MYCOVID: DECENTRALIZED AND PRIVACY FOCUSED COVID-19 CONTACT TRACING

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A project report submitted in partial
fulfilment of the requirements for the award of
Bachelor of Software Engineering (Hons.)

University Malaysia of Computer Science and Engineering (UNIMY)

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at University Malaysia of Computer Science and Engineering or other institutions.

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Specially dedicated to
my beloved mother, father, brothers, sister, and everyone
who has been supportive on this project.

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MYCOVID: DECENTRALIZED AND PRIVACY-FOCUSED COVID-19 CONTACT TRACING

ABSTRACT

The COVID-19 pandemic has been around for about two years. Due to this, there is a growing need for efficient contact tracing. The typical applications used for contact tracing in Malaysia require users to insert valuable personal data like Identification Card (IC) numbers and full names. Therefore, this project aims to develop an Android mobile application to improve current digital contact tracing that is widely used in Malaysia. The main focus of the proposed application is to preserve user's privacy and protection of data as well as increase the efficiency of contact tracing. RAD is chosen for this project due to its fast-paced nature since it focuses on the development of units incrementally. Therefore, bugs can be discovered in the early stage, where they could have been found in the later phase of the waterfall model. Besides that, RAD is suitable because it can make a better-quality product since it develops evolving prototypes. There are four phases in this methodology requirement planning, user design, construction, and cutover. In FYP 1, it focuses on creating the initial development project report of the proposed application. FYP 1 also includes studying and analysing the problems and finding justification for the need of the project. Therefore, several key elements have been achieved that are crucial for the next phase, which is FYP 2. The outcome in this report includes obtaining requirements, creating UML diagrams, and developing the first iteration of the user interface. The COVID-19 pandemic has been around for about two years at the time of writing and still does not give any sign of slowing down. It has changed the view of experts in handling this pandemic by living side by side with it or treating it as an endemic, just like we treat the dengue fever here in Malaysia. Combined with the powerful MySejahtera app, this assimilation of technology will make Malaysian digital contact tracing a powerful yet privacy-focused application that benefits both the government and its people.

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LIST OF SYMBOLS / ABBREVIATIONS

H	cryptographic hash function
SK	secret key
t	day
n	number of EphID
L	length of an epoch in minutes
PRG	pseudo-random generator
PRF	pseudo-random function
Broadcast key	fixed and public string

SME	Small-to-Medium Enterprise
COVID-19	Coronavirus Disease 2019
MCO	Movement Control Order
QR code	Quick Response Code
DP3T	Decentralized Privacy-Preserving Proximity Tracing
BLE	Bluetooth Low Energy
EphID	Ephemeral ID
UI	User Interface
iOS	iPhone Operating System
RAD	Rapid Application Design
SDLC	Software Development Life Cycle
NFR	Non-Functional Requirement

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CHAPTER 1

INTRODUCTION

1.1 Background

Coronavirus disease 2019 (COVID-19) is a contagious virus with an array severity of pneumonia which started in December 2019 from Wuhan City, Hubei Province, China. It has already spread to every corner of the world. According to World Health Organization (WHO), the COVID-19 virus has claimed 3,895,661 lives and a total of 179,513,309 confirmed cases around the world as of 25th June 2021 (*WHO Coronavirus (COVID-19) Dashboard*, n.d.). Here in Malaysia, we are currently experiencing the third wave of the pandemic where daily cases surge as high as eight thousand and with total death of 4,803 as of 25th June 2021, according to the Ministry of Health Malaysia. The pandemic poses a detrimental effect on the country's economy and especially people's livelihood as the third Movement Control Order (MCO) has taken into effect since early June 2021 that restricts SMEs from operating like a barbershop.

One of the leading causes of contracting the disease is by having close physical contact with a person that is positive for the virus (Fisher et al., 2020). To handle the spreading infection, the Malaysian government has done multiple things like posing early lockdowns, closing the borders from highly infected countries, and doing contact tracing of infected people. The MCO and contact tracing efforts have proven to be significant in the decrease of positive cases (Sunita et al., 2021). This is where contact tracing is crucial. Contact tracing is a way of targeted control that automatically focuses intervention on the subset of the population most likely to be infected (Eames

& Keeling, 2003). This was applied in the introduction of mobile applications that is made compulsory to the public and was made specifically for preventing the spread of COVID-19 disease such as MySejahtera and Selangkah.

The government, with the cooperation of the National Security Council (NSC), the Ministry of Health (MOH), the Malaysian Administrative Modernisation and Management Planning Unit (MAMPU), Malaysian Communications and Multimedia Commission (MCMC), and Ministry of Science and Technology and Innovation (MOSTI) created these applications to help in monitoring of the spread of the disease in the country and provide means for users to check their symptoms. MySejahtera, in particular, was done mainly to break the chain of the spread of the pandemic, assist users in assessing their health, and provide information of the nearest hospitals and clinics to get COVID-19 treatment (*FAQ | MySejahtera*, n.d.). These mobile applications are intended for mobile devices like smartphones or tablets that use wireless communication like Bluetooth or the internet. These applications are beneficial in the prevention and treatment of highly contagious diseases like COVID-19 (Zamri & Syed Mohideen, 2021).

However, there are several issues that are present in the current implementation. These problems have impacted greatly the government as well as people's concerns. From the user perspective, privacy has always been a questionable issue for current contact tracing applications. While from the government perspective, the efficiency of the app could be the contributing factor in the increase of cases in Malaysia. Further elaboration will be presented in 1.2.

1.2 Problem Statement

This section will elaborate on the existing problems that the proposed project would address. Three main issues are found, which will be discussed in the subsequent sections of 1.2.1 until 1.2.3.

1.2.1 Privacy

The mobile applications used primarily in Malaysia require users to insert valuable personal data like Identification Card (IC) or passport number, full name, address, age, gender, ethnicity, and contact number. Moreover, users do not have the option whether to give the information since the government made it compulsory to use the applications in everyday lives like going into shops, restaurants, malls, etc. These critical data are stored in a centralized database that is susceptible to data breaches. Besides that, Fong Choong Foo, who is an IT expert, raises concerns about the government's handling of the data and demanded the government to be more transparent in its security mechanism (Ainaa, 2020). Although the government assured the Malaysian citizen that the data gathered would not be used other than the intended purpose on 19th November 2020 (New Straits Times, 2020), there is no guarantee to the integrity of the data as the threat of malicious hackers will cause significant issues if they decide to act upon those particular data.

1.2.2 Practicality

The applications used in Malaysia operate similarly in terms of use or operation, which revolves around premise-based contact tracing. In general, if one would like to visit any premise like a supermarket, they would have to take out their smartphones, open the application, and scan the unique quick response (QR) code prior to entering the premise. Figure 1.0 shows the official steps to "check-in" into premises for MySejahtera.

Figure 1: taken from Director-General of Health Malaysia Facebook page.

These steps are impractical since they would have to experience the hassle of taking out their devices every time they go into a premise where sometimes they keep their device in their bag. This method also creates an unnecessary long queue of people before entering the premises, which would also defeat the purpose of preventing the spread of disease since long lines involve lots of people. New laws are created due to this, such as people will be given compound if they failed to scan the QR code before entering any premise as shown in the case of a form 5 student from Melaka compounded for RM10,000 for failing to use the MySejahtera application to buy paracetamol for her mother (Murali, 2021).

1.2.3 Efficiency

Before the wide use of digital contact tracing, countries rely solely on manual methods, which can be slower compared to the help of digital technologies. Generally, there are two methods of conducting digital contact tracing, which are centralized and decentralized. The government of Malaysia has chosen to use a centralized QR code-based contact tracing framework for its applications. Since this is a premise-based approach, it does not allow for specific selectivity in terms of quarantining. For example, if a premise is compromised with a positive case in a particular time and day, those who visit the premise in that exact timeframe will

be advised to quarantine. This can lead to unnecessary quarantine for people who had not been in the minimum distance for contracting the disease from the positively identified person in the same premise.

In order to solve these problems, several solutions are proposed. The DP3T protocol is crucial in most of the problems like privacy and efficiency. The protocol uses a decentralized mechanism that prevents various problems like a data breach. For the application, the data manipulation and storage are fully done by the device itself, while the database only stores unique codes for the positive cases. Efficiency, on the other hand, the proposed app uses Bluetooth Low Energy (BLE) technology which is more accurate in quarantining people (Hernandez-Orallo et al., 2020). Consequently, users do not have to take out their phones when visiting premises as the BLE technology allows the data transfer between people in close proximity.

1.3 Aim and Objectives

The purpose of this project is to develop an Android mobile application to improve current digital contact tracing that is widely used in Malaysia.

The meet the aim stated above, there are several objectives that need to be worked on. The following are the objectives:

1. To develop MyCovid: Decentralized and Privacy Focused Covid-19 Contact Tracing Application for Android devices.
2. To implement the DP3T protocol inside the application.
3. To test the effectiveness of the application through User Acceptance Test (UAT).

1.4 Scope

The scopes for the project are:

1. The application will be developed for Android mobile devices only.
2. The application will only have the function of contact tracing and does not track positive cases or detect hotspots.

3. The application will not share data for any purposes like research.
4. The application is intended for all people that reside in Malaysia.

1.5 Significance of the Project

The proposed project is expected to produce an application that will provide another perspective to a better solution for the current contact tracing application. This will help the government's effort in preventing the spread of COVID-19 by executing this project and producing the application. If successful, the application will improve current implementation in Malaysia from the aspect of efficiency, ease of use, and privacy. The proposed application is hoped to be the main platform that will replace current contact tracing apps or be integrated into the mainstream contact tracing application.

1.6 Organization of Thesis

The organization of the thesis is as follows.

1. Chapter 1: Introduction
   This chapter will discuss and elaborate on the background, problem statement, aim and objective, scope, as well as the significance of the project.

2. Chapter 2: Literature Review
   This chapter will explore and study previous journals and articles related to this project which include the current implementation of similar applications in Malaysia, the chosen mechanism, and the significance of privacy.

3. Chapter 3: Methodology
   This chapter will discuss the methodology in developing the MyCovid application along with a detailed description of the phases and activities for each stage of the methodology.

4. Chapter 4: Implementation of Design

This chapter will elaborate on the design, architecture, functional and non-functional requirements of the application. Sequence and use case diagrams are also provided here.

5. Chapter 5: Results and Discussion

   This chapter will discuss the findings of the whole project. It outlines the deliverables and the testing method used for this project.

6. Chapter 5: Conclusion

   This chapter will summarize the contents of this report and discusses future work for Final Year Project 2.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will study previous research and studies relating to this project to provide better insight into the proposed application. Aspects regarding the existing technology being implemented, comparative studies between different contact tracing mechanisms, and the existing applications in the market are elaborated in detail.

2.2 Assessing the differences in contact tracing technologies

The Malaysian government created the national contact tracing application called MySejahtera in an effort to prevent the spread of the COVID-19 virus (*FAQ | MySejahtera*, n.d.). In addition to that, some state government has also created their own application to be used within their state as in the case of Selangkah (*FAQ – General | SELangkah*, n.d.). However, both of these applications use a centralized, QR code-based technology only for their contact tracing effort.

As the nature of the centralized method, the lack of privacy-preserving features has raised concerns mainstream population (Ainaa, 2020). One study evaluates the methodology of the QR-based mechanism as a means of tackling the pandemic and discusses the efficiency of the method (Nakamoto, Wang, et al., 2020). The study discusses the framework of the mechanism and especially the quantitative analysis of the effectiveness of the method. They found that the centralized approach is different in three aspects which are the integration of features, the ability to self-diagnose for

individuals and scheduling for institutions, and pioneering role in combating the pandemic. In contrast, Nakamoto et al. also found that there is a concern for the case of data misuse, which can cause a significant effect on various aspects. They also acknowledge that the lack of privacy will be a concern for some populations that are more aware of it.

The case is the same for the MySejahtera application. A study was done to discusses the privacy aspect of the Malaysian contact tracing app (Hasan et al., 2020). The article has found that the government is able to collect sensitive information from the application by the concept of public interest and suggests that the data should be destroyed after a specific duration. This study also concludes that contact tracing application is a necessary tool in fighting the spread of the virus even with the cost of privacy invasion (Hasan et al., 2020). However, the study did not mention the existence of a decentralized contact tracing app where it is clear that the mechanism has a superior privacy-preserving feature (Duball, 2020).

One of the most significant features of decentralized contact tracing is its privacy-preserving nature. Another study by one of the same authors, Nakamoto et al., discussed and evaluated a Bluetooth-based mechanism that was deployed in Japan. The study found that the detection of close contact cases is much faster than the method that does not utilise Bluetooth technology. Other than that, they conclude that the load of the health care system can be reduced since most of the work is done locally by the device itself. People's confidence and trust towards the application could increase due to the data protection and privacy-focused mechanism, which certainly help in the overall effort of contact tracing (Nakamoto, Jiang, et al., 2020). They also stated that this methodology would prevent attackers from exploiting valuable data since there is no sensitive data available. Similarly, since there is no personal data is stored by the authorities, the reduction of data misuse can be achieved (Nakamoto, Jiang, et al., 2020).

Based on the studies that have been reviewed, we found that there is a significant strength for both centralized and decentralized mechanisms of contact tracing. However, one of the differences is in the aspect of data manipulation. For example, health authorities, government, and academic societies can benefit from the

former mechanism since the data stored can be shared and used for statistics and studies the overall trend for the spread of disease. In contrast, one of the benefits of the latter mechanism is towards its users. This is due to the feature of privacy-preserving for the mechanism where users' data is significantly protected and does not store in a single server.

2.3 The mechanism used in MyCovid

The proposed application is expected to use the Decentralized Privacy-Preserving Proximity Tracing (DP3T), which was introduced on 4th April 2020 on GitHub (carmelatroncoso, 2020). The protocol was made by the Swiss Federal Institute of Technology Lausanne (EPFL) with collaborations from universities such as ETH Zurich, KU Leuven, University of Oxford, et al. with the vision to reduce the risks of privacy and security while ensuring high data integrity and protection while being a digital contact tracing (Troncoso et al., 2020). Due to this, the protocol is highly suitable for this application because it provides the best solution for the problems that we have elaborated on in the previous chapter.

We elaborate on the DP3T infrastructure by referring to the current version (25 May 2020) of the official white paper for the protocol. The participating entities for the DP3T system are users with Bluetooth-capable devices, backend server, and health authorities. Although they specified three distinct protocols, they basically function similarly where ephemeral identifiers (EphIDs) are generated locally on devices and transmitted over BLE. Other devices detect these signals, which then record the time stamp, data to quantify exposure like signal attenuations and the EphIDs.

After a person is positively identified with COVID-19, health authorities will give a unique authorisation code allowing the user to upload a representation of their EphID to the server (Step 2 and 3, Figure 2.1). This authorisation method prevents false positives or spam from being uploaded into the server. Lastly, other devices request information, particularly the EphIDs representations to the server periodically (Step 4, Figure 2.1). If the device has previously gathered signals similar to the reported EphID in the server, then it is highly likely that they have been in close contact

with a positive case of COVID-19 and may have been exposed to it. The mechanism of the contact tracing is briefly illustrated in Figure 2.1.

