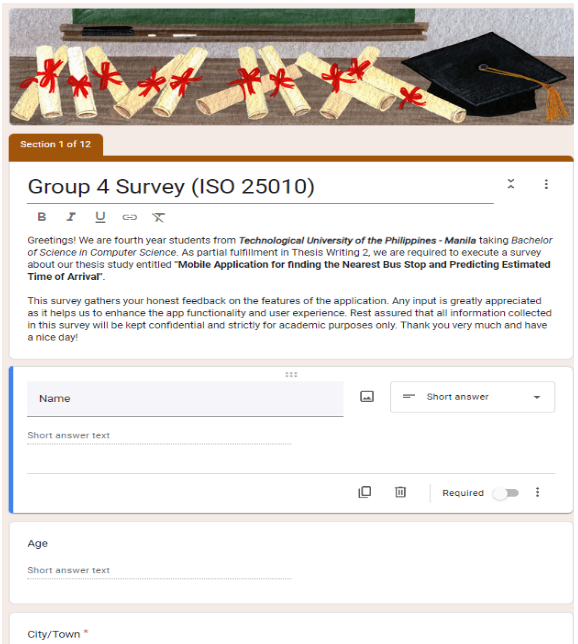
Testing Procedure

Module	Steps to be taken	Expected Results
Homepage	1. Display the driver and passenger profile 2. Choose between the "Driver Profile" and the "Passenger Profile".	1. The homepage displays clear buttons labeled as "passenger" and "driver". 2. Tapping on "driver" redirects you to the driver section. 3. Tapping on "passenger" redirects you to the passenger section.
Driver Profile Module	1. Tap "driver" on the homepage. 2. Input email address and password. 3.Display the assigned bus route, bus stop name, ETA to the next bus stop.	1. The "driver profile" section should be easily accessible from the homepage. 2. Successfully logged in. 3. Drivers will be redirected to the page displaying the ETA calculated, assigned bus route, and next bus stop. 4. Location should be shared without errors. 5. The assigned route info will be displayed.
Passenger Profile Module	1. Navigate to the homepage of the mobile application. 2. Locate and click "passenger" on the homepage. 3. Display "share location".	1. The "passenger profile" section should be easily accessible from the homepage. 2. Passengers should be allowed to share their current location. 3. Passengers should be

	4. Display the bus list.	able to see bus routes from the list.
Destination Selection	1. Choose a route from the bus list. 2. Display the details of the selected route. 3. Display the bus stops on the maps.	1. Passengers should be able to view a list of bus routes. 2. The passenger should display the bus stop, bus' ETA, and the travel distance. 3. The passenger should be able to see the bus stops on the maps 4. The nearest bus stop on the current location should be highlighted.

APPENDIX B

Survey Questionnaire Form


Section 1 of 12

Group 4 Survey (ISO 25010)

Greetings! We are fourth year students from ***Technological University of the Philippines - Manila*** taking *Bachelor of Science in Computer Science*. As partial fulfillment in Thesis Writing 2, we are required to execute a survey about our thesis study entitled **"Mobile Application for finding the Nearest Bus Stop and Predicting Estimated Time of Arrival"**.

This survey gathers your honest feedback on the features of the application. Any input is greatly appreciated as it helps us to enhance the app functionality and user experience. Rest assured that all information collected in this survey will be kept confidential and strictly for academic purposes only. Thank you very much and have a nice day!

