SMART MOBILE PET TRACKING SYSTEM

BY

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ABSTRACT

Despite the significant advancements in IoT sector, many pet owners still rely on inefficient search methods such as physical searches, posters and social media advertising. These methods not only pose financial burdens in pet owners but are also time-consuming and offer no guarantee of successfully locating lost pets or ensuring their survival. Additionally, the emotional toll of losing a pet can be substantial to pet owners too. This smart mobile pet tracking system addresses these challenges by enabling pet owners to track their pets' current locations and narrow down search areas based on their activity patterns. This project involves the development of a smart mobile pet tracking system designed for pet owners. The app allows pet owners to track their pets' real-time location and view their pets' travel path history which helps in determine their activity areas. The integration of a GPS tracking system ensures an unlimited tracking range.

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LIST OF SYMBOLS

Φ	Phi
λ	Lambda

LIST OF ABBREVIATIONS

GPS	Global Positioning System
RFID	Radio Frequency Identification
SMS	Short Message Service
SIM	Subscriber Identification Module
IoT	Internet of Things
WI-FI	Wireless Fidelity
iOS	iPhone Operating System
SQL	Structured Query Language

Chapter 1

Introduction

There is no denying the close relationship that exists between people and their pets, and many people view their pets as beloved family members. On the other hand, losing a pet may be a terrifying experience for both the animal and the owner. When their pets disappear, many pet owners still turn to traditional search techniques including physical searches, seeking professional assistance, and contact facilities **[1]**. These old-fashioned methods not only cost pet owners money but also take a lot of time and don't guarantee that missing animals will be found or survive. Furthermore, losing a pet can have a significant emotional toll on pet owners, negatively affecting their mental health and creating great sorrow **[2]**. Thus, a smart mobile pet tracking system has been created in response to these difficulties, addressing the drawbacks of conventional techniques. With the use of this cutting-edge technology, pet owners can always monitor the whereabouts of their animals and focus search areas according to their pet's path history.

The project involves developing an app that is easy to use and tailored especially for pet owners using mobile phone. Pet owners can use this system to follow their pets' current location and see a history of their travel routes which can help identify their activity areas and possible destinations. The user-friendly interface of the app ensures accessibility for pet owners with varying degrees of technological ability. Incorporating a GPS tracking system also guarantees an infinite tracking range, offering pet owners reassurance and an increased probability of finding their missing companions. This smart mobile pet tracking system provides pet owners who are experiencing the distress of a missing pet with a more trustworthy and effective solution by utilising the power of IoT and GPS technology.

The emotional and financial strains associated with pet loss can be mitigated by this system which not only makes it easier to find a lost pet but also greatly raises the likelihood of a happy reunion. In this paper, we will delve into the development and functionality of this smart mobile pet tracking system, outlining its features, benefits and potential impact on pet owners and their beloved companions.

1.1 Problem Statement

1.1.1 Inconvenient Web Application for Pet Owners

One primary issue is the inconvenience faced by pet owners when using web applications to track their pets during the search process. With the advancement of information technology, web applications can now be accessed by both computer and smartphone users through websites. However, these web applications were originally designed to cater computer users, so its layouts and contents are designed and optimized for computer screen sizes rather than smaller smartphone screens. Although responsive web design techniques have been introduced to enhance mobile friendliness, they often result in cramped content, disappearing images and extended development times. Additionally, web applications often feature an auto-logout session mechanism that automatically logs users out after a long period of inactivity for security purpose **[3]**. This poses a significant challenge for pet owners who desperately searching for their lost pets as they must continually divert their attention to prevent auto-logout sessions from initiating.

1.1.2 Limitations of Microchip Implants

Second challenge arise from the limitations of microchip implants in tracking missing pets. While many developed countries such as United States of America, European countries and Canada have implemented mandatory microchip implant policies for pets, such mandates are not in place in Malaysia except for imported pets and those required to travel internationally. Consequently, there is not centralized government database available for pet owners to verify their pet's identification. Besides that, microchip implants rely on passive radio-frequency identification (RFID) which requires a scanner to extract owner's personal information within a very close range. This means that microchips cannot track pet's location when it goes missing, instead they aid in identifying pet's owner once the pet is found.

1.1.3 Low Likelihood of Finding Missing Pets

Third significant issue is low likelihood of recovering missing pets. Domesticated pets have lost much of their wild nature and possess limited survival skills. When pets escape from their owner's homes and roam in unfamiliar areas, there is a higher risk of them being attacked by stray animals, abducted by strangers or injured in accidents. For instance, among 1044 missing cats, only one-third have a chance of surviving for seven days while the chances increase to

50% at 30 days and 56% at 61 days **[1]**. The faster the pet owners can pinpoint their pet's location and retrieve them, the greater the likelihood of their pets avoiding unpredictable injuries or accidents.

1.2 Motivation

In this project, we aim to develop a smart mobile pet tracking system, integrating a mobile application, GPS tracking system and a travelled path history system. Using mobile application, we can focus on designing a user interface that perfectly suits smartphone screen sizes and mitigates issues such as untimely auto logout, thus ensure pet owners can comfortably use our system. Thanks to its relatively small size and weight, mobile application also more useful and convenience for pet owners to track their pets during physical searching of their lost pets. By storing users and pets' information within a secure database, auto-login functionality can be enabled, pet owners able to track their pets with minimal efforts too. This convenience is invaluable when pet owners are already facing stress of their missing pets.

A GPS tracking system will also be developed using GPS chips to provide precise and real-time location data, thus empowers pet owners with real-time tracking capabilities at indoor and outdoor. WI-FI chip with support of SIM card will be used to stable transmission of location data via WI-FI at indoor environment and via cellular data at outdoor environment. Bluetooth chip also being utilized to enable pairing process and Bluetooth connection with mobile application. Furthermore, this GPS tracking system will be designed into a collar to minimize any discomfort experienced by pets when they are wearing while still capable to generate real-time location data to mobile application for users to track their location. In addition to real-time tracking, this system will also record and store the paths travelled by pets. This data will be presented to users, offering insights into their pets' favourite routes and approximate activity areas. These details are invaluable when pet owners are attempting to locate their lost pets as this enhance the chances of a successful reunion. Besides, to ensure stable data transmission,

1.3 Project Objectives

Our project which aims to create a smart mobile pet tracking system has total three objectives, which are:

1. **To develop a mobile application for tracking purpose instead of using web application**.
    - Easier for pet owners to track their pets using smartphone.
    - Mobile application is more suitable for smartphone screen size.
2. **To track pet's real time location using GPS tracking system**.
    - Provides real-time tracking capabilities and unlimited tracking range.
3. **To develop a travelled path history system**.
    - Know pet's favorite path.
    - Determine pet's activity area.
    - Minimize searching area.
    - Easier to pinpoint possible locations when their pet gets lost.

1.4 Project Scope and Direction

This project aims to develop a smart mobile pet tracking system which consist of three core components, a pet tracking mobile application, a GPS-based pet tracking system and a database system. First is **pet tracking mobile application**. This application will allow users to perform actions such as signing up, logging in, creating and storing both user and pet profiles and binding the application with GPS tracking system using Bluetooth connectivity. Mobile application also offers features to display pet's live location in real-time and its travelled path history. **GPS-based pet tracking system** will be employed using a smartphone to effectively track and generate real-time location data for pets in Malaysia. The employment of this smartphone only limited to pets that can withstand the weight of device This device will be the backbone of our system as it tasked to transmit location coordinates like longitude and latitude to database system. **Database system** will be created to serve as repository for all user and pet profile information as well as historical data related to pet travel routes and facilitate data retrieval and processing.

1.5 Contributions

Our project offers several contributions aimed at providing real-time tracking capabilities, enhancing experience of pet owners and improving chances of reuniting lost pets with their owners.

1. **Mobile Application Centric Approach**
    - Adoption of a mobile application over a traditional web application
    - The mobile application is tailored specifically for smartphones.
    - Enables pet owners to track their pets' real-time locations from anywhere and at any time.
    - Significantly enhances users' mobility compared to web-based alternatives.
2. **GPS Tracking System**
    - GPS tracking technology selected for integration due to its high cost-effectiveness and performance.
    - Provides unlimited tracking range and real-time tracking ability.
    - Ensures pet owners have access to precise and up-to-the-minute location data for their pets.
    - Enhances the ability to locate pets swiftly and efficiently.
3. **Travelled Path History System**
    - Development of a travelled path history system
    - Allows pet owners to gain insights into their pet's behaviour and favourite routes.
    - Stores and displays paths travelled by pets with its approximate activity area.
    - Useful, especially when searching for lost pets, increasing the likelihood of successfully locating missing pets by determining pets' activity area based on its travelled route.

1.6 Report Organization

This report contains total seven chapters. In first chapter, the report begins with introduction of this report then an overview of problem statement which are inconvenience of web application for pet owners, limitation of microchip implants and low likelihood of finding missing pets. Following the problem statement, project motivation, objectives, scope and direction, contribution and report organization was listed to function as a roadmap for readers.

Chapter two presents a comprehensive review of literature, focusing on review of technologies and previous works. For review of technologies, this section provides an overview of mobile operating system, database and programming language used with a detailed summary. For review of previous works, this section provides an overview of existing pet tracking system with some discussion on limitations presented on each work which followed by a comparison of previous works with limitation as summary.

Chapter three outlines the methodology and approach used in the development of smart mobile pet tracking system. This chapter is divided into methodology used which is rapid application development, system and functional requirements, project timeline with milestone, estimated cost and a concluding remark for this chapter. Chapter four focus on system design of smart mobile pet tracking system which covers system architecture diagram of system, use case diagram and activity diagram of mobile application and system flowchart for each activity of mobile application.

Chapter five details the implementation of the smart mobile pet tracking system such as hardware setup, software setup and settings and configuration for development and testing purpose, System operations which offers insight on what excepted output should each activity done for mobile application, implementation issues and challenges faced during this phase and a concluding remark.

Chapter six focus on providing evaluation of smart mobile pet tracking system and discussion of the system outcome and performance. This chapter includes testing and performance metrics of GPS tracking device, test case for mobile application, challenges faced during the project, evaluate how well the objectives being achieved and a concluding remark. Chapter seven provides conclusion and recommendation of report, focusing on summarize the result of project and provide suggestion for future research or development.

Chapter 2

Literature Review

This section provides a comprehensive review of technologies used and existing types of wireless technologies, types of locating technique and works on pet tracking systems. By carefully examining previous works and developments, we can gain valuable insights, extract innovative ideas and discern possible systems that align with the specific requirements of our project. Furthermore, limitations present in prior studies will be identified too to serve as guidance in avoiding similar pitfalls during development of the project system.

2.1 Review of Technologies

Throughout this section, detailed reviews and final selection of mobile operating system, database and programming languages used in this project will be shown.

2.1.1 Mobile Operating System

Current operating system market offers Android and iOS to mobile users. While both Android and iOS have their advantages, Android is more suitable for smart mobile pet tracking system due to several reasons. First, in terms of hardware diversity, Android's presence across various devices means that pet owners are not limited to use certain phone types. This is particularly helpful for pet owners in terms of pet tracking as not all users might have the latest devices. Android allows more people to access the service without needing to buy a new device while iOS, on the other hand, is limited to specific phone models, potentially limiting accessibility.

Besides that, Android is closely integrated with Google services including Google Maps. This integration makes it easier to utilize location-based services which are essential for smart mobile pet tracking system. Thus, using Android, real-time GPS tracking of pets can be efficiently implemented with the Google Maps API. While iOS does have integration with Google services including Google Maps, it might lack the deep integration Android offers.

Moreover, Android allows deep customization which allows developers to include features like customized alerts and integration with other apps, thus improving the efficiency and smoothness of pet tracking experience. Apart from that, thanks to Android’s open-source

nature, it provides more flexibility for developers to integrate new features and technologies. This allows for more rapid innovation, enabling pet tracking apps to incorporate the latest advancements in GPS and data tracking. In contrast, iOS is more restricted, offering limited flexibility compared to Android.

Finally, Android smartphones are more affordable for a wider variety of consumers due to their wide range of costs. Accessibility is crucial for a pet tracking system, and Android devices' lower price guarantees a larger user base. Conversely, iOS devices tend to be more expensive, which can restrict user accessibility. In summary, Android is more suitable as the operating system for our project. Table below shows the summary of comparison of Android and iOS.

Criteria	**Android**	**iOS**
Hardware Diversity	Presence across various devices, allowing more accessibility	Limited to specific phone models which potentially limiting accessibility
Google Services Integration	Closely integrated with Google services including Google Maps	Integration with Google services including Google Maps
Customization	Deep customization allows for highly tailored applications	Offers limited customization compared to Android
Development Flexibility	Open-source nature provides flexibility for developers	More restricted, thus provide limited flexibility compared to Android
Cost Consideration	Wide range of price points, making it more accessible to a broader demographic	Generally higher priced, potentially limiting user accessibility

Table 2.1.1.1 Comparison of Android and iOS

2.1.2 Database

Firebase and SQL database were offered to become database for our system. After comparison, Firebase was selected based on several reasons. In terms of real-time update, Firebase has a built-in real-time database which makes it ideal for tracking pets' live location while it is possible to achieve real-time updates using SQL database, additional setup is required which may take longer development time. Regarding cost, as our project is a small project, Firebase can be cost-effective as it can be started for free and only pay when size growing until reaching a limit while the SQL database may cost certain amount of money even if the scalability of project is small.

For a pet tracking system which constantly evolve in functionality, Firebase's flexibility makes it ideal for agile development environments and allows for data format modifications while presence of rigid structure and need for schema adjustments causing SQL databases to become less flexible. Moreover, Firebase is easy to set up with Firebase Authentication, thus easier to setup user authentication and access control while SQL databases offer more control over security settings with customizable security features and fine-grained access control. In short, Firebase is more suitable to act as database for the system. Table below shows the summary of comparison of Firebase and SQL.

Criteria	Firebase	SQL Database
Real-time Updates	Built-in real-time database	Requires additional setup which takes longer development time
Cost	Can be cost-effective for small to medium projects as user can start for free and only pay when limit reached	Cost may increase with scalability which may be higher for large projects and heavy usage
Flexibility	Highly flexible, thus suitable for agile development environments and accommodating changes in data structure	Less flexible as more rigid structure requiring changes in schema for any modifications
Security	Easy to set up with Firebase Authentication, thus easier to setup user authentication and access control	More control over security settings, customizable security features, offers fine-grained access control

Table 2.1.2.1 Comparison of Firebase and SQL Database

2.1.3 Programming Language

Java and Kotlin are the two main programming languages used by Android Studio to create Android applications. While Kotlin offers many modern features and a more concise syntax, there are several reasons to stick with Java. With decades of experience, the mature Java language provides stability and broad support from a sizable development community. Java applications can run on any device that has a Java Virtual Machine (JVM) thanks to its platform neutrality. Its object-oriented architecture also promotes the use of design patterns and neat code organisation which fits the documentation requirement of the project.

Although Java has a propensity for verbosity which increases boilerplate code and may have a learning curve for newcomers, this can be significantly reduced by support from large community base, extensive documentation, guides, libraries and Java 14 Records.

Criteria	Java	Kotlin
Community Support	Have a large and mature community of developers, providing extensive resources.	Growing community with increasing support, but smaller compared to Java.
Language Features	Offers an object-oriented paradigm, promoting clean code organization.	Provides concise syntax, modern language features like null safety, and interoperability with Java.
Platform Independence	Applications can run on any device with a Java Virtual Machine (JVM).	Interoperable with Java, allowing seamless integration into existing Java projects.
Development Speed	Tends to be more verbose, but can be reduced with help of libraries and Java 14 Records	Offers a more efficient development experience with concise syntax and modern features.
Learning Curve	Gentle learning curve since it is an established language, but new developers may find the verbosity challenging.	Features modern language elements which may require a learning curve for developers unfamiliar with its features.

Table 2.1.3.1 Comparison of Java and Kotlin Programming Language

2.1.4 Summary of Technologies Review

For mobile operating system, Android is the preferred operating system for a smart mobile pet tracking system due to its hardware diversity, close integration with Google services, deep customization capabilities, open-source nature, and affordability. Android's presence across various devices ensures accessibility, while its integration with Google services particularly Google Maps allows for efficient real-time GPS tracking. The deep customization and open-source nature of Android facilitate rapid innovation thus making it more suitable than iOS for the smart mobile pet tracking system.

