IN-NAVO

Augmented Reality Based Indoor Navigation App

23-FYP-106

Session 2019-2023

BACHELOR OF SCIENCE
IN
COMPUTER SCIENCE

SUBMITTED BY

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Abstract

This final year project aims to develop an indoor navigation system using Bluetooth beacon technology that is implemented as a mobile application with augmented reality features. The project aims to address the challenge of navigating indoor spaces where traditional GPS-based navigation is not effective. The mobile application will enable users to easily navigate complex indoor environments by providing real-time directions and interactive guidance using the mobile phone camera and augmented reality. The project will involve the design and development of a mobile application that utilizes Bluetooth beacons strategically placed throughout the indoor environment to accurately determine the user's location. The application will use augmented reality to overlay digital information on the user's real-world environment, providing visual cues and interactive guidance to the user. The system will also provide voice instructions and haptic feedback to further enhance the user experience. The project will be evaluated through extensive testing in a variety of indoor environments, and user feedback will be gathered to assess the effectiveness and usability of the system. The expected outcome of this project is a functional and user-friendly indoor navigation system that uses Bluetooth beacon technology and augmented reality to provide an intuitive and effective indoor navigation solution. This project has the potential to be widely adopted in various industries, such as healthcare, education, and hospitality, where indoor navigation is a critical requirement.

Keywords: Indoor Navigation System, Bluetooth Beacon Technology, Mobile Application, Augmented Reality, Real-time directions, User’s Location

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List of Abbreviations

AR	Augmented Reality
VR	Virtual Reality
2D	Two Dimensional
3D	Three Dimensional
GPS	Global Positioning Signal

CHAPTER 1
Introduction

1.1 Problem Statement

The world is fast-paced, and no one has time to stop and stand at a single place figuring out where to go. Everyone wants to get to their destination as quick as possible and as discreetly as possible. You can ask for directions, but chances are, the person you are asking might not have complete and accurate information, leaving you more confused than before. To solve this problem of navigation, we use Global Positioning System (GPS). The GPS works best when you are outdoors. Its capabilities are limited when it comes to navigating inside large indoor space such as shopping malls, airports, offices, and hospitals etc. While there are various indoor navigation systems available, many of them are either inaccurate or require specialized equipment, making them impractical for everyday use. In addition, most existing systems rely on GPS, which is not reliable indoors, further limiting their usefulness. Therefore, there is a need for an accurate and user-friendly indoor navigation system that can work without the need for specialized equipment and provide reliable and real-time navigation assistance to users in large indoor spaces. Our project aims to develop such a system, using Bluetooth Beacon Technology and Augmented Reality (AR) to provide accurate and real-time indoor navigation assistance to users via a mobile application.

1.2 Purpose

The purpose of this project is to develop a user-friendly indoor navigation system that uses Bluetooth beacon technology and Augmented Reality (AR) to provide accurate and real-time navigation assistance to users in large indoor spaces. The goal is to provide a practical and accessible solution for individuals with visual or cognitive impairments, as well as improve the overall quality of indoor navigation.

1.3 Project Goals

The primary goal of the project is to facilitate new users to navigate inside large indoor spaces they are not familiar with. Indoor navigation systems come with their own set of challenges such as signal scattering which can lead to reduced accuracy. Our aim will be to train the system and achieve maximum possible accuracy all while steering clear of bugs and problems. The mobile app will be user-friendly to further enhance the user experience. Lastly, the system will be as cost-efficient as possible along with being accessible to the masses.

1.4 Objectives

Objectives of the In-Navo are as follows:

- To develop a system architecture that integrates Bluetooth Beacon Technology and Augmented Reality (AR) to provide real-time indoor navigation assistance
- To give an estimation of the distance from the destination

• To use arrows and animation on the screen to make the navigation experience feel seamless

• To give real-time information about other destinations in the view of the camera

1.5 Project Scope

AR and VR are the future and are how humans will interact with the world. With the ever-expanding need of solutions that reduce human effort, the possibilities are limitless. This project will be scalable and will reduce human effort and hassle, all while saving a lot of time.

1.6 Existing Solutions

Here are some existing solutions to the problem at hand.

1.6.1 Visual Markers

AR markers, also called visual markers, are commonly utilized in indoor navigation to serve as reference images for delivering high-precision range accuracy. Essentially, visual markers operate in conjunction with AR 2.0, where the image of the markers is stored and then used to guide AR content placement. AR markers of this kind offer extremely precise positional range measurements.

1.6.2 Mapping

Navigation is dependent on maps, as it is impossible to navigate a location without them. Typically, Google Maps or Google Earth is used to obtain a location's map; however, in some cases, a map of the building or location being navigated is not available, so manual addition of a map is required. This involves recording the Cartesian coordinates and aligning them with geographic coordinates.

1.6.3 Wi-Fi

Indoor navigation using Wi-Fi involves using the signal strength of Wi-Fi access points to determine a user's location. As a user moves around an indoor space, the strength of the signals from nearby Wi-Fi access points changes, and this change is used to calculate the user's location. While this approach can provide some level of accuracy, it is not as reliable as other indoor navigation technologies such as Bluetooth beacons or Ultra-Wideband (UWB) due to a number of factors. The signal strength of Wi-Fi access points can be affected by interference from other devices or materials in the environment, which can lead to inaccurate location data. Additionally, the range of WiFi access points is often limited, which can make it difficult to accurately determine a user's location in larger indoor spaces. As a result, Wi-Fi-based indoor navigation is not always the best option and other technologies may be more suitable depending on the specific needs of a project.

1.7 Proposed Solution:

The technology we will be using for our project is as follows

1.7.1 Bluetooth Beacons

Navigation using Bluetooth beacons involves placing small, low-energy devices called beacons at fixed locations within an indoor space. These beacons transmit Bluetooth signals that are received by a user's smartphone or other mobile device, allowing the device to determine the user's location based on the strength and proximity of the signals. The user's device can then provide navigation instructions or other locationbased information, such as points of interest or emergency exits. Bluetooth beacons are a popular choice for indoor navigation because they offer a high degree of accuracy and can work in a variety of indoor environments, including areas with high levels of interference or large indoor spaces. Additionally, Bluetooth technology is widely available on most modern smartphones and does not require an internet connection, making it a cost-effective and reliable option for indoor navigation.

1.8 Project Scheduling

We use Gantt Chart to show the overall schedule of the project, the starting and ending times and the time duration of each activity takes. So, here is the list of all the activities in our project. The timeline of the project is shown by a Gantt chart in Figure 1.1.

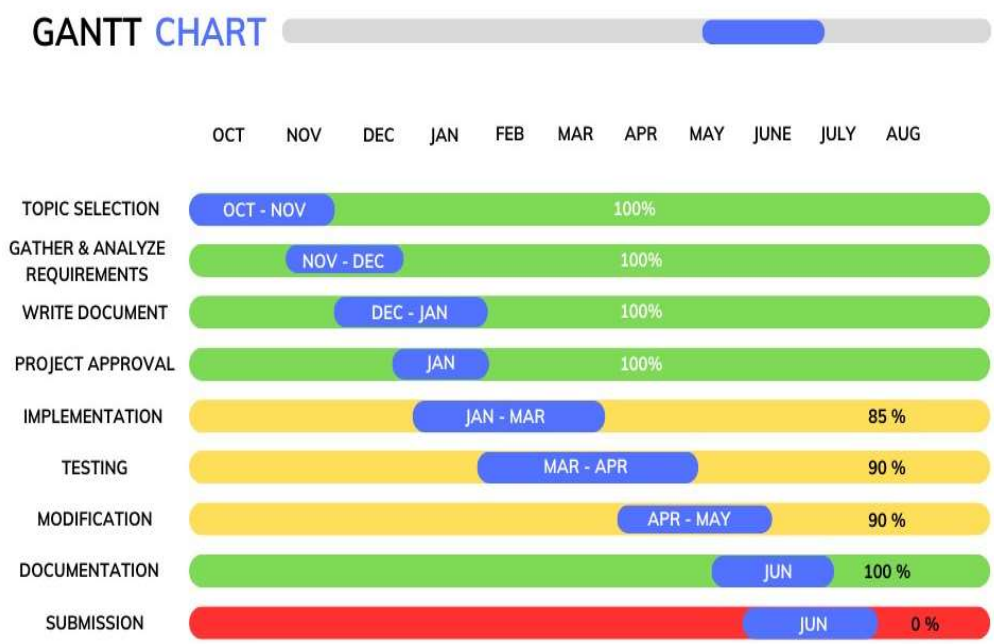

Figure 1 Gantt Chart

1.9 Risks and Risk mitigation

1.9.1 Risks

Some of the risks involved in the development cycles of this project are as follows:

- Technical issues with Bluetooth beacons or mobile devices can lead to inaccuracies in the location data or other errors.
- Privacy concerns are related to collecting user location data and transmitting it over the internet or other networks.
- Physical barriers in the indoor space, such as walls or other obstacles, that can interfere with the Bluetooth signals and impact the accuracy of the system. • Security risks related to the transmission and storage of sensitive user data, which could potentially be intercepted or hacked.

1.9.2 Risk Mitigation

To mitigate these risks, the following measures can be taken:

- Through testing of the Bluetooth beacons and mobile application to identify and resolve technical issues before deployment.
- Implementing strong data privacy and security measures, such as encryption and data anonymization, to protect user data.
- Conducting a site survey to identify and map any physical barriers that could impact the accuracy of the system and adjusting the placement of the Bluetooth beacons accordingly.
- Regularly updating the software and security protocols to ensure the system remains secure and up-to-date with the latest best practices.

CHAPTER 2

Literature Review

In this chapter, we will take a look at the related work which has been done on Indoor Navigation Systems and topics closely related to it. We will be discussing some ongoing work, already implemented technologies and in-progress solutions. Below we have discussed a paper published in the International University of Beirut, in IEEE Transactions on Consumer Electronics, as well as the Indoor Navigation System implemented at Gatwick International Airport.

2.1 Related Work

The research paper presented by the students of Lebanese International University in Beirut, Lebanon focuses on indoor navigation using Wi-Fi trilateration [14]. The method relies on measuring distances from Wi-Fi access points and calculating angles to determine the user's location accurately.

Noteworthy companies such as Google [7], Alibaba, Apple [2], and Cisco have implemented indoor navigation systems based on Wi-Fi trilateration due to its impressive accuracy, which can reach up to 1 meter. Apple, for example, invested $20 million in an indoor localization project that incorporates Wi-Fi, sensors, GPS, cell tower trilateration, and fingerprints to achieve precise positioning [2].

Wi-Fi SLAM, a technology utilizing pattern recognition and machine learning [7], has also been employed for indoor positioning. In contrast, Google Maps primarily serves outdoor positioning needs, offering limited capabilities for indoor navigation.

An IEEE Transactions on Consumer Electronics study explores Vision-Based location positioning for indoor navigation [3]. The system leverages image sequences of the indoor environment to automatically recognize the user's location and implement augmented reality by overlaying relevant information onto their view [3]. By creating an image database and a location model based on the indoor layout, the system achieves accurate location recognition [3]. The mobile phone camera captures the image sequence, which is then processed by a remote PC for marker detection, location recognition, and image sequence matching [3]. The location information is subsequently transmitted back to the mobile phone, allowing for identification of similar locations and the display of related information [3]. The system demonstrated an impressive 89 percent accuracy in testing [3].