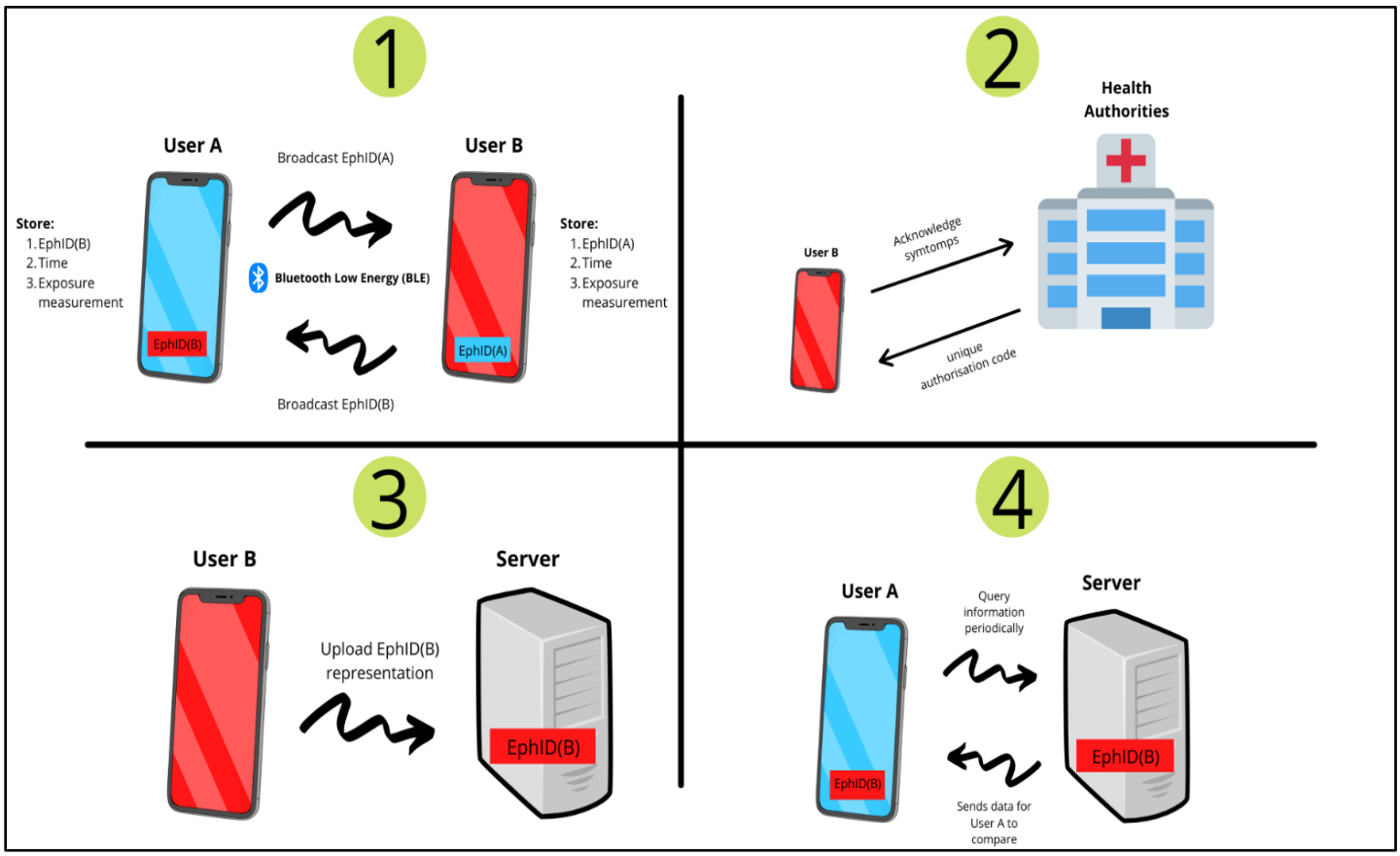

Figure 2.1: simple illustration of the contact tracing mechanism

2.3.1 Using the low-cost mechanism

Although they made three mechanisms for contact tracing in the DP3T protocol, we opted for the low-cost mechanism due to its attributes of privacy and small bandwidth requirements. This is in the hope of reaching for a wider group of people, especially those without a highly resourceful and capable device like the 20,000 low-quality Yes Altitude smartphones distributed to families from the Perak state government (Wong, 2021).

The application generates the initial seed or secret key SK_t during setup where t is the current day. Each day, the secret key is expired and will be changed using the formula

$$SK_t = H(SK_{t-1}) \tag{1.1}$$

where

H = cryptographic hash function

SK = secret key

t = day

Ephemeral IDs are broadcasted through an epoch (the duration for the device to broadcasts the same EphID), which is a modifiable duration using the system parameter of *L*. For the start of each day, the application generates *n* number of new EphID to be broadcasted for the duration of the whole day. The total number of EphIDs are generated by

$$n = (24 * 60)/L \tag{1.2}$$

where

n = number of EphID

L = length of an epoch in minutes

Each secret key generates a number of *n* ephemeral IDs of 128 bits using the formula

$$EphID_1 || \dots || EphID_n = PRG(PRF(SK_t, "broadcast\ key")) \tag{1.3}$$

where

PRG = pseudo-random generator such as AES-CTR or Salsa20

PRF = pseudo-random function such as HMAC-SHA256

broadcast key = fixed and public string

The application uses the Bluetooth interface to broadcast the latest EphID as a beacon periodically. Bluetooth has a limited range, and the strength of the signal reflects the distance between two devices. In addition to that, the broadcast frequency is not mentioned in the paper. The application, on the other hand, retains incoming beacons as well as other information like the time, proximity which is determined by signal attenuation, and other metadata. For privacy concerns, one of DP3T's

principles is to save as little data as possible. The other principle is that data gathering takes place locally on the user's device rather than a central database.

The server is updated with pairs of SK_t and their validity times by the user after they have been authorized by the health authority. They are keys that were utilised by the app and were carried by a positively reported person. The application can re-generate the EphIDs for each pair and evaluate if they were stored at the right time. Due to this, the app can calculate a risk-based on how long and how far the infected individual has been encountered. The app will generate an alert if the risk meets the requirements. Users act upon the alert by contacting health authorities and personal quarantine.

2.4 Existing Applications

Other similar applications have already been deployed and used widely in Malaysia, as mentioned previously. This section will elaborate on all the existing apps that are made for contact tracing efforts, as well as the notable differences and similarities between those apps and the proposed app. Aside from MySejahtera, which is the national contact tracing application, notable state government applications from Sarawak and Selangor are also presented, which are CovidTrace and Selangkah, respectively. However, there are notable mentions of Gerak Malaysia which were developed to track the movement of population and were discontinued on 31st July 2020 (Bernama, 2020b). At the end of the section, a comparative table that summarizes all the points is made that discusses the differences and similarities in the applications.

2.4.1 MySejahtera

MySejahtera is a mobile software created by the Malaysian government to help in the management of COVID-19 outbreaks in the nation. It enables individuals to self-assess their health as well as that of their family. During the COVID-19 outbreak, people can also track their health status. The National Security Council (NSC), the Ministry of Health (MOH), the Malaysian Administrative Modernisation and Management Planning Unit (MAMPU), the Malaysian Communications and Multimedia Commission (MCMC), and the Ministry of Science, Technology, and Innovation

(MOSTI) have collaborated to create MySejahtera. The application was launched and introduced by the Minister of Health Malaysia, YB Dato' Sri Dr. Adham Baba, on 20th April 2020 (BERNAMA, 2020). The application is available in the Gallery of Malaysian Government Mobile Application (GAMMA) and the app store of popular mobile operating systems in Malaysia, which are Google Play, Apple Store, and Huawei AppGallery (*FAQ | MySejahtera*, n.d.).

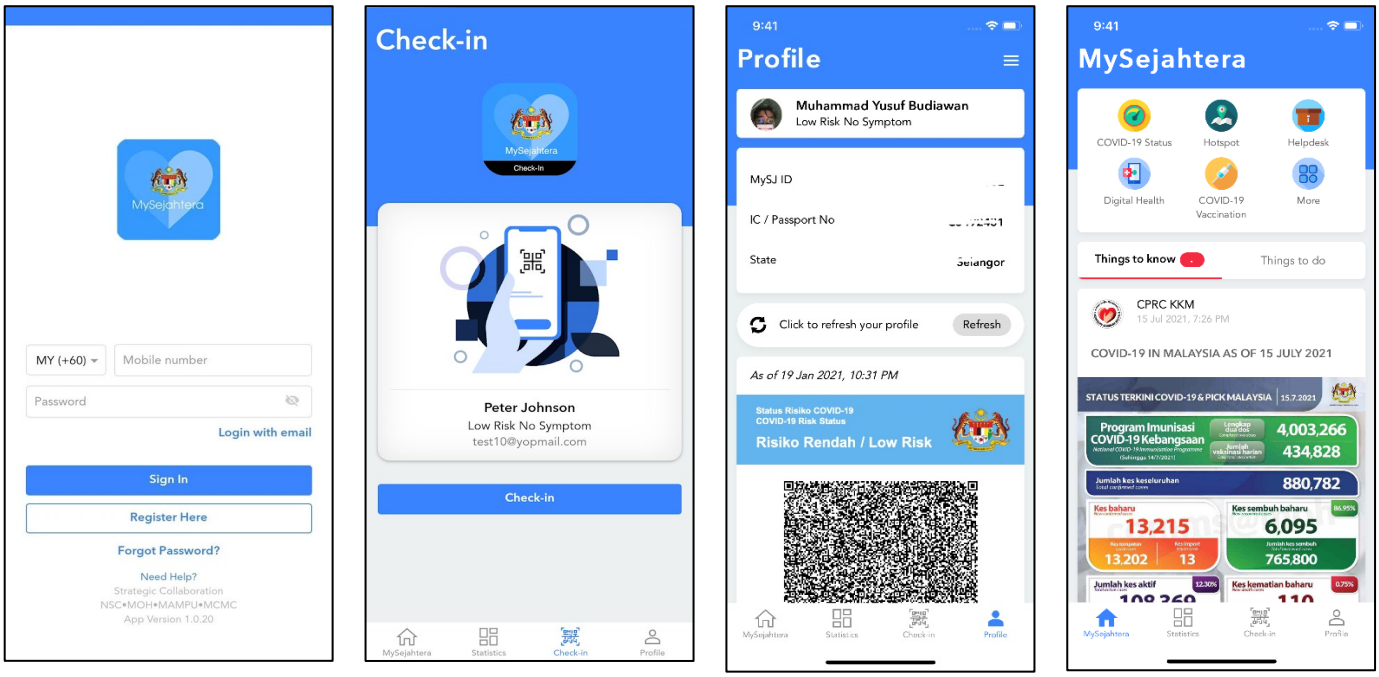

Figure 2.2: illustrates the current MySejahtera user interface. From left to right; login, check-in, profile, and home page.

The main purpose of the MySejahtera application is to help the department manage and mitigate the COVID-19 outbreak by allowing users to track their health throughout the outbreak, assisting users in receiving medical attention if they are diagnosed with COVID-19 disease, and locating nearby medical centres for COVID-19 treatment. Another important function of the app is digital contact tracing that assists in the health authority's effort of manually tracing. The application is a premise-based method and uses the QR code mechanism where every premises is required to display their unique QR code for MySejahtera users to scan and log in. The application request myriad of users' personal data such as IC number, address, mobile number, location, etc. (*MySejahtera Privacy Policy*, n.d.). Figure 2.2 shows the current UI for MySejahtera version 1.0.39 in iOS.

Aside from the contact tracing capabilities, another important feature of the application is the registration of vaccination which was introduced in version 1.0.28. Users can book immunisation appointments online using the app. Similarly, through the 'MySejahtera' app, users would be notified of their vaccination date and the steps are provided to assist users till the vaccination procedure is completed. However, there are reported issues during the registration phase where users cannot access and check the vaccination module in the application (Yeoh, 2021). A digital certificate will be produced after the user has finished the second dosage of the vaccination.

2.4.2 Selangkah

Selangkah stands for "Langkah masuk dengan selamat", or "Step in, safely". It is a mobile application developed by the Selangor state government to assist health authorities in tracing and ensuring the health of the people during the pandemic (*FAQ – General | SELangkah*, n.d.). It was introduced by the chief minister of Selangor, Amirudin Shari, on 4th May 2020 (Bernama, 2020a). Selangkah is a QR-code-based automated entry registration system that will be installed at commercial locations. Upon registering, each premise will be issued a distinct QR code, which customers are instructed to scan with their devices and submit their personal information to the app.

Selangkah is available on Android Google Play, Apple App Store, and Progressive Web App (PWA). Similar to MySejahtera, the main purpose of the application is to curb the growing spread of COVID-19. However, this application only caters to the population of the Selangor state, while MySejahtera is intended for anyone who resides in Malaysia. The application is also a premise-based method and uses the QR code mechanism. Selangkah notable features include super scanner, GPS, and Map.

Figure 2.3: shows the user interface of Selangkah. From the left; Home, Map, Check-in page.

There are two ways to log into premises which are either through the QR code or GPS. The GPS method is an effort by the developer to save time from queuing to scan a QR code. Another important feature is Map. Distinct from MySejahtera, Selangkah offers a zonal area that has a higher case of COVID-19 detected which is shown on the Map page where the red or orange line highlights the location in Figure 2.3. Besides that, it has other features like Bubble, the ability to create a group for an easier check into premises. Vaccination registration and health assessment are also present in the application.

2.4.3 CovidTrace

CovidTrace is a contact tracing application for mobile devices that was developed by Sarawak Information Systems (SAINS) with the collaboration of Sarawak Multimedia Authority (SMA) to assist the Sarawak's government in reducing the spread of the COVID-19 disease, which is similar to Selangkah in terms of the state focused users. It was launched by the chief minister of Sarawak, Datuk Patinggi Abang Johari Abang

Openg on 29th May 2020 (Kawi, 2020). The application uses Bluetooth technology as opposed to QR code technology presented in the previous example.

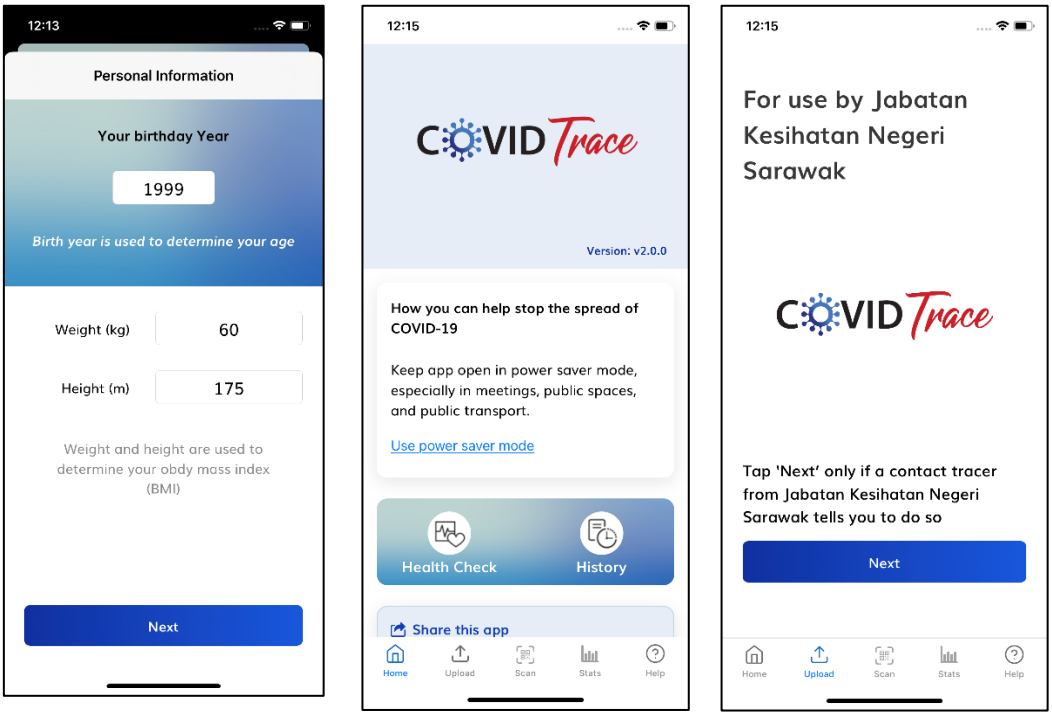

Figure 2.4: shows the user interface of CovidTrace

The application put a heavy focus on the privacy aspects as it can be shown by the list of privacy preservation of CovidTrace shown on the front page of the official website. The app preserves the privacy of its users by not collecting sensitive information aside from mobile number, location data, ability to revoke consent so that data will be erased by the system. The history of encountering possible cases is also stored only in the user's device.

The contact tracing function is a community-driven effort rather than health authorities which is a similar method to the proposed application in this project. This is because after the recording of the data between devices, the positive person needs to upload their information to the Sarawak Health Authority Database so that others can be notified if there was any close encounter with the reported person (*COVIDTrace | FAQ*, n.d.).

2.4.4 Summary of the comparison between similar applications

Table 2.1: Comparison between MyCovid and existing applications in Malaysia

Aspect	MySejahtera	Selangkah	CovidTrace	MyCovid
Technology	QR code	QR code and GPS	Bluetooth and QR code	**Bluetooth**
Data storing mechanism	Centralized	Centralized	Hybrid between centralized and decentralized	**Decentralized**
OS	iOS, Android, HarmonyOS	iOS, Android, Web Browser	iOS, Android	**Android**
Personal data request	Required	Required	Required	**Not Required**
View statistics	Yes	Yes	Yes	**Yes**
Contact tracing method	Mostly by health authorities	Mostly by health authorities	Individual effort	**Individual effort**
Area of tracing	Premises only	Premises only	Premises and non-premises	**Premises and non-premises**

Table 2.1 shows the significant similarities and differences between the proposed application, MyCovid, and other similar apps currently being used in Malaysia. The project will only use Android due to limitations in time and resources as well as developer expertise. Other than that, MyCovid will be using a decentralized mechanism to better preserve privacy similar to CovidTrace. However, the latter app also has a centralized database due to storing user's data while entering premises using QR code. Besides that, MyCovid does not request any personal data. The case is not the same for MySejahtera and Selangkah, where it asks for multiple sensitive information for the app to work. On the other hand, CovidTrace only asks for mobile number as well as the date of birth, weight, and height for health assessment. In conclusion, there are a lot of similarities between MyCovid and CovidTrace with few distinctions. The differences between these apps have their own strength and limitation as explained in the previous section.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss the type of development methodology that has been chosen in this project to create MyCovid. Then, the elaboration of each phase is also provided in the subsequent sections. Besides that, this chapter will also discuss all the necessary software and hardware that will be used in order to fully develop the proposed application.