For database, Firebase was selected as the database for the system due to its built-in real-time database, cost-effectiveness, flexibility, and ease of setup with Firebase Authentication. Firebase's flexibility makes it ideal for agile development environments, accommodating changes in data structure, while SQL databases are less flexible due to their rigid structure. Although SQL databases offer more control over security settings, Firebase's ease of setup and cost-effectiveness make it more suitable for the pet tracking system.

For programming language, Java is chosen as the programming language due to its stability, broad support from a large development community, platform independence, and object-oriented architecture. Although Kotlin offers modern features and a more concise syntax, Java's maturity and extensive resources make it the preferred choice. Despite Java's propensity for verbosity, the support from a large community, extensive documentation, libraries and Java 14 Records can help in mitigating this issue.

In conclusion, our mobile application for pet tracking will be developed using Java programming language and focus on Android while Firebase was selected to become the database system of our smart mobile pet tracking system.

2.2 Previous Works on Pet Tracking System

In this section we will focus on three existing works which used different wireless communication technologies and locating techniques.

2.2.1 An SMS-Based Pet Tracking System

Zhang **[4]** introduced an innovative IoT-based mobile pet tracking system that leverages SMS for transmitting GPS location data to users across Canada. Unlike many pet tracking systems reliant on Device-to-Device communication which typically necessitate users to have data plans or access to WI-FI networks, this system offers a distinct advantage. According to information from MobileSyrup **[5]**, Canada stands out as one of the costliest countries for mobile data where streaming an hour of Netflix costs approximately $12.55 USD. In contrast, majority of monthly mobile plans often include unlimited SMS text services. Consequently, this SMS-based approach eliminates the need for data plans. This helps in increasing system's accessibility and appeal to users who prefer not to rely on expensive data services for pet tracking.

2.2.2 PetTracker – Pet Tracking System Using Motes

In the work by Tang et al. **[6]**, a specialized pet tracking system was introduced with a primary focus on indoor pet tracking using radio frequency technology. The primary goal of this project is to offer users comprehensive insights into their pet's location, activity levels and surrounding indoor environments. To achieve this, pets are equipped with a mobile mote which includes environmental sensor boards. Additionally, multiple stationary motes are strategically placed throughout the indoor environment.

Mobile mote worn by pet is responsible for generating real-time data related to pet's location and activity. Meanwhile, stationary motes serve as relay points, facilitating transmission of these vital information to recipient's personal computer. This innovative system not only tracks pets within indoor spaces but also provides valuable insights into their interactions with surrounding environment.

2.2.3 GPS-Less Animal Tracking System

Joshi et al. **[7]** introduced an innovative Wireless Sensor Network based animal tracking system designed to monitor the movements of small-sized animals for which GPS tracking is not suitable. Primary objective of this project is to provide wildlife researchers with a versatile tracking system capable of accommodating animals of varying sizes and behaviours. This system encompasses collection of critical data such as animal movement patterns, behaviour, micro-climate and hibernation periods.

To accomplish this, mobile sensor nodes are attached to animals serving as data collection points. Data collected by these mobile sensor nodes is then transmitted back to researchers for further analysis and research purposes. This tracking system is particularly well-suited for animals characterized by small size, slow movement speeds and limited home ranges. Through this system researchers are able to obtain valuable insights into behaviour and habits of these creatures for wildlife research and conservation efforts.

2.3 Limitation of Previous Studies

Project proposed by Zhang **[4]** employed SMS services for data transmission. But there is a significant limitation arises from lack of inherent encryption in traditional SMS services **[8]**. This necessitates the development and integration of a secure encryption system into the project, leading to increased development costs and time.

System developed by Tang et al. **[6]** relies on radio frequency technology and motes which result in facing limitations related to cost and tracking range. Multiple stationary motes are required to act as data relays, incurring additional costs. Moreover, tracking range is limited to areas covered by stationary motes which poses challenges if pets move beyond the tracking range. Additionally, the use of personal computer as a receiver restricts mobility of recipient.

System built by Joshi et al. **[7]**, designed for small-sized animals, presents challenges related to localizing tracking targets without GPS. Developing a localization algorithm based on existing techniques is necessary which increase development time. Multiple fixed sensor nodes are required as relay stations and must be strategically placed based on chosen localization technique which also incurs additional project costs. Furthermore, the system is best suited for animals with limited home ranges as larger home ranges would demand more

fixed sensor nodes for effective tracking. Additionally, an algorithm must be developed and able to adapt to changing environmental conditions to ensure accurate results.

2.4 Comparison on Previous Works and Its Limitation

Previous Work	Function	Limitation
An SMS-based Pet Tracking system	Use SMS service to transmit location data instead of using WIFI or cellular data	Traditional SMS Service does not provide encryption. Pet tracking system needs to include additional encryption system.
PetTracker - Pet Tracking System Using Motes	Track pet's location, activity and surrounding environment to user within indoor environment	Requires multiple stationary motes to relay data which is costly. Tracking range limited to indoor environment. PC as receiver which limits user's mobility.
GPS-less animal tracking system	Track movement, behaviour, micro-climate and hibernation period of small size animal. Suitable for animals which has small size, slow speed and small home range	Requires localization algorithm to localize target. Only suitable for animals which has small home range. Requires additional algorithm to produce more accurate result and fits environmental changes.

Table 2.4.1 Function and Limitation of Existing Pet Tracking System.

Chapter 3

System Methodology/Approach

This chapter provides a comprehensive overview of the methodology employed, hardware and software utilized, system requirements, project timeline with milestone set, and the estimated cost for the implementation of the smart mobile pet tracking system.

3.1 Methodology

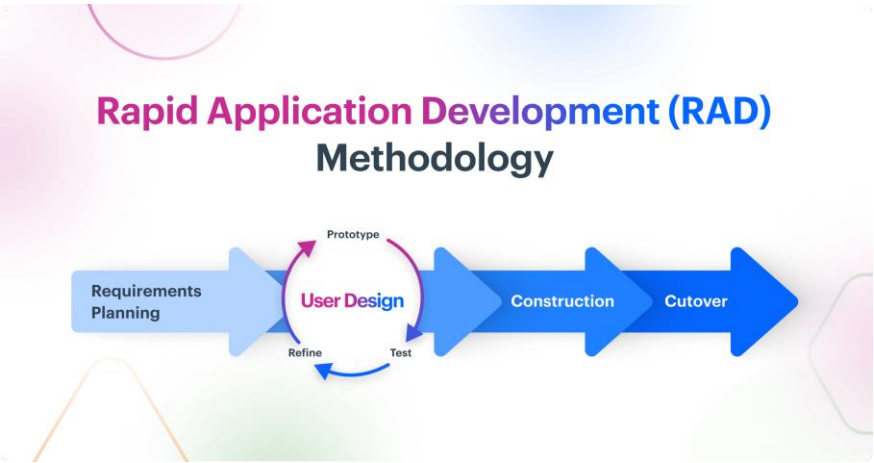


Figure 3.1.1: The Visual Representation of Rapid Application Development.

Source: Adapted from **[9]**

Rapid Application Development is a software development methodology that prioritizes speed and flexibility in the creation of software applications. It aims to accelerate development process by emphasizing rapid prototyping and quick feedback cycles. Rapid Application development methodology is made up of 4 phases which are requirement planning, user design, construction and cutover.

First phase is requirement planning. In this phase, developers, potential users and stakeholders such as supervisors will collaboratively defines high-level requirements and objectives of the system. It aims to establish a shared understanding of what the system should achieve. In this project, system requirements will be collected from supervisors and friends who have pets. For the results, this smart mobile pet tracking system will be expected to have a mobile application to show users real-time location and travelled path history of their pets, a GPS tracking system for providing pet's data location and a database for data storage and retrieval.

The second phase involves developing and refining prototypes for the mobile application, GPS tracking system, and database system with an emphasis on user-centric design. For the mobile application, users will be able to watch the real-time whereabouts of their pets and view their travel history on a Google Map interface by interacting with the application through login and signup features. Users can maintain pet profiles on a pet's page which is required for tracking feature. A user profile page also provides choices for viewing, amending, and logging out of the profile. For precise location data transmission in both indoor and outdoor settings, the GPS tracking system combines GPS, SIM card, WI-FI, and Bluetooth technologies. User and pet profiles, location data, and binding information between the application and the tracking system are all stored in a database system. Iterative testing and feedback loops make sure that prototypes are improved until they satisfy the requirements set forth by stakeholders throughout this phase.

Third phase is construction. This phase involved actual development of system. Developers will use the feedback from user design phase to build components of the system. Our systems will be created in separate parts, each of them is tested for a single functionality. Mobile application system will be developed and tested using android studio using Java programming language and virtual mobile device machine embedded to it. GPS chip, SIM card and Wi-Fi chip will be brought and assembled to form GPS tracking system and test whether the system works properly. Firebase will act as base of database system and configure to store GPS coordinates and user and pet's profile and firebase website will be used to debug error occur in firebase. Separate systems will then be combined to create mobile pet tracking system and test rigorously. GPS tracking system will transfer and store location data to firebase and mobile application will retrieve those location data from firebase to activate real-time location tracking and travelled path history system. Profile of pets and users and GPS tracking system binding data will be stored in firebase too.

Last phase is cutover. Mobile pet tracking system will be shown to supervisor for checking and evaluation purposes. Supervisor may provide feedback to any possible bugs or errors occur when using the system and then perform maintenance regularly.

3.2 System Requirements

Throughout this section, we will focus on hardware and software used in this project.

3.2.1 Hardware

The hardware involved in this project is laptop, GPS tracking device and android mobile device. A laptop used for development of mobile app aims to receive and process pet's location data for user. A GPS device will be tasked generating pet's real time location data. A mobile device is used for establishing connection with GPS collar using Bluetooth and act as receiver for pet's data location and test mobile app developed.

Table 3.2.1.1 Specifications of Laptop

Description	**Specifications**
Model	HP Laptop - 15s-du2029tx
Processor	Intel(R) Core (TM) i7-1065G7 CPU @ 1.30GHz
Operating System	Windows 11
Graphic	NVIDIA GeForce MX330, Intel(R) Iris(R) Plus Graphics
Memory	4GB Samsung 2667MHz, 4GB Kingston 2667MHz
Storage	476.94 GB SAMSUNG MZVLB512HBJQ-000H1

Table 3.2.1.2 Specifications of Android Mobile Device

Description	**Specifications**
Model	Xiaomi 13T (2306EPN60G)
Processor	Dimensity 8200-Ultra Octa-core Max 3.1GHz
Android Version	14 UP1A.230905.011 | Android security update: 2024-01-01
Memory	12.0 + 4.0 GB
Storage	256GB

Table 3.2.1.3 Specifications of GPS Tracking System (Smartphone)

Description	**Specifications**
Model	Redmi Note 5 (M1803E7SG)
Android Version	9 PKQ1.180904.001
WLAN	Wi-Fi 802.11 a/b/g/n/ac, dual-band, Wi-Fi Direct
Bluetooth	5.0, A2DP, LE
Positioning	GPS, GLONASS, BDS

3.2.2 Software

Android Studio will be used as development platform for mobile application. Java will be the programming language in developing mobile application while programming language php will be used to establish connection and check data transmitted between GPS tracking system and firebase using Visual Studio Code. Firebase will be database to store user and pet's profile information and pet's location data.

3.3 Functional Requirements

To ensure that the system can function effectively, requirements were listed in below:

1. User Registration - pet owners should be able user accounts seamlessly either through email registration or by linking their social media accounts such as Gmail. This enables personalized tracking and interactions.
2. GPS Tracker Connection - users must have the capability to establish a secure Bluetooth connection between tracking device and mobile application for pairing process. This connection is vital for locating pet data for location updates.
3. GPS Tracker Data Transmission – Device must be able to switch between WI-FI module and SIM card during data transmission. In details, device should prioritize WI-FI connectivity at indoor environment and switch to cellular connectivity at outdoor environment or if WI-FI is unavailable.
4. Pet Profile Registration - users should be able to perform create, view, edit and delete pet profiles with details inside.
5. Live Tracking – mobile application must provide real-time tracking functionality, enabling users to monitor their pets' exact locations on a map at any given moment.
6. Path History – users should be able to view pets' travelled route displayed on the map and their activity area.
7. User Profile – users should allow to view and modify their profile.

3.4 Project Milestone

This part shows the timeline of project I and project II with its milestone.

3.4.1 Project I Timeline

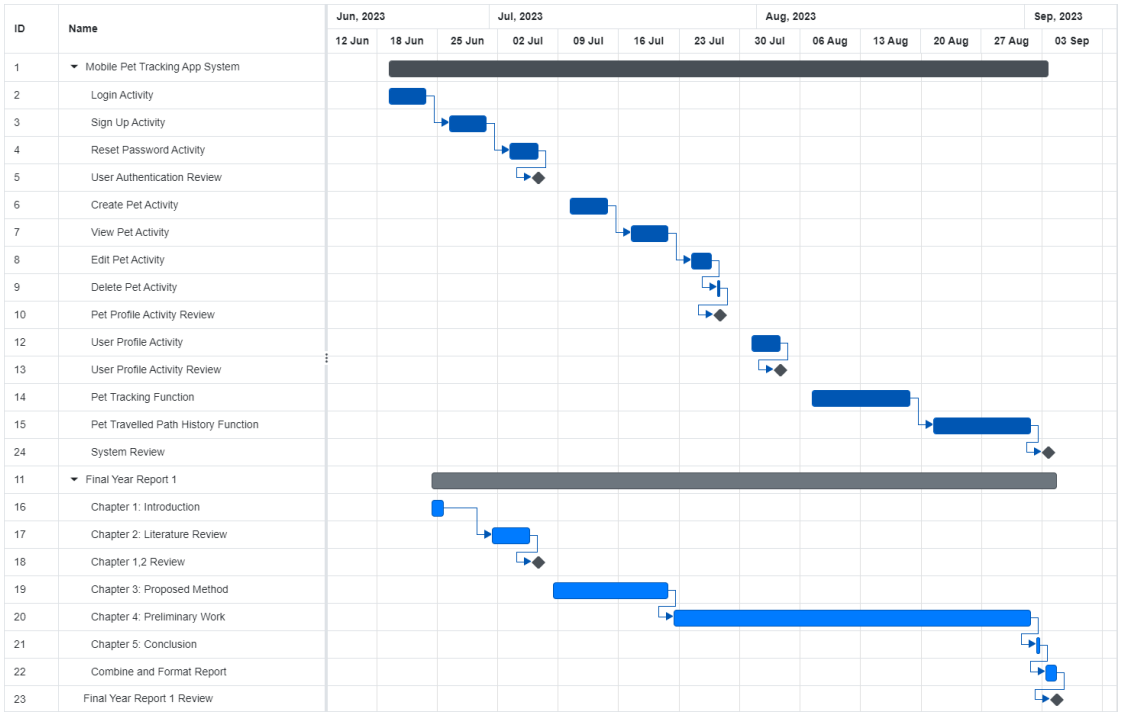


Figure 3.4.1.1 Gantt Chart of Project I Timeline

For smart mobile pet tracking system, the milestone is completion of user authentication process, user able to perform create, view, edit and delete pet profiles, user able to view their profile and perform logout and finally completion of pet tracking and travelled path function. For final year report 1, first milestone is completion of chapter 1 and chapter 2, second milestone is completion of full final year report 1 with inclusion of chapter 2, 3, poster, weekly report, Turnitin report and others.