London Gatwick Airport has introduced an indoor navigation system that relies on 2000 beacons to provide an augmented reality wayfinding tool [30]. This system assists passengers in navigating the airport by displaying directions on their mobile phone cameras, making it easier to locate check-in areas, departure gates, and luggage belts [30]. The airport claims that this system offers superior reliability and accuracy compared to GPS [30]. In recognition of its innovative approach, the system has received several awards, including the Mobile Innovation of the Year and Cloud Project and Mobile App of the Year at the Real IT Awards [30]. Notably, London Gatwick Airport introduced the world's first cloud-based Flight Information System [30].

In the 5th International Conference on Control, Automation, and Robotics (ICCAR), a research paper was presented on an augmented reality-based navigation system that utilized a JAQL robot and a Google Pixel Android smartphone [6]. The study explored the capabilities of augmented reality in indoor localization and object detection [6]. The researchers developed a mobile application using Google ARCore, which served as both a sensor and the controller for the system [6]. Various ARCore features were employed for navigation [6]. The system's accuracy was further evaluated through experiments conducted in diverse real environment conditions [6].

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2.2 Reason to Develop

Reasons to develop an Augmented Reality Based Indoor Navigation System using Bluetooth Beacon:

2.2.1 Enhanced User Experience

The integration of AR with an indoor navigation system provides the users with an interactive experience, making the navigation more engaging and interactive.

2.2.2 Accurate Indoor Navigation

Bluetooth beacons provide precise location tracking within indoor spaces, allowing users to navigate complex environments, such as shopping malls, airports, museums, and hospitals, with ease and accuracy.

2.2.3 Improved Efficiency

The app can help users save time and effort by providing optimal routes, avoiding obstruction, and offering real-time information on facilities, and services within indoor venues.

2.3 Workflow in AR University:

Unity is a game engine that can be used to create augmented reality (AR) applications. In Unity, AR is typically implemented using the AR Foundation package, which provides a set of tools for building AR applications that can run on a variety of devices, such as smartphones and tablets. AR Foundation works by using a technique called marker less tracking, which allows the application to determine the position and orientation of the device in the real world without the need for a physical marker. The system uses the device's camera to capture images of the environment and then analyzes the images to identify feature points and estimate the camera's position and orientation in real-time. Once the camera's position and orientation have been determined, Unity can use this information to overlay 3D objects on top of the real-world environment, creating the illusion of virtual objects coexisting with the real world. This allows developers to create interactive AR experiences that can be used for a variety of applications, such as gaming, education, and advertising.

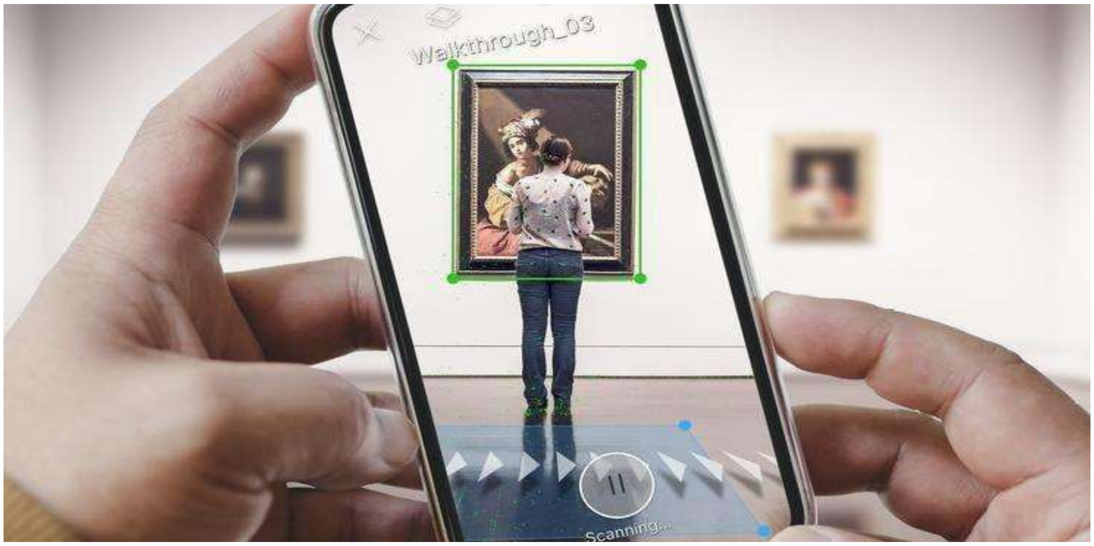

Figure 2 - Workflow in AR university

2.4 Image Processing in Unity:

In Unity, the image processing for AR typically involves two stages: image recognition and image tracking. Image recognition is the process of identifying an image or a specific pattern in an image. It involves using computer vision algorithms to analyze the image and identify specific features or patterns that can be used to recognize the image. Unity uses the Vuforia engine for image recognition, which allows developers to create image targets and detect them in real-time using the device camera. Once an image target is recognized, the image tracking stage begins. Image tracking is the process of using the recognized image target as a reference point to track the position and orientation of the device camera in real-time. This allows the AR content to be anchored to the real world, creating the illusion of virtual objects existing in the physical world. Unity's AR Foundation provides a set of tools for image tracking, including plane detection, hit testing, and anchoring objects to the real world. In summary, the image processing workflow for AR in Unity involves using computer vision algorithms to recognize an image target, and then using that target as a reference point to track the position and orientation of the device camera in real-time, allowing AR content to be anchored to the real world.

CHAPTER 3

System Requirements

In this chapter, all the functional requirements of the application and the overall requirement of the stockholders are documented because it's an essential part of a project or product that helps to meet stakeholder's requirements. Now, we will discuss system requirements, functional requirements, software development, and existing and selected methodology with the reason of methodology. These sections describe software methodologies that are existing and selected for this project with the flow of system and application detail depicted.

3.1 Functional Requirements

3.1.1 Registration and Authentication of User

Users will be able to register themselves in the system and afterwards they have been registered, the system will be able to authenticate them. Upon authentication, they will be able to make use of the AR-based indoor navigation system.

3.1.2 Scanning Environment

Users will be able to scan the surrounding environment by using their camera and identify the obstacles which might come in their way.

3.1.3 Navigation

Using AR User will be able to pick a destination and will be able to navigate using 3D models implemented in real-time in the environment. Bluetooth Beacons will give out the initial location and the final destination while also navigating.

3.2 Non-Functional Requirements

Following we have mentioned the Non-Functional Requirements of our system. These requirements are put in place to ensure the satisfy the stakeholder and ensure quality of finished product.

3.2.1 Performance

The system should be able to provide real-time navigation and location information to the user without any significant delay or lag.

3.2.2 Usability

The user interface should be intuitive and easy to use, with clear instructions and visual aids to guide the user. The system should also be accessible to users with disabilities.

3.2.3 Reliability

The system should be reliable and consistent in providing accurate location and navigation information to the user, even in challenging environments such as areas with poor connectivity or low lighting.

3.2.4 Compatibility

The system should be compatible with a wide range of devices, including smartphones, tablets, and wearables, across multiple platforms and operating systems.

3.4 Use Case Diagram

For graphical visualization of actor interaction with the components of the systems, the most appropriate approach is to use case diagrams that graphically represent which actor may perform or access which functionality or component of the system.

3.4.1 Use Case of Member Navigation

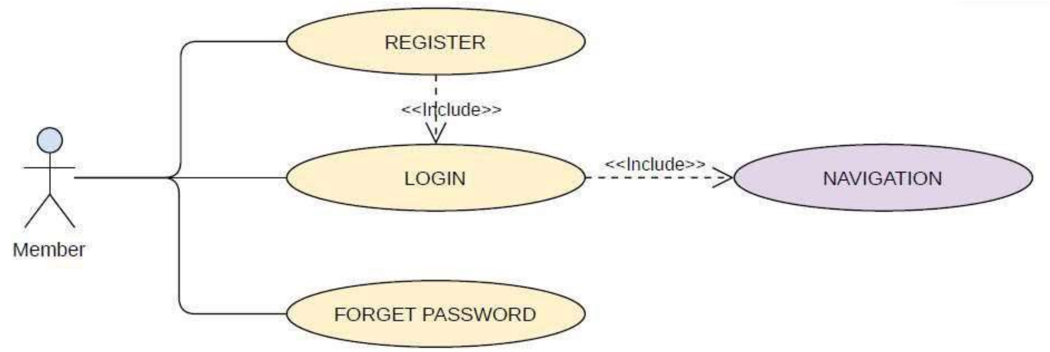

Figure 3 Member Navigation

3.4.2 Use Case of Guest Navigation

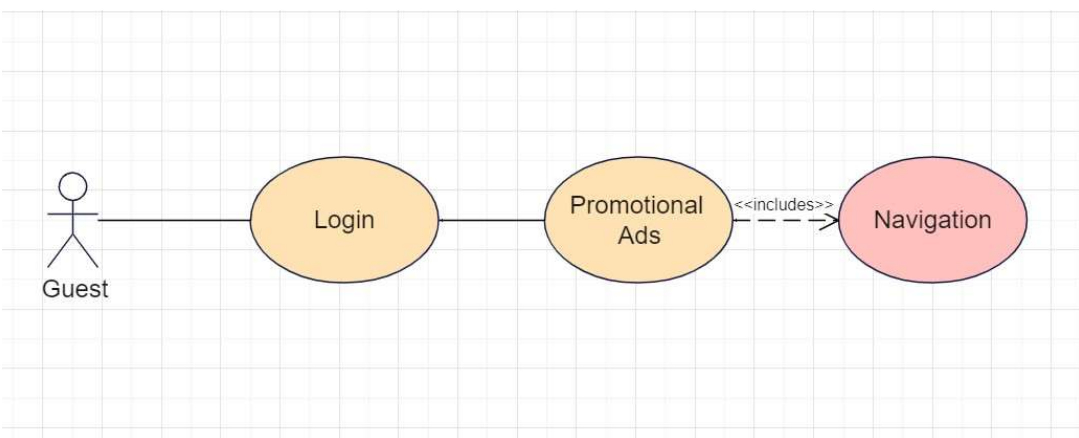

Figure 4 - Guest Navigation

3.5 Use case Description.

Use case description contains every piece of information (use case id, use case name, description, pre and post-conditions) of each use case.

3.5.1 Use Case of Member Navigation

Table 3.1 shows the detail of getting the started use case.

Table 3. 1 Member Navigation Use Case

USE CASE ID	01

USE CASE NAME	Member Navigation
Actors	User
Description	User will register, login, select destination, navigate
Pre-condition	Must login and have Bluetooth enabled
Post-condition	AR Content will be displayed

3.5.2 Use Case of Guest Navigation

The table 3.2 shows the detail of get started use case.

Table 3. 2 Guest Navigation Use Case

USE CASE ID	02
USE CASE NAME	Guest Navigation
Actors	User
Description	User will enter their name to start navigating as a guest and ads will be dis-played.
Pre-condition	The app must be able to interact with the Bluetooth beacons and the entered location must a valid location
Post-condition	The user will reach their destination with the help of AR

Chapter 4

Methodology

This chapter provides detailed knowledge of the life cycle of the project; also, the project's Feasibility and Schedule will be discussed in it. Development methodology plays a vital role in software development, as it shows the delivery of the software and ensures that software products will be made. In this section, we will study methodologies for software development, existing and methodologies that we select with flow of the project along with the Project Schedule. So, let's start with an explanation of the existing methodologies and one that we are implementing.