3.2 Rapid Application Development (RAD)

Initially, RAD was developed in the 70s and 90s as Structured Systems Analysis and Design Method (SSADM) in response to the plan-driven waterfall model (Ashworth, 1990). However, it was made based on the traditional engineering model commonly used in civil engineering. Therefore, various alternatives were made to improve the method and subsequently, James Martin developed the currently popular RAD approach in the 80s at IBM and formalized it through a book in 1991 titled “Rapid Application Development” (Martin, 1991). In RAD software development, less attention is concentrated on the planning phase and more focus is given on the adaptive process. Usually, prototypes are used as a complement to the design specification and sometimes replace altogether. RAD is particularly well suited to producing software with user interface expectations.

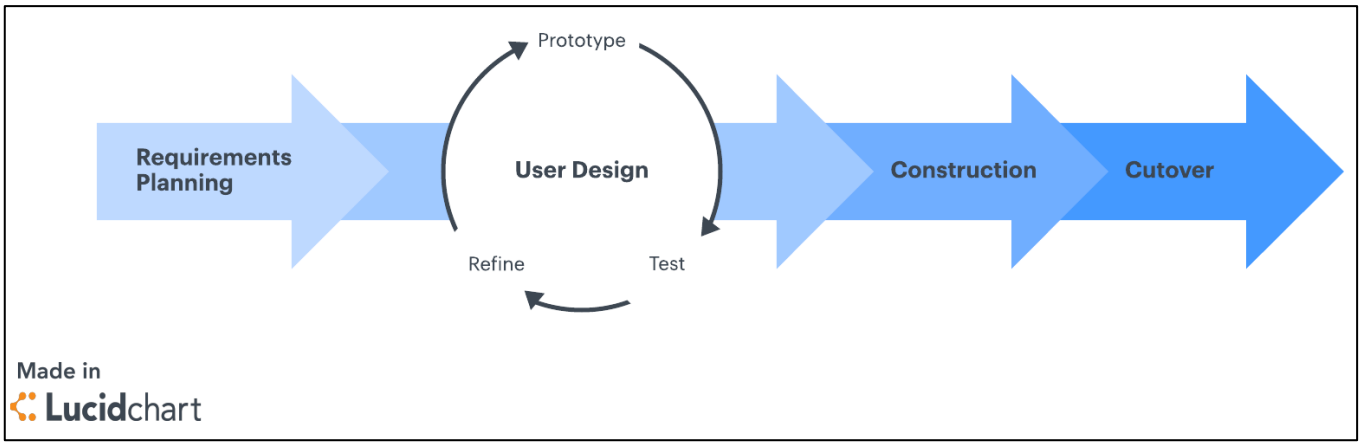

Figure 3.1: Illustrates the phases in RAD methodology

RAD is chosen for this project due to its fast-paced nature since it focuses on the development of the incremental unit. Due to this, bugs can be discovered in the early stage, where they could have been found in the later phase of the waterfall model. Besides that, RAD is suitable because it can make a better-quality product since it develops on evolving prototypes. The evolving prototypes focus on the functionality and business functions that are significant as opposed to technical requirements. Moreover, RAD enables any modification or module to be inserted through every iteration and uses stakeholder feedback to improve it. RAD is divided into four unique phases; requirement planning, user design, construction, and cutover, as illustrated in figure 3.1.

There are several key aspects that made RAD more suitable than the traditional Waterfall model. For the risks, the latter model poses a higher risk than RAD for developing software. This is because small modifications or mistakes in the finished program might generate plenty of complications (Alshamrani & Bahattab, 2015). Secondly, if there will be any changes made in the later stage of the Waterfall model, it would be costly and highly time-consuming to fix. For RAD, however, changes can be done in any phase without incurring much cost and resources where risks are distributed to a smaller increment of unit (Alshamrani & Bahattab, 2015). Thirdly, the delivery of the product in the Waterfall model is at the end of the development cycle. The documentation is only presented until the final stage (Alshamrani & Bahattab, 2015). Since this project needs to be presented to the supervisor frequently, it would

not be suitable for that. RAD, on the other hand, promotes early deliveries, and developers can modify the software upon feedback from other parties.

3.2.1 Requirement Planning Phase

In the requirement planning phase, all the related stakeholders like the project manager and development team plan and reach an agreement on the project's scope, needs, and requirements. However, what sets RAD apart is that broad requirements are gathered so that it can be flexible throughout the development (Martin, 1991). Generally, the purpose of this phase is to give a piece of clear information to the stakeholders, especially the development team of what is going to be built.

The requirement gathering for this project is done by analysing current technologies being implemented for contact tracing. Besides that, previous journals and studies regarding digital contact tracing are also reviewed to get all the relevant data that is significant for this project. Lastly, consulting with peers and supervisors for their input regarding the project is also one of the main ways to gather requirements. This phase is crucial in the overall development of the product because it provides the foundation and structure when going forward in the development. This converts the needs of potential users into viable specifications. Once the scopes and requirements are finalized, approval to continue to the user design phase is given.

3.2.2 User Design Phase

During this phase in RAD, users cooperate with system developers to create models and prototypes that portray all of the system's processes, inputs, and outputs (Martin, 1991). To translate user needs into functioning models, RAD groups often employ a combination of Joint Application Development (JAD) methodologies and Computer-aided Software Engineering (CASE) tools. This phase is a continuous activity that enables clients to interact, modify, and eventually approve a functioning model that meets the requirements. In this phase, users provide feedback, and an improved iteration is made based on the feedback until the best prototype is achieved.

Initially in this phase, a detailed system area model of the application will be created. The model is made based on the analysis of the overall function and data flow related to the proposed application. Due to this, the scope can be refined to ensure the significant functions of the application meet the requirements and are delivered within the timeframe. After the model is approved, an outline of the system based on the model is developed and will be refined by the developer. One of the purposes is to find out the data flow and interaction between the functions of the app. Once the refined design is created, the developer team will prepare how to implement the design into a working application. This is where the design is finalised, and the outcome of the prior activities is approved for the construction phase.

3.2.3 Construction and Testing Phase

Similar to the SDLC, it focuses on system and application development activities. Clients in RAD can keep contributing and offer adjustments or enhancements when actual interfaces or reports are produced. Application development, coding, unit integration, and system testing are among its responsibilities. The construction phase's goals are finalizing the detailed design from the previous phase, developing and testing the system that implements the design, preparing documentation to use the app and preparing it for deployment. Feedbacks provided from users are not limited only to functionality; it also may include user interface, user experience, aesthetics, etc. The construction phase continues until all or most feedbacks are taken into consideration or satisfied.

Before the development of the application, the environment for it is prepared and finalised like the developer's workstation, the software tools for the coding, and all the related elements in both physical and virtual environments. Furthermore, the database is built using the data structure that was defined during the user design phase. After this, the development activities are initiated which include the coding or implementing each specified function based on the requirements. Then, the development team will create test data that is made for testing the functions and the system documentation which elaborates how the system is operated. This is important during the system verification activities because multiple tests are done to ensure that each module of the application exactly meets the requirements.

3.2.4 Cutover Phase

The cutover phase is the final phase of RAD. Data migration, testing, switching to the new system, and user training are all part of the cutover phase, which matches the latter activities in the SDLC implementation phase. The entire procedure is compressed when compared to traditional approaches. As a result, the new system may be created, installed, and put into service significantly more quickly (Martin, 1991). the finalisation of the software program's aesthetics, features, functionality, and user interface, as well as other aspects, is also done in this phase. Interfaces between several independent components must be thoroughly tested by utilising automated tools followed by user acceptance testing. This makes sure that the usability, integrity, and availability meet the user requirements before releasing the product.

During this phase, data required for the new system's operation is translated from old sources of data into a format that the new system can understand. After that, the transformed data is fed into the system's database. Then, the software is installed into the device, where adjustments to the hardware and software are performed as needed. The installation is considered successful if it operates within a specified time period and performance. The success of the installation is agreed upon by the developers, users, and other stakeholders, as well as the information management like system documentation and project report.

3.3 Software and Hardware Technologies for Development

This section will elaborate on the list of tools that will be used to develop the mobile application. It is divided into two sub-sections which are for hardware and software. Suitable tools are necessary to create a fully functioning mobile application. The technologies used can be the definition of success to a project as it can affect several aspects like development time, developer well-being, and others.

3.3.1 Hardware

3.3.1.1 Workstation

The main workstation that will be used to develop the application is a desktop computer. Its specifications meet all the minimum requirements to support the software tools for development, as shown in Table 3.1.

Table 3.1: Workstation specification

Aspects	**Description**
Processor	AMD Ryzen 5 3500X 6-Core Processor, 3593 Mhz, 6 Core(s), 6 Logical Processor(s)
Installed Physical Memory (RAM)	16.0 GB
Total disk space	1.25 TB
Monitor	144Hz 24", 1080P
Operating System (OS)	Microsoft Windows 10 Home
System Type	x64-based PC

Figure 3.2-3.3: Similar representation of the workstation being used. Picture from builds.gg and Philips.com for illustration purposes only

3.3.1.2 Android Device

The android device will be used to install and test the application throughout the development. The source code can be run physically with the Android Device or virtually by Android Studio. One of the important components is Bluetooth Low Energy (BLE) that will be used for contact tracing shown in Table 3.2.

Table 3.2: Android device specification

Aspects	**Description**
Model	Asus Zenfone 3 ZE520KL
Processor	Qualcomm MSM8953 Snapdragon 625 (14 nm)
Operating System (OS)	Android 8.0.0
Graphic	Adreno 506
Memory	4 GB
Storage	64 GB
Bluetooth	Version 4.2, A2DP, EDR, LE

Figure 3.4: Similar representation of the android device being used. Picture from gsmarena.com for illustration purposes only

3.3.2 Software

3.3.2.1 Android Studio

Android is the most used mobile operating system in the world with over 2.8 billion active users and 75% global market share for the year 2020 (*Android Statistics (2021) - Business of Apps*, 2021). Since the proposed application is based on Android, a higher percentage of users can be reached for the early version of the application. Integrated Development Environment (IDE) is needed to write the source code. Therefore, we choose Android Studio since it is the official IDE for android application development (*Android Studio | Android Developers*, n.d.). The IDE u was built on JetBrains' IntelliJ IDEA software and made especially for Android development (Ducrohet et al., 2013).

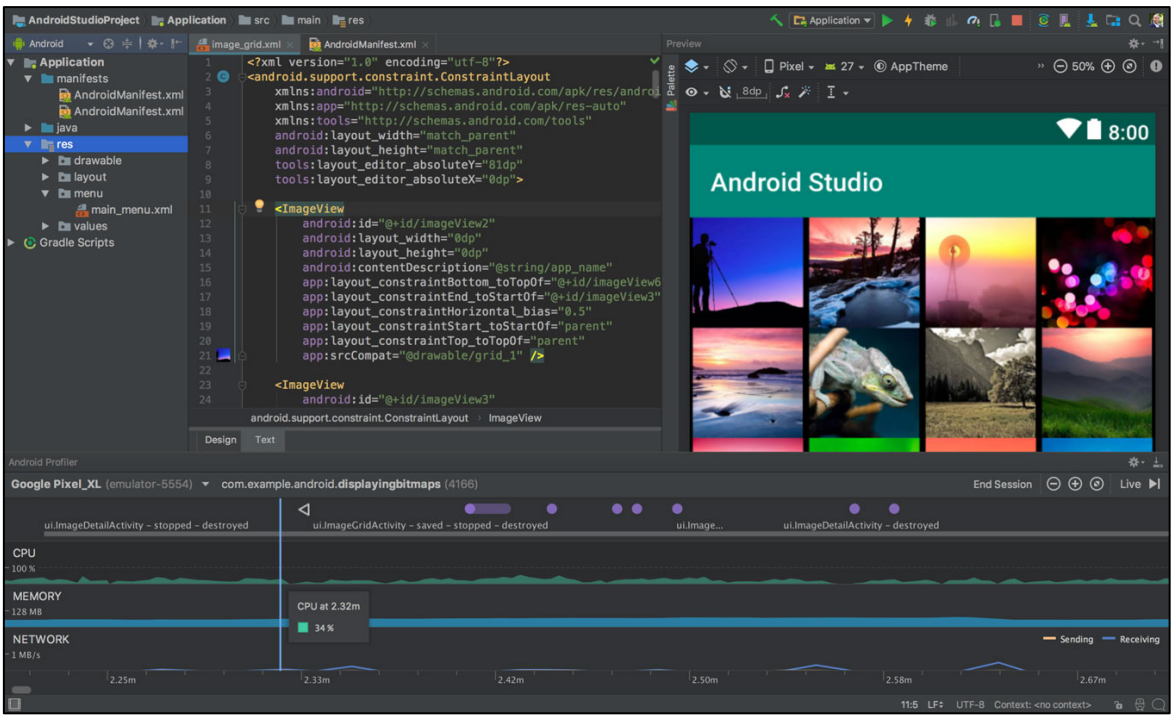

Figure 3.5: interface example of Android Studio taken from developer.android.com

There are many features of Android Studio that distinguish itself from others. First, it has flexible Gradle-based build support which allows you to personalise the build and generate several build variations for multiple devices from a project. For the emulator, it installs and launches the apps quicker than on a physical device and test

alternative configurations and features, such as ARCore, Google's virtual reality technology. This provides wider options for apps execution during development. The IDE includes an advanced code editor with code suggestions for Java, Kotlin, C, and C++. Lastly, it has a visual editor built in where we can create complex designs, and choosing one of several devices or simply adjusting the preview window; we can see the layout on any screen size.

3.3.2.2 Adobe XD

Adobe Experience Design, also known as Adobe XD is a design tool made specifically for user experience or user interface design made by Adobe Incorporated. The software is suitable for designing web and mobile application prototypes. It's supported for macOS and Windows. However, there are also iOS and Android versions to allow the designer to see the results of their work on their smart devices. This makes it easier and more productive to work on the prototype design. Website wireframing and click-through prototypes are both supported by Adobe XD (Lardinois, 2016).

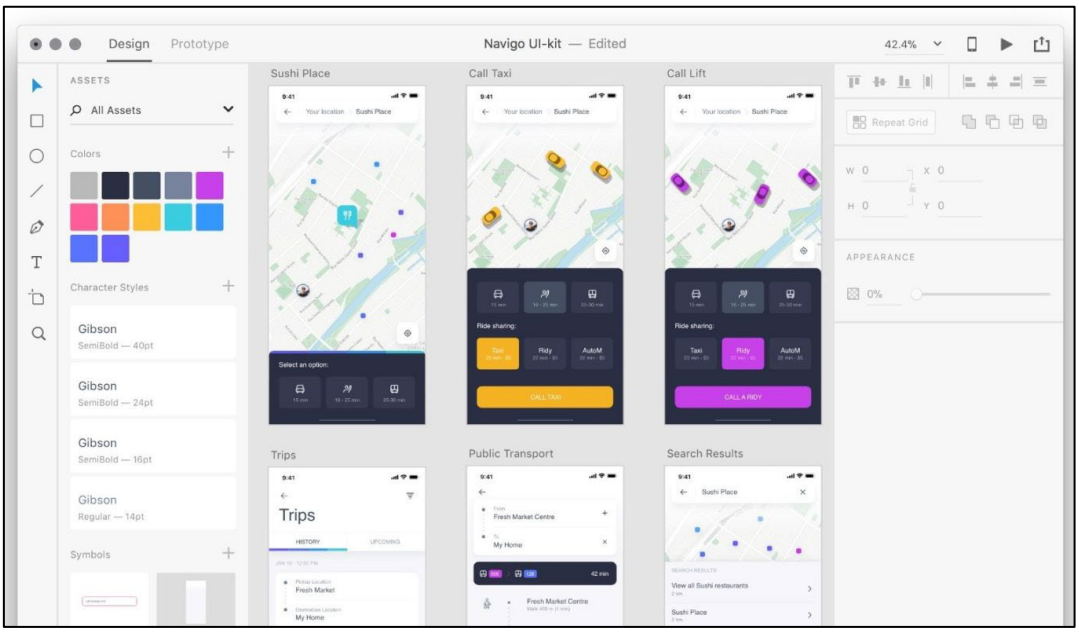

Figure 3.6: interface example of Adobe XD taken from blog.adobe.com

Adobe XD has various features that become the reason it is chosen between other designing software tools. With a simple function switch within Adobe XD, we can build a dynamic and interactive prototype. Features like reusable buttons,

resizable cards, repeat grid, states, and content-aware layout can improve the workflow of the development team as it assists tremendously in prototyping. It can emulate the working flow of the website or application and give it motion by using animations to generate transitions and then share an interactive preview in real-time with teams or stakeholders to evaluate the design (*Features Overview | Adobe XD*, n.d.).

3.3.2.3 Canva

Another important software used for designing is Canva. It is a graphic design application that is made for presentation, social media, documents graphics and other visual media. The app can be accessed through a web browser for desktop computers and mobile applications in iOS or Android. It is a convenient and robust design tool suitable for this project.