3.4.2 Project II Timeline

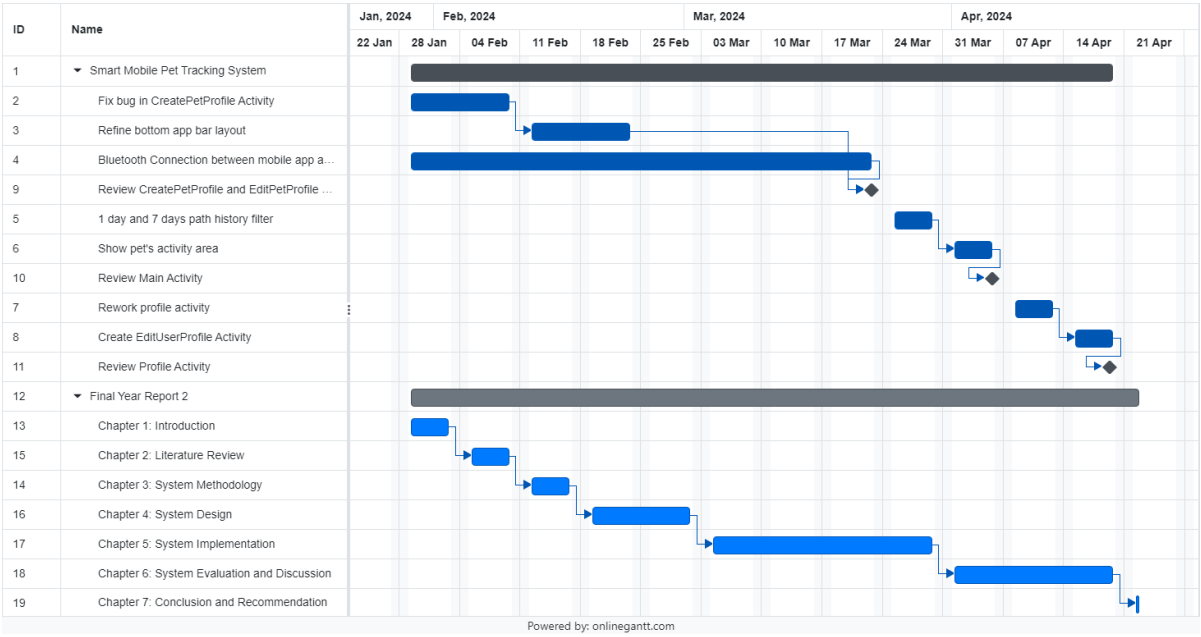


Figure 3.4.2.1 Gantt Chart of Project II Timeline

According to the project timeline. Early efforts focused on bug fixes related to creating pet profiles and refining the layout of the app's bottom bar. Throughout February, some work have been done in implementing Bluetooth connectivity to connect the app with a pet tracking device.

February also saw a code review for creating and editing pet profiles. By March, functionalities were being added that allowed users to filter a pet's location history and view their activity area. The timeline reflects ongoing review and rework of the main activity screen and profile activity screen throughout March and April which a new activity screen for editing a user profile was created and rework on profile activity was performed between March 17th 2024 and April 7th 2024.

While the timeline focuses on app development, it also provides insights into the progress of the final year report II. By the mid of February, the first two chapters, introduction and literature review, were completed. The timeline indicates that work on the remaining chapters, which are system methodology, design, implementation, evaluation, and conclusion with recommendations will be done before 21 April 2024.

3.5 Estimated Cost

The smart mobile pet tracking system use hardware which are smartphone and software which are Firebase and Android Studio. For software, Android studio is a free Integrated Development Environment is readily downloadable from its official website, thus no cost is needed. Additionally, Firebase offers a free plan encompassing essential features like Realtime Database, Authentication and Cloud Messaging which are crucial for real-time updates and user authentication for the system. These tools eliminate the need for direct expenditure on software. For hardware, since smartphone was used as GPS tracking device, no additional purchase of components such as GPS module and WI-FI module were needed.

In conclusion, the estimated cost of smart mobile pet tracking system was zero Ringgit Malaysia.

3.6 Concluding Remark

The implementation of the smart mobile pet tracking system utilizing Rapid Application Development methodology allows for the creation of a cost-effective solution. By utilizing readily available resources such as Android Studio and Firebase, the system has been designed to be both efficient and budget friendly. This approach ensures that the pet tracking system can be developed without incurring any direct expenses, making it an ideal solution for pet owners.

Chapter 4

System Design

This chapter focus on design of the smart mobile pet tracking system and the expected behaviour for each activity of the mobile application.

4.1 System Architecture Diagram

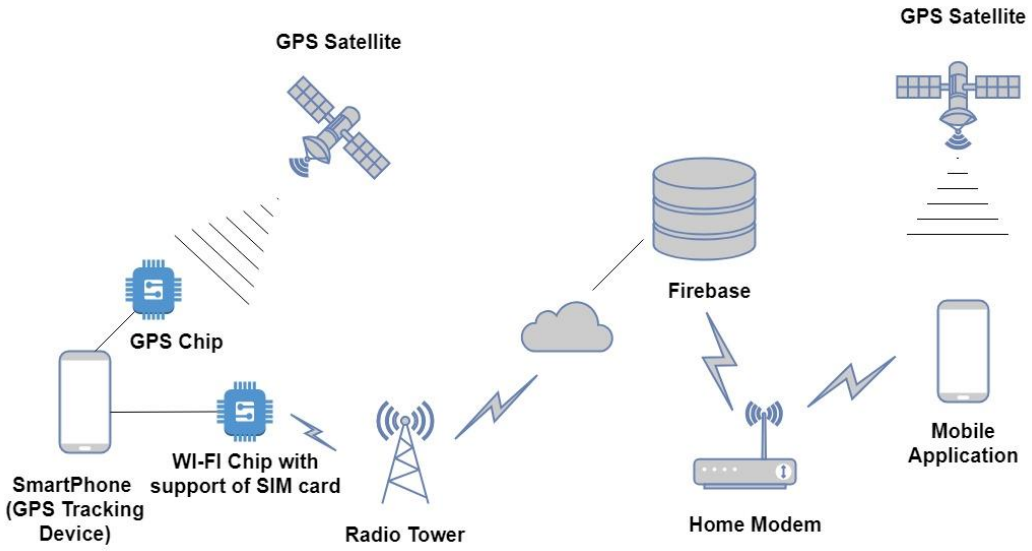


Figure 4.1.1 System Architecture Diagram of Smart Mobile Pet Tracking System

To guarantee precise pet monitoring and location, a smart mobile pet tracking system depends on a network of components. At the centre of it all are GPS satellites, which are in orbit around the Earth and send out signals with exact time and location data. The location of the pet must be determined via these signals to provide real-time tracking capabilities.

The GPS tracking gadget fastened to the pet's collar is the system's main component. Using the time it takes for the signals to travel, this device determines the pet's position by receiving signals from GPS satellites. Pet owners can use this technology to locate their pets with amazing accuracy, even in difficult-to-reach places.

Terrestrial radio towers and modem are crucial sites of contact for the GPS tracking gadget, Firebase and mobile app to stay in constant connection via WI-FI and cellular network. Even when the pet is not in direct line of sight of the GPS satellites, these towers can help to maintain contact by providing approximate pet’s location to the mobile app. Because of this strong

communication system, pet owners can consistently track the whereabouts of their animals and ensure stable data transmission for the system.

A smartphone application that interfaces with the GPS tracking gadget and Firebase enables pet owners to easily obtain their pet's location information. Real-time updates from the tracking device are sent to the Firebase first for storage purpose, then the application obtains the required location data which allows plotting of pet's location with its previous route history on a map. The application can also create, update and delete user and pet data which will then be stored in Firebase.

In addition, the system makes use of Firebase to handle, store, and retrieve location data, handle pet profile and handle user profile. The most recent information about a pet's location is always available to pet owners thanks to Firebase's ability to synchronise and update in real-time across devices. The smart mobile pet monitoring system offers improved usefulness and simplicity for pet owners looking for peace of mind by utilising cloud computing.

4.2 Use Case Diagram

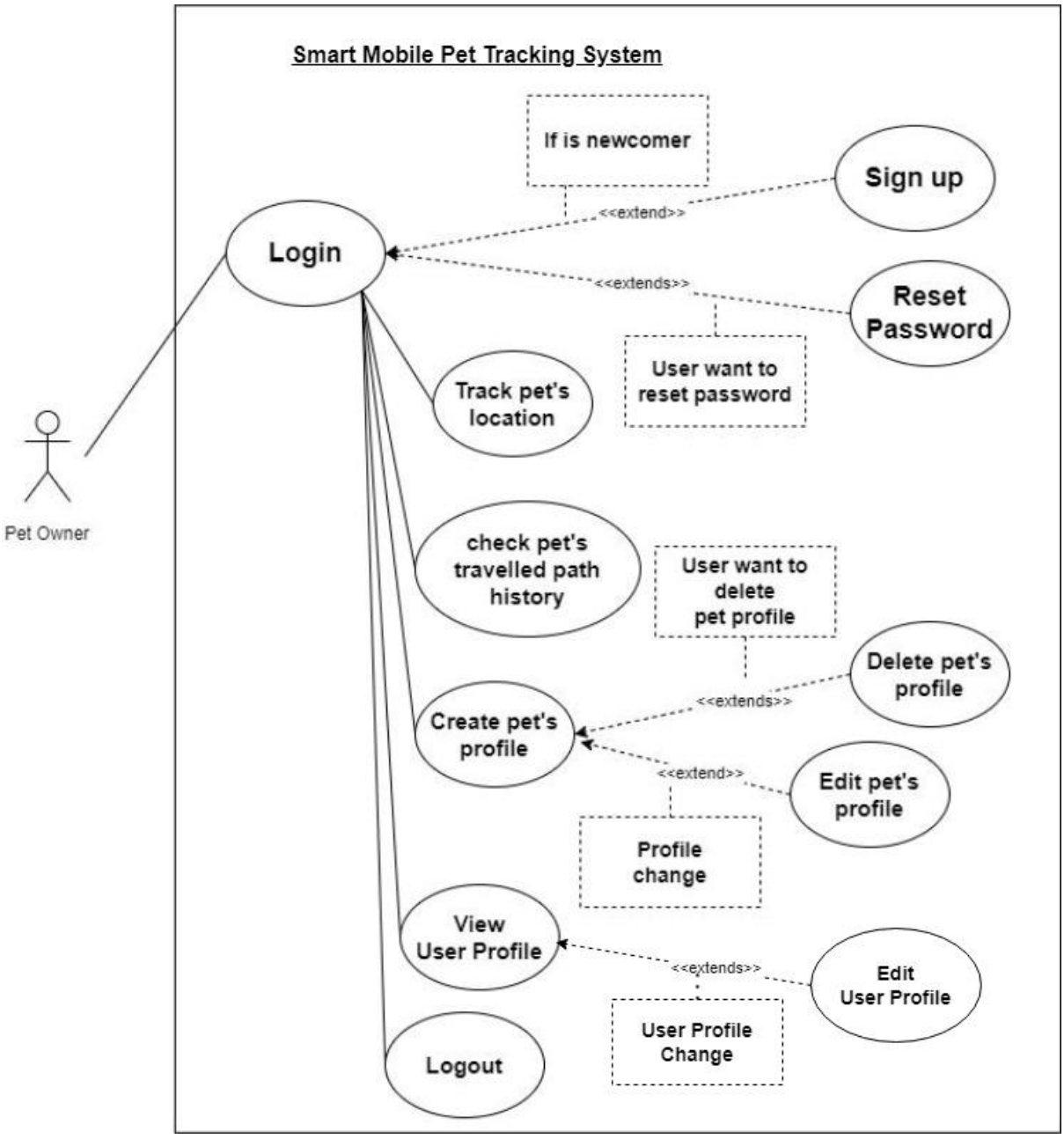


Figure 4.2.1 Smart Mobile Pet Tracking System Use Case Diagram.

Use case diagram is a type of diagram that is used to visually represent different ways that users can interact with the system. It also helps to illustrate functional requirements of our system from a user's perspective. Based on the use case diagram, users able to login, sign up, reset password, track pets' location and its travelled path history, perform create, edit and delete pets' profile functions, view and edit user profile and also logout from mobile application.

4.3 Activity Diagram

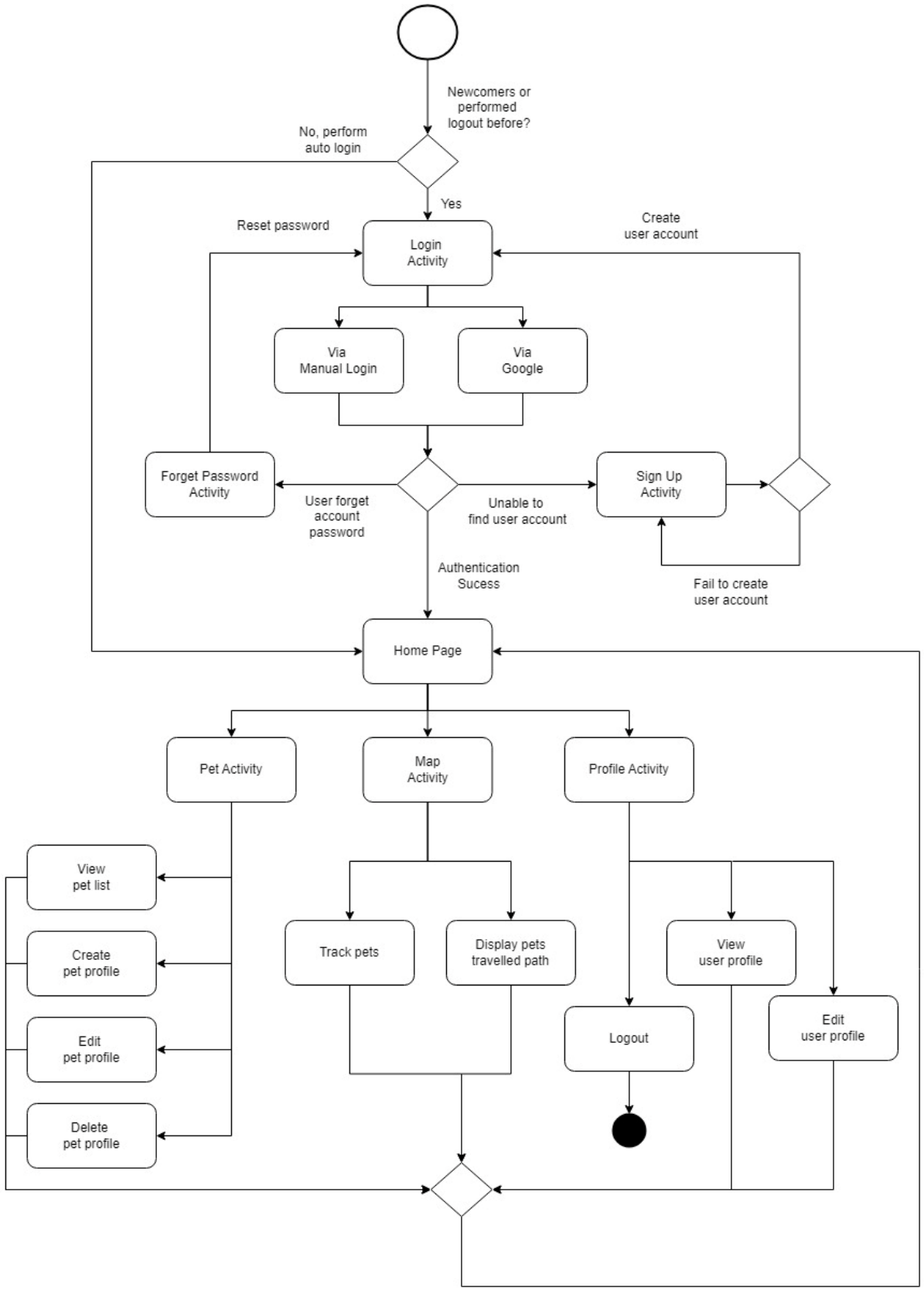


Figure 4.3.1 Smart Mobile Pet Tracking System Activity Diagram

Based on figure 4.3.1, users will first see login page. Users can decide whether to login manually or via Google, create a user account manually or reset password of user account. If authentication failed, users could move to sign up page to create a new user account and then redirect to login page for another authentication process. If users want to reset its account password, users can move to forget password activity to reset its password and then redirect to login page for another authentication process. For users who are not newcomers, successfully authenticated and didn't manually log out from the system, they will be redirected to home page which consist of pet activity, map activity and profile activity.

In pet activity, users can perform create, view, edit and delete function towards pet profile. In map activity, users will see a google map with markers on it for pet tracking purpose and also see routes which are the history of pets' travelled path. If users want to view or edit their profile, they can move to profile activity. Users also can perform manual log out by pressing log out button.