4.1 Project Planning

Project planning in the iterative waterfall model is focused on breaking down the project into smaller, manageable phases and ensuring that each phase is well-defined, well-planned, and well-executed. The iterative nature of the model allows for continuous feedback and improvement, ensuring that the project stays on track and meets the needs of stakeholders.

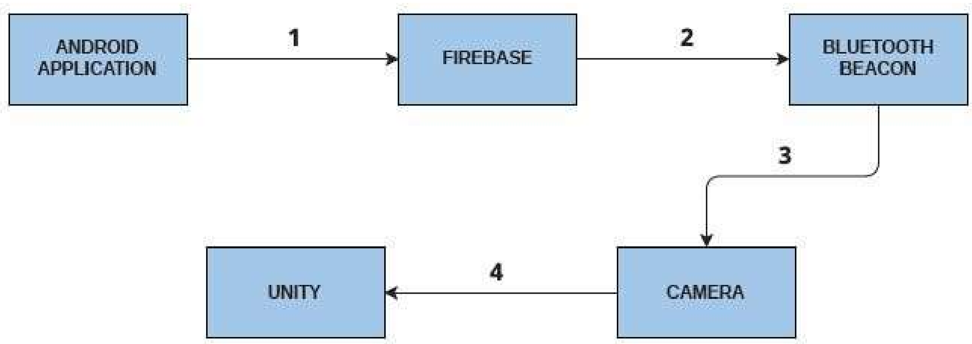

Figure 5 - Project Planning Diagram

4.2 Methodology for Software Development

A software development methodology is a way to improve development work with the help of dividing the development process into distinct phases to make a system with better productivity. It also helps to structure and control the whole system. It involves different methodologies, also called the Software Development Life Cycle, that are stages for software development with a certain set of rules. Generically, we categorized the methodologies into Rapid application development and planned-driven. Waterfall, spiral is planned driven while agile is Rad based.

4.3 Reason of selected methodology

There are multiple software development methodologies which can be opted for depending upon the needs of the user or the stakeholder. The first step is to access your priorities and the compare them with an existing methodology. Whichever methodologies aligns with your needs, you can pick that one.

4.3.1 Waterfall

The Waterfall model is a linear-sequential lifecycle in which each stage must be fully completed before the next can begin, with no overlapping of stages. However, if changes occur during any stage, the process must return to the initial stage. As a result, the iterative Waterfall model is typically preferred over the initial version, particularly in the backstage where changes are more likely to occur.

4.3.2 Extreme Programming

Extreme Programming is a software development methodology that emphasizes short development cycles and multiple releases to enhance software quality and facilitate communication and responsiveness among developers. However, the requirement for ongoing customer involvement can be a challenge, as some stakeholders may find it cumbersome or may not be always available.

4.3.4 Spiral Model

The spiral model is a software development approach that incorporates both iterative and sequential development models, with a focus on risk analysis. It consists of four key phases, including objective setting, risk assessment and reduction, development and validation, and planning.

4.5 Selected Methodology

Through careful considering and assessment, For the purpose of this project, we have opted for "Agile" methodology. Agile meets most of our requirements for development that is why we have opted for.

4.5.1 Reason

For Selection of Methodology Agile is a popular and effective development methodology that has several advantages over traditional methodologies such as the Waterfall model. Other factors have been given below.

- **Flexibility:** Agile is renowned for its flexibility and adaptability, allowing development teams to quickly respond to changing requirements and priorities. The iterative and incremental approach will enables us to mitigate project risks and improve stakeholder's satisfaction by responding rapidly to changes in project scope or other needs.
- **Collaboration:** Agile methodologies prioritize close collaboration between the development team and stakeholders. Regular feedback and communication channels help ensure alignment of project objectives, resulting in improved outcomes and enhanced stakeholder satisfaction.
- **Faster time-to-deployment:** Agile's iterative and incremental approach enables the earlier delivery of functional software, which can be tested and validated. This shortened feedback loop helps to reduce time-to-market and improve overall project success rates.
- **Continuous improvement:** Agile methodologies foster a culture of continuous improvement and learning. Each iteration offers an opportunity for the team to reflect on its successes and areas for improvement, driving continuous improvement in both the development process and the quality of the software delivered.
- **Improved quality:** Agile methodologies prioritize testing and quality assurance throughout the development cycle. This continuous focus on quality enables early identification and remediation of issues, leading to a higher-quality end product.

Chapter 5

System Architecture

Architecture helps to describe system flexibility that includes process planning and design. It defines the major software components, set of containers and connectors. In this chapter, we will discuss system architecture , and activity diagram

