SMART DOOR LOCK SYSTEM WITH FINGERPRINT BY USING RASPBERRY PI

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This report is submitted in partial fulfilment of the requirements for the Bachelor of Computer Science (Computer Network) with Honours.

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DECLARATION

I hereby declare that this project report entitled

SMART DOOR LOCK SYSTEM WITH FINGERPRINT BY USING RASPBERRY PI

Is written by me and is my own effort and that no part has been plagiarized without citations.

STUDENT : _____ Date: 9 SEPTEMBER 2021

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DEDICATION

Especially committed Towards my supportive and lovely friends and siblings, whom always encouraged, lead the way, motivated myself on my educational journeys. Many thanks because encouragement from beginning of the start and completion of my project, to my supportive lecturer

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ABSTRACT

This report is about developing some additional smart door lock system by using fingerprint that is built-in Raspberry Pi 4 Model B and the Node-RED application. This project aims to use biometric identification, the fingerprint sensor, to authenticate the smart door lock system. The biometric identification project focuses on using fingerprint recognition and how the system will be implemented. If implemented in this project, this system would give the authorised user access to the smart door. The scanner that will be used in this project is the R307 fingerprint scanner. This project also uses the Telegram application to send a smart notification and act as a backup if any miscommunication occurs from fingerprint to smart door. The user enables to send a Telegram command to control the smart door, such as unlock and lock. Furthermore, the smart door lock system enables users to gain the log and tracking module where there are databases about the user and the door activity will be display by using Node-RED dashboard application.

ABSTRAK

Laporan ini adalah mengenai penambahbaikkan sistem kunci pintu pintar dengan menggunakan cap jari yang terdapat dalam Raspberry Pi 4 Model B dan aplikasi Node-RED. Projek ini bertujuan menggunakan pengenalan biometrik, sensor cap jari, untuk mengesahkan sistem kunci pintu pintar. Projek pengenalan biometrik memberi tumpuan kepada penggunaan pengecaman cap jari dan bagaimana sistem akan dilaksanakan. Sekiranya dilaksanakan dalam projek ini, sistem ini akan memberi akses kepada pengguna yang dibenarkan ke pintu pintar. Pengimbas yang akan digunakan dalam projek ini adalah pengimbas cap jari model R307. Projek ini juga menggunakan aplikasi Telegram untuk mengirim pemberitahuan pintar dan bertindak sebagai sandaran sekiranya terdapat salah komunikasi dari cap jari ke pintu pintar. Pengguna membolehkan untuk menghantar arahan Telegram untuk mengawal pintu pintar, seperti buka kunci dan kunci pintu. Selanjutnya, sistem kunci pintu pintar membolehkan pengguna memperoleh modul log dan penjejakan di mana terdapat pangkalan data mengenai pengguna dan aktiviti pintu akan dipaparkan melalui aplikasi Node-RED.

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INTRODUCTION

1.1 Introduction

The Smart Door Lock system with fingerprint uses a biometric identification that is an automated identification that will support human biological characteristics for the authentication function. Nowadays, using a physical key or card reader locks is the way everyone is familiar with it. Furthermore, although the way is a common way that people currently applied, it has many flaws. For example, careless users need to carry many keys, lose their key, and forget to bring the key, misplaced or lost. The project aims to secure access control that can replace the physical key or the card reader lock. We proposed a solution by using a fingerprint sensor to unlock the door.

Therefore, few features will be added to the project to overcome the problem: log and tracking module and smart notification. Furthermore, this project will be using the Node-RED application to provide details about the door activity, such as the time and date the user enters and left the door, the number of user access, and who accesses the door. The smart notification features are a technique designed to make real-time for the user. These features will send notifications through the Telegram application if any unauthorized users try to access the smart door. Therefore, the user can take immediate action and is more secure. It will heighten security and will eliminate the need to carry physical keys and card readers every time.