4.4 Database Design Diagram

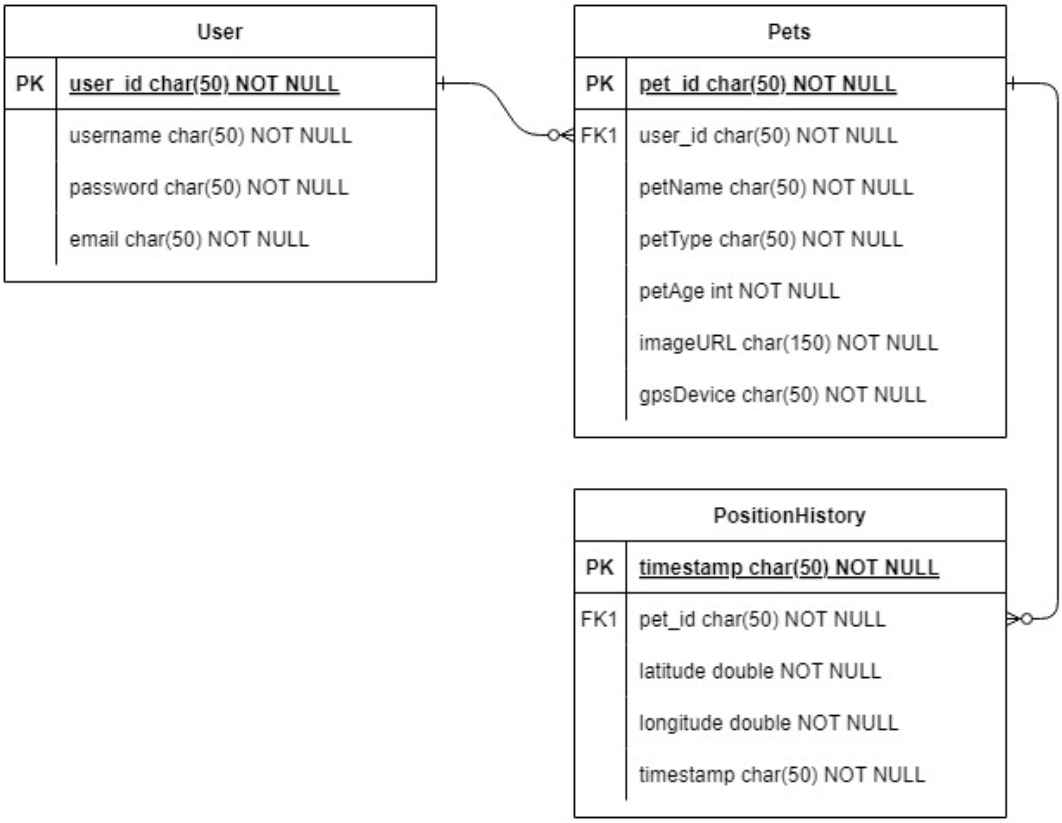


Figure 4.4.1 Database Design Diagram of Smart Mobile Pet Tracking System

The **Users** table stores user username, email address and password. Each user is uniquely identified by a user_id. This table enables the system to manage users' authentication and security. The **Pets** table stores details about the pets, linked to their respective owners through the user_id. Each pet is uniquely identified by a pet_id. This table allows tracking of various attributes associated with each pet, such as name, type, age, and the GPS device used to track them. Additionally, it stores the URL of the image of the pet.

The **PositionHistory** table is responsible for tracking the historical positions of the pets. Each position is uniquely identified by timestamp. This table is linked to the Pets table by the pet_id. It stores the latitude and longitude coordinates of the pet's position, along with a timestamp indicating when the position was recorded. This allows for the tracking and visualization of the pet's movement over time. This database design facilitates efficient management and tracking of pets, enabling users to monitor their pets' locations and histories effectively.

4.5 System Flowchart

Throughout this section, flowchart of each activity created for mobile application were shown.

4.5.1 Login Activity

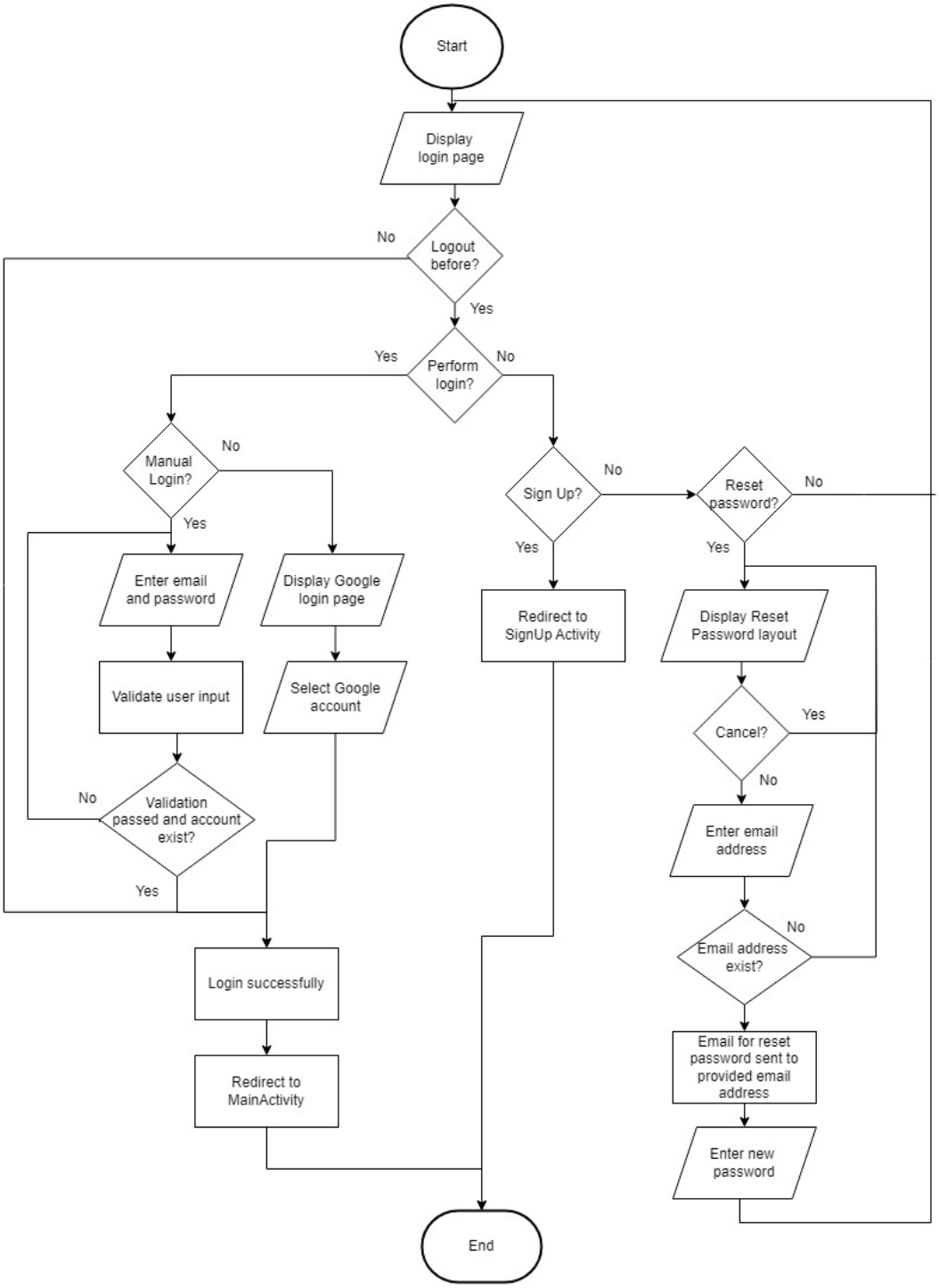


Figure 4.5.1.1 Flowchart of Login Activity

The flowchart depicts the process of creating a login page for a website and allowing users to log in. It begins by displaying the login page. Here, the system checks if a user has already logged out. If they have, the login page is simply displayed again. If not, the flowchart investigates the user's intent.

If the user isn't attempting to log in, they are presented with three options: sign up for a new account, reset their password, or cancel. Selecting sign up redirects them to a separate signup process. Choosing reset password displays a layout where they can enter their email address. The system verifies if this email exists. If not, the user is informed. If it does exist, the system sends a password reset email to that address. Selecting cancel ends the process.

However, if the user is attempting to log in, they enter their email address and password. The system validates this information. If validation fails or the account doesn't exist, the user is informed that the login failed, likely returning them to the login page to try again. Conversely, if the validation is successful and the account exists, the user logs in successfully and is redirected to the main activity of the website.

4.5.2 Sign Up Activity

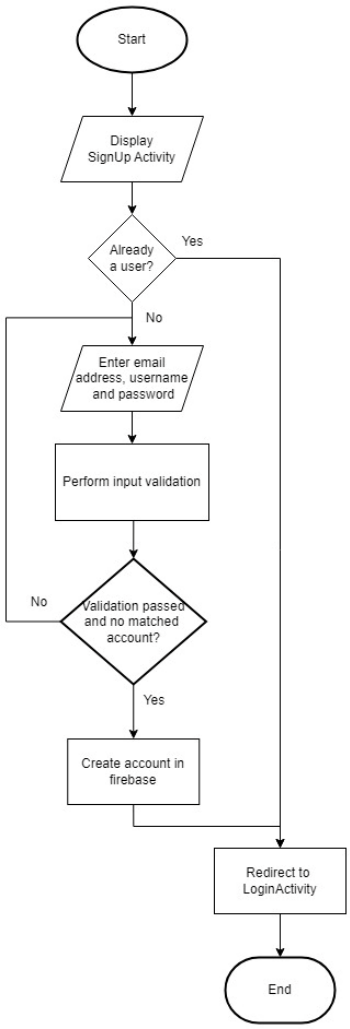


Figure 4.5.2.1 Flowchart of Sign Up Activity

This flowchart outlines the process for signing up for a website. It begins by displaying a signup activity where the user enters their email address, username, and password. The system then performs validation on this information.

If the validation fails, or the email address is already associated with an existing account, the signup attempt is unsuccessful. The user will be notified of this issue and requested to try again with valid information. On the other hand, if the validation is successful and the email address is available, the system creates a new account for the user in Firebase. Following this successful account creation, the user is redirected to the login activity, presumably to log in with their newly created credentials. This marks the end of the signup process.

4.5.3 Main Activity

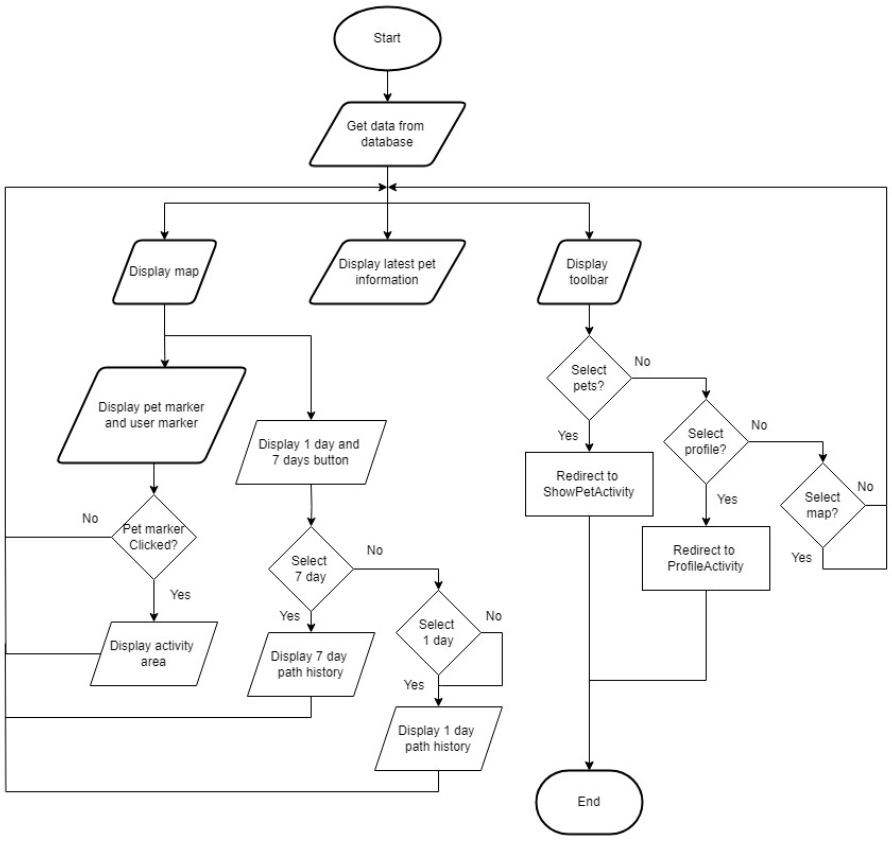


Figure 4.5.3.1 Flowchart of Main Activity

This flowchart illustrates a system that displays information about pets on a map. It starts by fetching data from a database. Then pet information, a map with path history options, and toolbar will be shown. Pet information will be in a list of pet profile and user are allowed to scroll in finding desire pet information.

In map view, it contains user marker, pet markers with its path history and two buttons. Buttons allow user to pick between one-day or seven-day path history. Selecting one day shows buttons for both one-day and seven-day options. Choosing "1 day" displays the pet's path history for that day, while "7 days" shows the pet's entire path history for the week. In default, the map will show “1 day” path history. Besides that, the system checks if they clicked on a pet marker. Clicking a pet marker prompts the user to see the pet's activity area. If not, it will still show the map.

Finally, for toolbar, pet icon will redirect user to Show Pet Activity, profile icon for Profile Activity and map icon will let user remain in Main Activity.

4.5.4 Profile Activity

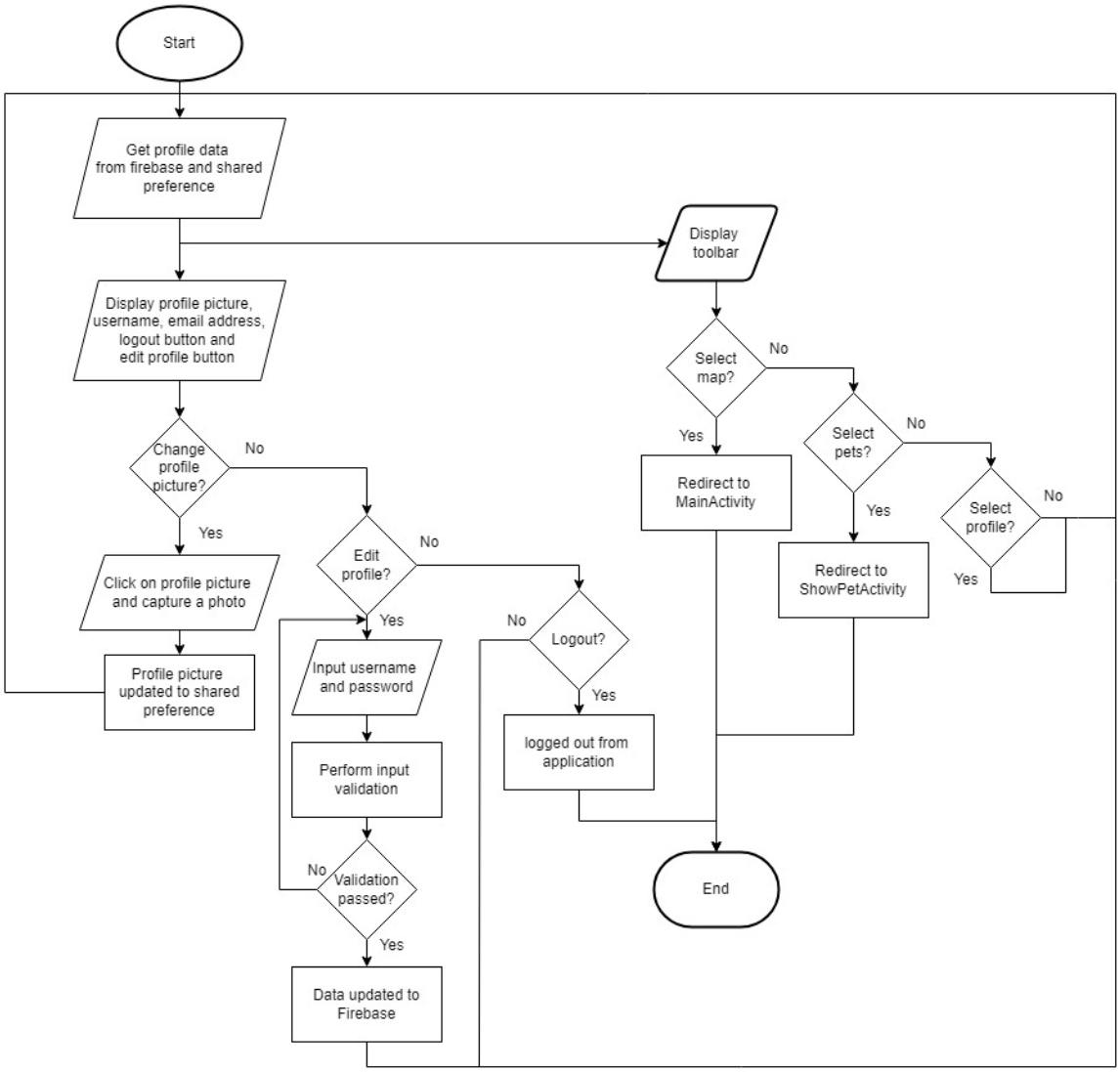


Figure 4.5.4.1 Flowchart of Profile Activity

This flowchart outlines the process for showing and edit user profile in a mobile application. It starts by fetching the user's profile information, including username, email, and current profile picture from Firebase and shared preferences on Android devices. The user's profile information, along with a toolbar, "Edit Profile," text and "Logout" buttons are then displayed on the screen.