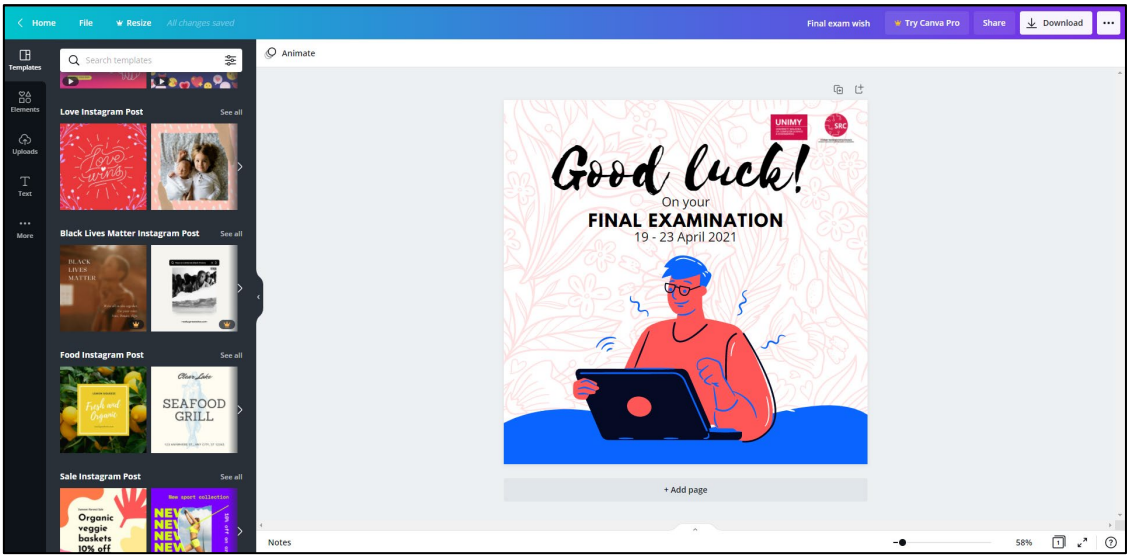

Figure 3.7: the interface of Canva in a web browser that provides templates

Canva has a lot of advantages that made it suitable for the development of the proposed application. Firstly, it has a wide array selection of professional templates to choose as shown in Figure 3.5 (Demarest, 2020). This is crucial to give ideas and input to the designer of the application. Other than that, it has the ability to share and work the design together simply with a link share which eases developers for collaboration. Lastly, it provides the ability to download designs in multiple file formats like png, pdf, jpg, and svg. However, Canva is not similar to Adobe XD in the aspect of uses.

Canva is highly suitable for designing the interface and other media, while Adobe XD is used for prototyping with identical operation flow to the final product. Thus, these tools will work for hand in hand to get the best UI/UX for the application.

3.4 Summary

In a nutshell, this chapter has provided the arguments and points to shows that RAD is a suitable development methodology for this project. This is since it enables for fast prototyping and requirements changing during the development. Other than that, to support the RAD development, the physical tools are explained like workstations that meet the requirements for the IDE, prototyping and designing software. In the next chapter, the implementation for the project is elaborated.

CHAPTER 4

IMPLEMENTATION OF DESIGN

4.1 Introduction

This chapter will elaborate and demonstrate the whole implementation of the design for MyCovid. The functional requirements will be illustrated with the use of diagrams like use case and sequence diagrams to give more clarification to the reader. These diagrams will assist in discussing the critical functions of the app. Moreover, the non-functional aspects are discussed in the next subsection for this app to make it more feasible and suitable for deployment. Lastly, the initial user interface design will be included and presented in this chapter by using the Adobe XD program to create the early UI design to give some idea to the user of the final product of the app.

4.2 User Requirements

User requirements describe how a user will interact with a system and what they anticipate from the interaction. A user requirement may be established on what occurs when the user selects an operation on the screen when the system includes a screen or human-machine interface component. Perhaps pressing a button not only initiates a procedure but also switches to a different screen. All the use cases interacted by the user will be described. This section will discuss both the functional and non-functional requirements for MyCovid.

4.2.1 Functional Requirements

The functional requirements statements describe all the functions or services the system should provide, react to a specific input, as well as the behaviour of the system in specific situations. The only actor that interacts with the MyCovid application is the User. The following states the functional requirements for MyCovid: -

1. The user must be able to view the statistics of the pandemic, home, and information pages.
2. The user must be able to insert a specific code when tested positive of Covid-19.
3. The system should alert the user if they have been in close proximity with a positive case person.
4. The systems should be able to retrieve information about the reported cases from the database.
5. All exposure events should be recorded by the history function.
6. Users must be able to view the history of exposures.

The use case diagram for the application is displayed in Figure 4.1: -

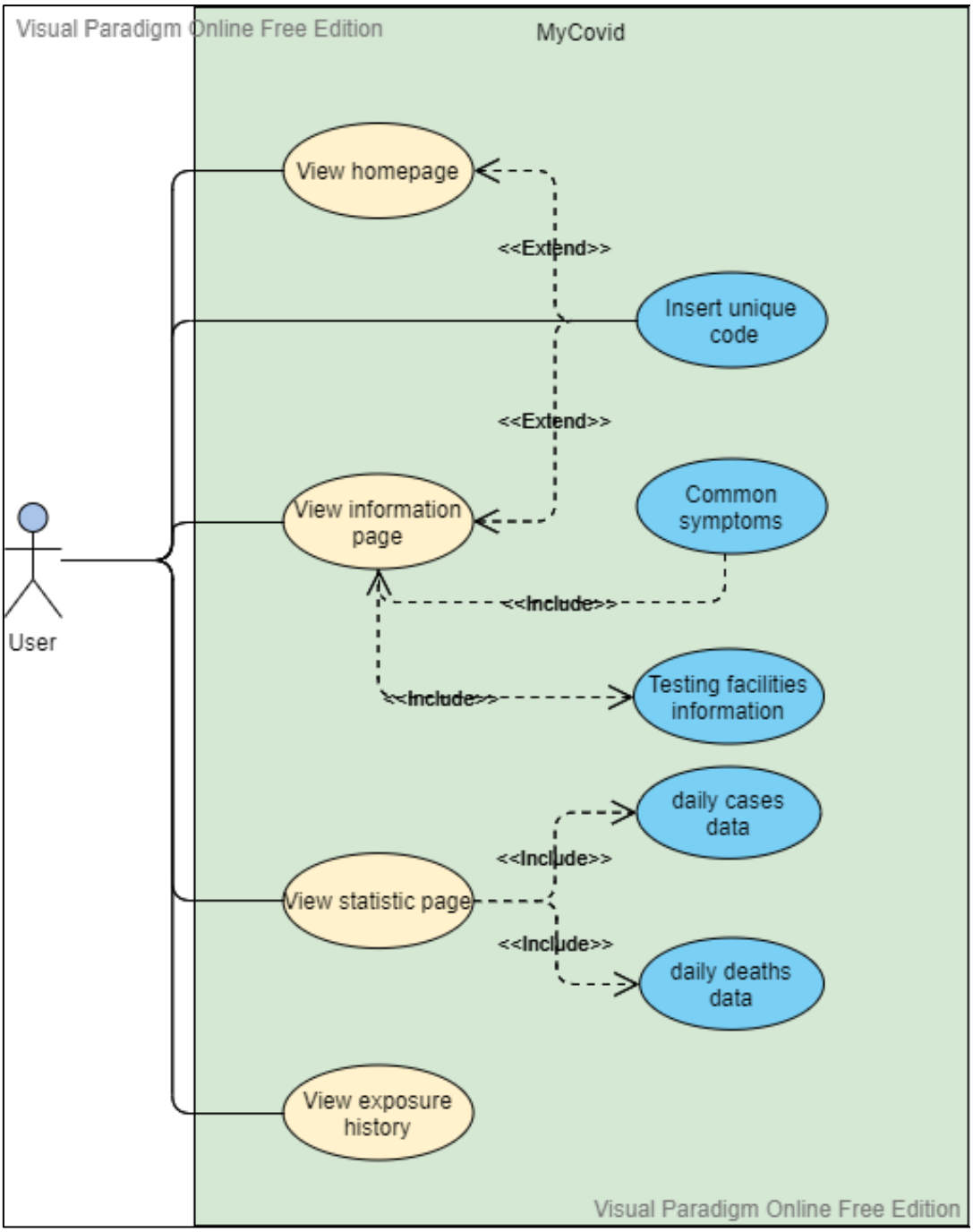

Figure 4.1: Use Case Diagram for User and MyCovid

Figure 4.1 shows the critical interactions of the users to the MyCovid application illustrated in several use cases. Both the home and information page can redirect users to insert the unique authorization code. The information page also contains the common symptoms to aid users in self diagnose. Furthermore, the page can redirect users to testing facilities websites provided by the government. On the statistics page, the data will be obtained by the official Ministry of Health (MoH) repository in GitHub.

4.2.2 Non-functional requirements

Non-functional requirements (NFR) describe the behaviour and the constraints or limits of the systems. NFR is as important as functional requirements in an application because it ensured the quality of the application operations. Many authors have different definitions of NFR such as “Describe the non-behavioural aspects of a system, capturing the properties and constraints under which a system must operate” by Anton, and “The required overall attributes of the system, including portability, reliability, efficiency, human engineering, testability, understandability, and modifiability.” by Davis (Glinz, 2007). Based on these, the NFR is commonly referred to as the words that have “-illities” or “-ities” as in usability and integrity (Chung & Do Prado Leite, 2009).

The NFR for the proposed application are elaborated as follows: -

1. **Availability**. The MyCovid application shall be available to use everywhere and anytime. This is because the app is intended to be one of the crucial technologies in contact tracing for Malaysia to be utilised by the people. If the app is not available for a specific time or place, it will hinder the contact tracing efforts. The users should not be restricted and constrained to use the app like the need for internet connection since it uses Bluetooth.

2. **Privacy.** The app shall protect the privacy of the individual that uses the application. It should comply with the privacy acts, and protection guidelines pose by the Malaysian government. The app shall not share any personally identifiable data with a third party to protect privacy. Next, the critical data operation shall be done by the individual device itself and not the database which is in line with the decentralized nature.

3. **Security.** MyCovid shall use mechanisms that have a secure element during operation. The DP3T mechanism uses a cryptographic hash function to create the EphIDs. This is to increase security by encrypting the data. Other than that, the app also periodically changes the EphID to be broadcasted to other devices.

This is because malicious users cannot track using the broadcasted identifiers since it is always changing.

4.3 Sequence Diagram

This section will describe the flow of interaction for users and the proposed application by illustrating with sequence diagram. This is to get a better understanding of the requirements for the application. These diagrams are also known as event diagrams as it explains the events that occurred in a particular interaction.

4.3.1 Onboarding process

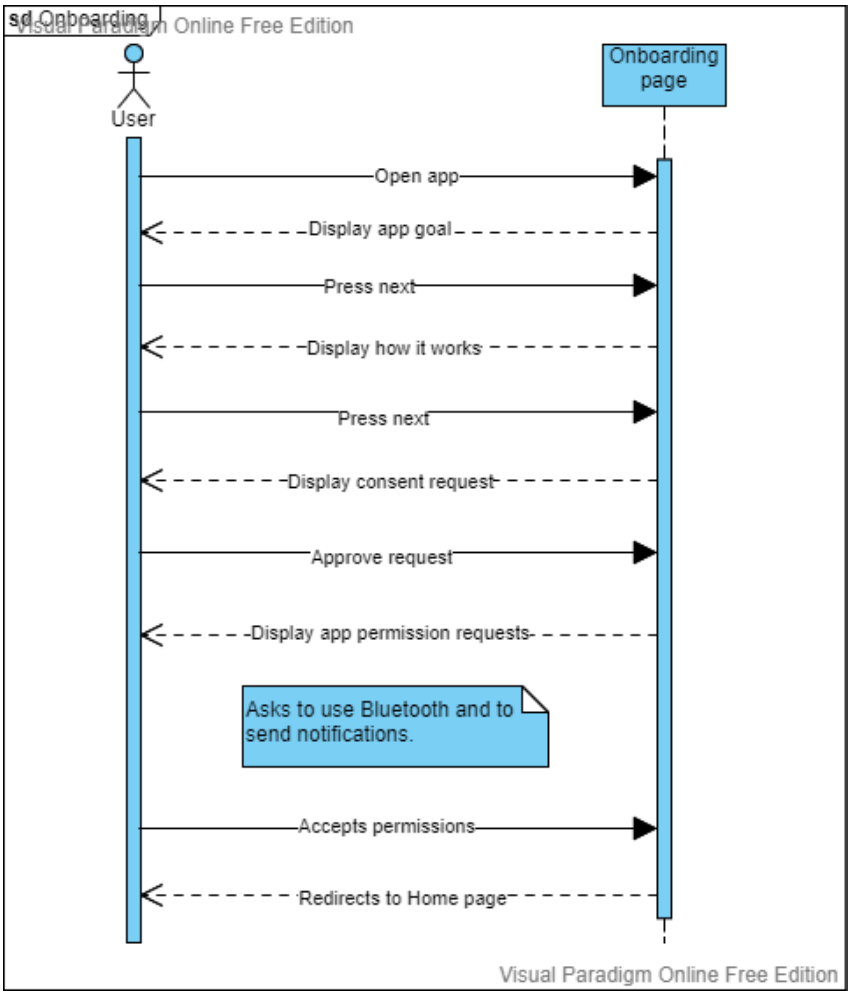

Figure 4.2: Sequence diagram for onboarding event

This event only occurs once when the users open the application for the first time. This event is to introduce the app to the users which displays the goals, how the app works and to set up for use. The onboarding activity is important to give a good first impression to give a better reception from the users. Figure 4.2 shows the onboarding activities and setting up to use by requesting app permissions. After it has been done, users will be redirected to the home page.

4.3.2 Insert authorisation code

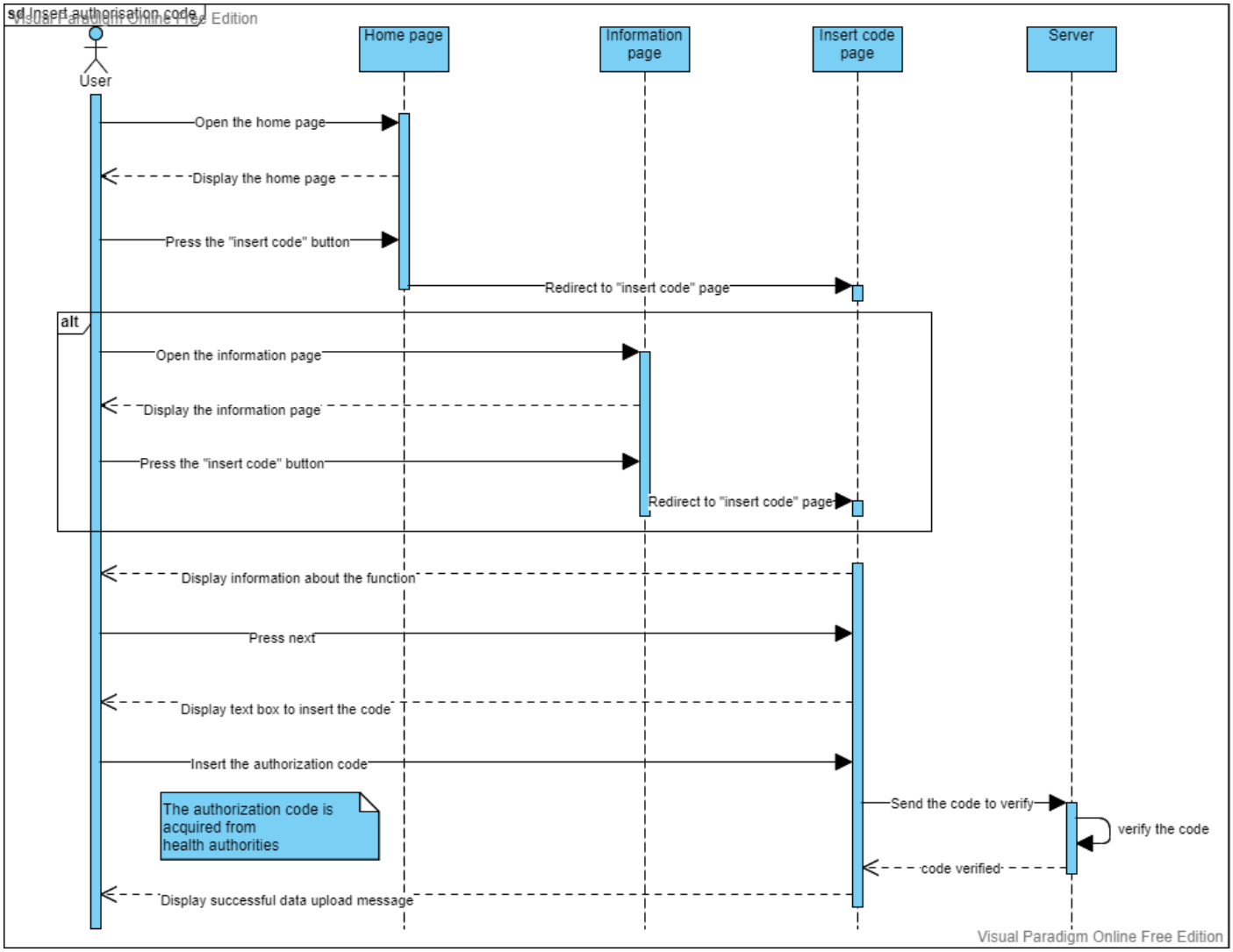

Figure 4.3: Sequence diagram for authorisation code insertion event

The event starts when users press the home button. The code insertion function can be accessed by two pages which are home and information pages. Prior to this event, the user should have obtained the authorisation code from the health authorities. This is to

eliminate false positives and increase authenticity. The user then inserts the code in the text box, which is then verified by the server. Once verified, the EphID representation is uploaded to the database for others to check their encounters.