Name

Short answer

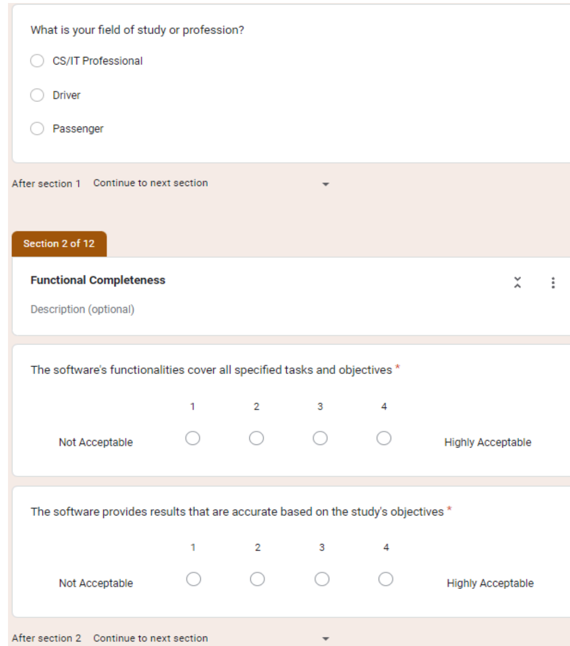
Short answer text

Required

Age

Short answer text

City/Town *


What is your field of study or profession?

- CS/IT Professional
- Driver
- Passenger

After section 1 Continue to next section

Section 2 of 12

Functional Completeness

Description (optional)

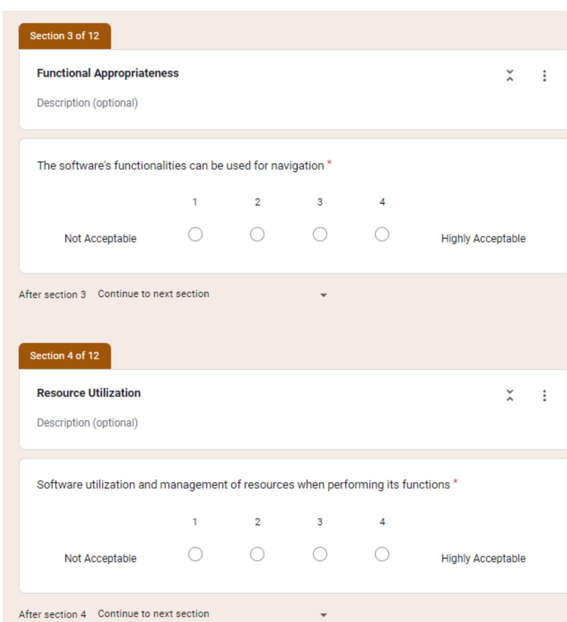
The software's functionalities cover all specified tasks and objectives *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

The software provides results that are accurate based on the study's objectives *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 2 Continue to next section


Section 3 of 12

Functional Appropriateness

Description (optional)

The software's functionalities can be used for navigation *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 3 Continue to next section

Section 4 of 12

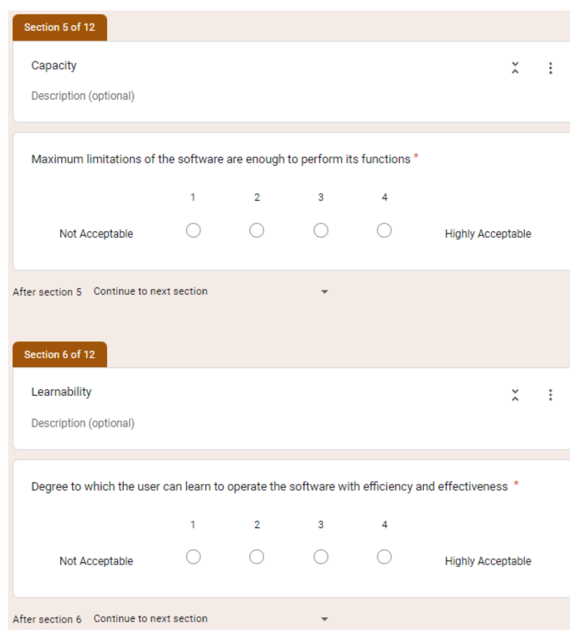
Resource Utilization

Description (optional)

Software utilization and management of resources when performing its functions *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 4 Continue to next section


Section 5 of 12

Capacity

Description (optional)

Maximum limitations of the software are enough to perform its functions *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 5 Continue to next section

Section 6 of 12

Learnability

Description (optional)