If user want to update their profile picture, they can click on their current picture or profile icon to capture a new one using the device's camera. Once captured, the newly taken photo is uploaded and becomes the new profile picture within the app's shared preferences.

Following these potential profile picture changes, the flowchart checks if the user wants to log out. If they choose to stay logged in, the process likely loops back to displaying the profile information. Conversely, if they select logout, they will be redirected to Login Activity with a “Logout Successfully” message.

Else, users decided to edit profile, they will be prompted to enter their username and password. To avoid any potential error, email address was not allowed to edit except username and password. If the validation is successful, the data will be stored into Firebase and redirect back to Profile Activity. In case of unsuccessful validation, the user will receive an error message indicating incorrect login credentials and ask user to re-enter again.

4.5.5 Show Pet Activity

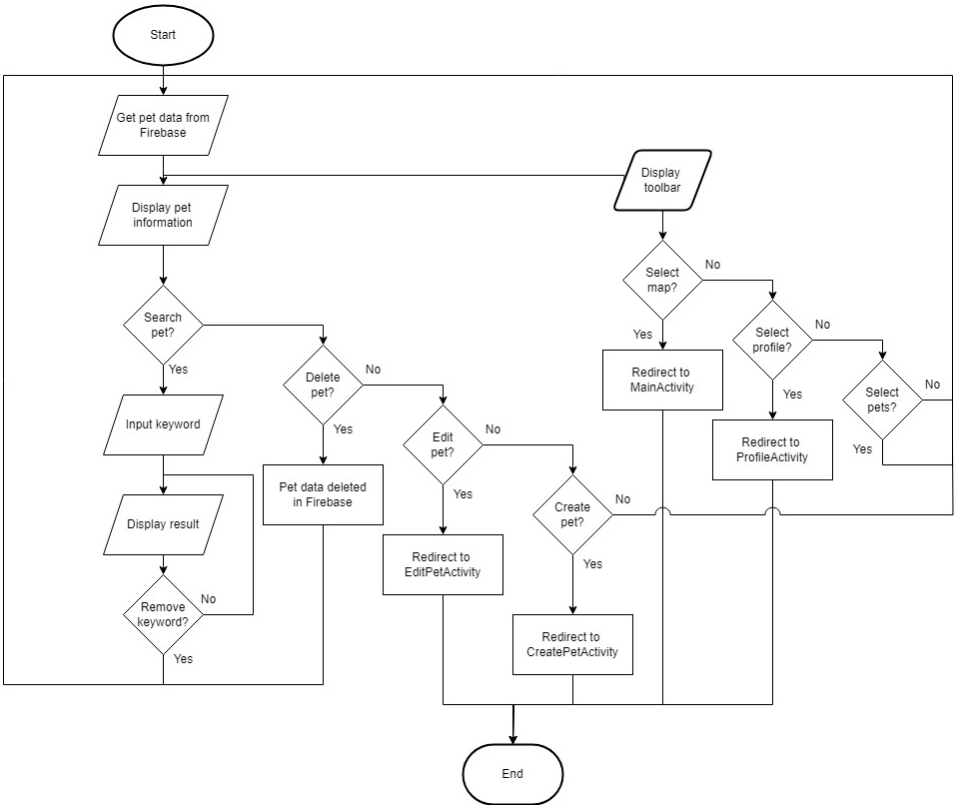


Figure 4.5.5.1 Flowchart of Show Pet Activity

This flowchart outlines the process of viewing and managing pet information. Upon launching of page, the application will retrieve all pet data from firebase for populate pet information list which shows pet's name, breed type, age and picture to user. User was allowed to search for a specific pet by entering keywords in search bar. If match is found, the pet information will be displayed to user.

Apart from that, user also allow to edit and delete selected pet information. Selecting delete option will prompts a conformation message. Cancelling the deletion returns user back to show pet activity page while confirming deletion will remove the pet data from Firebase, then the updated pet information list will be displayed. If user decides to create a new pet profile, it can click the floating button and be redirected to Create Pet activity. For toolbar, user can access to profile page or home page by clicking respective icons.

4.5.6 Create Pet Activity

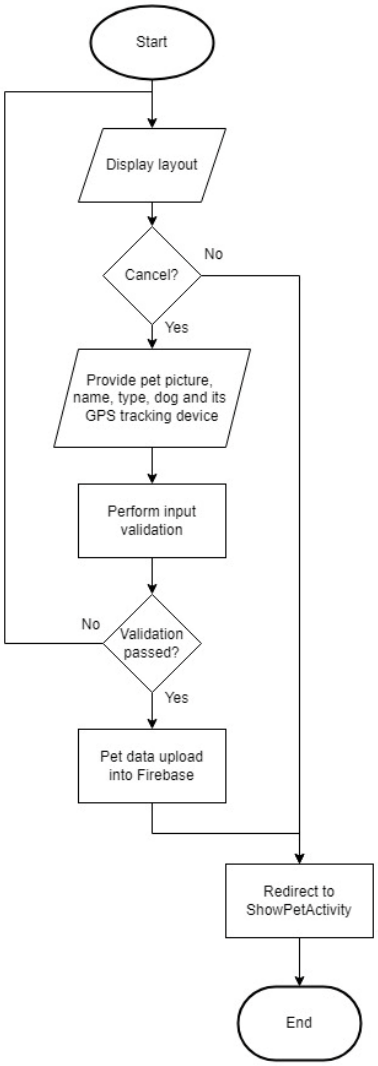


Figure 4.5.6.1 Flowchart of Create Pet Activity

The flowchart involves the process of adding new pet profile. When user decides to add a new pet, users are prompted to provide information about their pets. This information includes pet picture, name, pet type, age and its GPS tracking device. Input validation will be performed to ensure all fields are filled with correct format. If errors detected, an error message will be shown to user and ask to re-enter their pet information again. Once validated, the pet data will be uploaded to Firebase and the mobile application will redirect user back to Show Pet Activity.

4.5.7 Edit Pet Activity

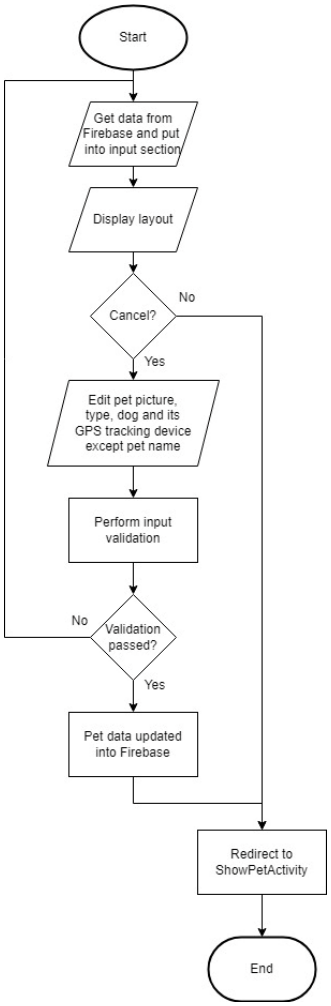


Figure 4.5.7.1 Flowchart of Edit Pet Activity

This flowchart outlines the process of editing pet's information. Upon reaching this page, current pet data will be retrieved from Firebase and populated into respective input sections. This information includes pet's name, picture, type, age and its GPS tracking device. At this point, user has the option to cancel editing process and redirect back to Show Pet Activity. If they choose to proceed, user can edit pet's picture, name, type, age and GPS tracking device. The input validation will then be performed to ensure all required fields are filled with correct format. Any errors trigger messages prompting the user to re-enter their information. Once all information is validated, the updated pet data will be uploaded to Firebase. Following a successful upload, user will be redirected back to Show Pet Activity.

Chapter 5

System Implementation

This chapter delves into the setting and configurating hardware and software components, overcoming challenges and showing expected system's operation.

5.1 Hardware Setup

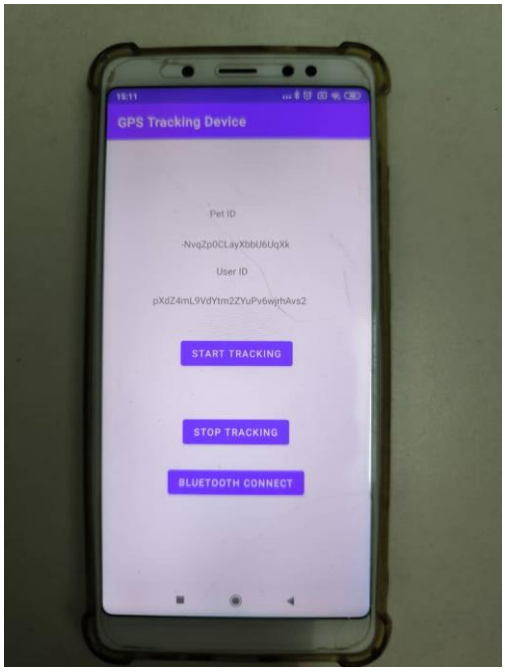


Figure 5.1.1 Redmi Note 5

Hardware used in this project Redmi Note 5 which will act as GPS tracking device. To achieve the goal, a simple mobile application was designed and implemented to trigger smartphone's GPS chip, Bluetooth chip and WI-FI chip with support of mobile data. Two buttons which are "START TRACKING" and "STOP TRACKING" are for user to start or stop generate location data using smartphone's GPS chip which those data will be then sent to Firebase via WI-FI or cellular network depends on the situation. To ensure the GPS tracking device able to update location data for the pet which binds with it, user can initiate Bluetooth connection when creating pet profile in mobile application for exchange of user ID and pet ID. These data are crucial for locating and accessing pet profile for updating pet's location data.

5.2 Software Setup

In this section we will provide list of software required to develop smart mobile pet tracking system which are Android Studio and Firebase.

5.2.1 Android Studio

Before starting to develop smart mobile pet tracking system, we need to download android studio for mobile application development. In our project the version used is Android Studio Chipmunk | 2021.2.1 Patch 2 which can be downloaded using this link: https://developer.android.com/studio/archive.

After finishing download and setup, we need to create a project. Below are the steps to create a project:

1. Open Android Studio home page.
2. Choose “Project” in left panel and the select “New Project” to create a new project.
3. Create a new empty activity by select “Empty Activity”.
4. Fill in the name, package name and save location of the project. Language will be Java and minimum software development kit remained as default which is API 21:Android 5.0 (Lolipop) as it allows our mobile application to run on approximately 99.5% of Android devices.
5. Click “Finish” button to create the project for development.

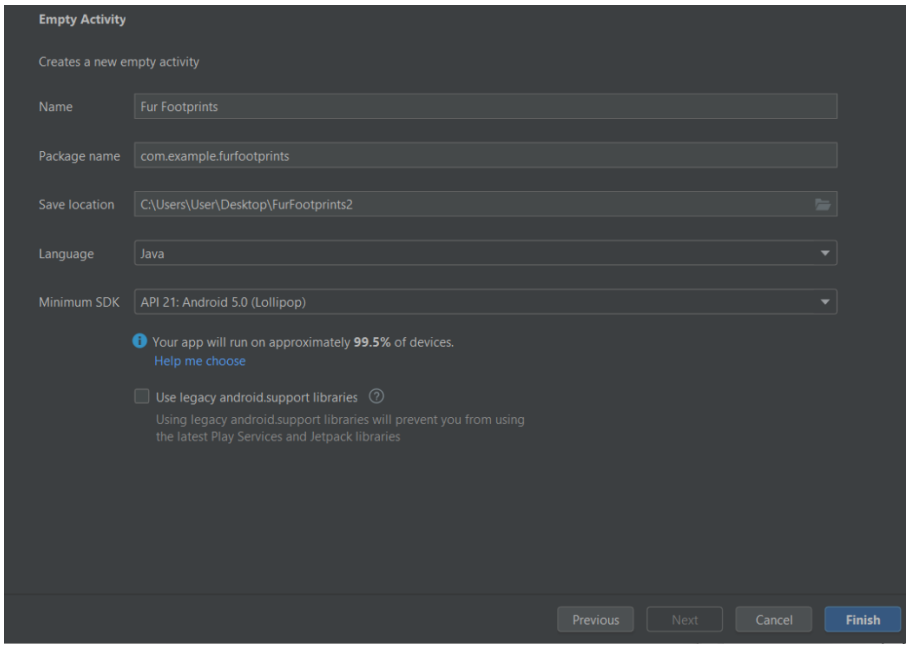


Figure 5.2.1.1 Create New Project in Android Studio.

5.3 Setting and Configuration

To ensure that Firebase can function as intended, some settings and configuration need to be done.

5.3.1 Firebase

To configure and setting up Firebase, we need to follow some steps.

1. Create a Firebase project in Firebase console. It can be found using link: https://console.firebase.google.com/u/0/.
2. After creation, select setting icon residue on right side of "Project Overview" on left panel and then choose "Project settings".
3. Press "Add App" button in "Your Apps" button and choose circle with Android icon.
4. Register the app with Android package name and debug signing certificate SHA-1 for connection and authentication purposes. App nickname is optional.
5. Download google-services.json file and put the file into the project created.
6. Add firebase dependencies provided into build.gradle file stored inside the project.
7. Press "Finish" button to complete setup.
8. Add in Authentication, Realtime Database and Firebase Storage for authenticating users, store user and pet details and store images.
9. To activate user authentication service, select "Authentication" in left panel and choose "Sign-in-method" on menu bar.
10. Press "Add new provider" button and choose "Email/Password" and Google as our sign-in providers.

5.4 System Operation

In this section we will focus on user interfaces created by Android Studio for mobile application.

5.4.1 Login Activity

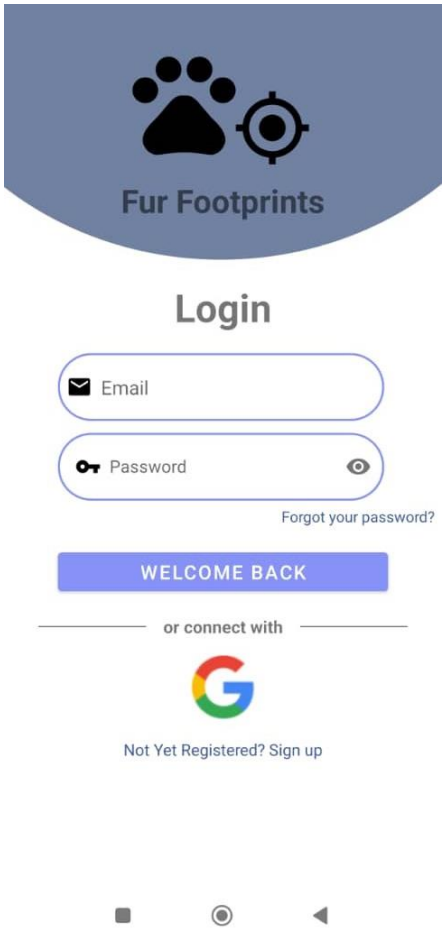


Figure 5.4.1.1 Login Activity Layout

Through login activity, users can login manually by entering email and password of its user account or via Google. If users leave input fields empty, enter wrong email address format or failed to pass authentication, a message will pop out to indicate users the error. If user successfully authenticated, they will be redirected to Main Activity Page. For newcomers, they can press “Not Yet Registered? Sign Up” to create a new user account in Sign Up Activity. For users who forgot their user account’s password, they can press “Forgot your password?” to reset their password in Reset Password Activity.