4.3.3 View common symptoms

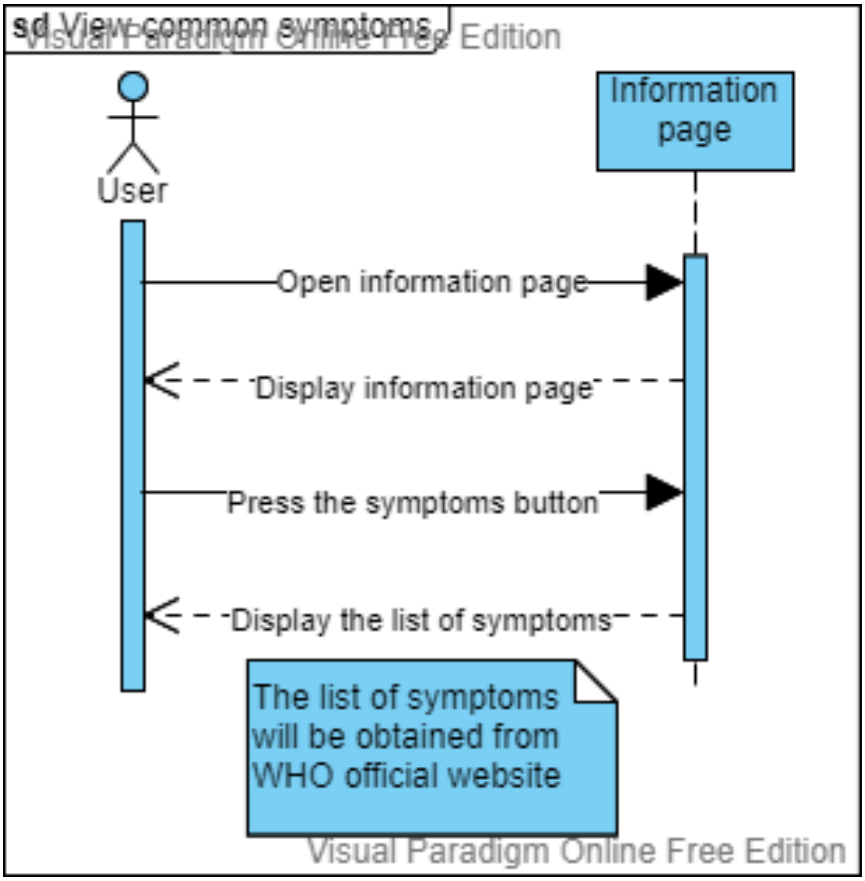

Figure 4.4: Sequence diagram for viewing common symptoms event

This event started when the user presses the information page where the page is then displayed. The common symptoms information is obtained from the official WHO website. This information is crucial to give knowledge to the user whenever they are feeling ill. If they have the related symptoms, they will be provided with testing facilities information which is in the next sequence diagram in Figure 4.5.

4.3.4 Browse covid-19 testing facilities

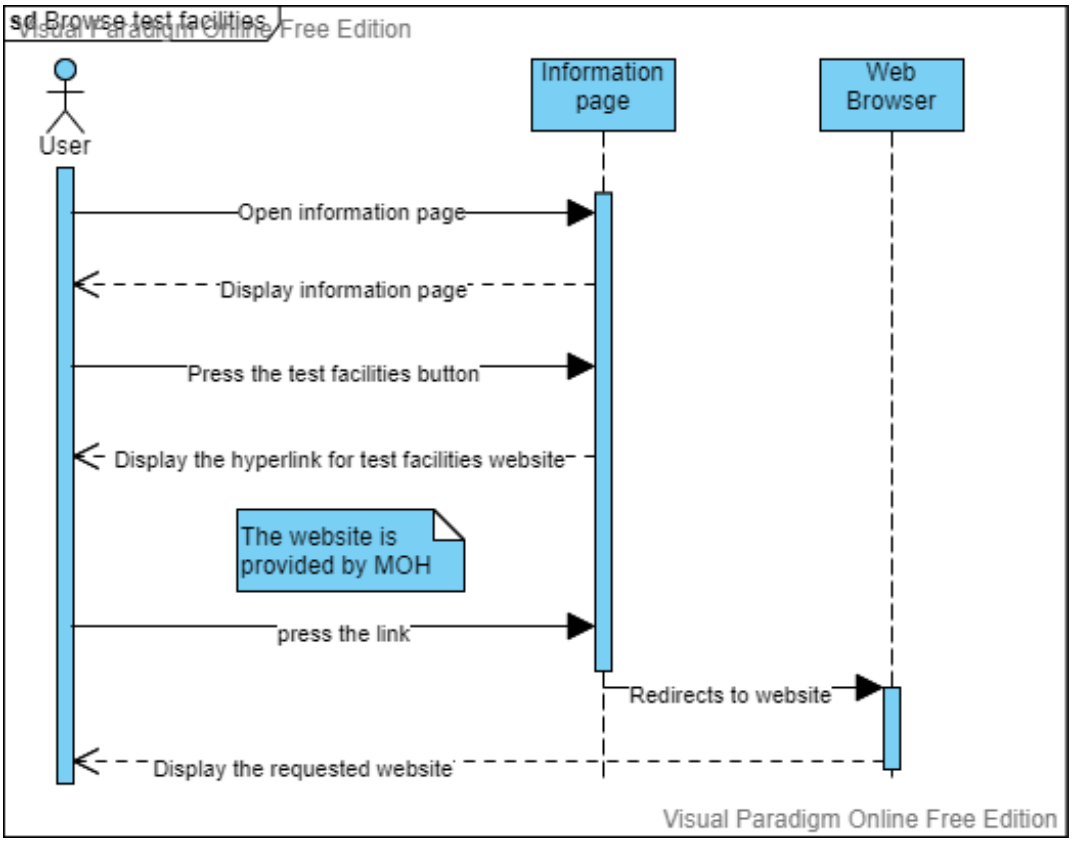

Figure 4.5: Sequence diagram for browsing test facilities event

When users have symptoms of the disease, they are advised to get tested for it. Thus, this event will give information related to the testing facilities around Malaysia. Inside the information page, the user presses the test facilities button, and a hyperlink is displayed. When users click the link, they will be redirected to a website by the Ministry of Health (MoH).

4.3.5 View statistics page

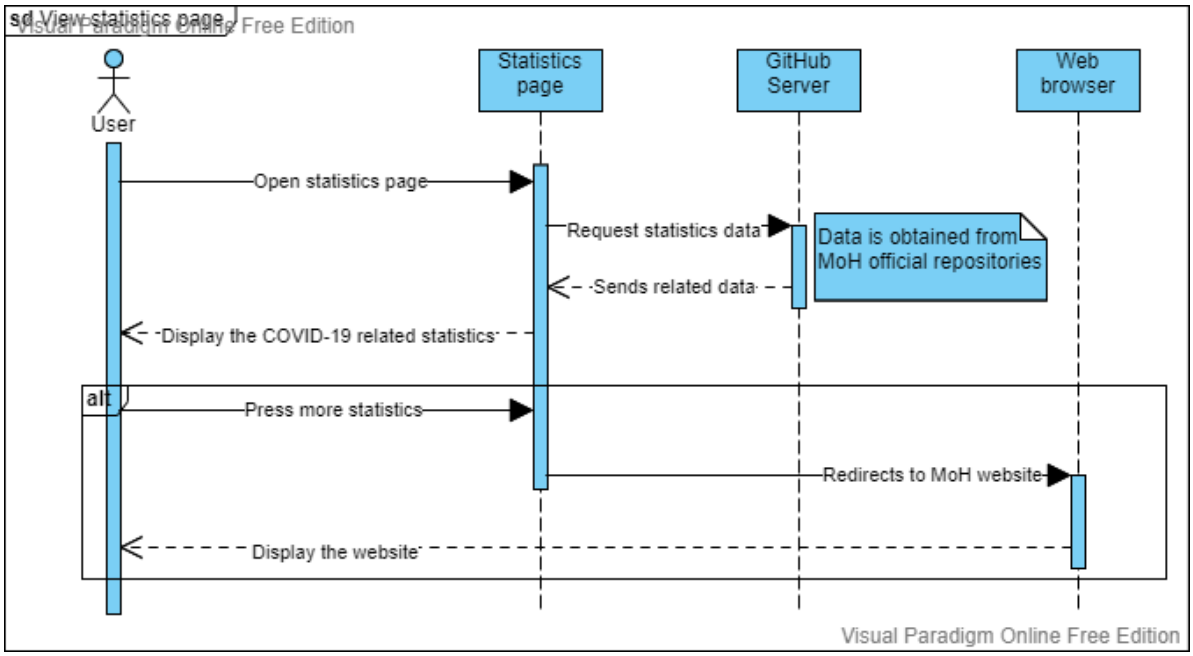

Figure 4.6: Sequence diagram for viewing COVID-19 statistics event

The event starts when users press the statistics button. Then the application will request the total daily cases and deaths data from the official repositories from MoH found in GitHub. The data is then displayed on the statistics page to the user. If users would like to know more statistics like total testing, they can click the hyperlink and would be redirected to the official MoH website that shows the pandemic statistics in Malaysia.

4.3.6 View encounter history

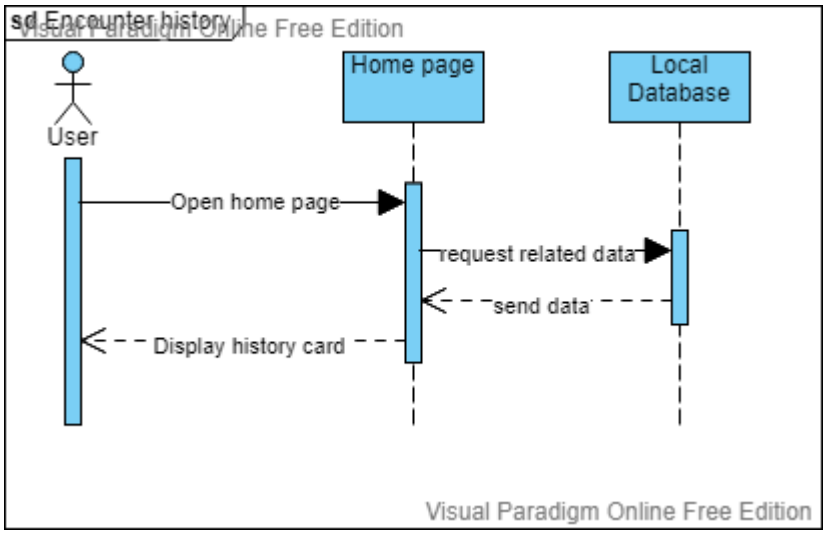

Figure 4.7: Sequence diagram for viewing encounter history event

The event starts when users press the home button. Then the application will request the required data from the local database in the device. The data is then displayed on the home page to the user. The history data will be stored in a determined timeframe and will be deleted at a specific time. This is to prevent the data from being manipulated or acted upon by malicious people.

4.3.7 Notify user on positive case encounter

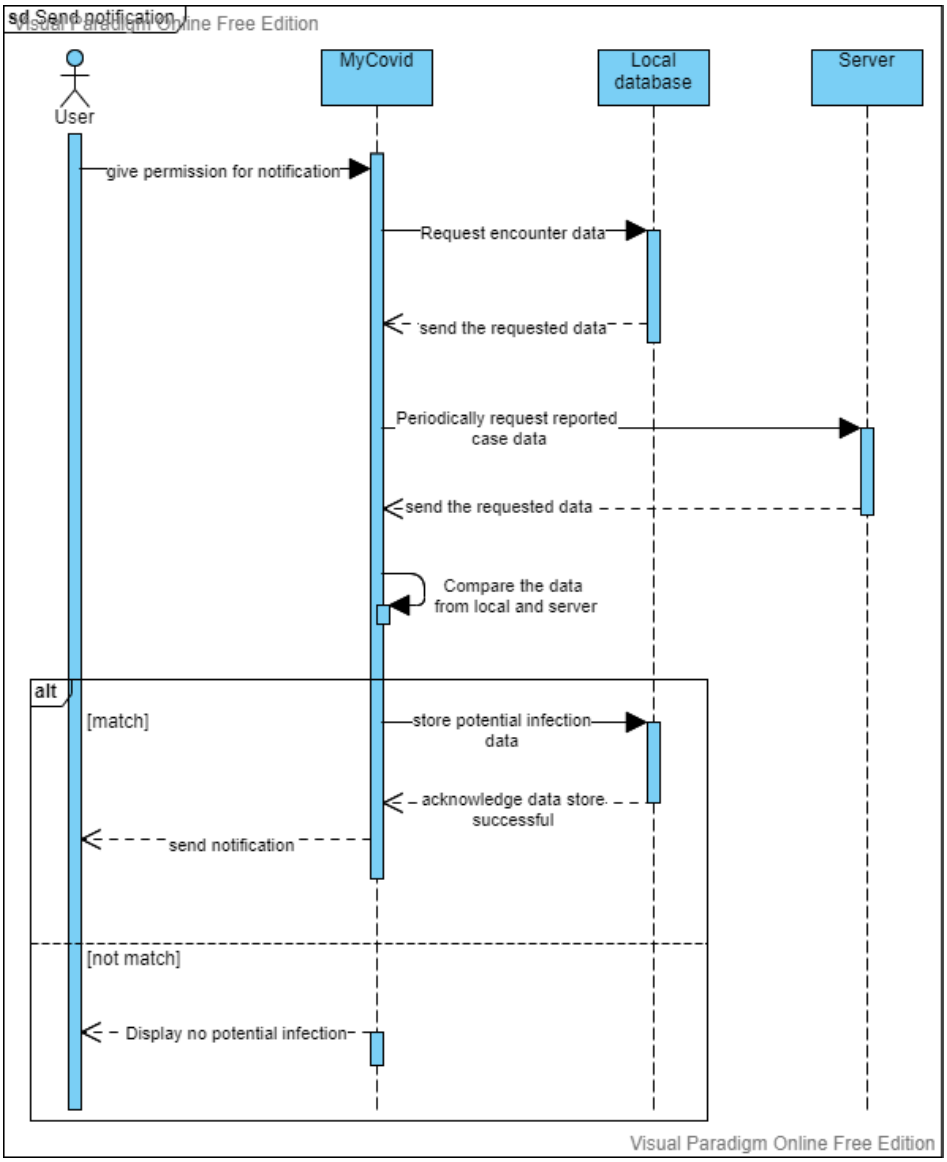

Figure 4.8: Sequence diagram for alerting user via notification event

This event required users to allow the proposed application to give notifications. After that, the application will record encounter data and store it in the local database. The app periodically requests reported data from the server for it to compare the data from the server and from the local database. If the data are matched, then the app will send a notification to the user, alerting a potential infection.

4.4 Proposed User Interface

User interface (UI) is one of the most crucial parts in terms of interacting hardware devices with a human. UI is the front-end application interface where users engage the device to do operations. The objective of this interaction is to enable efficient software operation and control by the user, and the application continuously updates the information to assist users in deciding on the application. When designing a UI for MyCovid, it is paramount that usability aspects are met, such as consistency, flexibility, and using metaphors to create an effective UI design. (Sajedi et al., 2008).

4.4.1 Onboarding

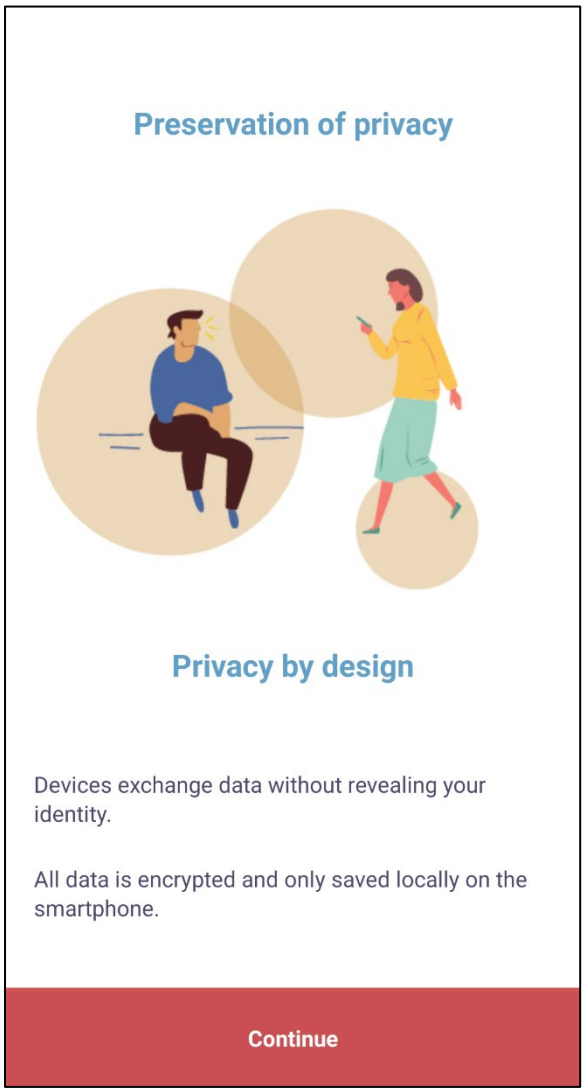

Figure 4.9: Initial design for onboarding activity

Onboarding activity assists users in understanding the things that they have to do to get the most out of an application, or in this case, MyCovid. It is a method of instilling confidence and trust in its users, which benefits them as well as the contact tracing efforts by the government. This is an important element to include in the user experience due to the ability to increase users' retention on the proposed application (Chapin, n.d.). In MyCovid onboarding activity, it explains the purpose of the app thoroughly and also sets up the users into using the app by requesting app permissions.