5.1 Three Layer Architecture Diagram

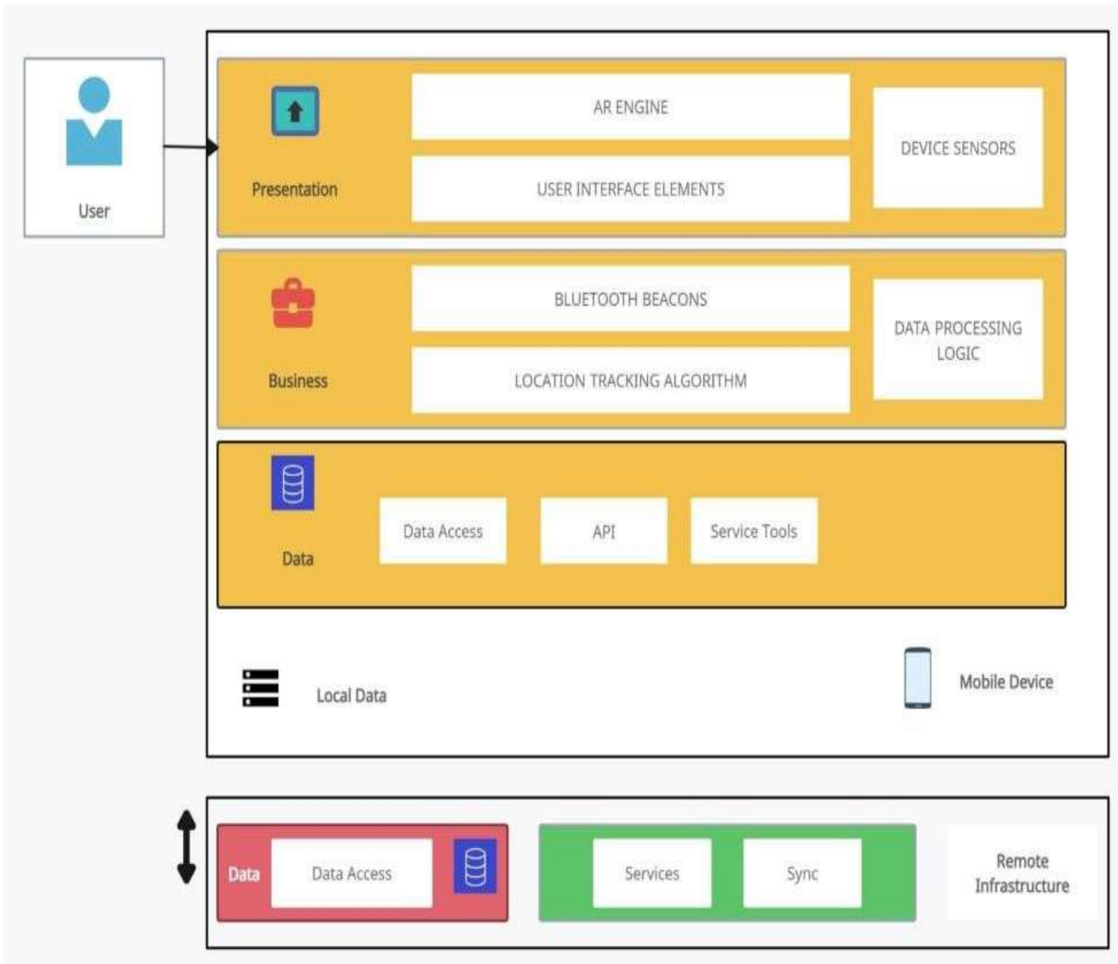

Figure 6 - Three Layer Architecture Diagram

5.2 System Architecture Diagram

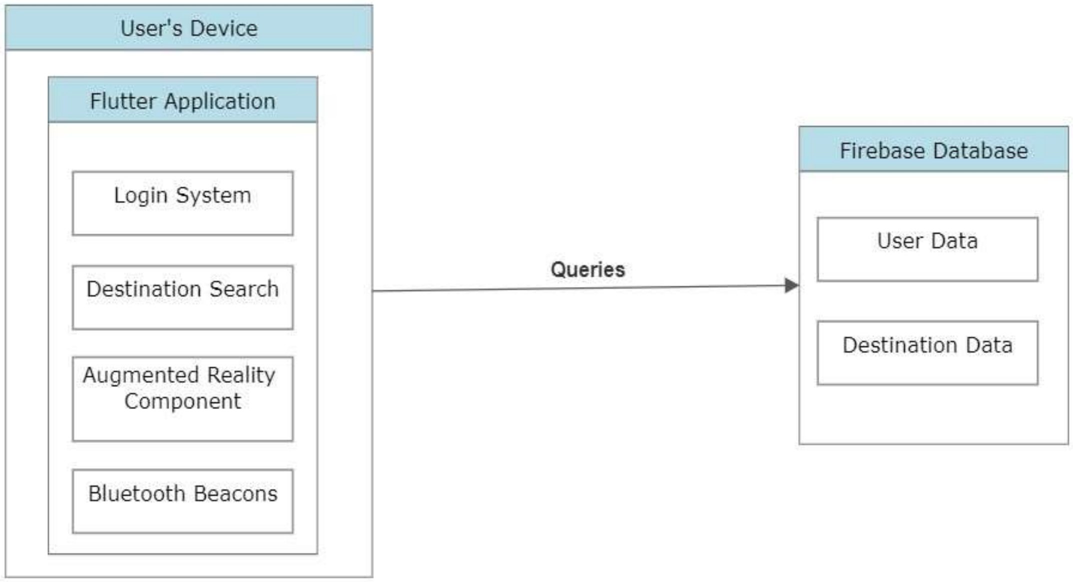

Figure 7 - System Architecture Diagram

5.3 Activity Diagram

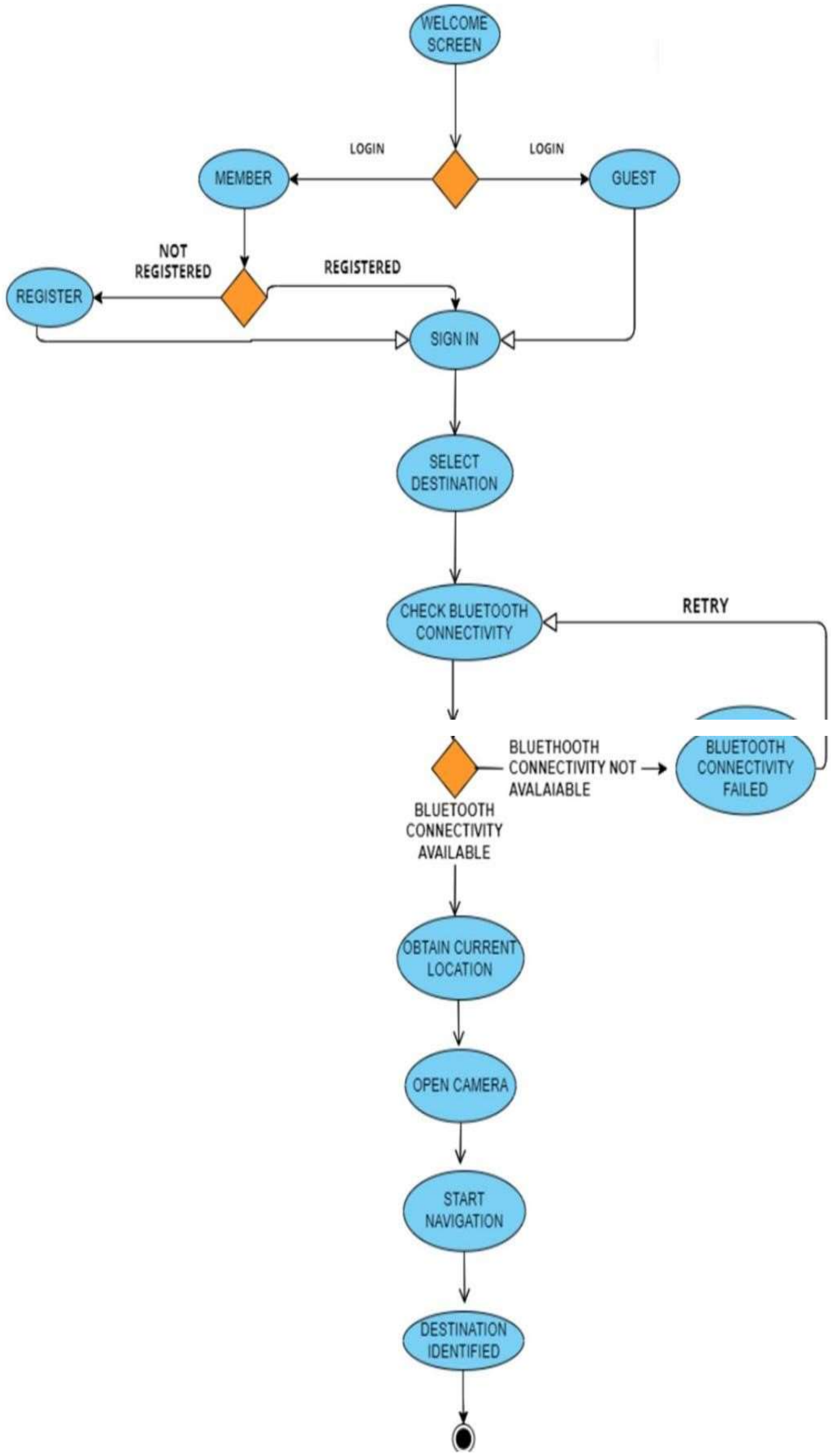

Figure 8 - Activity Diagram

5.4 Sequence Diagram

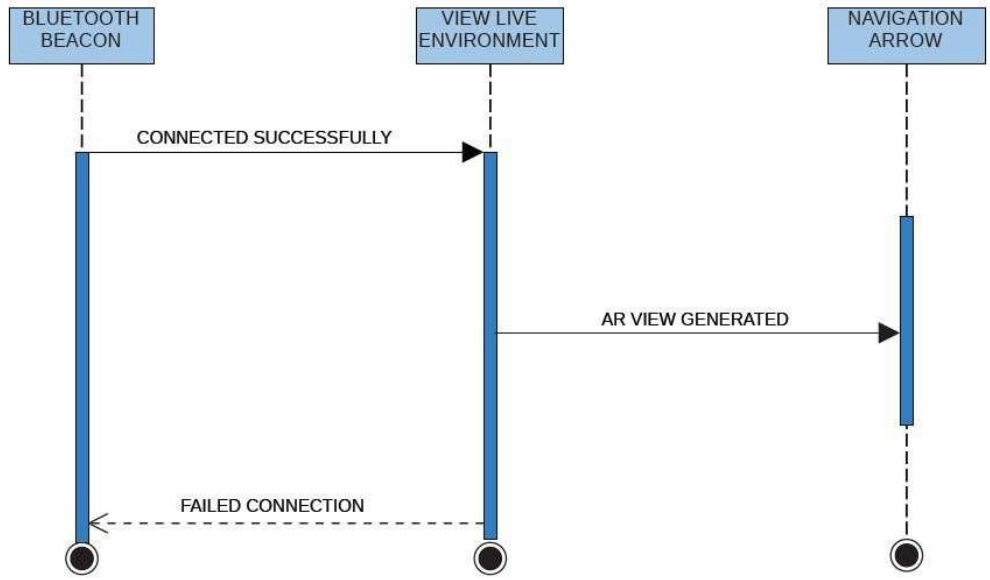

Figure 9 - Bluetooth Beacon Successful Connectivity to scan environment and show arrow for navigation.

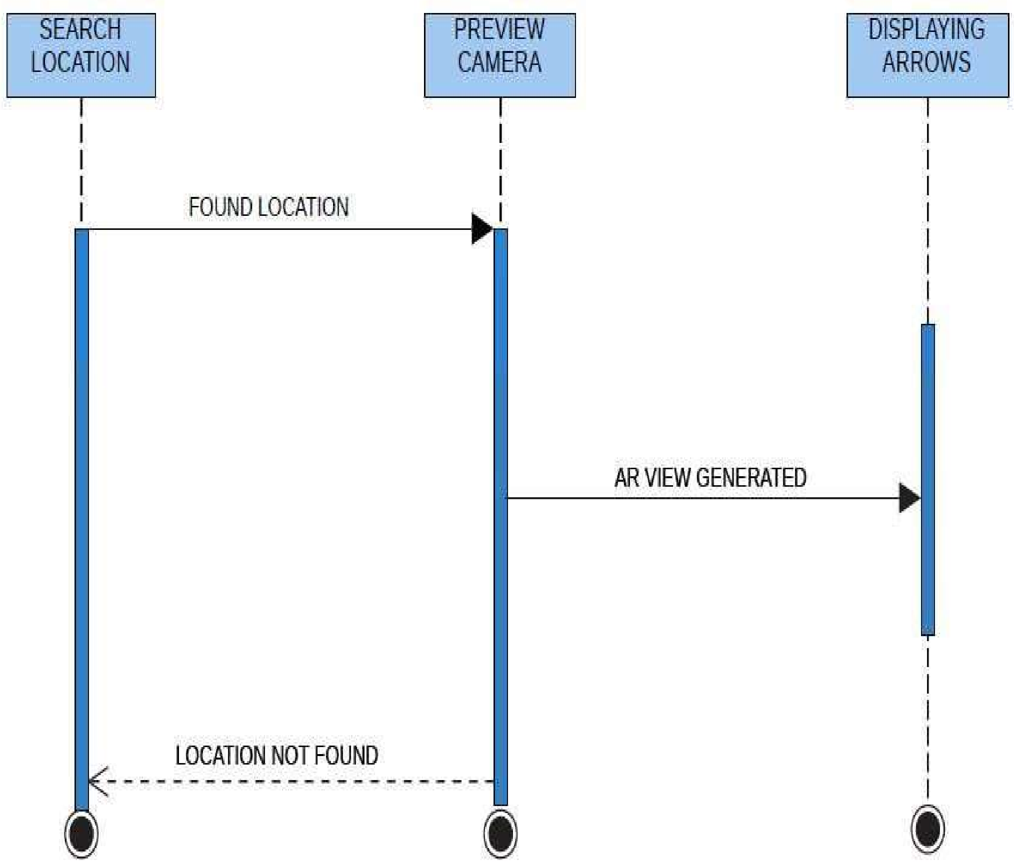

Figure 10 - Location Detection will lead towards camera opening and arrow will move towards the destination.

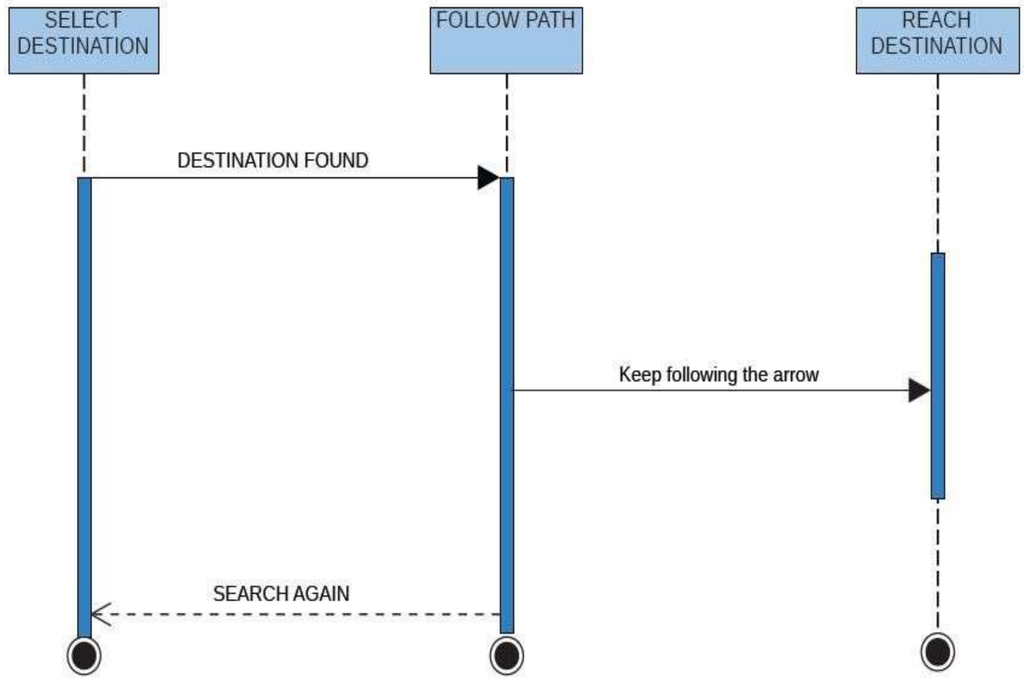

Figure 11 - Selection of Destination will fetch the searched destination from Firebase and by following path user will reach destination.