5.4.2 Sign Up Activity

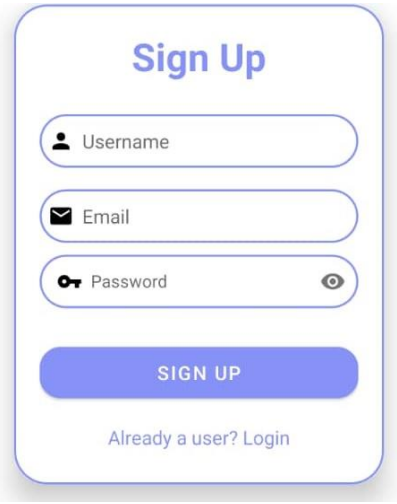


Figure 5.4.2.1 Sign Up Activity Layout

In sign up Activity, users are required to provide username, email address and password to create a user account. If users leave input fields empty, enter wrong email address format or failed to create user account, a message will pop out to indicate users the error. If user successfully create their own user account, the data will be stored in Firebase and they will be redirected to Login Activity Page for authentication purpose. Users also can click “Already a user? Login” if they change their mind and they will be redirected to Login Activity Page.

5.4.3 Reset Password Alert Dialog Box

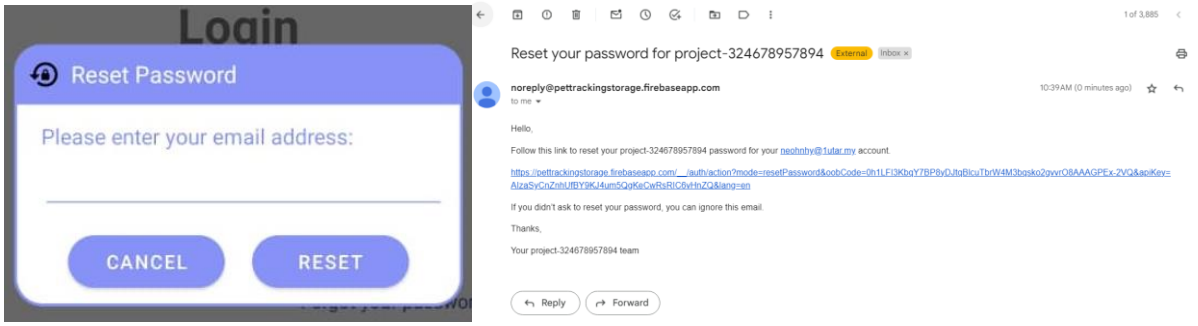


Figure 5.4.3.1 Reset Password Alert Dialog Box Layout with Associated Email

In reset password alert dialog box, users need to provide registered email address of their own user account with correct email address format. If error found, a message will pop out to indicate error encountered. If no error occurs, an email will be sent to the provided email address and users can reset their account password by clicking link provided in the email.

5.4.4 Main Activity

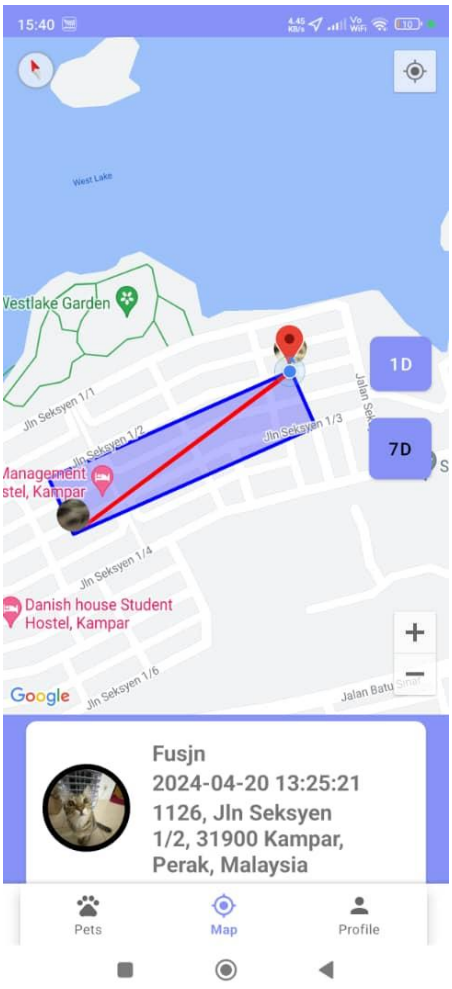


Figure 5.4.4.1 Main Activity Layout

Users will be redirected to this activity after successful login and will be asked to provide location access to the system. Users can select precise or approximate location access for its user marker. In this page, users will be able to see their real-time location which is labelled as red marker and pets' location which are presented in circular view with pets' images. Thankfully, the presence of GPS tracking device allowed the system to provide real-time pet tracking capability to users and able to show pets' one day or seven days travelled path history.

When clicked one of pet marker, an approximate activity area will be drawn and shown to user based on location data obtained within three months. Besides that, user able to see the pet information which containing pet image, pet name, last location update time and last known location located in recycler view. The bottom navigation bar allows users to move freely between show pet activity, main activity and profile activity.

5.4.5 Show Pet Activity

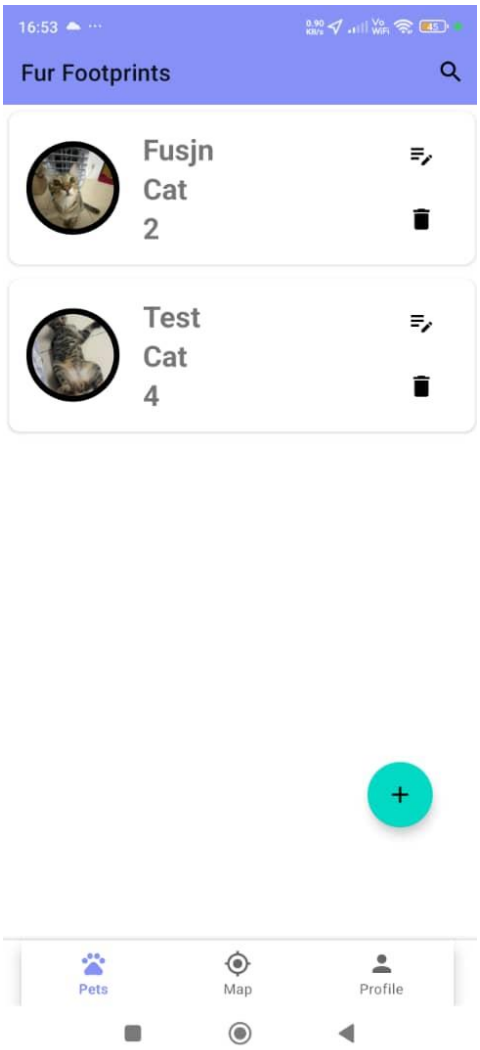


Figure 5.4.5.1 Show Pet Activity Layout

After users click “Pets” in bottom navigation bar, they will be redirected to this activity. Pet profile data are retrieved from Firebase and shown in form of recycler view to users. The floating action button will redirect users to create pet activity to create a new pet profile. There will be two icons, edit icon and delete icon. Edit icon will redirect users to edit pet activity which allow users to edit current pet profile and delete icon will redirect users to delete current pet profile. A search bar will allow users to search for specific pet profile by entering keywords.

5.4.6 Create Pet Activity

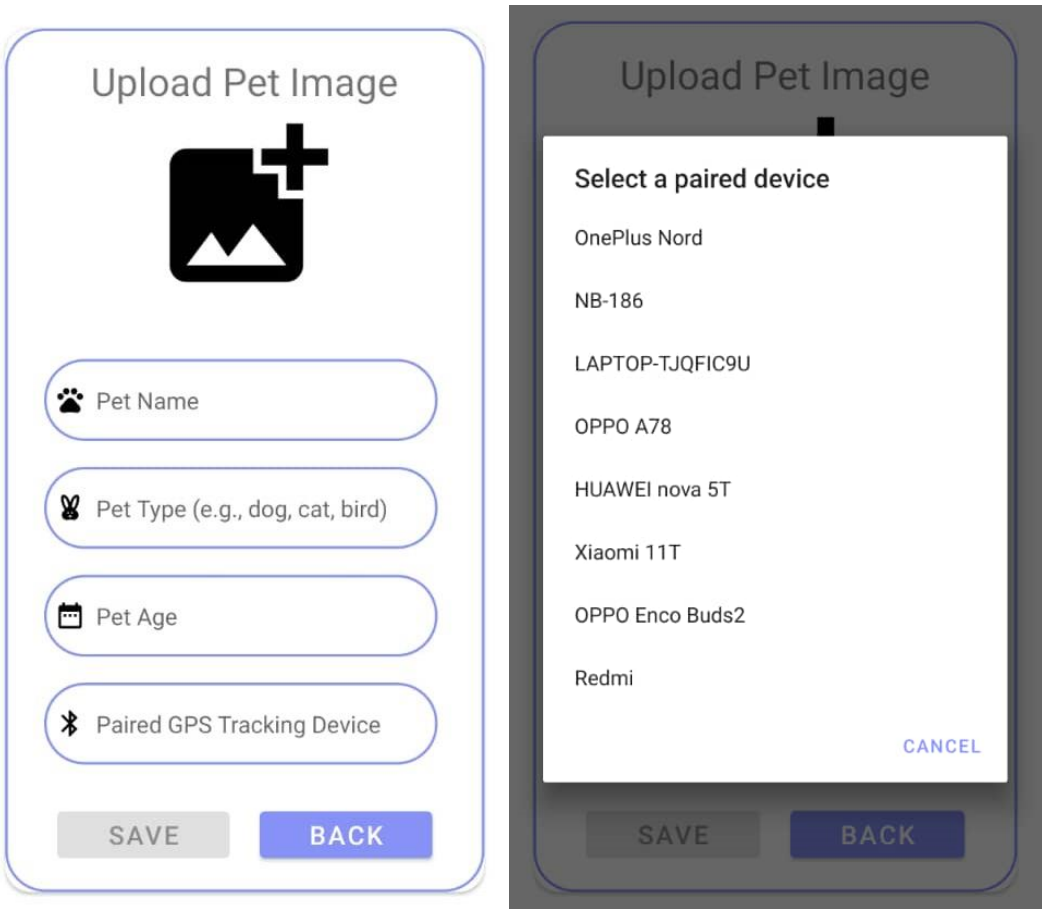


Figure 5.4.6.1 Create Pet Activity Layout

In this activity, users can create a new pet profile by providing image, name, type, age and GPS tracking device used. If unable to retrieve image, a message will pop up to indicate the error. User also can select paired GPS tracking device from list of paired devices shown after clicking paired GPS tracking device input. After pressing save button, the new pet profile data will be stored in Firebase and users will be redirected to show pet activity page to see the update. If users change their mind, they can press back button and they will be redirected to show pet activity page.

5.4.7 Edit Pet Activity

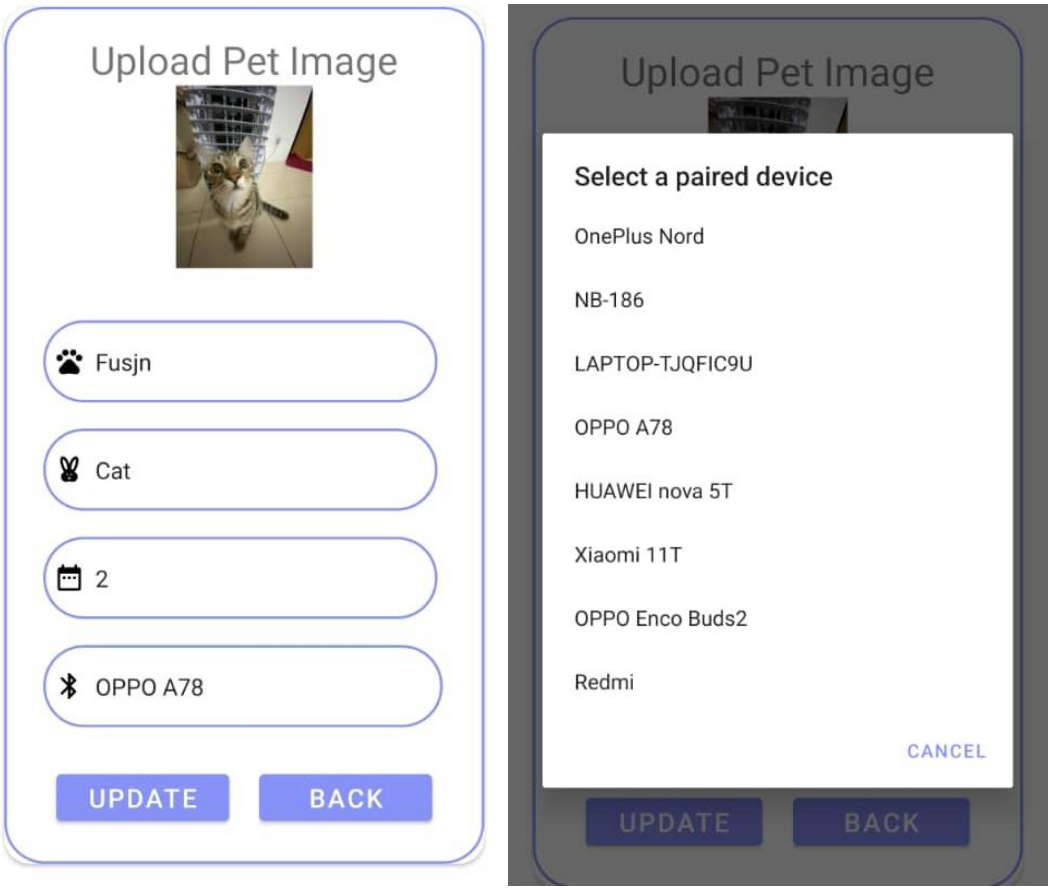
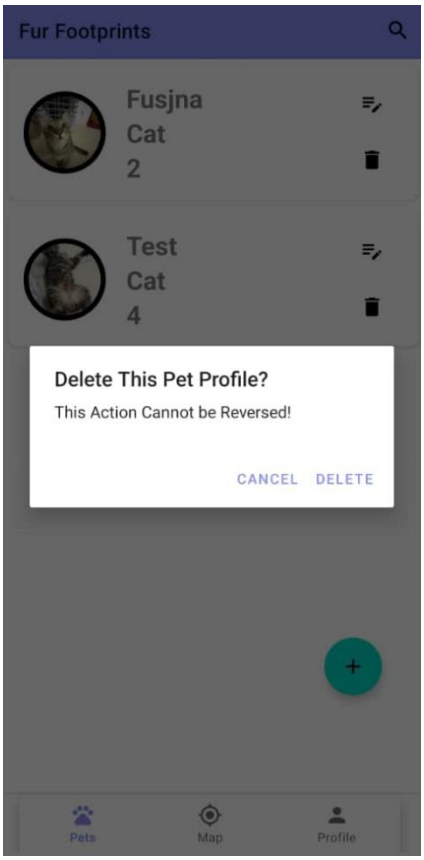


Figure 5.4.7.1 Edit Pet Activity Layout

After users click edit icon, they will be redirected to this activity page. The pet details of selected pet profile will be shown in each category. Users can change pet image, pet name, pet type, pet age and GPS tracking device. After that, users can press update button to update the data in Firebase and they will be redirected to show pet activity page to view the update. If users change their mind, they can press back button to redirect back to show pet activity page.

5.4.8 Delete Pet Alert Dialog Box



5.4.8.1 Delete Pet Alert Dialog Box Layout

After user click delete icon, this dialog box will pop up. Users can cancel this action by clicking cancel or continue the action by clicking delete. After that, the pet profile will be deleted from Firebase and the pet profile will not be shown in show pet activity.

5.4.9 Profile Activity

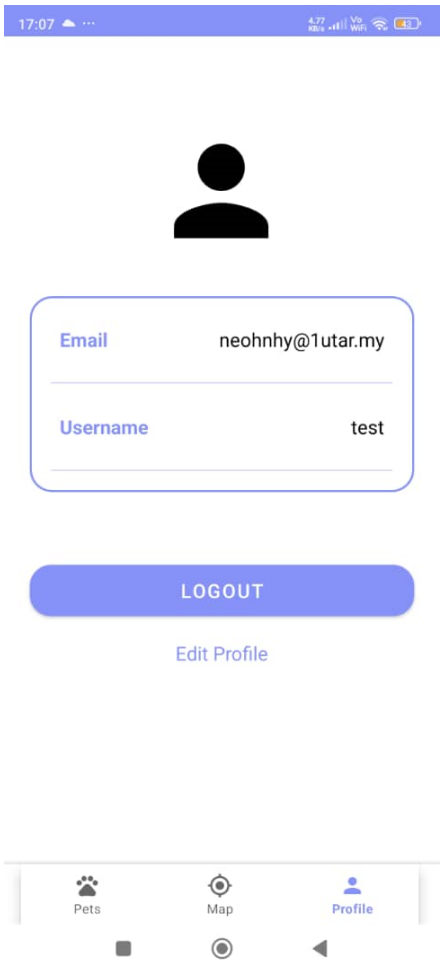


Figure 5.4.9.1 Profile Activity Layout

In this activity, users can see their username and registered email account of their user account. A logout button was shown for users to logout from their user account. After pressing the button, users will be logout from the mobile application and will be redirected to login activity page. User also able to edit profile by clicking “Edit Profile” text. Upon clicking the profile icon or image, user can capture an image and set it as its profile image.