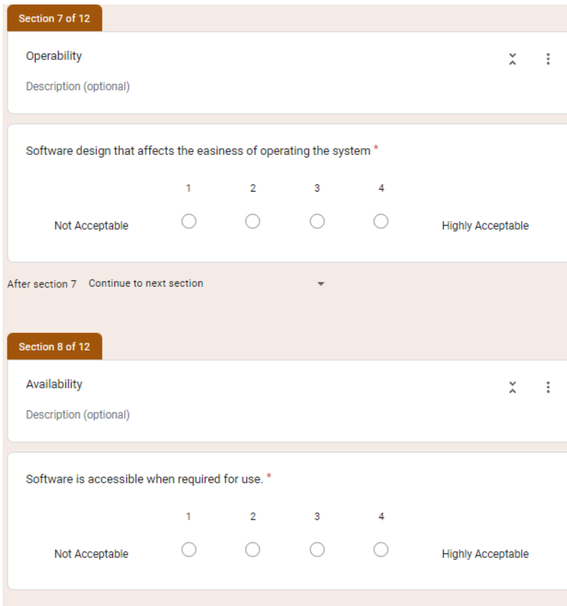
Degree to which the user can learn to operate the software with efficiency and effectiveness *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 6 Continue to next section

APPENDIX B

Survey Questionnaire Form



Section 7 of 12

Operability

Description (optional)

Software design that affects the easiness of operating the system *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 7 Continue to next section

Section 8 of 12

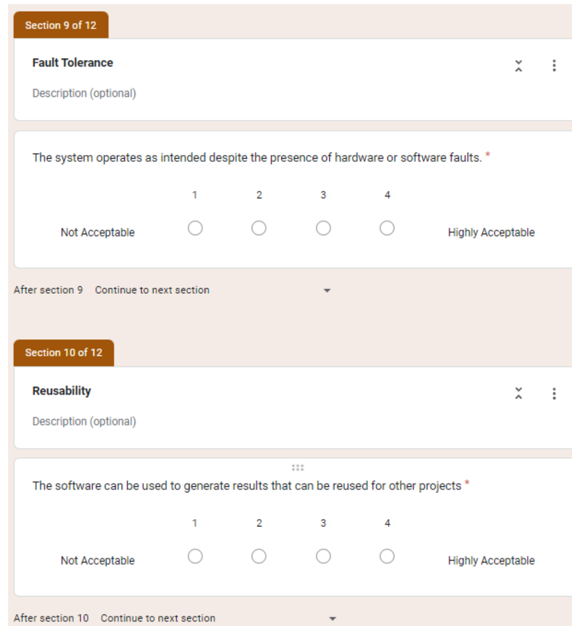
Availability

Description (optional)

Software is accessible when required for use. *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 8 Continue to next section



Section 9 of 12

Fault Tolerance

Description (optional)

The system operates as intended despite the presence of hardware or software faults. *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 9 Continue to next section

Section 10 of 12

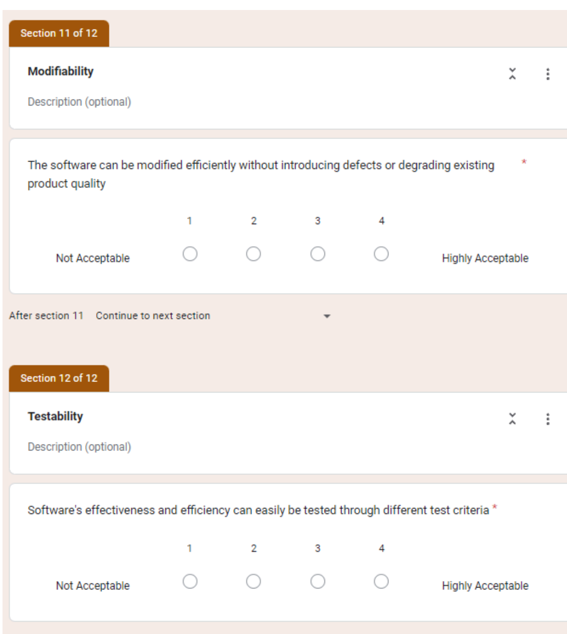
Reusability

Description (optional)

The software can be used to generate results that can be reused for other projects *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 10 Continue to next section



Section 11 of 12

Modifiability

Description (optional)

The software can be modified efficiently without introducing defects or degrading existing product quality *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

After section 11 Continue to next section

Section 12 of 12

Testability

Description (optional)