1.2 Problem statement

Table 1.1: Problem Statement

PS	Problem Statement
PS_1	The duration to open the door take longer time by using physical keys and user's careless action such as lost the keys and forgot to bring keys

1.3 Project Question

Table 1.2: Project Question

PS	PQ	Project Question
PS_1	PQ_1	What are the current technology of smart door?
	PQ_2	How to develop the fingerprint sensor for smart door that enable the user to control the door?
	PQ_3	How to validate the functionality of prototype?

1.4 Project Objective

Table 1.3:Project Objective

PS	PQ	PO	Project Objective
PS_1	PQ_1	PO_1	To identify the current technology in smart door which are using biometric sensor
	PQ_2	PO_2	To develop the fingerprint sensor for smart door that enable the user to control the door
	PQ_3	PO_3	To validate the functionality testing of the prototype

1.5 Project Scope

The smart door lock system using fingerprints can be applied anywhere and anytime. It can be applied in many doors that need to be remotely controlled, such as home, door office, and industrial door. The smart door lock system will provide faster accessing the door for the user within a few seconds. Furthermore, it will provide a complete and user-friendly application to understand and access all the data easily. The system includes the fingerprint sensor, smart notification via Telegram application, remotely access the door via Telegram command and data storage with details via Node-RED.

1.6 Project Contribution

Table 1.4: Project Contribution

PS	**PQ**	**PO**	**PC**	**Project Contribution**
PS_1	PQ_1	PO_1	PC_1	Help the user to increase the security by using smart door and propose a faster processing time to open the door with accurate details of the door activity
	PQ_2	PO_2		
	PQ_3	PO_3		

1.7 Conclusion

This chapter explains the purposes of the project for the user by outline the main point such as problem statement, objective, scope, and project question. The project's aim is to higher the security of the door to the user. It also will be applied a smart notification and logs and tracking module. This project is really convenient as it can make life easier and faster, including for older adults.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Internet of things, known as IoT, is an emerging technology that can change world technology, primarily industrial operations. The IoT enables us to control, configured, and operate our devices remotely. The IoT has had a tremendous impact on the home automation development field. The smart door lock system is essential for a house to maintain more robust security. The implementation has been made to an integrated door automation system with smart devices technology that will make people's lives easier and increase the quality of life. There are many issues regarding the previous manual door that the user forgets to bring their key, lost the key, and duplicated many keys for each member, but still keeping in mind the key of security level.

Chapter 2 is a study about literature review. This topic will enhance previous work regarding the smart door lock system or door automation. Therefore, we will analyze the previous work problem, including the solution, which will be tabulated. Ten previous work has discovered to analyzed from the table, and proposed solutions have been made to overcome the problem. The last subtopic of this chapter is the conclusion of the overall chapter.

2.2 Supporting Technologies

The supporting technologies that related to the project key is the Internet of Things(IoT), smart home and the recognition device.

2.2.1 Internet of Things (IoT)

The IoT, Internet Of Things, is an emerging technology that can change world technology, primarily industrial operations. The IoT enables us to control, configured, and operate our devices remotely. The IoT has a tremendous impact on the home automation development field. The smart door lock system is essential for a house to maintain more robust security. The implementation has been made to an integrated

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There are a few components in IoT that represent the integration of the system work, which is the sensors, connectivity, data processing, and a user interface:

1. The sensor or device that collects data from the surrounding environment includes the time we insert fingerprint, temperature, and many more.
2. The connectivity is when the data is collected and sent to the cloud infrastructure using various mediums such as Wi-Fi, Bluetooth, cellular, and many more.
3. Data processing occurs when the data is collected and gets to the cloud, where the software will be processing each information it obtains.
4. The user interface is where the end-user obtains their information through many platforms such as email, notification, website, and many more. A user will have the interface to check any data or update their system proactively.

2.2.2 Smart Home

The smart home is a term given to an essential home filled with communication technology, enabling remote-controlled devices in the house. The home appliance that is primarily can be controlled include the appliance such as the fridge, garage, home security system and environmental such as the lighting and air conditioning.

The smart home can be feature either in a wireless or hardwired system or both. The wireless system is much convenient as it is more cost-friendly than the hardwired system. A hardwired system is more reliable as it is more challenging to be a hack, but it is much more expensive as the user needs to install a luxury hardwired smart system.