5.4.10 Edit Profile Alert Dialog Box

Figure 5.4.10.1 Edit Profile Alert Dialog Box Layout

In this section, users are able to edit username and password of their profile while email address was prohibited from editing to avoid any error or crashing the app for both manual sign in and google sign in users. User can return back to profile activity by pressing “CANCEL” button. After user enter all the inputs and press “UPDATE” button, the user data for authentication and storage purpose will be updated and user will be redirected back to profile activity.

5.5 Implementation Issues and Challenges

The challenge is the acquisition of GPS tracking device. During the development of this smart mobile pet tracking system, I have tried to obtain total three GPS tracking devices and all attempts return fail result. First device's functionality is not tally with the descriptions provided by seller. This device only able to provide last known location instead of real time location tracking. Another two devices have the functionality I want but all two shipments have been delayed in China's customhouse for a long time. To avoid any delay in development, I have decided to utilize smartphone's GPS chip, WI-FI chip with support of SIM card and Bluetooth chip by develop a application to gain control over these three chips.

Implementation issues are mostly in the GPS tracking interface and initiate Bluetooth connection. I failed to provide GPS tracking application the ability to generate and send location data in the background of the smartphone, thus the device only works well when it is running in foreground of the smartphone. For Bluetooth connection, I didn't realize that in order to initiate a successful Bluetooth connection, Bluetooth server socket is needed. It takes a long time for me to discover this problem, thus significantly affected my development schedule.

5.6 Concluding Remark

The Smart Mobile Pet Tracking System's implementation phase was plagued with difficulties, namely in finding an appropriate GPS tracking device and resolving problems with Bluetooth connectivity and GPS tracking. Despite these challenges, a workaround was come up by using the GPS, Wi-Fi with support of SIM card, and Bluetooth chips integrated into the smartphone. The project was able to proceed and stay on track with its development timetable thanks to this modification.

The Redmi Note 5 is now effectively used by the system as the GPS tracking device, together with a specially created mobile application. Users may easily register, log in, and carry out a number of operations associated with managing their dogs' profiles by integrating Firebase. The Android Studio-designed user interfaces make it easy to do everything from create and manage pet profiles to log in.

This implementation phase's successful conclusion provides a solid framework for the ensuing testing and deployment phases. Notwithstanding these difficulties, the project has progressed towards creating a dependable and effective smart mobile pet tracking system by overcoming its early hurdles.

Chapter 6

System Evaluation and Discussion

In this chapter, an evaluation will be conducted to the system for testing purposes. Some discussion will be done to determine the challenges faced and how well does the project objectives have been achieved.

6.1 System Testing and Performance Metrics

System testing for smartphone's GPS chips was conducted to ensure its accuracy which is crucial to its performance. Two coordinates will be obtained which tester will stand on the same location outside of the building. In this case, the location will be 1124, Jalan Seksyen 1/2, 31900 Kampar, Perak and the tester will stand outside of the building to avoid inaccuracies of collected data. Figure below shows the example of coordinates obtained.

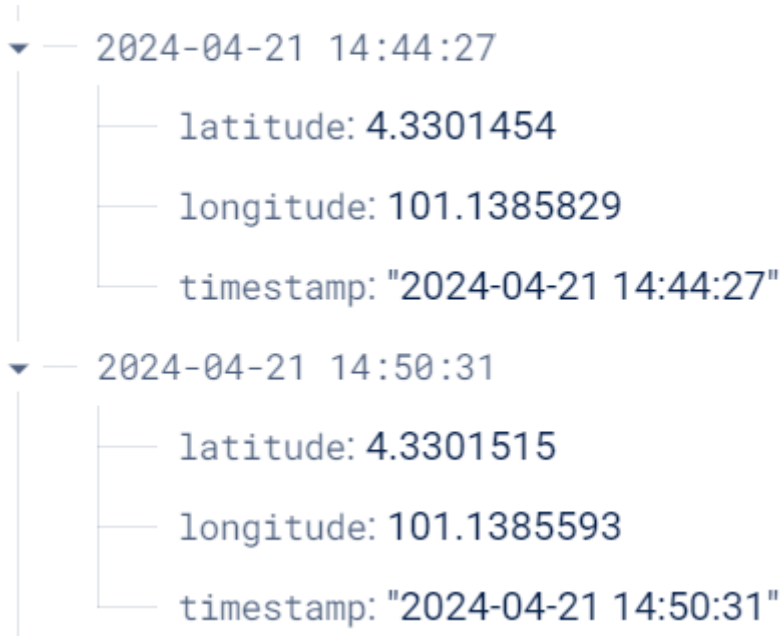


Figure 6.1.1 Coordinates Stored in Firebase

Total four coordinates including initial position were obtained. During accuracy testing, we focus on Mean Position Error which is calculated by taking the average of differences between measured positions and the true positions. It gives an indication of how close the smartphone GPS chip's measurements to actual position. In this test we will assume that first coordinate obtained is the actual position. According to National Coordination Office for Space-Based

Positioning, Navigation, and Timing **[10]**, smartphones with GPS capabilities usually have an accuracy of 4.9 meters at outdoor. So, our acceptance criteria for Mean Position Error are value obtained less than 4.9 meters after calculated using Haversine formula.

$$d = 2rsin^{-1}\left(\sqrt{sin^2\left(\frac{\Phi_2-\Phi_1}{2}\right) + cos(\Phi_1)cos(\Phi_2)sin^2\left(\frac{\lambda_2-\lambda_1}{2}\right)}\right)$$

Figure 6.1.2 Haversine Formula

Source: Adapted from **[11]**

Based on Haversine formula, r is the radius of earth which is 6371km, d is the distance between two points, Φ_1 , Φ_2 is the latitude of two points and λ_1 , λ_2 is the longitude of two points. According to formula, Φ_1 will be 4.3301454 and Φ_2 is other latitude obtained while λ_1 will be 101.1385829 and λ_2 is other latitude obtained. Below is the distance calculated in table form.

Latitude (Φ_2)	Longitude (λ_2)	Distance from coordinate 4.3301454, 101.1385829 (m)
4.3301515	101.1385493	3.787
4.3301521	101.1385432	4.467
4.3301667	101.1385632	3.222

Table 6.1.3 Haversine Formula Calculation

After calculation, we can notice that distance calculated are within Mean Position Error less than 4.9 meters which ensures the accuracy of location data generated from GPS chip.

6.2 Testing Setup and Result

In this section, test cases for each activity of mobile application will be shown.

6.2.1 Login Activity

Test Case	Expected Result	Actual Result	Status
Login with empty email field, password field filled	Show “Incorrect Email Address”	Show “Incorrect Email Address”	Pass
Login with email field filled, empty password field	Show “Please Fill Up All Fields”	Show “Please Fill Up All Fields”	Pass
Login with empty email field and password field	Show “Incorrect Email Address”	Show “Incorrect Email Address”	Pass
Press “show eye” icon	Show password	Show password	Pass
Press “hide eye” icon	Hide password	Hide password	Pass
Login with invalid email address format	Show “Invalid Email Address”	Show “Invalid Email Address”	Pass
Login with account which does not exist	Return Firebase error message	Return Firebase error message	Pass
Login with valid credentials and account exist	Show “Login Successfully” and redirect to Login Activity	Show “Login Successfully” and redirect to Login Activity	Pass
Click Google icon	Show Google account selection page	Show Google account selection page	Pass
Login via Google account	Show “Login Successfully” and redirect to Login Activity	Show “Login Successfully” and redirect to Login Activity	Pass
Press “Not Yet Registered? Sign up”	Redirect to Sign Up Activity	Redirect to Sign Up Activity	Pass
Press “Forgot your password?”	Show reset password alert dialog box	Show reset password alert dialog box	Pass

Table 6.2.1.1 Login Activity’s Test Case

6.2.2 Sign Up Activity

Test Case	Expected Result	Actual Result	Status
Sign up with one of fields (username, email and password) remain empty	Show “Please Fill Up All Fields”	Show “Please Fill Up All Fields”	Pass
Sign up with invalid email address format	Show “Incorrect Email Address”	Show “Incorrect Email Address”	Pass
Sign up with valid credentials (username, email and password)	Show “Registered Successfully!”, create user and store data in Firebase and redirect to Login Activity	Show “Registered Successfully!”, create user and store data in Firebase and redirect to Login Activity	Pass
Press “show eye” icon	Show password	Show password	Pass
Press “hide eye” icon	Hide password	Hide password	Pass
Press “Already a user? Login”	Redirect to Login Activity	Redirect to Login Activity	Pass

Table 6.2.2.1 Sign Up Activity’s Test Case

6.2.3 Reset Password Alert Dialog Box

Test Case	Expected Result	Actual Result	Status
Reset password with empty email field	Show “Please enter your registered email address”	Show “Please enter your registered email address”	Pass
Press “Cancel” button during reset password process	Redirect back to Login Activity	Redirect back to Login Activity	Pass
Reset password with invalid email address format or email address which does not exist	Show “Fail to send”	Show “Fail to send”	Pass
Reset password with valid and existing email address	Show “Please check your email” and inbox will have the reset password email	Show “Please check your email” and inbox will have the reset password email	Pass
Enter new password via reset password email	Password reset	Password reset	Pass

Table 6.2.3.1 Reset Password Alert Dialog Box’s Test Case

6.2.4 Main Activity

Test Case	Expected Result	Actual Result	Status
Enable GPS alert dialog box	Redirect to location setting if yes, exit application if no	Redirect to location setting if yes, exit application if no	Pass
See user marker and pet markers	User marker and pet markers with one day path history shown on map	User marker and pet markers with one day path history shown on map	Pass
One day path history button	Show pet's one day path history	Show pet's one day path history	Pass
Seven day path history button	Show pet's seven day path history	Show pet's seven day path history	Pass
Click pet marker	Show pet approximate 3 months activity area, close if click again	Show pet approximate 3 months activity area, close if click again	Pass
List of pet information	Able to show and scroll pet information list	Able to show and scroll pet information list	Pass
Press pet icon in bottom navigation bar	Redirect to Show Pet Activity	Redirect to Show Pet Activity	Pass
Press map icon in bottom navigation bar	Remain in Main Activity	Remain in Main Activity	Pass
Press profile icon in bottom navigation bar	Redirect to Profile Activity	Redirect to Profile Activity	Pass

Table 6.2.4.1 Main Activity's Test Case

6.2.5 Show Pet Activity

Test Case	Expected Result	Actual Result	Status
Show pet information lists	Show pet information lists	Show pet information lists	Pass
Click edit icon on each pet	Redirect to Edit Pet Activity	Redirect to Edit Pet Activity	Pass
Click delete icon on each pet	Show Delete Pet Alert Dialog Box	Show Delete Pet Alert Dialog Box	Pass
Click plus icon floating button	Redirect to Create Pet Activity	Redirect to Create Pet Activity	Pass
Search pet using keyword	Show matched pet information	Show matched pet information	Pass
Press pet icon in bottom navigation bar	Remain in Show Pet Activity	Remain in Show Pet Activity	Pass
Press map icon in bottom navigation bar	Redirect to Main Activity	Redirect to Main Activity	Pass
Press profile icon in bottom navigation bar	Redirect to Profile Activity	Redirect to Profile Activity	Pass

Table 6.2.5.1 Show Pet Activity's Test Case

6.2.6 Create Pet Activity

Test Case	Expected Result	Actual Result	Status
Enter pet details without image	Save button disabled	Save button disabled	Pass
Click image upload icon	Show selection of gallery, photos and file manager. Replace icon with image retrieved if success, else show "Unable to retrieve image"	Show selection of gallery, photos and file manager. Replace icon with image retrieved if success, else show "Unable to retrieve image"	Pass
Click "Paired GPS Tracking Device" input	If Bluetooth inactive, ask user to activate Bluetooth, else show paired device list	If Bluetooth inactive, ask user to activate Bluetooth, else show paired device list	Pass
Create pet profile with empty fields	Show "Please Fill Up All Fields"	Show "Please Fill Up All Fields"	Pass
Bluetooth connection interrupted during pet profile creation	Show error message	Show error message	Pass
Create pet profile with valid inputs	Show "Created Successfully" and data stored under user data in Firebase	Show "Created Successfully" and data stored under user data in Firebase	Pass
Press "BACK" button	Redirect back to Show Pet Activity	Redirect back to Show Pet Activity	Pass

Table 6.2.6.1 Create Pet Activity's Test Case

6.2.7 Edit Pet Activity

Test Case	Expected Result	Actual Result	Status
Enter Edit Pet Activity	Show pet data stored	Show pet data stored	Pass
Click image	Show selection of gallery, photos and file manager. Replace image with image retrieved if success, else show “Unable to retrieve image”	Show selection of gallery, photos and file manager. Replace image with image retrieved if success, else show “Unable to retrieve image”	Pass
Click “Paired GPS Tracking Device” input	If Bluetooth inactive, ask user to activate Bluetooth, else show paired device list	If Bluetooth inactive, ask user to activate Bluetooth, else show paired device list	Pass
Update pet profile with empty fields	Show “Please Fill Up All Fields”	Show “Please Fill Up All Fields”	Pass
Bluetooth connection interrupted during pet profile creation	Show error message	Show error message	Pass
Update pet profile with valid inputs or input with edit	Show “Updated Successfully” and update pet data in Firebase	Show “Updated Successfully” and update pet data in Firebase	Pass
Press “BACK” button	Redirect back to Show Pet Activity	Redirect back to Show Pet Activity	Pass

Table 6.2.7.1 Edit Pet Activity’s Test Case

6.2.8 Delete Pet Alert Dialog Box

Test Case	Expected Result	Actual Result	Status
Press “DELETE” button	Pet profile in Show Pet Activity disappear alongside with pet data in Firebase deleted	Pet profile in Show Pet Activity disappear alongside with pet data in Firebase deleted	Pass
Press “CANCEL” button	Redirect back to Show Pet Activity	Redirect back to Show Pet Activity	Pass

Table 6.2.8.1 Delete Pet Alert Dialog Box’s Test Case

6.2.9 Profile Activity

Test Case	Expected Result	Actual Result	Status
Enter Profile Activity	Display user profile image, username and email, logout button and edit profile	Display user profile image, username and email, logout button and edit profile	Pass
Click profile icon or image	Show camera selection. Replace icon or image with image captured if success, else show “Unable to retrieve image”	Show selection of gallery, photos and file manager. Replace image with image retrieved if success, else show “Unable to retrieve image”	Pass
Press “LOGOUT” button	Logout from Firebase authentication and redirect to Login Activity	Logout from Firebase authentication and redirect to Login Activity	Pass
Press “Edit Profile” text	Redirect to Edit Profile Activity	Redirect to Edit Profile Activity	Pass
Press pet icon in bottom navigation bar	Redirect to Show Pet Activity	Redirect to Show Pet Activity	Pass

Press map icon in bottom navigation bar	Redirect to Main Activity	Redirect to Main Activity	Pass
Press profile icon in bottom navigation bar	Remain in Profile Activity	Remain in Profile Activity	Pass

Table 6.2.9.1 Profile Activity's Test Case

6.2.10 Edit Profile Activity

Test Case	Expected Result	Actual Result	Status
Enter Profile Activity	Allow edit of username and password, except email disabled	Allow edit of username and password, except email disabled	Pass
Update user profile with empty fields	Show "Please Fill Up All Fields"	Show "Please Fill Up All Fields"	Pass
Update user profile with valid inputs	Username and password stored in Firebase updated successfully for authentication and storage, then redirect to Profile Activity	Username and password stored in Firebase updated successfully for authentication and storage, then redirect to Profile Activity	Pass
Google user update password	Show error message and does not trigger update	Show error message and does not trigger update	Pass
Press "CANCEL" button	Redirect back to Profile Activity	Redirect back to Profile Activity	Pass

Table 6.2.10.1 Edit Profile Activity's Test Case

6.3 Project Challenges

The development of the smart mobile pet tracking system comes with a set of challenges that need to be addressed throughout the project. First is integration of GPS tracking system. Integration of GPS tracking system seamlessly with the mobile application poses a challenge as it requires an establishment of stable temporary Bluetooth connection between tracking device and mobile application during pairing process. User ID and pet ID data sent during Bluetooth connection are crucial for providing accurate and up-to-date location data of pets which is important for real-time tracking functionality.