Software's effectiveness and efficiency can easily be tested through different test criteria *

	1	2	3	4	
Not Acceptable	○	○	○	○	Highly Acceptable

APPENDIX C

Evaluation Procedure

Characteristics	Rating			
	4	3	2	1
A. Functional Suitability				
1. Functional Completeness. The software's functionalities cover all specified tasks and user objectives.				
2. Functional Correctness. The software provides results that are accurate based on the industry standard applications.				
3. Functional Appropriateness. The software's functionalities can be used for accomplishment of specified tasks and objectives.				
B. Performance Efficiency				
1. Time-Behavior. Time taken for the software to process data and give responses to its users.				
2. Resource Utilization. Software utilization and management of resources when performing its functions.				
3. Capacity. Maximum limitations of the software are enough to perform its functions.				

C. Usability				
1. Learnability. Degree to which the user can learn to operate the software with efficiency and effectiveness				
2. Operability. Software design that affects the easiness of operating the system.				
D. Reliability				
1. Availability. Software is accessible when required for use				
2. Fault Tolerance. The system operates as intended despite the presence of hardware or software faults.				
E. Maintainability				
1. Reusability. The software can be used to generate results that can be reused for other projects.				
2. Modifiability. The software can be modified efficiently without introducing defects or degrading existing product quality.				
3. Testability. Software's effectiveness and efficiency can easily be tested through different test criteria				

APPENDIX D

Grammarian Certificate

	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Ayala Blvd., Ermita, Manila, 1000, Philippines Tel No. +632-5301-3001 local 608 | Fax No. +632-8521-4063 Email: cos@tup.edu.ph | Website: www.tup.edu.ph	Index No.	
		Revision No.	
		Effectivity Date	
VAA-COS	THESIS GRAMMARIAN CERTIFICATION	Page	

This is to certify that the thesis entitled,

DEVELOPMENT OF AN ANDROID-BASED MOBILE APPLICATION FOR FINDING THE NEAREST BUS STOP AND PREDICTING THE ESTIMATED TIME OF ARRIVAL

authored by

Abag, Jeanne Mari S.
Menguito, Jermaine H.
Nofuente, Khaled R.
Roda, Johanna Mae E.
Romano, Jane Leslie A.

has undergone editing and proofreading by the undersigned.

This Certification is being issued upon the request of Abag, Jeanne Mari S., Menguito, Jermaine H., Nofuente, Khaled R., Roda, Johanna Mae E., Romano, Jane Leslie A. for whatever purposes it may serve them.

MS. FRANZE NAVARRO OROCEO
Grammarian

Technological University of the Philippines

June 11, 2024

Transaction ID	
Signature	

APPENDIX E

Turnitin Report

Similarity Report

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WORD COUNT 14394 Words	CHARACTER COUNT 85741 Characters
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EDUCATIONAL BACKGROUND

Tertiary

Technological University of the Philippines – Manila
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Bachelor of Science in Computer Science
2020 – Present

Secondary

La Salle College Antipolo
1985 La Salle Ave, Antipolo City, Rizal
STEM Strand
2018 – 2020

St. Jerome's Academy
Turentigue St. Brgy. San Jose, Morong
2014 – 2018

AFFILIATIONS

Tertiary

Social Media Management Committee-Assistant Head, TUP-Compawnion
Technological University of the Philippines - Manila
October 2022 - Present

Promotions and Social Media Lead, UX Society TUP Manila
Technological University of the Philippines Manila
December 2022 - July 2023

Secondary

Marketing Staff, SHS Student Council Officers
La Salle College Antipolo
2018 - 2020

SKILLS

Languages and Technologies: C, Dart, Flutter Framework, Python, HTML, CSS, Visual Studio Code, Github, Multimedia software (Adobe XD, Figma, Canva, Wix, WordPress)

PROJECTS

Development of an Android-Based Mobile Application for Finding the Nearest Bus Stop and Estimated Time of Arrival
Thesis – Developer
October 2023 – Present

Improving the Image Quality of Underwater Images with Particle Swarm Optimization (PSO)
Developer
November 2022 – July 2023