4.4.2 Home page

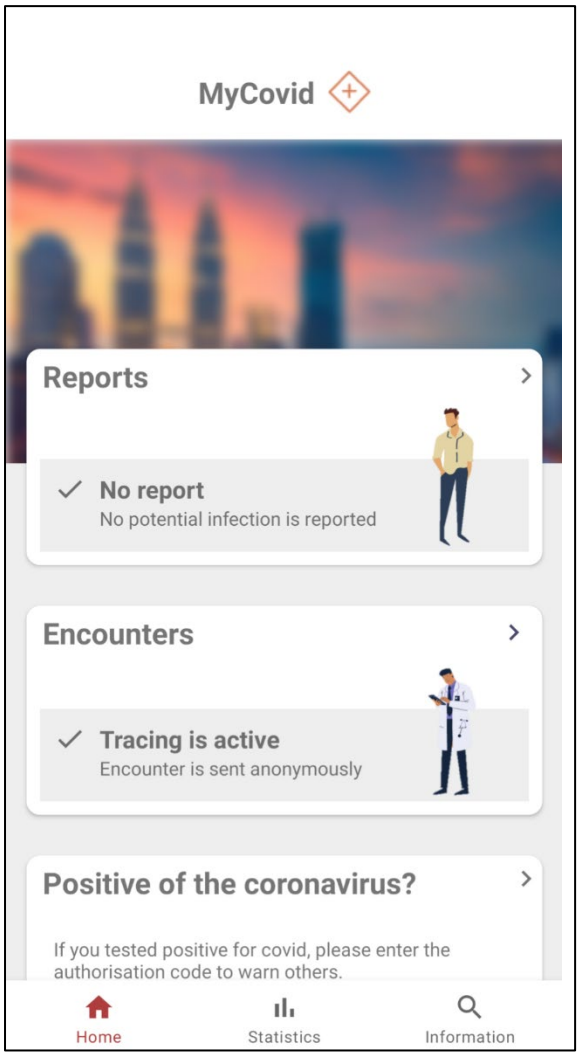

Figure 4.10: Initial design for the home page

On the home page, it is crucial to display the important information that the users need to know while not giving too much data. This is because the home page is the first page they will see whenever users open the application. The design for the homepage (figure 4.9) uses card-like shapes to group the information because most people are used to information being transmitted in a physical card. This design adheres to Nielsen's ten heuristics of matching between systems and the real world (Nielsen, 2005).

4.4.3 Information page

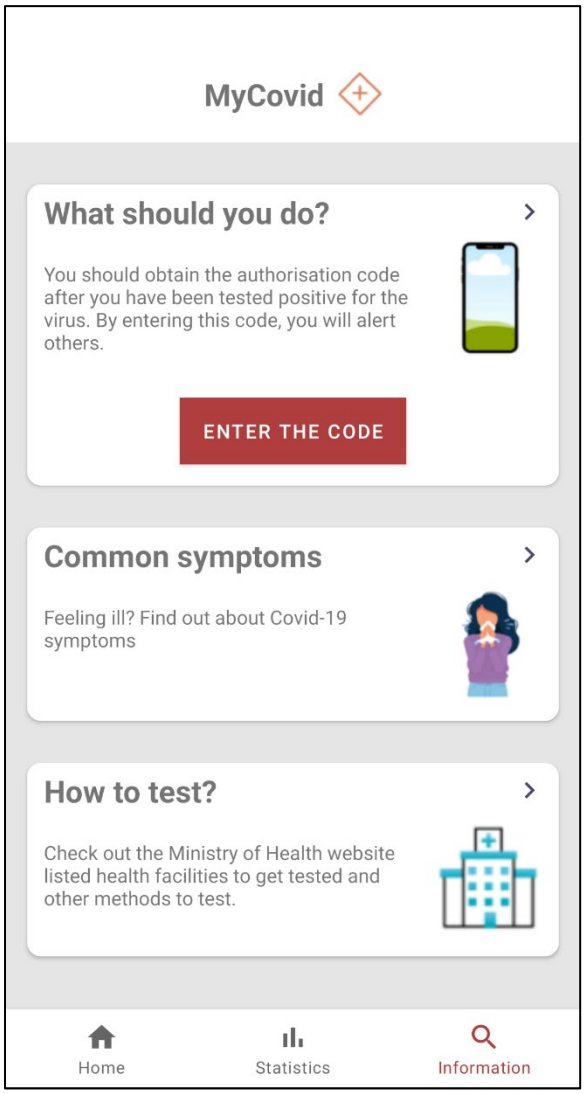

Figure 4.11: Initial design for the information page

It is crucial to apply an internal and external consistent design between the different pages in the proposed application. This is to make users familiar with the interfaces and not be confused about them. This also follows the Nielsen heuristic of consistency and standards (Nielsen, 2005). The functions present in this interface are viewing common symptoms, test facilities, and uploading authorisation code.

4.4.4 Statistics page

Figure 4.12: Initial design for the statistics page

The statistics page has a consistent design with other pages with cards layout. It shows a comprehensive statistic of the COVID-19 pandemic in Malaysia without making the interface too complex for the user's eyes. Other than that, the designs of this page, including the others, are minimalist and have good aesthetics which also follows the rule of thumb sets by Jakob Nielsen that suggests that irrelevant information should not be included (Nielsen, 2005).

4.4.5 Insert code card

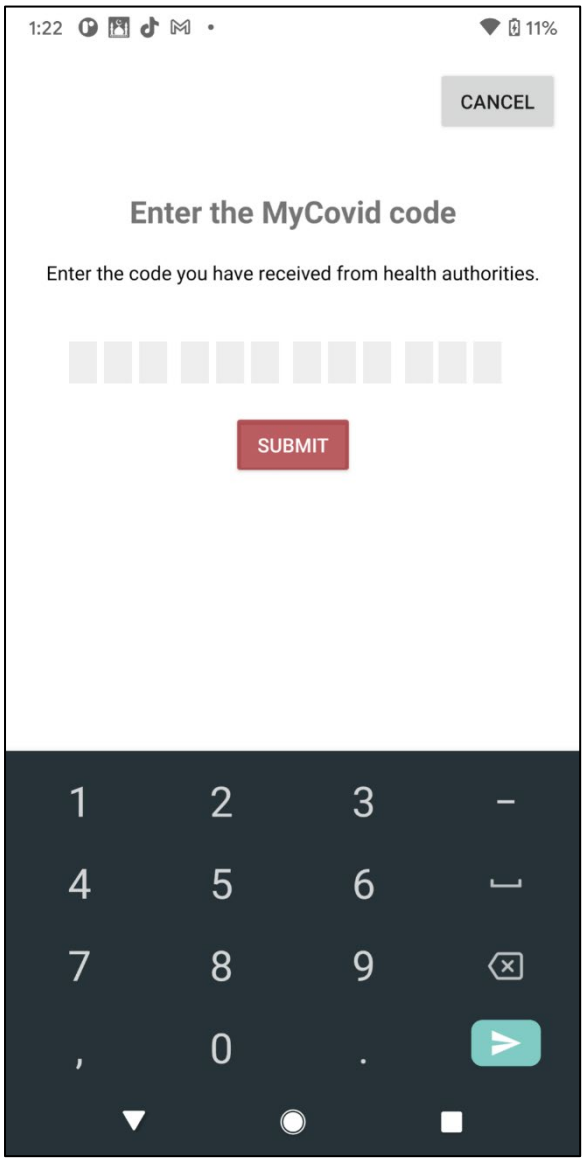

Figure 4.13: Initial design for the code insertion interface

Code authorisation insertion is one of the critical functions of this application. This is because it is used to alert others that have been in close proximity with the user that has been identified positive of the disease. Figure 4.9 shows a full card that swiped up after being activated by the user and can be dismissed by swiping down. This is a common design in current applications in the market. The minimalist interface helps the user to understand much better what is needed to be done in this phase.

4.5 Summary

In conclusion, this chapter has presented the functional and non-functional requirements of the proposed application. Then, by using diagrams such as sequence and use case diagram, the flow of operation between the users and the software can be illustrated and explained for each use case when using the app. Lastly, the initial interface designs for the application are shown in 4.4 which is crucial in giving the mock design for the final implementation.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

The result and the findings of the whole project will be discussed in this chapter. Throughout the development, there were several key elements that were integral in the progress of this project. A User Acceptance Testing (UAT) was done after the development of the application was finished. The goal of UAT was to guarantee that the app can handle real-world tasks while also meets the project requirements. The test found that there are a few bugs in the application and minor user interface issues.

5.2 Project Deliverables

The deliverable for this project is an Android application titled MyCovid and a backend system. The app has met the objectives set in the beginning of the report. Besides that, the app has also solved the problems stated in Chapter 1 which are mainly to increase the efficiency of contact tracing and alert of exposure. The backend system is a web service provided by DP3T and configured using Microsoft Visual Studio. Figure 5.1 shows the actual user interface of the application while Figure 5.2 shows the backend system running in terminal.

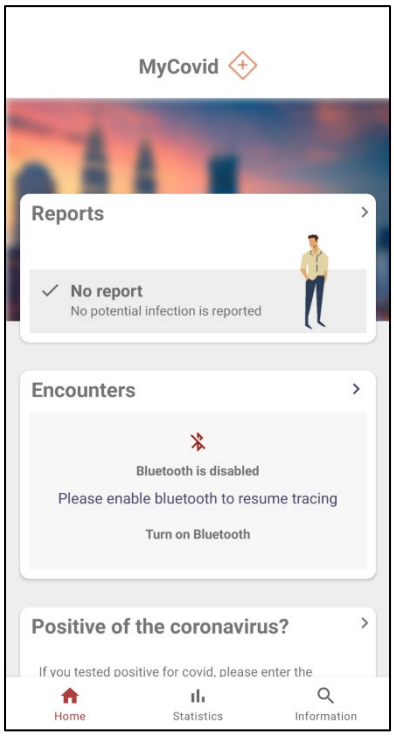

Figure 5.1: Actual home interface for MyCovid in Google Pixel 2 XL with Bluetooth disabled

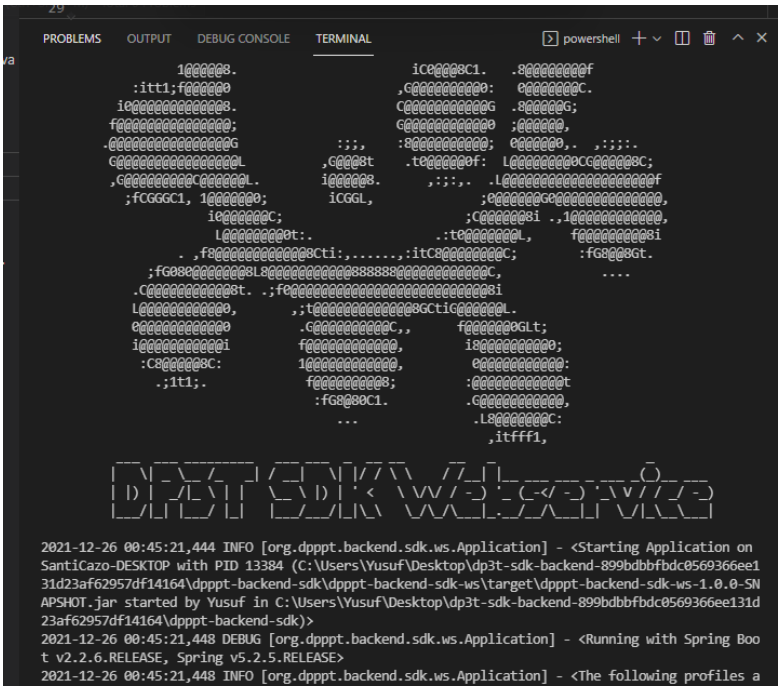

Figure 5.2: Illustrates the web service of the application running in the terminal of the desktop

5.3 User Acceptance Testing (UAT)

User Acceptance Testing (UAT) is another method of testing where the intended user or client verifies and accepts the software application before everything is deployed in the production environment. Following functional, integration, and system testing, UAT is performed in the final step of testing. The reason this test is done is because the user perspective and feedback are mostly different than the perspective of the developer. Developer's understanding and knowledge regarding the application could be ineffectively communicated in the app itself. The UAT performed for this project was given to 19 unique people where results are discussed in the next subsection.

5.3.1 User Background

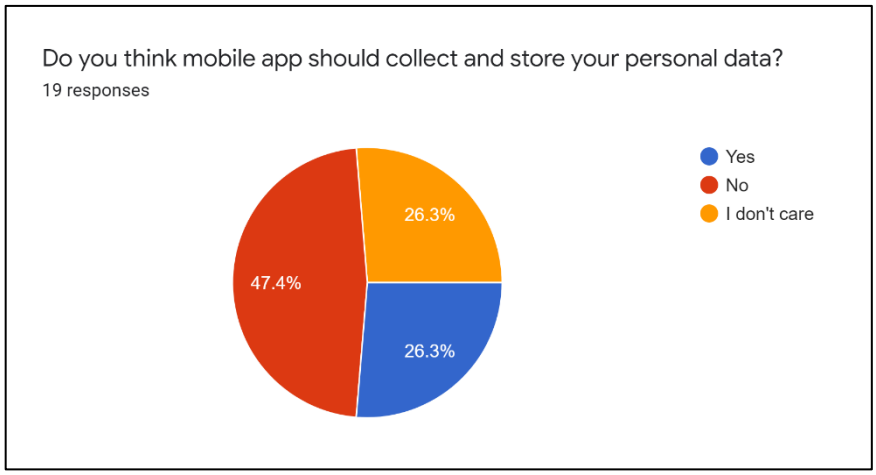

Figure 5.3: Pie chart regarding user's opinion for collecting personal data in application

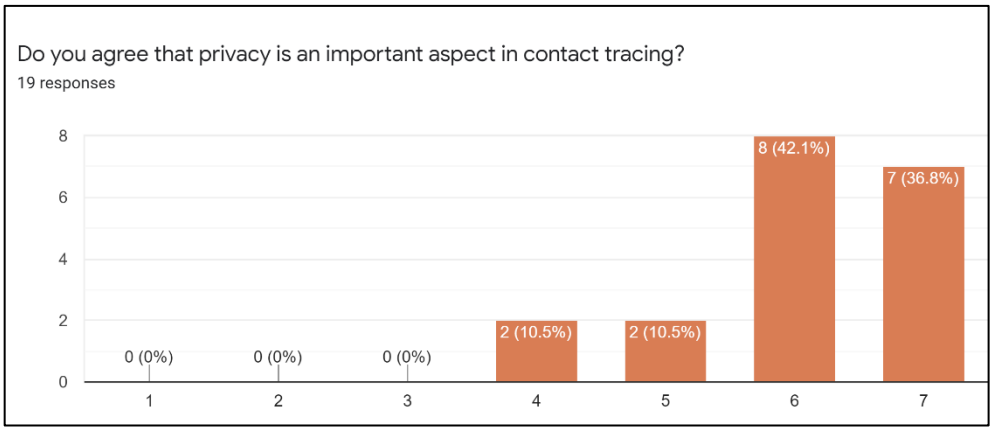

Figure 5.4: Bar chart that shows user's opinion on privacy in contact tracing

For context, the test was given to 19 respondents where they are mostly between 18-30 years old, and the rest are either below 18 years old or between 31 to 45 years old. Other than that, 47% of the respondents also think that mobile application should not collect and store personal data while 26.3% stated that they are not bothered for the collection of personal data which is shown in Figure 5.3. Lastly, most (15) of the respondents have agreed that privacy is an important aspect for contact tracing application as illustrated in figure 5.4.