There is a lot of advantage installing the smart home technology as it provides the homeowner with convenience. The homeowner can control their appliance using only one device, such as a phone or tablet. Besides, the user is also enabled to get a notification and any updates issues about their home. For example, the homeowner can obtain notification when someone is trying to access their house when they are not at home.

2.2.3 Biometric identification

The biometric is a unique characteristic of a person or personal characteristics that can be used to validate the person's identity. The biometric identification cannot be transferred or copy from one user to another easily. The biometric characteristic is common, including the use of fingerprints, face recognition and the voice recognition.

There are many benefits of using biometric as it, unlike the passcards, key or password that can be transferred to each other easily. Biometric identification is very secure and less susceptible to fraud as it is only concerned with individual identification. Furthermore, biometrics cannot be removed easily using physical characteristics such as fingerprint, hands, and eyes. Besides, it is really a beneficial technology as the user does not need to memories anything such as the password and carry anything such as the key or cards. Hence, it provides higher security for the user.

There are several examples of biometric authentication that are using in today's technology. Firstly, the fingerprint biometric will compare the user's fingerprint to a stored fingerprint template in order to validate the user's identity. The fingerprint biometric has many benefits. It will be much harder to be duplicate, convenient, and easy for the user, cannot be guessed, forgotten, or misplaced, and is considered one of the most secured authentication methods. Besides, facial recognition has very instantly become a mainstream component in our daily life today, such as unlocking our mobile devices. Facial recognition has increased security in society, preventing any crime and reducing human interaction. Face recognition works by using a computer algorithm to pick out the specific detail of a person's face, such as the gap between eyes or the pattern of the user's chin. It will be converted into a mathematical representation and compare the data on other faces that are collected in the database.

2.2.4 Minutiae Algorithm

A fingerprint is a unique identity for each individual as it has a pattern of ridges and valleys. The uniqueness of each person's fingerprint is defined by the local ridge aspect of the fingerprint. There are two prominent local ridges which are ridge ending and ridge bifurcation. Both of the ridges are called minutiae. The ridge ending is defined as the point where the ridge ends abruptly, while the ridge bifurcation is the point where a ridge forks or diverse into branches of ridges.

The fingerprint matching algorithm is using phase correlation based on the minutiae points. It is a popular choice to undergoes image registration because of its robust performance and simplicity. The theorem use in phase correlation is the Fourier shift theorem. The phase cannot have used the two align point directly as it needs to be converted the minutiae sets into 2D image space that called as Minutiae Direction Map (MDM). These alignments will parameters will be determined by differentiating the two-phase correlation of MDM. Figure below shows the algorithm that are used to differentiate the two images:

$$\mathfrak{M}^{M}(m,n)=\begin{cases}\cos\alpha_i + j\sin\alpha_i & m=x_i, n=y_i, \\ 0 & \text{otherwise}\end{cases}$$

Figure 2.1: Minutiae algorithm

The phase correlation will experience two stages which are the alignment stage and matching stage. The alignment stage will occur transformation, including the rotation and translation between two minutiae sets. Both of them will be calculated, and then the input minutia set is aligned to models of similarity measurement. Both of the similarities between the aligned input minutiae set and template will be calculated in the next stage, which is the matching stage.

In the matching stage, the minutiae set will be aligned to a new set regarding the parameter of transformation. It will compare both of the sets to see the comparison and the percentage of matching. If the distance of both minutiae sets is less than the threshold, the two images might be from the same finger. Else it comes from a different finger.

2.3 Related Work/Previous Work

2.3.1 Door-Automation System Using Bluetooth-Based Android for Mobile Phone

From the journal by *Kamelia L, et al. (2014),* the smart door automation system uses a Bluetooth-based Android Smartphone and uses Arduino platforms that are more easy and efficient as it is a free open source software. The Bluetooth will act as a command agent, Arduino will microcontroller as a control center or data processing center, and solenoid act as door lock output. The device provides a safe and effective solution for controlling home automation. Rather than using a key, it uses a command delivered by Bluetooth on a Smartphone and other mobile devices. The uses of Bluetooth on Android smartphones are to provide better security than conventional keys.