TEAMBA Programming Language
Assistant Developer
October 2022 – February 2023

Implementation of Sex Education in Web-based Learning Application for Pre-teens (9-11 years old) in Barangay Maybunga
Lead Developer
November 2022 – July 2023

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STEM Strand
2018 – 2020

Pateros Catholic School
B. Morcilla St., Pateros, Metro Manila
2014 – 2018

AFFILIATIONS

Tertiary

Public Relations Director, UX Society TUP Manila
Technological University of the Philippines– Manila
October 2022 - July 2023

Member, Google Developer Student Clubs TUP Manila
Technological University of the Philippines - Manila
October 2021 - July 2022

Secondary

PCS Corps of Cadets
Pateros Catholic School
2015 – 2020

SKILLS

Languages and Technologies: C, C++, JavaScript, TypeScript, Dart, HTML, CSS, Angular, Flutter, Express, NodeJS, MySQL, Sequelize, Postman, Visual Studio Code, Github, Multimedia software (Figma, Canva)

PROJECTS

Development of Android-Based Mobile Application for Nearest Bus Stop and Estimated Time of Arrival
Thesis – QA, Data Gathering, Documentation
October 2023 – Present

Insight Website Homepage Redesign
UX Designer
March 2024

Web-Based Application that Translates Basic Filipino Sign Language
QA, Data Scientist
November 2022 – July 2023

Help Me Decide
Lead Developer
October 2022 – February 2023

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	Muntinlupa Business High School Main 146B Espeleta St, Cupang, Muntinlupa, 1780 Metro Manila 2014 - 2018

AFFILIATIONS

Secondary	**English Club** Muntinlupa Business High School Main 2016 – 2018

SKILLS

Languages and Technologies: C, Python, HTML, CSS,Visual Studio Code, Github, Multimedia

PROJECTS

Development of an Android-Based Mobile Application for Finding the Nearest Bus Stop and Estimated Time of Arrival
Thesis – Data Gathering, Documentation
November 2022

Land Division using Last Diminisher Algorithm
Data Scientist
October 2022 – February 2023

TEAMBA Programming Language
Data Scientist
October 2022 – February 2023

Classifying Volleyball Hand Signals using CNN (Convolutional Neural Networks)
Lead Developer
November 2022

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2020 – Present

Secondary

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STEM Strand
2018 – 2020

Angono National High School
Kalayaan, Angono, Rizal
2014 – 2018

AFFILIATIONS

Secondary

Editorial - The Grains
Angono National High School
2014 – 2015

SKILLS

Languages and Technologies: HTML, CSS, Multimedia software (Figma, Canva, WordPress)

PROJECTS

Development of an Android-Based Mobile Application for Finding the Nearest Bus Stop and Estimated Time of Arrival
Thesis – Data Gathering, Documentation
October 2023 – Present

Developing a Web-Based Application that Translates Basic Filipino Sign Language
Data Scientist
November 2022 – July 2023

Improving the Image Quality of Underwater Images with Particle Swarm Optimization (PSO)
Data Scientist
November 2022 – July 2023

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Secondary	**STI College Fairview** Dr. Sixto Antonio Ave.Pasig, Metro Manila STEM Strand 2018 – 2020
	North Fairview High School Astor, Novaliches, Quezon City, Metro Manila 2014 – 2018

AFFILIATIONS

Secondary	**English Club** North Fairview High School 2017 - 2018
	Science Club North Fairview High School 2014 – 2016

SKILLS

Languages and Technologies: C, C++, C#, Dart, Flutter Framework, SQL, Python, JavaScript, HTML, CSS, Postman, Visual Studio Code, Github, Android Studio

PROJECTS

Development of an Android-Based Mobile Application for Finding the Nearest Bus Stop and Estimated Time of Arrival
Thesis – Developer
October 2023 – Present

Improving the Image Quality of Underwater Images with Particle Swarm Optimization (PSO)
Developer
November 2022 – July 2023

Web-Based Application that Translates Basic Filipino Sign Language
Lead Developer
November 2022 – July 2023

Translation of Tagalog to Gaylingo Using Natural Language Processing
Lead Developer
October 2022 – February 2023