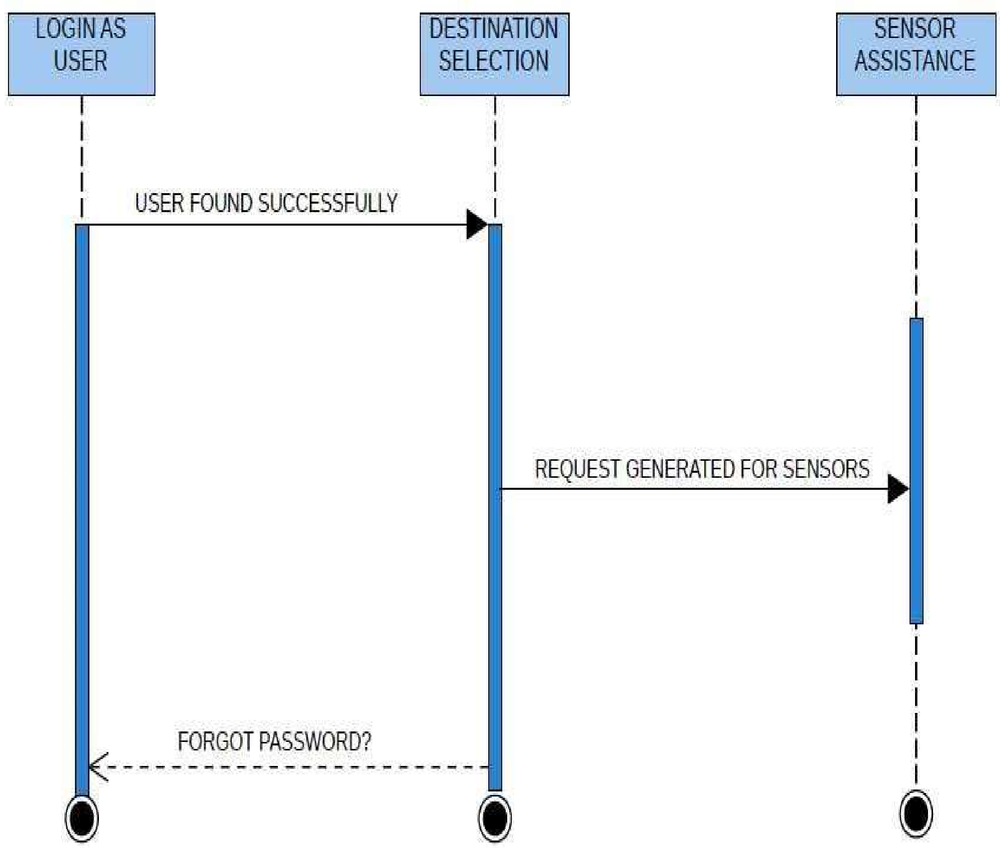

Figure 12 - Registered Member logs in to navigate with the help of Bluetooth Beacons

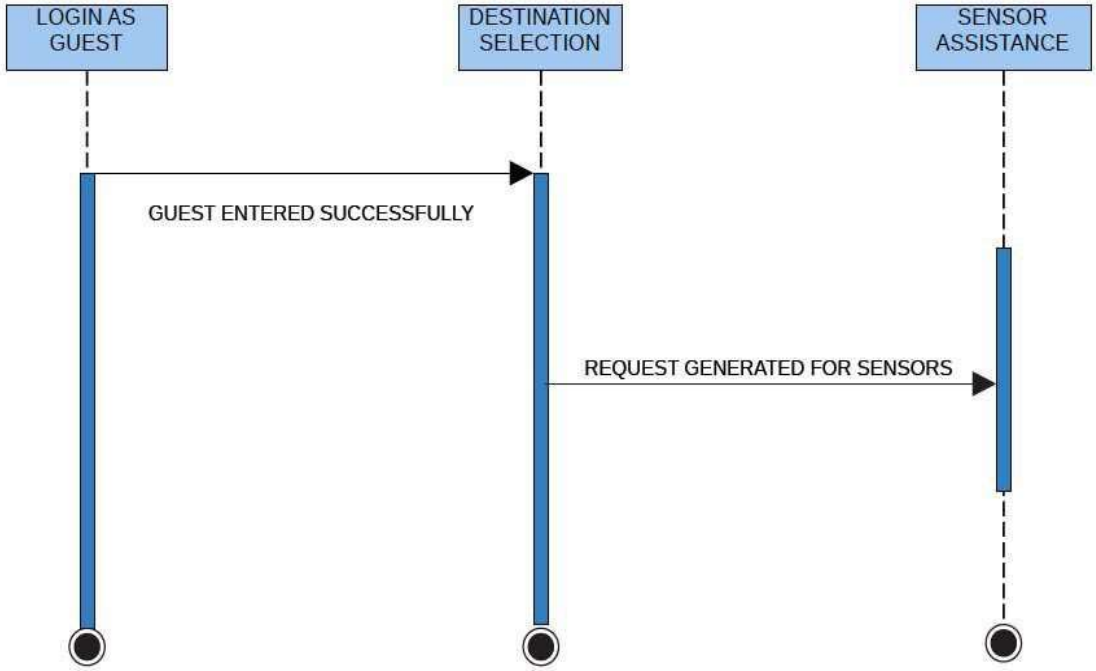

Figure 13 - Guest enters the destination for navigation while Bluetooth Beacons helps with Destination Detection

5.5 Database Diagram

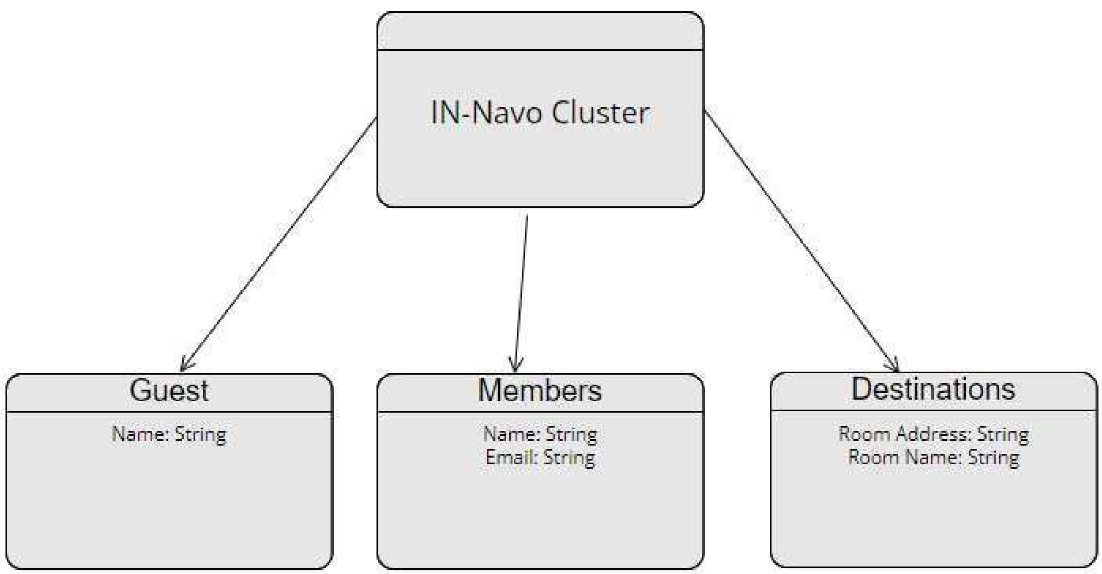

Figure 14 - Database Diagram

Chapter 6

System Implementation

After successfully designing all the previous phases of development that were the first steps in developing a system, now the final approach is to develop the system according to the UML visualization of the intended system. In this section, software develops just coded the system according to the diagrams and the technologies which are used here are mentioned below:

6.1 System Tools and Technology

The tools and technologies used are given as follows:

- Flutter
- Firebase
- Unity

6.1.1 Tool Name:

- **Visual Studio Code:** Primary Code Editor
- **Android Studio:** Secondary Code Editor
- **Smart Phone:** Platform for running the application.

6.2 Class Diagram

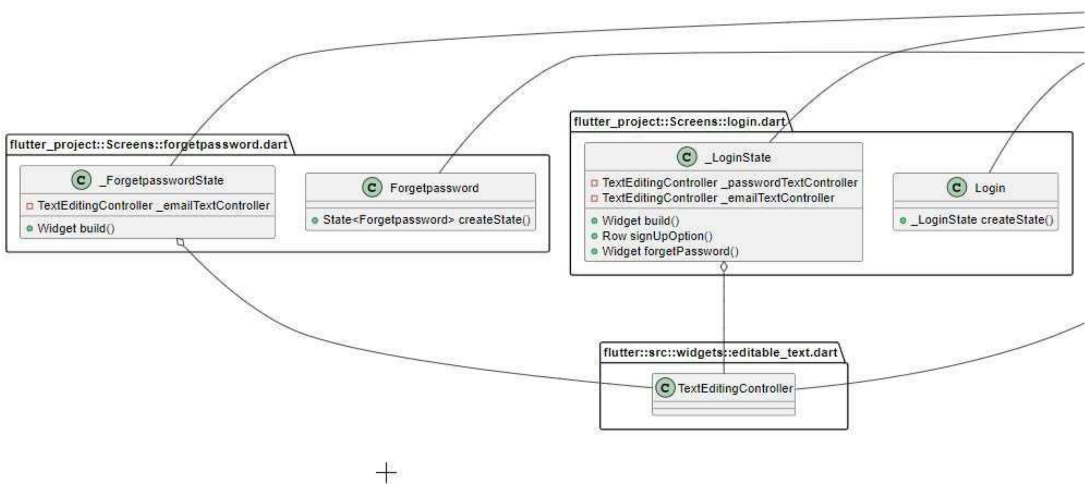

Figure 15 - User Login and Password setting diagram.