It will be controlling and conducted by sending a command via Bluetooth to the Arduino circuit that will connect the Android smartphone and the solenoid. The diagram represent the block diagram of the door automation system by using android. The block diagram in Figure 1 shows that the android system's input uses Arduino software while the output solenoid is connected to the Arduino microcontroller circuit.

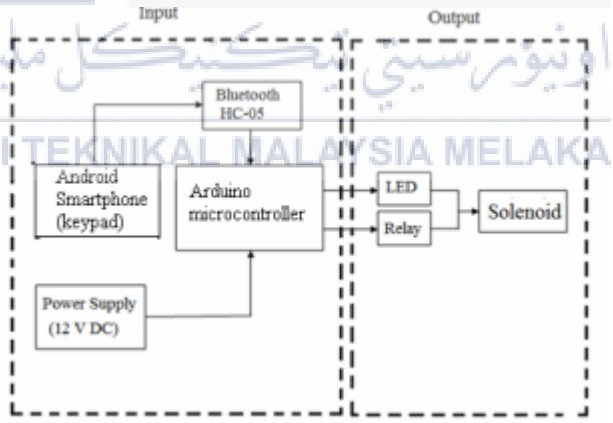


Figure 2.2: Block diagram of smart door (Kamelia L, et.al 2014)

2.3.2 Smart Door Using Bluetooth Technology and Camera Verification

The journal from *Pandurang et al. (2016)* states that the system is designed with a user motion-captured from the camera, and the user will be detected, and then he will be given a key to lock and unlock. It purposes to secure the door that can replace a good amount of human working force and humans are more prone to making errors.

The system contains an application that will allow the user to check the door's status. The mobile devices will require a password to increase the security of the system. The Bluetooth will be used as a communication method as it has been integrated into many Android devices and secured through its own protocol. Furthermore, the system will be designed for security purposes. For example, when someone is ring the bell at the door, it will trigger the camera, and the camera will capture the video of the person standing in front of the door. It will capture the person's motion from the camera, and the user will be detected, and he will be given the key to unlock and lock the door.

2.3.3 The Automatic Door Lock to Enhance Security in RFID System

Based on the paper that has been written by *Hasan et al. (2020),* there are people who always tend to use the conventional key as security, but it easily brings in crime. The door lock system will traditionally use the conventional key to operate mechanically by inserting the correct key. Unfortunately, it is not good to identify unauthorized users. RFID that stands for Radio Frequency Identification, will be used to accessing the door. Testing has occurred on RFID. The RFID tag which has been registered will be received; otherwise, an unregistered ID tag will be declined. The table shows the tag RFID testing result. It shows that the unregistered tag will be rejected while the registered tag will be received. Figure 2 shows the result of RFID timing access to open the door. As we can observe, the average timing result per person is around 3 seconds.

Card Number	Tag Frequency	Tag Register	Number Tag ID	Solenoid Condition
1	13,65 MHz	Registered	150221413344	Open
2	13,65 MHz	Registered	52071824581	Open
3	13,65 MHz	Registered	612011539162	Open
4	13,65 MHz	Registered	5319156455151	Open
5	13,65 MHz	Registered	832316839201	Open
6	13,65 MHz	Registered	6714111439155	Open
7	13,65 MHz	Unregistered	671383739203	Close
8	13,65 MHz	Unregistered	11511225339217	Close
9	125 KHz	Unregistered	0012512033190	Close
10	125 KHz	Unregistered	00031292277027	Close

Figure 2.3: Tag RFID testing result (Hasan, et.al 2020)

User	Time (sec)			
	T_1	T_2	T_3	$T_{Average}$
1	3,25	3,10	3,15	3,2
2	3,47	2,58	3,18	3,1
3	3,12	3,37	3,29	3,2
4	3,10	3,45	2,50	3
5	2,56	3,14	3,25	3
6	3,27	3,10	2,59	3
7	-	-	-	-
8	-	-	-	-
9	-	-	-	-
10	-	-	-	-