5.3.2 Functionality

5.3.2.1 Onboarding

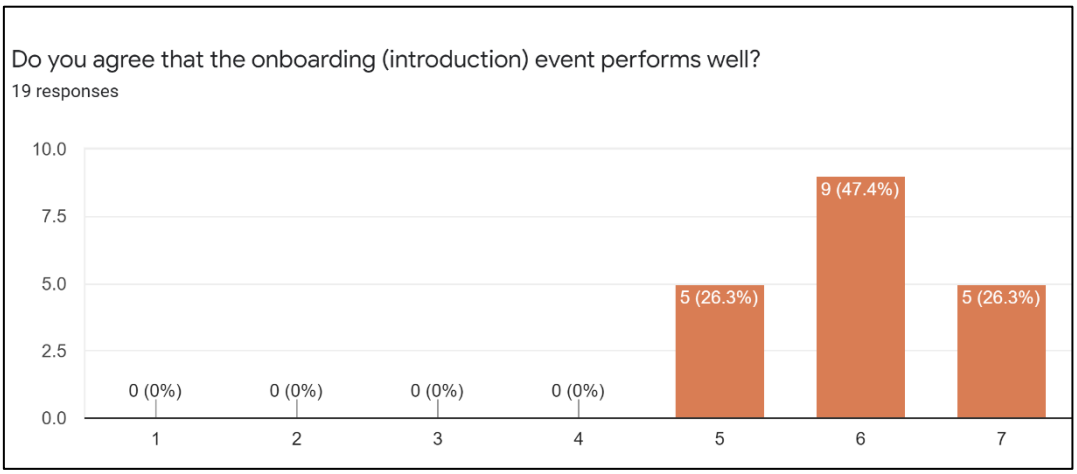

Figure 5.5: Bar chart that shows performance of the onboarding event from users

Onboarding event enables users to understand the purpose of the app and what they have to do to use the app as intended. It's a technique of instilling confidence and trust in the users, which not only benefits them but also helps their retention for on using the application. Figure 5.5 shows that 5 people strongly agree that the onboarding event of the application performs as intended without fail while the majority of the respondents agree on this case. There were no respondents that find that the onboarding does not perform as expected.

5.3.2.2 Navigation

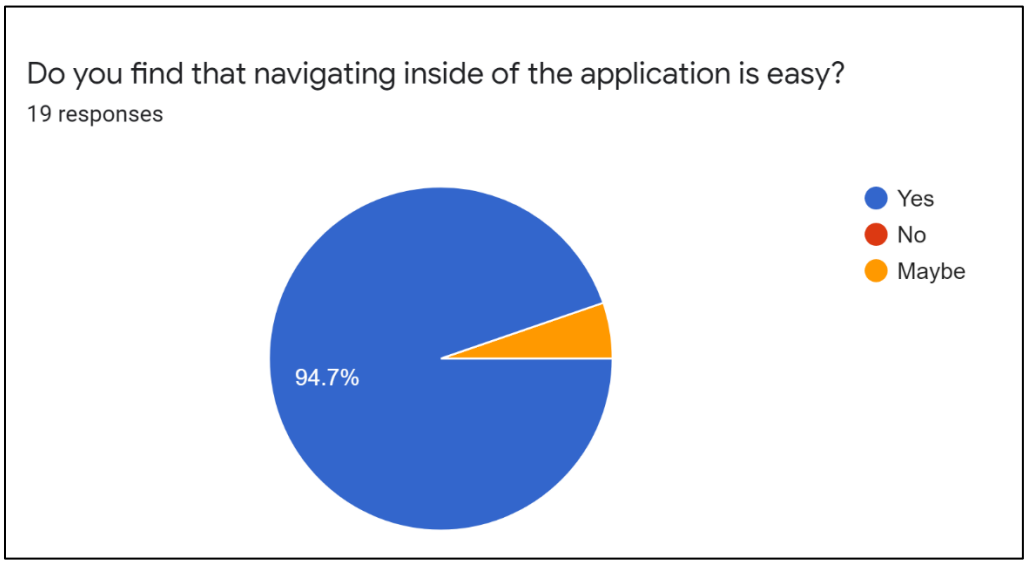

Figure 5.6: Pie chart that shows the navigation of the application result

The process of going between screens of an app to fulfil tasks is known as navigation. Customized navigation elements, integrating navigation behaviour into content, and platform attributes are all used to make this possible. The app's navigation is really significant for the whole experience for using it. Users may dislike the application if the navigation is poor. The UAT shows that eighteen (94.7%) of the respondents find that navigating inside the application is easy while only one did not sure whether navigating is easy which is shown in figure 5.6. Other than that, none of the respondents found that navigation inside the application is hard.

5.3.2.3 Reporting

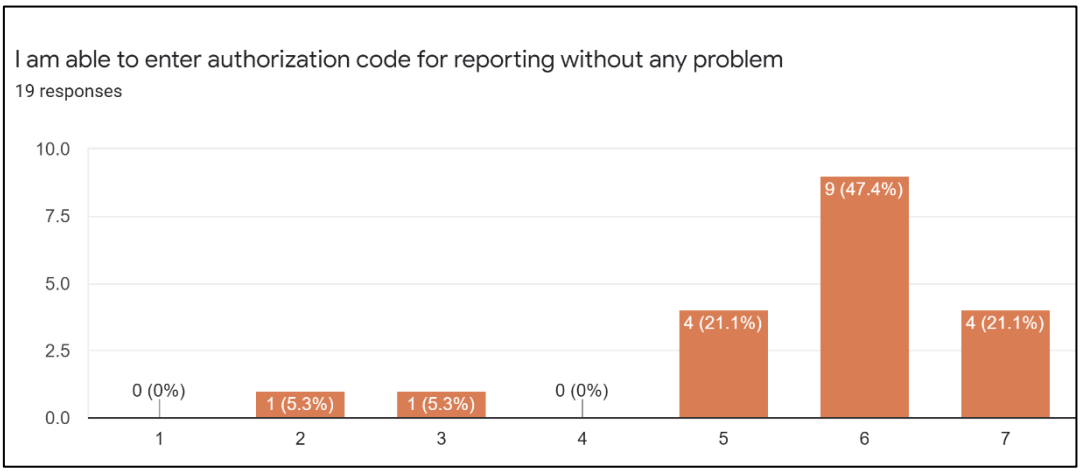

Figure 5.7: Bar chart of the test result for authorization code reporting

This case was to test the reporting functionality by inserting authorization code. This event is important to prevent problems like false positive or spam into the database. Figure 5.6 shows that nine respondents agree that they can enter authorization code without any problem while eight people mildly agree and strongly agree equally. However, this test found that two respondents disagree regarding this case where they encounter problem while entering authorization code for the reporting functionality.

5.3.2.4 Information and Statistics

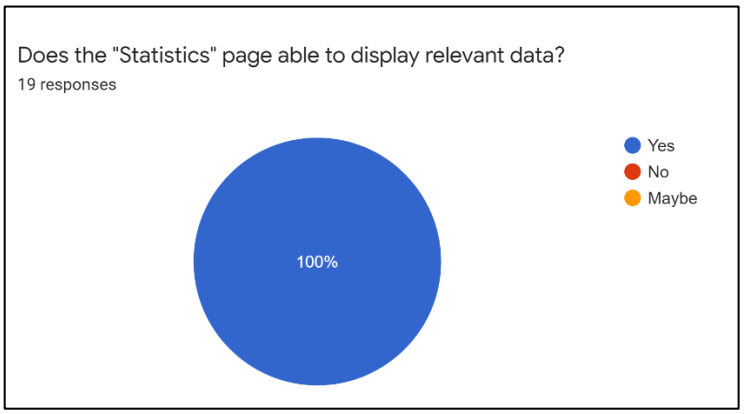

Figure 5.8: Pie chart that shows the statistics page test result

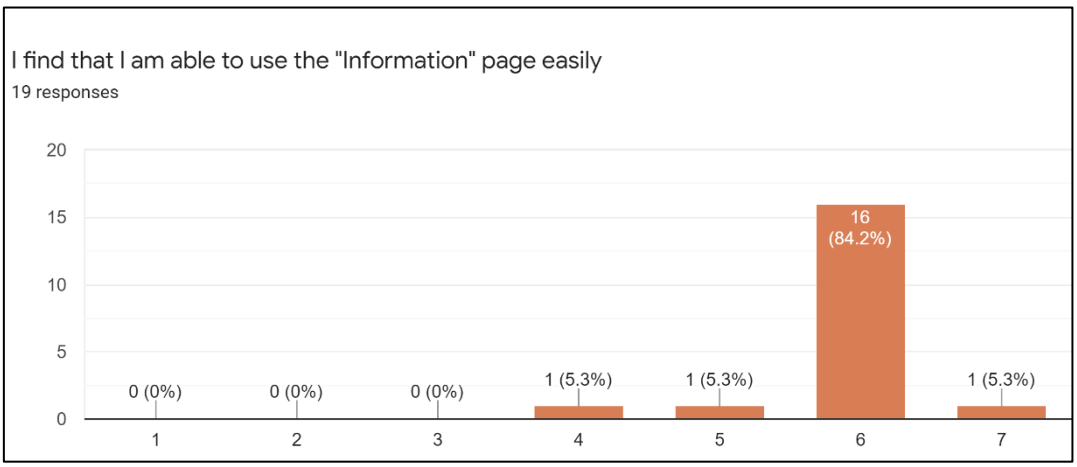

Figure 5.9: Illustration of the test result of using information page

The two pages which are “Information” and “Statistics” are similar in terms of presenting information to the user. All of the respondents agreed that the statistics page able to display relevant data regarding the pandemic which was shown in Figure 5.8. This shows that the Statistics page works as intended. Besides that, sixteen respondents agree that they were able to use Information page easily without problem. While one person each were felt neutral, slightly agree, and strongly agree that they can use it easily. Based on these tests, it was found that both of the pages had no major issues and can perform well.

5.3.2.5 Post self-reporting

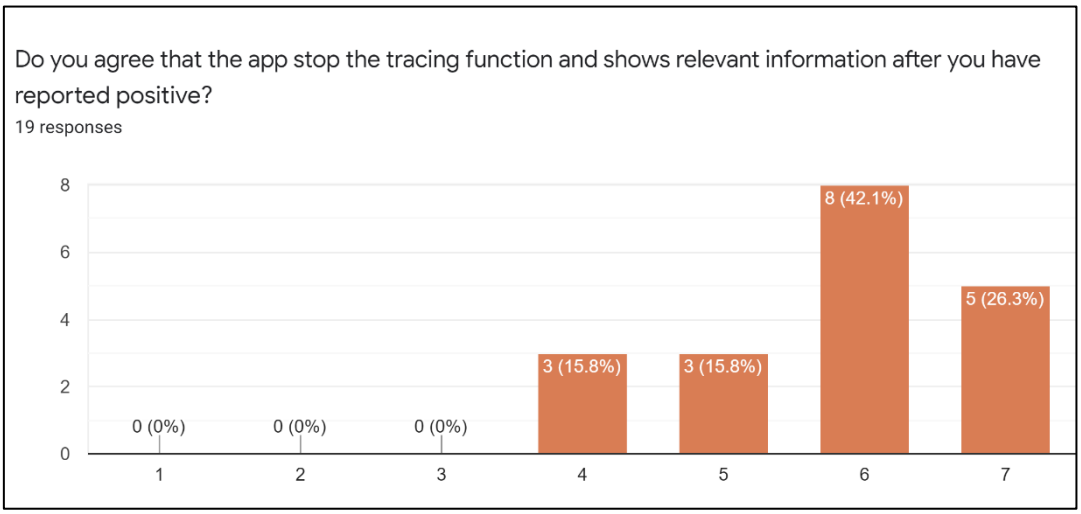

Figure 5.10: Bar chart that shows the post reporting test result

Another significant state of the application is after the user had reported for positive case of Covid-19. This is important to implement because it gives instruction on what to do and the application behaviour for this case. The chart gives information about the distribution of respondents' answers regarding the behaviour after reporting event. According to the chart, eight (42.1%) of the respondents agreed that the app stopped the tracing capability and thus show the relevant information after they have reported positive, and another five (26.3%) people strongly agreed the behaviour of the app for the post reporting event. Lastly, three people felt neutral and the same number of respondents slightly agreed for this case. Overall, the app behaves as intended based on the result of the test.

5.3.2.6 Exposed with Covid-19

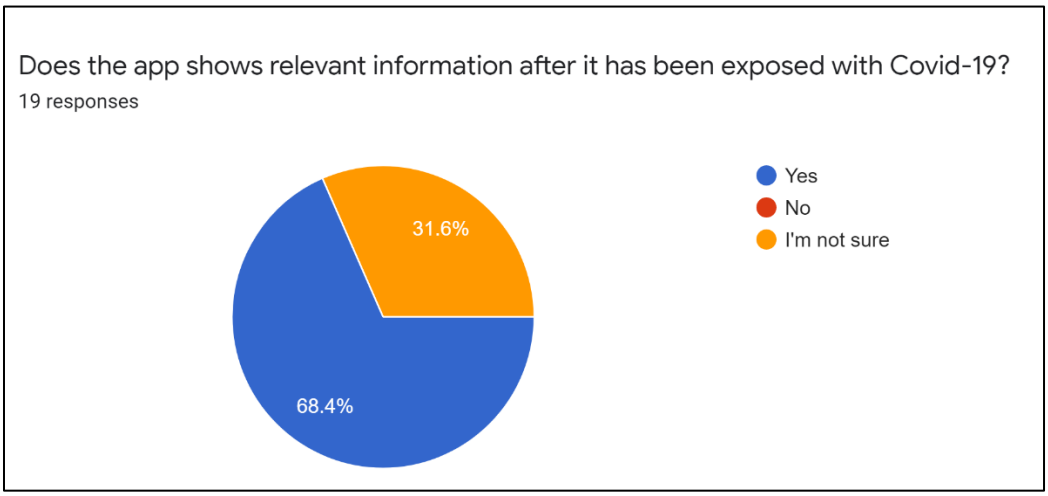

Figure 5.11: Bar chart that shows the exposed state of the application test result

Another important aspect in the application is when the application has been exposed with Covid-19. This is triggered when another device has reported positive, and their data was uploaded to the backend. Then, the exposed device sync with the backend to check whether they had been exposed. According to the chart above, 68.4% of the respondents find that the app shows relevant information after the app has been exposed. Besides that, 31.6% of the respondents felt that they did not sure whether the app show relevant information when it has been exposed.

5.3.3 Feature Recommendation and Suggestions to Improve

The last section of the UAT asks the respondents opinion on features to be added and suggestions to be improved regarding the application. Obtaining qualitative feedback from the intended users assist the developer in validating the concept during the development phase, as well as allowing the app to improve in tandem with the demands and preferences of users for the remainder of the app existence. And besides, the product was created to solve the problems raised by users in the first place.

There is a myriad of features suggestions from the respondents that they felt suitable to be added in the application. The prominent feature is adding vaccination

information section in the app. This is most probably because the vaccination is an important aspect in this pandemic and having the information at the application might be crucial for the application. In addition, vaccination status is also another significant aspect in this section where the application can detect others vaccination status without breaching personal data. Other than that, they also suggested to add a better mechanism to show on how to use the application. This can be implemented in the future by giving a video tutorial, Frequently Asked Question (FAQ) section, and also providing dynamic hints after the app has been downloaded.

Besides recommending features for the app, the respondents also suggest some improvements elements to make the application better. The type of element that are mentioned can be divided into two types, which are user interface (UI) and functionality. For the UI, some respondents suggest using a diverse combination of colour in the app to make it pleasant for the eye. Other than that, one of the respondents suggests an option of dark mode to be integrated in the UI. A few suggestions for the functionality that need to be improved is the entering authorization code. Few users have found that the code might be too long while others found that they can submit the code without entering any input. Other suggestions are providing a user profile and calendar to inform the user when they have been exposed Covid-19.

5.4 Summary

In summary, this chapter has elaborated the findings of the UAT that was conducted for this project. They were opted to either download the .apk file of the app or view the demonstration of the app in a form of a video. The test was proven to be effective in providing the necessary input and feedback from users for the overall function of the app. In the UAT, as many as ___ respondents answered the survey regarding the app. Other than that, this chapter also discussed the issues about the app and the suggestions that were given by the respondents which will be integral in the future development of this application.

CHAPTER 6

CONCLUSION

6.1 Project summary

The COVID-19 pandemic has been around for about two years at the time of writing and still does not give any sign of slowing down. This has changed the view of experts in handling this pandemic by living side by side with it or also known as treating it as an endemic, just like we treat the dengue fever here in Malaysia (Philips, 2021). With the rise of technology, we can help in mitigating and reducing the severity of the pandemic to all aspects like health, economy, and more. This project is one of the prime examples of using technology in combating the pandemic, specifically in terms of contact tracing. The use of Bluetooth technology has shown better, and faster detection of encounters as seen in chapter 2. This application is aimed to be a contact tracing app that focuses heavily on user's privacy and data protection. Combined with the powerful MySejahtera app, this assimilation of technology will make Malaysian digital contact tracing a powerful yet privacy-focused application that benefits both the government and its people. This report has elaborated all aspects in developing the proposed application, from explaining the mechanism behind the application, development methodology used in the project, as well as elaborating the flow of the application using diagrams.