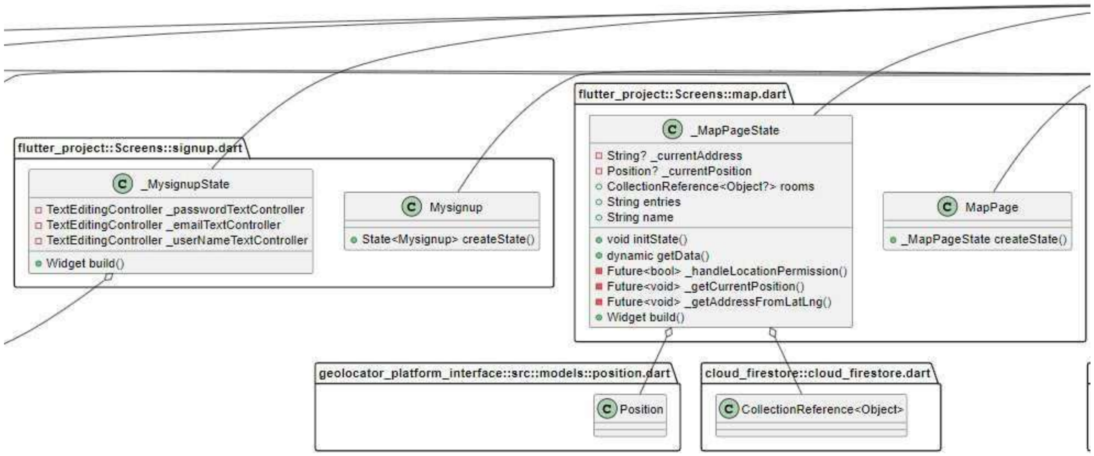

Figure 16 - Destination Selection Diagram

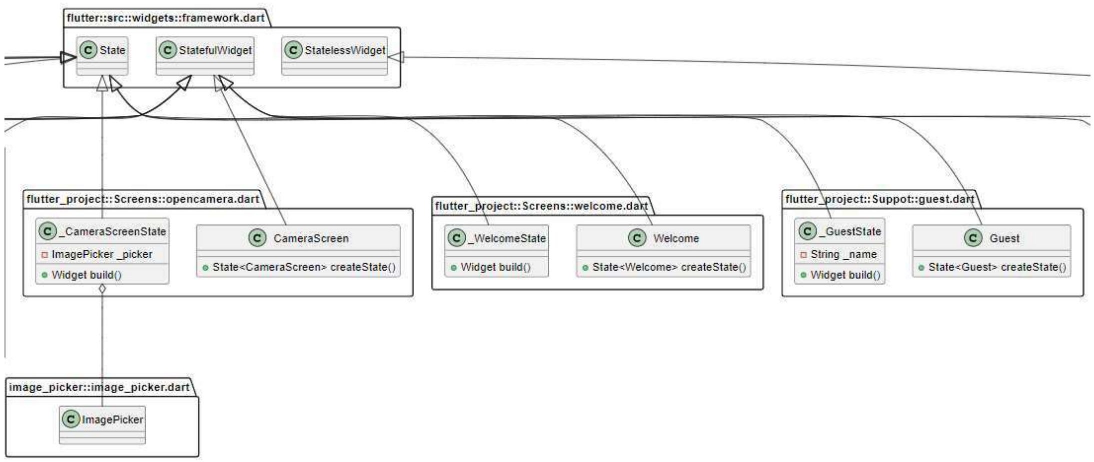

Figure 17 - Camera Preview Diagram

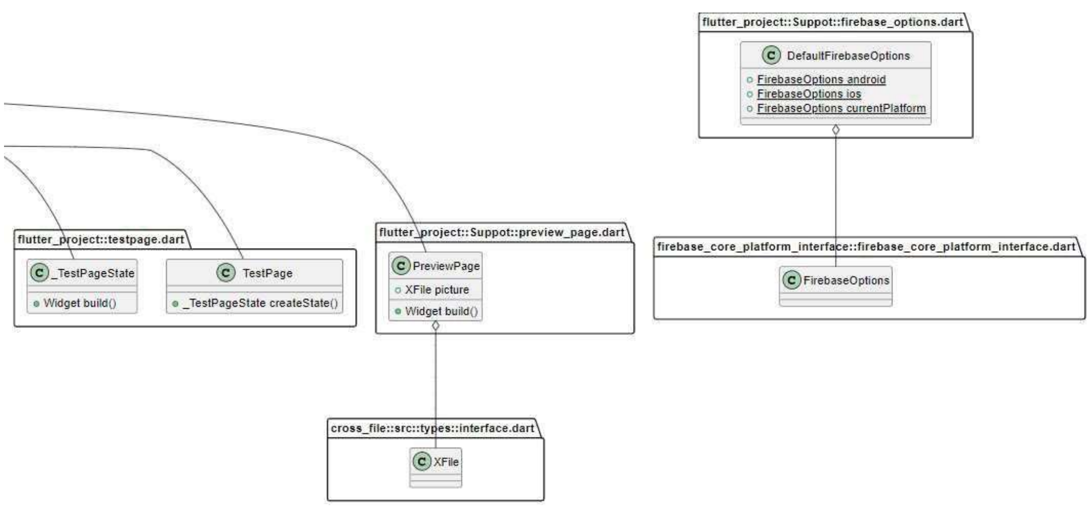

Figure 18 - Navigation Diagram

6.3 Deployment Diagram

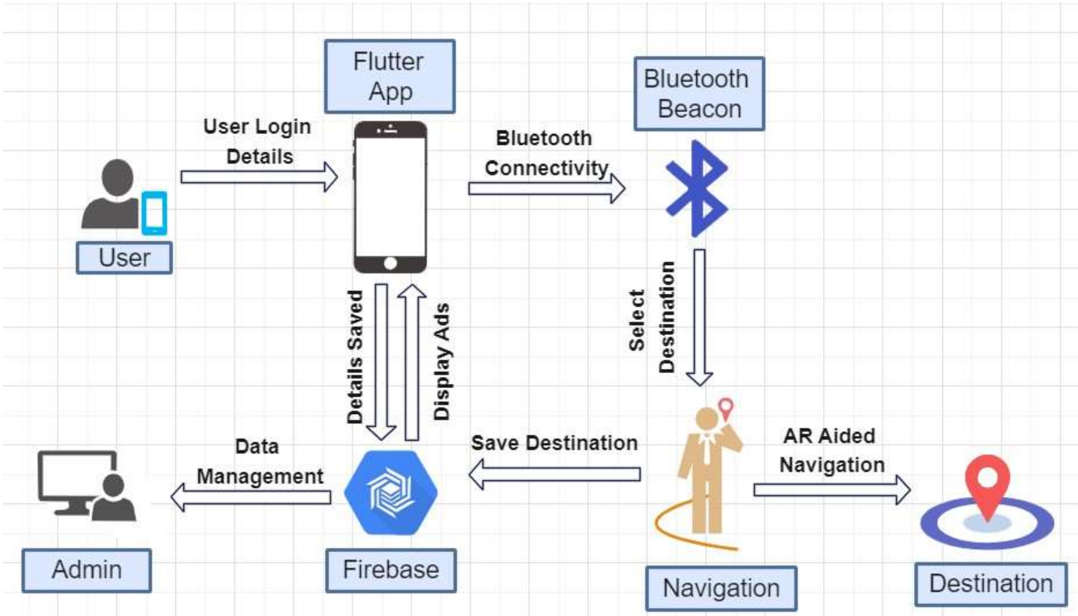

Figure 19 - Deployment Diagram

Chapter 7
System Testing

7.1 System Testing

7.1.1 Black Box Testing

Black box testing is a method where the functionalities of a system are tested without any knowledge of its internal structure, code implementation, or specific details. The main emphasis is on examining the system's input and output. This technique aims to verify the system's output when provided with various inputs.

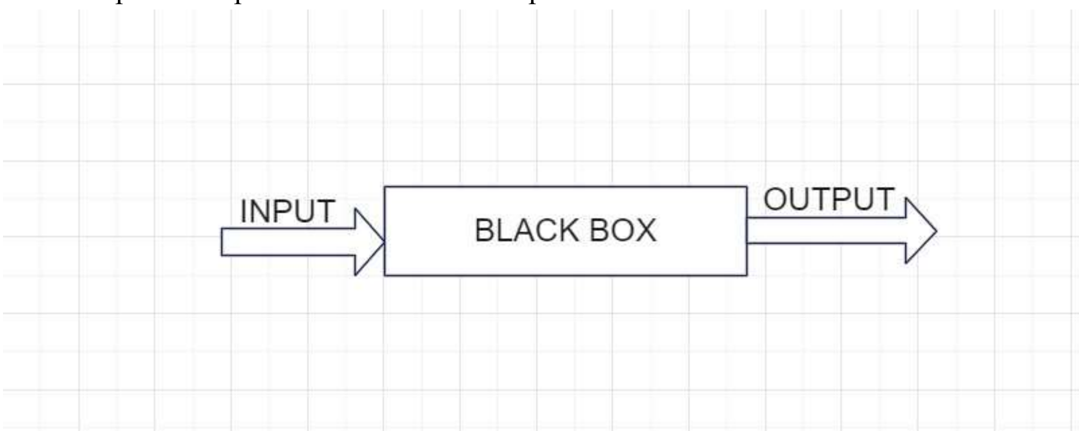

Figure 20 - Black Box Testing

7.2 Test Cases

Test cases are instructions or actions created to validate and verify specific aspects of a system or software. They serve as a guide for testers, outlining the steps to be taken and the expected outcomes to ensure that the product's functionality aligns with the defined requirements. These test cases are derived from the functional requirements of the system.

7.2.1 Test Case: Successful Login

Table 7.1 Test Case Successful Login

Component Name	Mobile App
Module Name	Login System
Condition being tested	Successful Login
Expected Result	Successful User Login
Success Scenarios	User Logged In Successfully
Failure Scenarios	User not Logged In
Test Result (Pass/ Fail)	Passed

7.2.2 Test Case: Failed Login

Table 7.2 Test Case Failed Login

Component Name	Mobile App
Module Name	Login System
Condition being tested	Failed Login
Expected Result	Failure of User Login
Success Scenarios	User Login Failed
Failure Scenarios	User logged in
Test Result (Pass/ Fail)	Passed

7.2.3 Test Case: Forget Password

Table 7.3 Test Case Forget Password

Component Name	Mobile App
Module Name	Login System
Condition being tested	Forget Password
Expected Result	Receiving of Confirmation Email
Success Scenarios	Confirmation Email Received
Failure Scenarios	Confirmation Email is not Received
Test Result (Pass/ Fail)	Passed

7.2.4 Test Case: Valid Destination Search

Table 7.4 Test Case Valid Destination Search

Component Name	Mobile App
Module Name	Navigation
Condition being tested	Valid Destination Search
Expected Result	Destination Finding
Success Scenarios	Destination Found
Failure Scenarios	Destination not Found
Test Result (Pass/ Fail)	Passed

7.2.5 Test Case: Navigation

Table 7.5 Test Case Navigation

Component Name	Mobile App
Module Name	Navigation
Condition being tested	Camera opens and arrow display
Expected Result	Arrow Displays
Success Scenarios	Arrow is displayed
Failure Scenarios	Arrow isn't displayed
Test Result (Pass/ Fail)	Passed

7.3 Unit Test Cases

7.3.1 Test Case: Test User Login

Test Case 1: Validate Credentials

Expected Result: User logged in successfully.
Description: The credentials added by the user are accurate.
Test Steps:

- Provide Valid username and password.
- Ensure that the user is logged in successfully.
- Verify that the user session is created and maintained.

Test Case 2: Invalidate Credentials

Expected Result: User login should be failed.
Description: The credentials added by the user are inaccurate.
Test Steps:

- Provide invalid username and password.
- Ensure that the user is not able to login into the system.
- Verify that the user session is not created.

Test Case 3: Network Error

Expected Result: The login process should fail.
Description: Testing the handling of network errors.
Test Steps:

- Disable the internet connection.
- Provide valid credential details.
- Verify that the login fails because of internet disability.
- Test Searching of destination location.

7.3.2 Test Case: Search Results

Test Case 1: Accurate Search Results

Expected Result: The search function should give the appropriate user-destination.
Description: Verify that the destination given by the app matches with the destination added by the user.
Test Steps:

- Enter valid search destination.
- Initiate the search.
- Verify that the user reaches the accurate destination.

Test Case 2: Inaccurate Search Results

Expected Result: The search function should not give the appropriate user-destination. **Description:** Verify that the destination given by the app do not matches with the destination added by the user.
Test Steps:

- Enter invalid search destination.
- Initiate the search.
- Verify that the results give no matching destinations.