Besides that, real-time tracking functionality and display pet's traveled route on map pose a challenge due to the need for reliable data transmission between GPS tracking system and mobile application.

6.4 Objective Evaluation

Objective	Evaluation	Conclusion
To develop a mobile application for tracking purpose instead of using web application	For ease of tracking, the application allows users to view their pet's location on their smartphone, thus providing easy access to tracking functionalities. For suitability of smartphone screen size, the user interface is optimized for smartphone screen which ensures that all features are easily accessible and usable.	Achieved
To track pet's real time location using GPS tracking system	The system allows real-time updates of pet's location with 5 minutes interval regardless of distance between user and their pets	Achieved
To develop a travelled path history system	The system store and visualize pet's travelled path history alongside with approximate activity area, allowing user to identify frequently visited area of their pets	Achieved

Table 6.4.1 Objective Evaluation

6.5 Concluding Remark

The system evaluation and testing phase played a critical role in ensuring the reliability and accuracy of the developed mobile application for pet tracking. The accuracy of the GPS chip in the smartphone undergoes rigorous testing to guarantee that it satisfies the necessary performance requirements. It was discovered that the Mean Position Error of tested location data fell within the acceptable range thus guaranteeing accurate location tracking. Additionally, consistent results were obtained from evaluating the application's numerous activities, including login, sign up, password reset, main activity, show pet activity, create pet activity, edit pet activity, delete pet activity, profile activity, and edit profile activity. Every task executed based on their expected behaviour which guarantees a smooth user experience.

In conclusion, the mobile application that was created has effectively fulfilled the stated goals and offers a dependable and easy-to-use option for tracking pets. The application gives owners an effective and convenient way to keep an eye on their pets by optimising the user interface for smartphone displays, implementing real-time GPS tracking, and storing and visualising the pet's travelled route history alongside with activity area.

Chapter 7

Conclusion and Recommendations

In the concluding section, a summary of this smart mobile pet tracking system project along with recommendations for future improvements based on the knowledge gained from our thorough study and development plan.

7.1 Conclusion

This report has presented a comprehensive analysis and development plan for a pet tracking system. The initial exploration highlighted the existing problems in pet tracking systems, including inconvenient web applications for pet owners, limitations of microchip implants, and the low likelihood of finding missing pets. The motivation behind the project was to address these issues and provide an efficient and reliable pet tracking system. The objectives were clearly defined, aiming to develop a user-friendly mobile application that utilizes the latest technologies to overcome the limitations of existing systems. The scope and direction of the project were determined and the contributions of the proposed system to the field were outlined.

A thorough literature review examined the relevant technologies and previous works on pet tracking systems. The review identified the gaps in existing systems, laying the foundation for the development of an improved solution. The system methodology and approach were then outlined, detailing the research design, functional requirements, project milestones, estimated cost, and concluding remarks. Following the methodology, the system design was elaborated, providing insights into the architecture, use case, activity, and database design. The system implementation section detailed the hardware and software setup, configuration, system operation, and challenges encountered during the implementation phase. System evaluation and discussion delved into the testing, performance metrics, challenges faced, and the evaluation of project objectives.

In conclusion, the "Smart Mobile Pet Tracking System" system has been effectively devised to tackle the difficulties encountered by pet owners in monitoring their missing animals. To assist pet owners in more successfully locating their animals, the system provides a mobile application, a GPS tracking system, and a travelled path history system.

7.2 Recommendation

First recommendation is algorithms which can increase precision of location coordinates received from GPS system could be implemented to further improve tracking accuracy. For example is Kalman filter algorithm. It is an optimal estimation algorithm that can significantly improve the accuracy and reliability of tracking system by reducing noise in GPS data.

Second recommendation is incorporation of machine learning algorithms into the system for better forecasting of pet's potential position. For example, utilization of behavioural analysis allows prediction of possible future positions of pets by analyzing previous movement patterns and behaviour. Besides that, other learning models such as classification and regression algorithms can be used to predict pet's future position based on the learning experience gained from historical location data.

In conclusion, implementation both Kalman filter and machine learning algorithms can significantly enhance the accuracy and reliability of pet tracking systems, thus ensuring further improvements and increasing effectiveness of future pet recovery.

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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3, Y3	**Study week no.: Week 2**
Student Name & ID: Neoh Howe Yik 20ACB03431	
Supervisor: Puan Nor 'Afifah Binti Sabri	
Project Title: Smart Mobile Pet Tracking System	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

I have managed to fix the bug where after clicking back button in CreatePetProfile Activity will crash the app.

2. WORK TO BE DONE

Find and fix remaining bugs, rework the user profile activity, add day filter for showing route history and allow Bluetooth communication between GPS tracking system and mobile application. Final year report too.

3. PROBLEMS ENCOUNTERED

Although I started the Bluetooth communication coding, I encountered a problem where user id cannot be transferred using Bluetooth.

4. SELF EVALUATION OF THE PROGRESS

I think I still on track.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3, Y3	**Study week no.: Week 4**
Student Name & ID: Neoh Howe Yik 20ACB03431	
Supervisor: Puan Nor 'Afifah Binti Sabri	
Project Title: Smart Mobile Pet Tracking System	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

I fixed another layout issue where bottom app bar is in displacement and also refined the code snippet regarding Bluetooth communication in mobile application.

2. WORK TO BE DONE

Find and fix remaining bugs, rework the user profile activity, add day filter for showing route history and allow Bluetooth communication between GPS tracking system and mobile application. Final year report too.

3. PROBLEMS ENCOUNTERED

It seems the Bluetooth data transfer problem is due to missing Bluetooth server socket part in GPS tracking device which act as data receiver. I will look into it.

4. SELF EVALUATION OF THE PROGRESS

I think that this Bluetooth problem will take much of my time.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3, Y3	**Study week no.: Week 6**
Student Name & ID: Neoh Howe Yik 20ACB03431	
Supervisor: Puan Nor 'Afifah Binti Sabri	
Project Title: Smart Mobile Pet Tracking System	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

I have added Bluetooth server socket code snippet into GPS tracking device and created shared preference in both mobile application and tracking device to store data transferred through Bluetooth communication. Some debug code also being inserted. Chapter 1 and 2 of final year report have been done.

2. WORK TO BE DONE

Find and fix remaining bugs, rework the user profile activity, add day filter for showing route history and allow Bluetooth communication between GPS tracking system and mobile application. Left chapter 3,4,5,6,7 of final year report.

3. PROBLEMS ENCOUNTERED

Although Bluetooth server socket code snippet was added, mobile application still unable to establish Bluetooth connection with GPS tracking device.

4. SELF EVALUATION OF THE PROGRESS

This Bluetooth part has already used up much of my time and I need to start divert some of my time for academic assignment.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3, Y3	**Study week no.: Week 8**
Student Name & ID: Neoh Howe Yik 20ACB03431	
Supervisor: Puan Nor 'Afifah Binti Sabri	
Project Title: Smart Mobile Pet Tracking System	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

After adding button in GPS tracking device to trigger Bluetooth server socket, the data can now be transferred and stored into shared preference through Bluetooth connection. Some code also being written to filter route history for 1 day and 7 days. Done chapter 3 and 4 of final year report.

2. WORK TO BE DONE

Find and fix remaining bugs, rework the user profile activity and add day filter for showing route. Left chapter 5,6,7 of final year report.

3. PROBLEMS ENCOUNTERED

Since all data stored in Firebase with a structure, I need to figure a way to get and filter the location data based on the timestamp. A formula was needed to calculate and show the activity area based on the filtered location data.

4. SELF EVALUATION OF THE PROGRESS

For day filter for route history and display of activity area, I need to allocate more time to catch up the progress.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3, Y3	**Study week no.: Week 10**
Student Name & ID: Neoh Howe Yik 20ACB03431	
Supervisor: Puan Nor 'Afifah Binti Sabri	
Project Title: Smart Mobile Pet Tracking System	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

I managed to make two filters in MainActivity activity to show 1 day and 7 days route history and show activity area after pet marker was clicked. Finished chapter 5 and 6 of final year report.

2. WORK TO BE DONE

Find and fix remaining bugs and rework the user profile activity. Left chapter 7 of final year report.

3. PROBLEMS ENCOUNTERED

Current formula for calculate activity area maybe not so accurate and I may need to find a more suitable formula for replacement.

4. SELF EVALUATION OF THE PROGRESS

I think I am on the track.

Supervisor's signature

Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: T3, Y3	**Study week no.: Week 12**
Student Name & ID: Neoh Howe Yik 20ACB03431	
Supervisor: Puan Nor 'Afifah Binti Sabri	
Project Title: Smart Mobile Pet Tracking System	

1. WORK DONE

[Please write the details of the work done in the last fortnight.]

I have rework the user profile activity, allow user to view user profile with a new layout and also edit the user profile. Finished chapter 7 and polished layout of final year report.

2. WORK TO BE DONE

Find and fix remaining bugs.

3. PROBLEMS ENCOUNTERED

There may still some hidden bugs not yet be found.

4. SELF EVALUATION OF THE PROGRESS

I think I am on the track.

Supervisor's signature

Student's signature

POSTER

Universiti Tunku Abdul Rahman

Faculty of Information and Communication Technology

Smart Mobile Pet Tracking System

Introduction

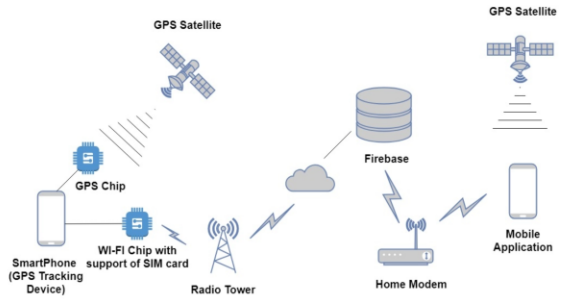
This project aims to develop a smart mobile pet tracking system for pet owners, enabling real-time tracking of their pets' locations and travel paths.

This system integrates GPS technology for an unlimited tracking range, addressing the challenges of inefficient search methods and the emotional toll of losing a pet.

Project Objectives

1. To develop a mobile application for tracking purpose instead of using web application.
2. To track pet's real time location using GPS tracking system.
3. To develop a travelled path history system.

Methodology



- Global Positioning System (GPS) tracking device tasked to receive and send location data periodically from satellite to Google Firebase via WI-FI or cellular network.
- Google Firebase tasked to provide user authentication services, store user and pet profiles and store pets' location data.
- Mobile application act as platform for displaying users and pets' location data, pets' travelled path, obtain user's current location and manage user and pet profiles.

Result

GPS Tracking Device -	• Able to obtain and update location data to Firebase • Able to initiate Bluetooth connection for data transmission purpose
Mobile Application -	• User able to perform login, signup, reset password, create, view edit and delete pet profile, see pets' and its location, view and edit user account and logout. • User able to see pets' path history alongside with their approximate activity area
Google Firebase -	• Able to provide user authentication service and act as storage for user profiles, pet profiles and location data.

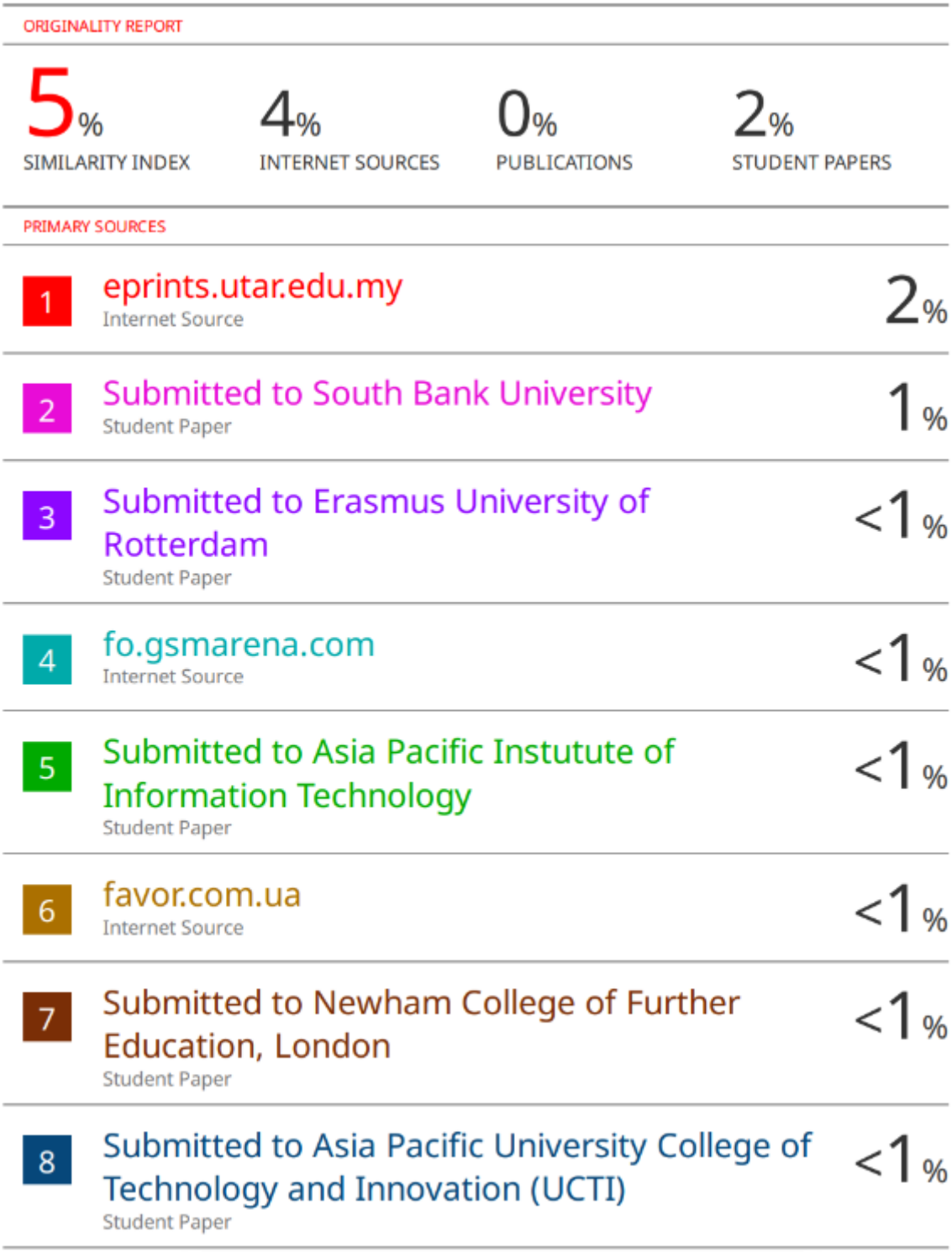
Conclusion

We have successfully created a smart mobile pet tracking system with all three objectives were achived. The creation of this system offers alternative way for pet user in tracking and finding their pets.

Users will be able to track their pets in real time while also gain insights on route history and activity area of pets.

Project Developer: Neoh Howe Yik
Project Supervisor: Puan Nor 'Afifah Binti Sabri

PLAGIARISM CHECK RESULT



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FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Neoh Howe Yik
ID Number(s)	20ACB03431
Programme / Course	CN
Title of Final Year Project	Smart Mobile Pet Tracking System

Similarity	**Supervisor's Comments (Compulsory if parameters of originality exceeds the limits approved by UTAR)**
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Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Signature of Supervisor

Name: Puan Nor 'Afifah Binti Sabri

Date: 24/04/2024

Signature of Co-Supervisor

Name: _____

Date: _____

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY
(KAMPAR CAMPUS)

CHECKLIST FOR FYP2 THESIS SUBMISSION

Student Id	20ACB03431
Student Name	Neoh Howe Yik
Supervisor Name	Puan Nor 'Afifah Binti Sabri

TICK (√)	DOCUMENT ITEMS Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
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