6.2 Achieved Objectives

The development of the application has been proven to be successful by measuring by the specific objectives that has been established in Section 1.3 of Chapter 1. The first objective was to develop the mobile contact tracing android application called MyCovid which is a privacy focused system aimed to improve the current contact tracing ability in Malaysia. The application was mainly developed using Android Studio, while the backend was implemented using Microsoft Visual Studio and it used a PostgreSQL database to store data. The objective was assessed by the key deliverables from the whole 14 weeks of development and the UAT which can be seen in the previous chapter that proved the application was developed effectively by assessing the results.

The second objective of this project was to implement the DP3T SDK inside the application which is the main technology behind the contact tracing capability. There are several aspects that was integral into the achievement of this objective. One of its aspects is testing the data exchange through Bluetooth or "handshakes" between two devices. Other than that, connection to the backend also perceived to be the aspect for the successful of the DP3T integration. Lastly, since there were no issues regarding the SDK were found during the final version of the application, it is also a key factor in determining the successful of this objective.

Lastly, the final objective for this project was to test the effectiveness of the application through User Acceptance Testing (UAT). The test was conducted after the completion of the application. The test was given to potential users of the application from all walks of life to determine its effectiveness. Beside UAT, testing was also done during the development of the system that include functional testing, integration testing, and unit testing. The test has proven that MyCovid is an effective application for contact tracing of Covid-19.

6.3 Recommendations and Future Work

There are a few limitations of the current app that need to be addressed in the future. Firstly, the authorization code function of the current implementation must be made to be more secured and fool proof to make sure that there are no fake or false positive cases to be reported. Other than that, a simple guide on using the application could be useful to further clarify on using the application for anyone that requires it. This is important because the aim was to make this application to be as accessible as possible to the masses.

There are also a few features in the user interface element of the application that can be improved like adding a dark mode version of the application which can be toggled manually or automatically using the system settings. Other than that, future implementation should also include multi-language support like Bahasa Melayu to appeal more audience to download this app. Providing animations could also be helpful for the UI such as a pulsing circle is shown when tracing is active.

Besides that, a feature that detects vaccination status of the surrounding users should be implemented in the future since it is one of the significant information in alerting users of potential exposed users of the Covid-19 virus. This feature can be implemented by using sonar technology as it works similarly to Bluetooth technology in the aspect of transmitting data in a specific range. Lastly, it is recommended that the app is to be integrated with the current contact tracing application in MySejahtera since this app can further improve the efficiency of contact tracing.

//check in check out mysejahtera

6.4 Summary

In summary, this project was successfully executed in the product of contact tracing application. MyCovid provide an efficient contact tracing application while also not neglecting the privacy of the user. In addition to that, this solution also gives a better performance in the aspects of privacy and also core functionality of contact tracing while also providing the necessary alerts, statistics, and information like testing facilities and common symptoms. Thus, this application could be a significant effort

in the advancement of technology in regards of the contact tracing system in Malaysia which also preserving the privacy of the user.

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APPENDICES

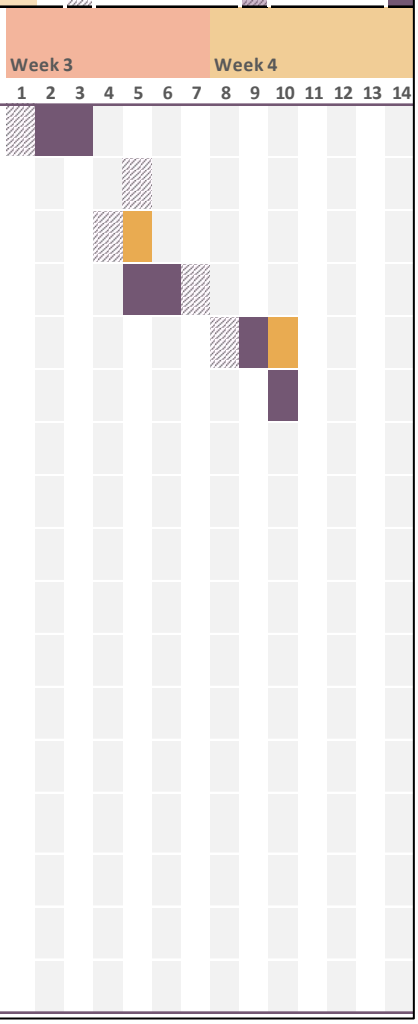
APPENDIX A: Gantt Chart for FYP 1

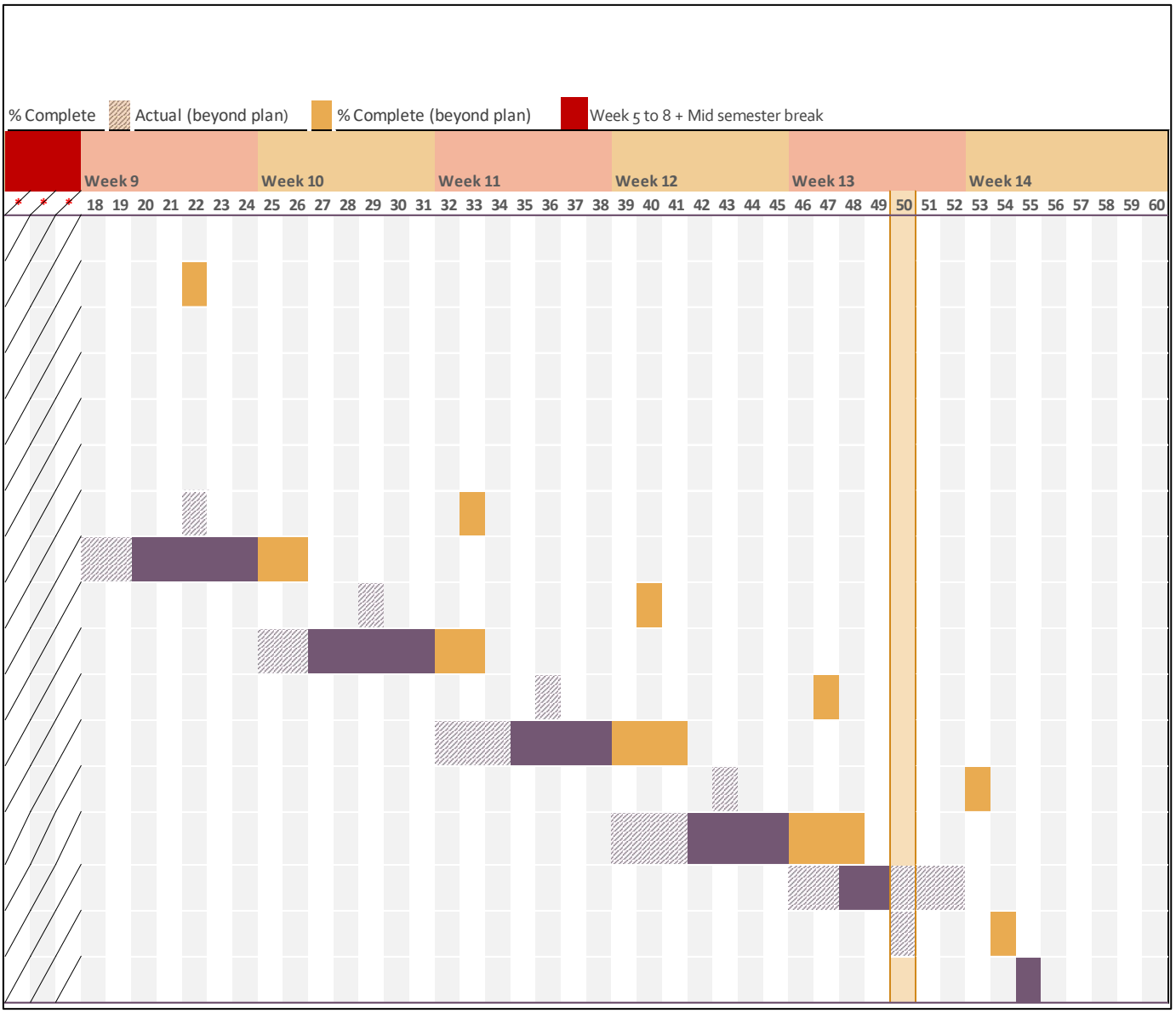
FYP 1 Planner

Select a period to highlight at right. A legend describing the charting follows.

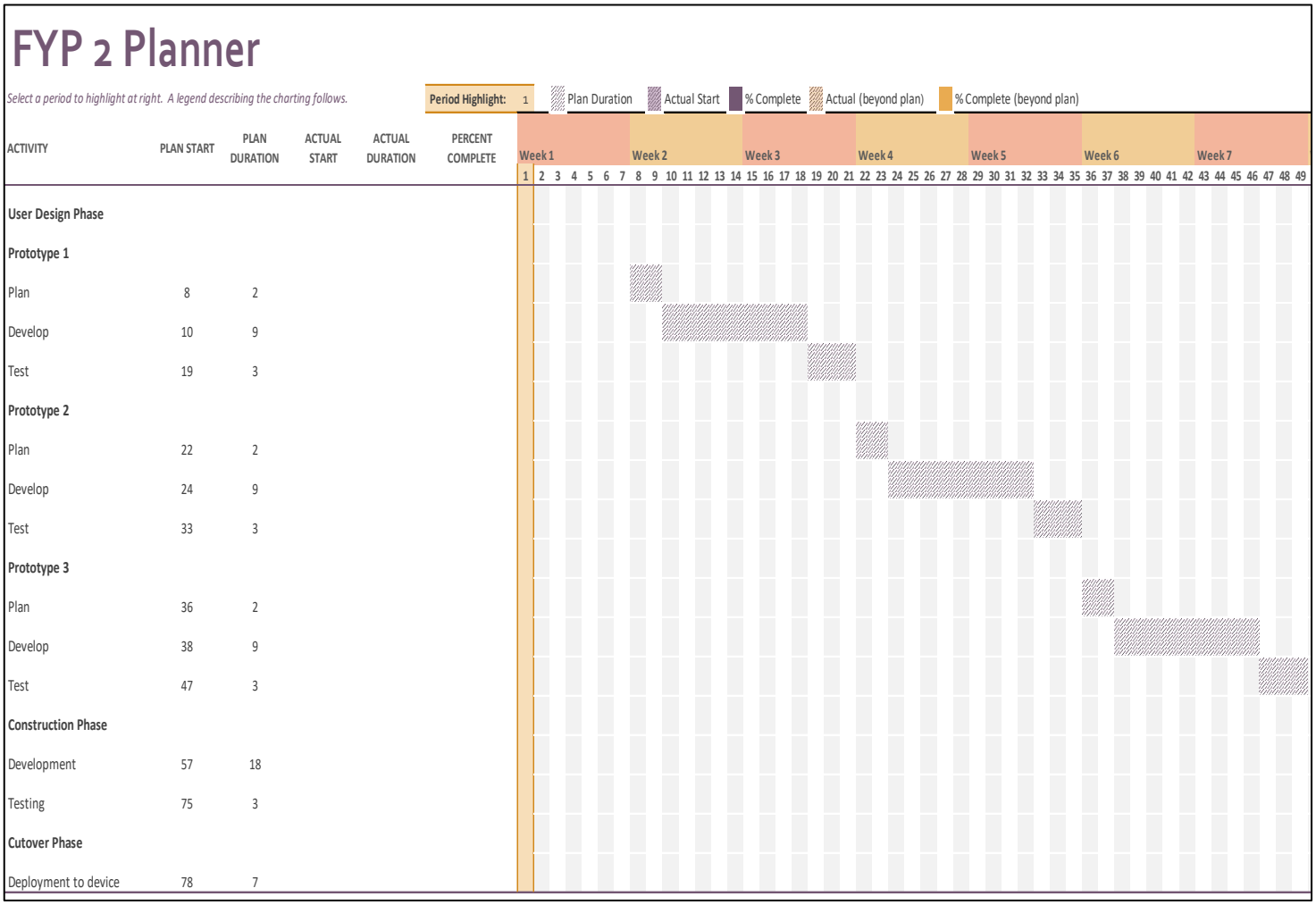
Period Highlight: 50 | Plan Duration | Actual Start

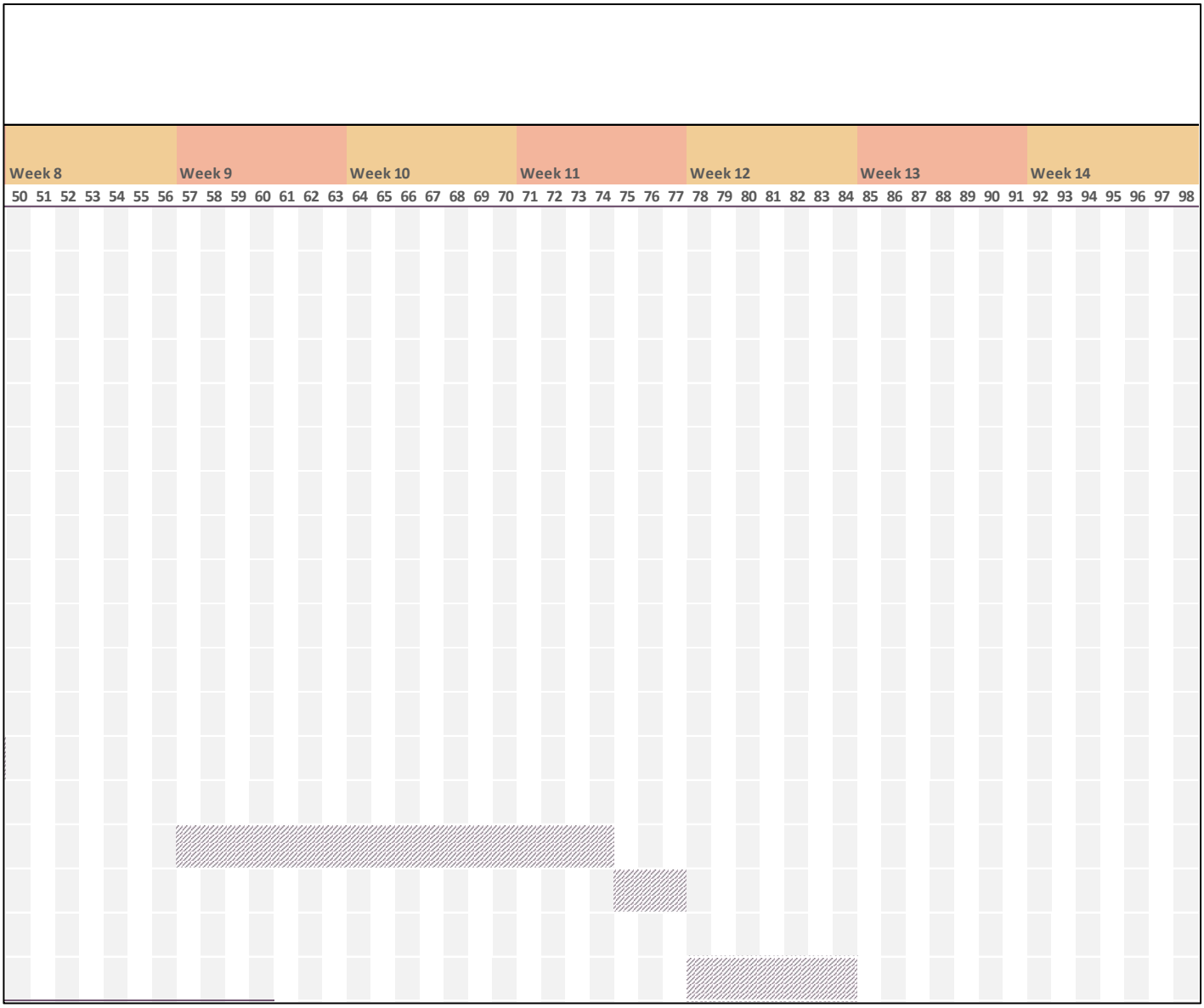
ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Proposal Development	1	3	2	2	100%
1st Supervisor Meeting	5	1	22	1	100%
Topic Development	4	1	5	1	100%
Proposal Content Development	5	3	5	2	100%
Proposal Content Development	8	2	9	2	100%
Proposal Submission	10	1	10	1	100%
2nd Supervisor Meeting	22	1	33	1	100%
Report: Chapter 1 Development	18	7	20	7	100%
3rd Supervisor Meeting	29	1	40	1	100%
Report: Chapter 2 Development	25	7	27	7	100%
4th Supervisor Meeting	36	1	47	1	100%
Report: Chapter 3 Development	32	7	35	7	100%
5th Supervisor Meeting	43	1	53	1	100%
Report: Chapter 4 Development (Requirement planning phase)	39	7	42	7	100%
Report: Chapter 5 Development	46	7	48	2	100%
6th Supervisor Meeting	50	1	54	1	100%
Full Report Submission	55	1	55	1	100%




% Complete
Actual (beyond plan)
% Complete (beyond plan)
Week 5 to 8 + Mid semester break
Week 9
Week 10
Week 11
Week 12
Week 13
Week 14
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

APPENDIX B: Gantt Chart for FYP 2




Week 8
Week 9
Week 10
Week 11
Week 12
Week 13
Week 14
50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98