Chapter 8

Application Prototype

8.1 Main Screen

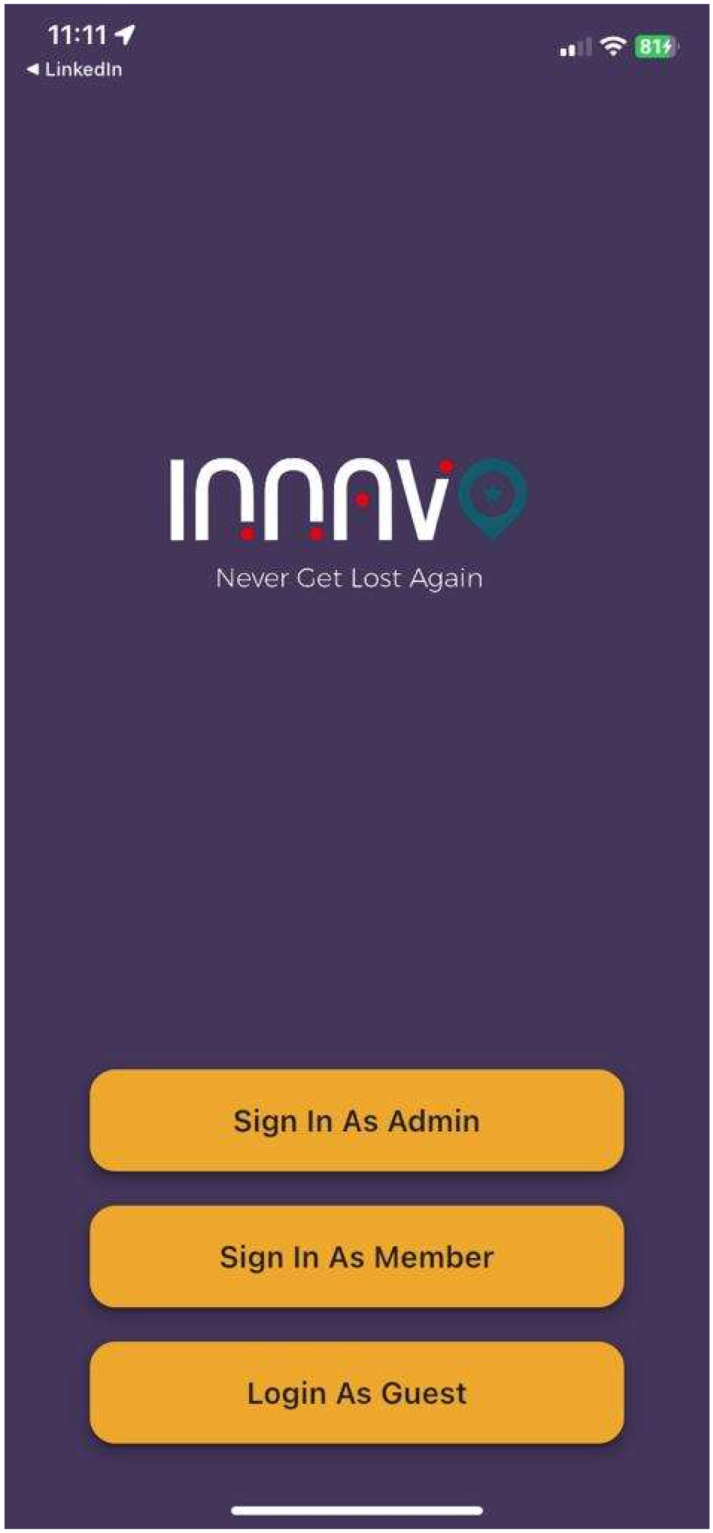

Figure 21 - Main Screen

8.2 User/Admin Login Screen

Figure 22 - User/Admin Login

8.3 User/Admin Registration Screen:

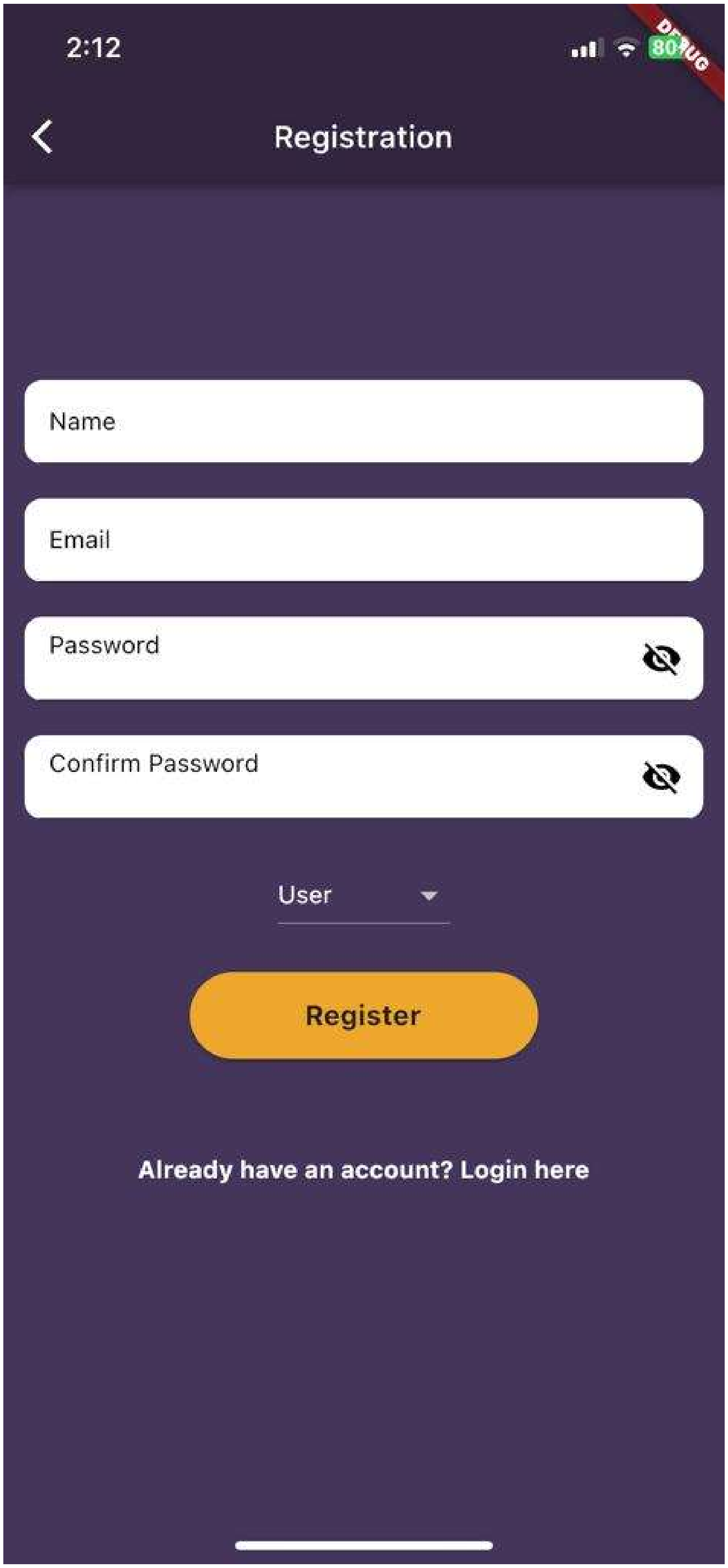

Figure 23 - User/Admin Registration

8.4 Forgot Password

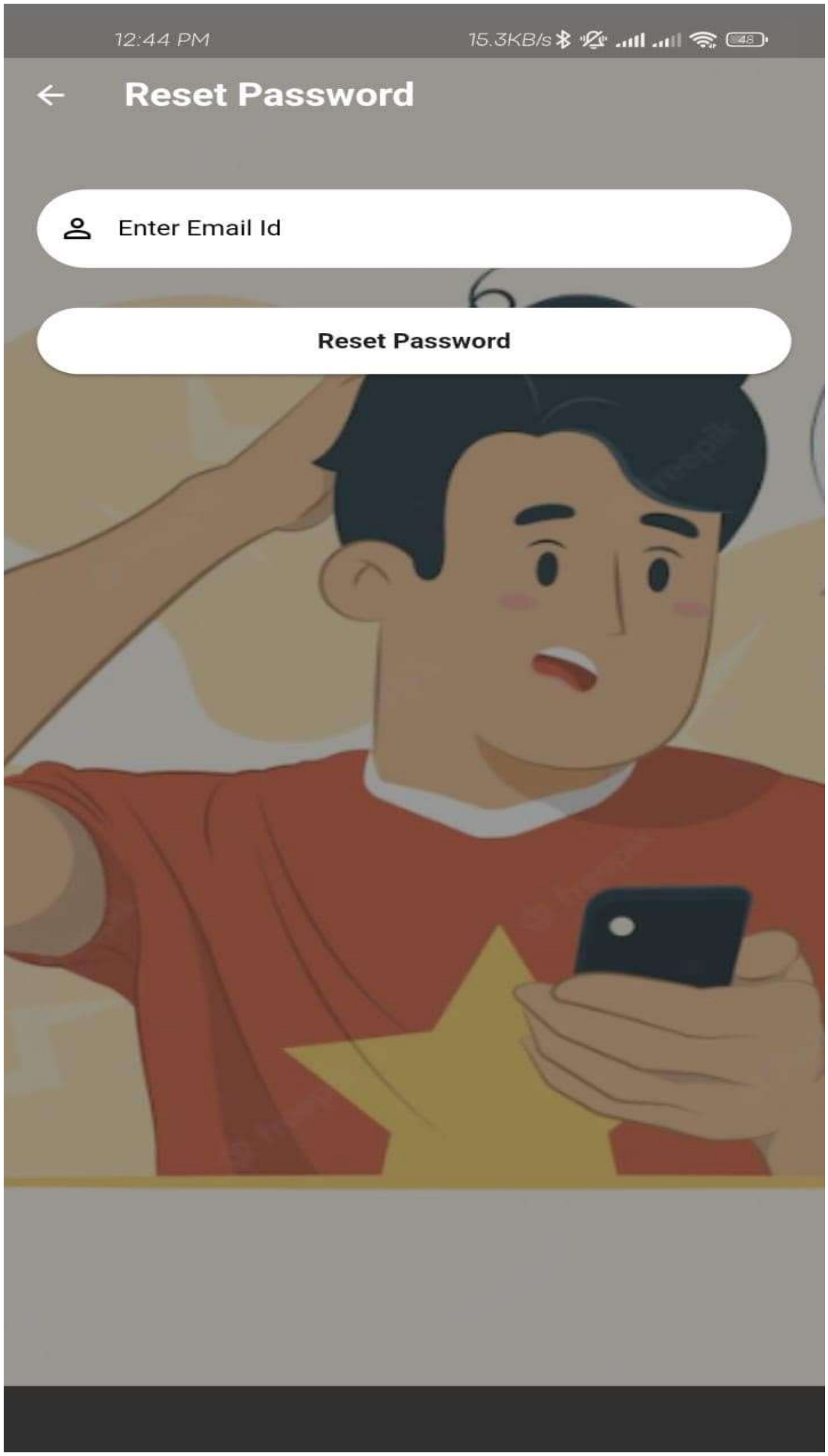

Figure 24 - Forgot Password

8.5 Search Destination:

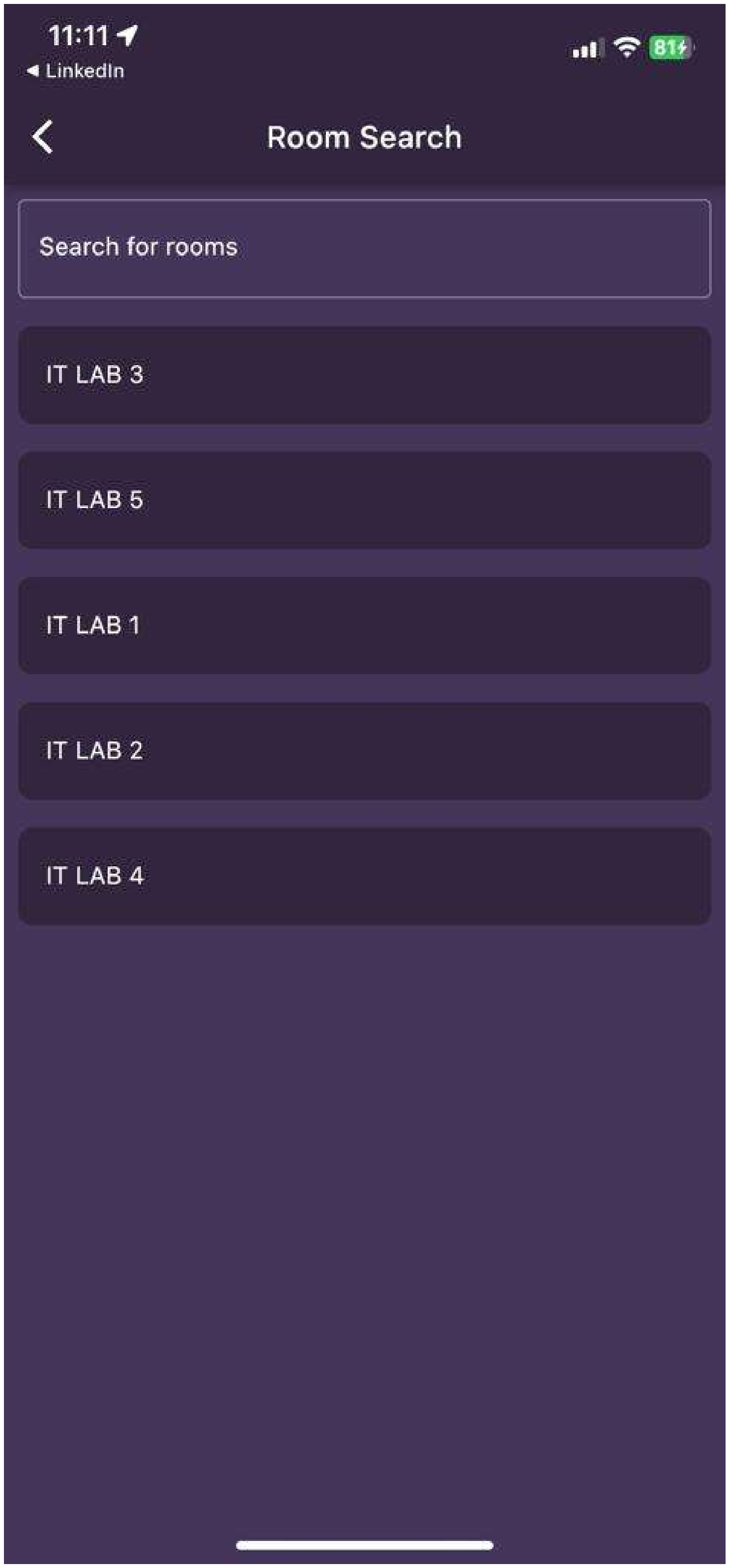

Figure 25 - Search Destination

8.6 Node Selection

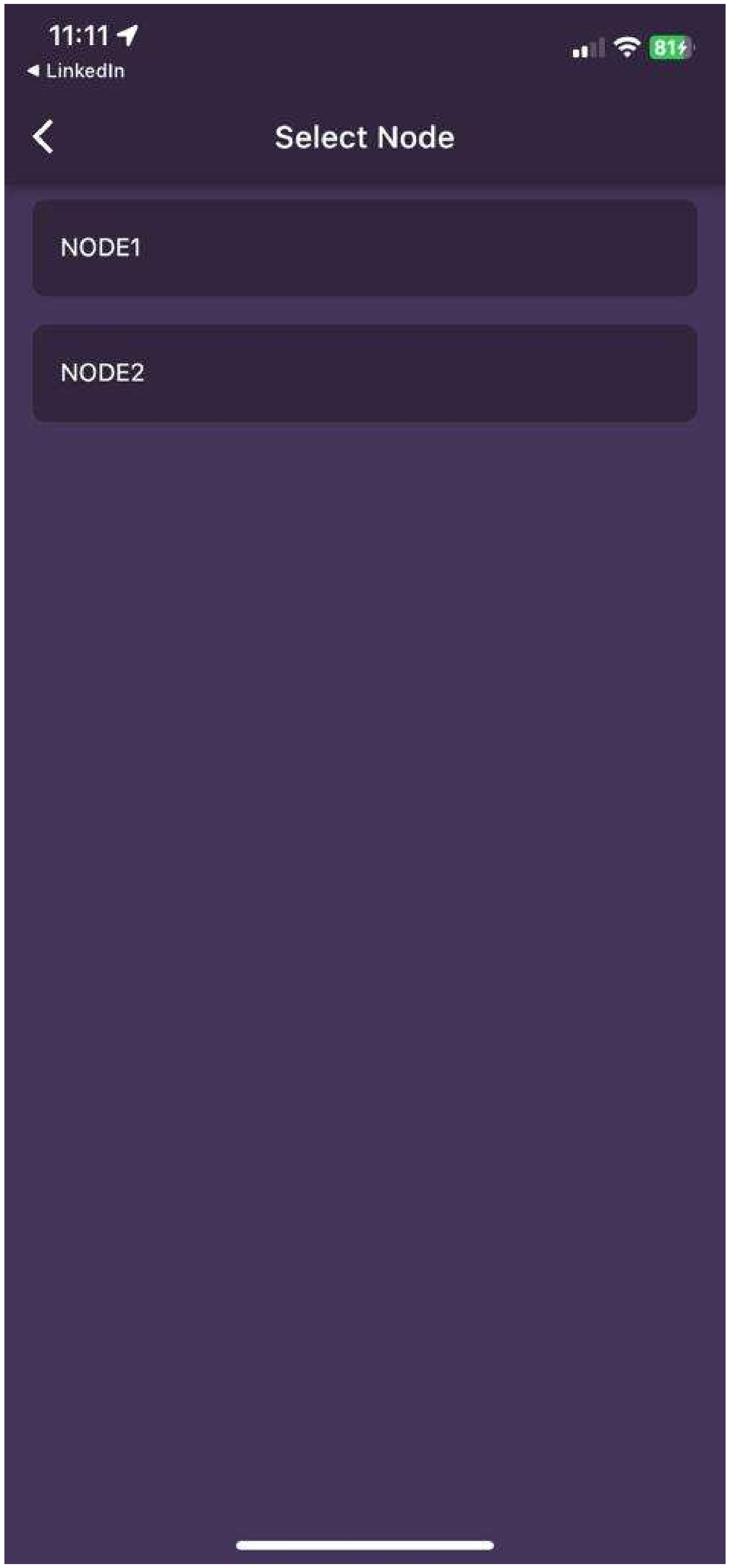

Figure 26 - Destination Result

8.7 Navigation:

Figure 27 - Navigation

8.8 User/Admin Login

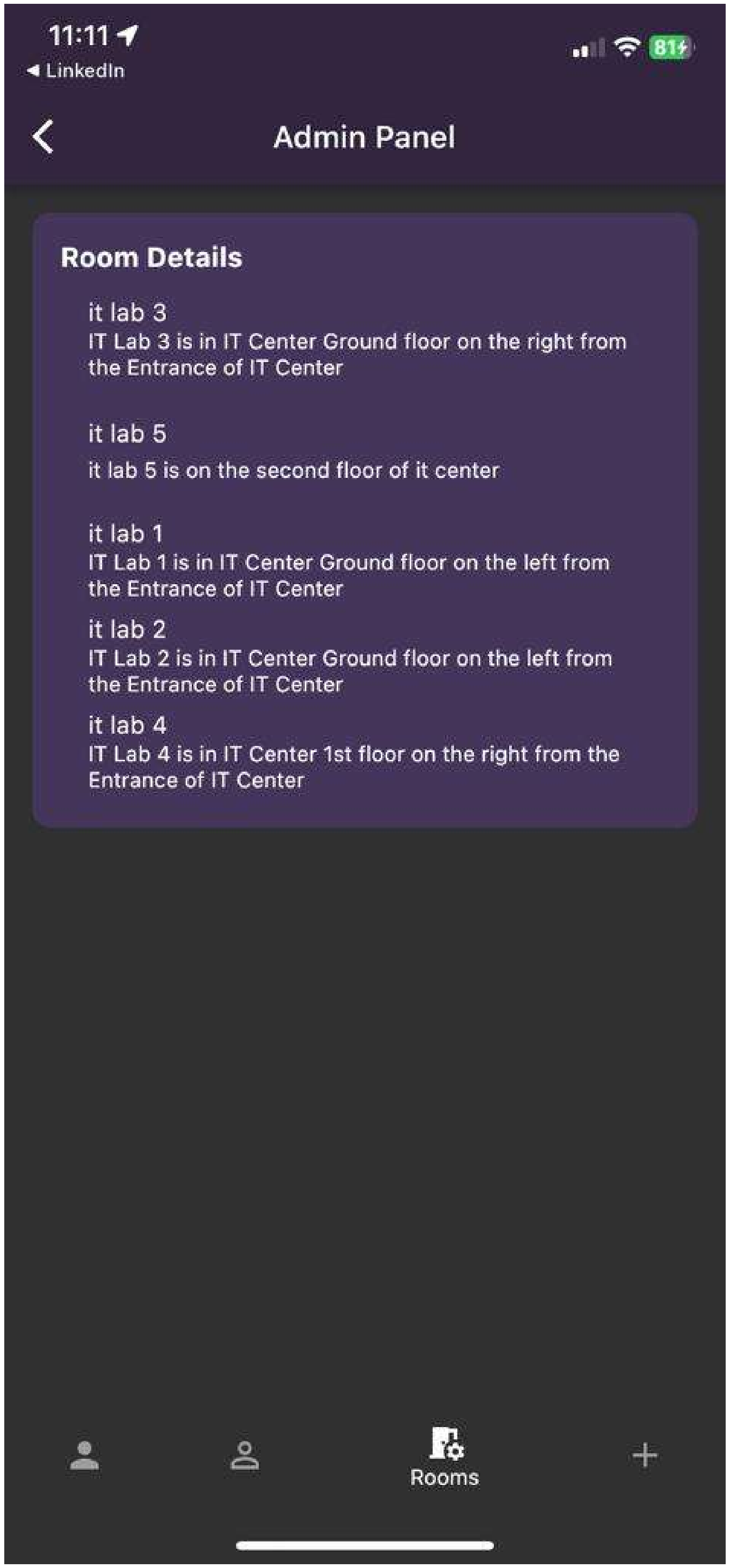

Figure 28 - User Admin Login

Chapter 9

Limitation and Future

9.1 Limitation of Project

Certainly, there are a few limitations that our project still have to over. But keeping in view the limitations of project we've certain strategies in mind that could be of massive help to make it more better and expandable. Following are the limitations that our project can face.

- **Internet Connectivity:** Disruption of internet can cause a little uncertainty in the user experience as the user will have difficulty while using the app.
- **Bluetooth Beacon Range:** Bluetooth Beacon has a certain range but when the user will keep on moving away from the beacon it'll stop the navigation certainly. The accuracy will also be effected.
- **Battery Consumption:** The combined use of Firebase, Bluetooth, and augmented reality can be resource-intensive and may lead to increased battery consumption.
- **Offline Functionality:** As the app relies on Firebase as the database, it'll have limited app functionality. Functions related to destination and information retrieval will also be impacted.

9.2 Future of Project

The scope of this project is vast. Day-by-day the need of indoor navigation is increasing inside large buildings such as Offices, Airports, Hospitals, Shopping malls etc. We're planning to firstly fully develop it for our department. Afterwards, when it'll giving the effective results we'll further expand it on the market level. The demand of this project is highly trending in the foreign market. Keeping in view, the increasing demand for this project we're confident enough to make it stable enough that it'll be able to compete on market level.

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