Figure 2.4: Timing access result (Hasan et.al, 2020)

2.3.4 Smart Digital Door Lock for Home Automation

Based on the paper by *Yong Tae Park, Pranesh Sthapit, et al. (2009*), the smart door lock operates over a network's wireless sensor. The system uses a ZigBee module embedded in the digital door lock and acts as the main controller. The door lock system consists of an RFID reader for user authentication, a touch LCD, a motor module for opening and closing doors, and sensor module to detect the house's condition, a communication module, and a control module controlling other modules. The smart digital door lock system can be divided into few parts: the sensor module, communication, and the I/O module. The user can access the I/O module to access the door as it includes the RFID reader and digital dial pad for authentication. TFT Touch LCD can control individual devices and display relevant information.

Furthermore, the smart door lock system has been implemented with a camera module, microphone, and speaker. It is to enable the user to interact with their visitor. The figure below shows the differences between a typical wired home server system and the smart door lock-based server system.

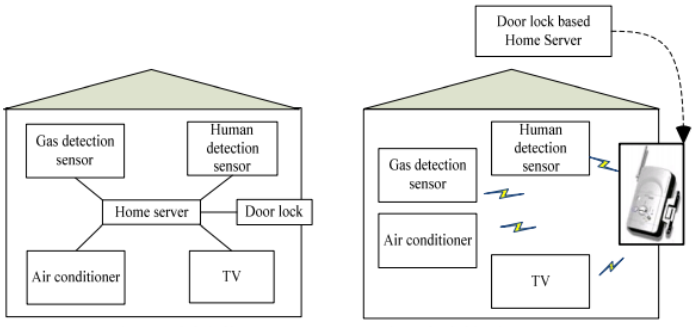


Figure 2.5: System architecture (Park et.al, 2009)

2.3.5 Facial Recognition Enabled Smart Door Using Microsoft Face API

Based on *Karan Maheshwari et al. (2017),* the method used is the face recognition and detection method. Automatic face recognition has been done by using Neural Networks, and the main component in this project is Raspberry Pi, which acts to control the door access. It will show the immediate response from the monitor. This system is suitable to be implemented in many places that need maximum security.

2.3.6 Door Automation System Based on Speech Command and Pin using Android Smartphone

Based on *R. Dinar Hayu Arifin and R. Sarno (2018),* the method they use in this project is speech command and can also be accessed via pin authentication. Besides the smartphone application and Arduino board, the proposed design method are using a based Bluetooth module. The investigation has done about 25 experiments to observe whether the android application can detect sound with different distances. In 25 experiments, only four experiments have failed to detect words. The figure below shows that the longer the distance between the speaker and smartphone, the longer the application needs to detect the word spoken.

Distance Speaker mouth to the phone (cm)	Time (Second)
2	2
4	2
6	3
8	4
10	4

Figure 2.6: Time detection results (R. Dinar Hayu Arifin, et.al 2018)

2.3.7 Development of Electronic Locks Using Gesture Password Base On RSA Algorithm

Based on *Lee et al. (2017).*, the system is using a gesture password to unlocking the door. There are four subsystems implemented in this system: the gesture password, RSA encryption and decryption, hardware circuit integration, and the integration of the cloud monitoring system. The RSA algorithm developed in the project was applied a novel gesture password electronic lock system by using a smartphone as the communication carrier to unlock and lock the door via Bluetooth module.

2.3.8 Design of Smart Lock System for Doors with Special Features using Bluetooth Technology

Based on *Hadis et al. (2018)*, the system proposed is a system that uses Bluetooth technology as a communication protocol between the authorized user and the lock system. This system is special for disabled people as the user does not need to do any action to open or lock the door. The system works by using a device that activated Bluetooth and is located near the door. The system that matches the user's identity will be connected to the communication of the lock control system. Hence, the system will open if the person is an authorized user located near the validation area. Besides, it also has a featured website and smartphone application.

2.3.9 Smart Security: Remotely Controllable Door lock

Based on *Shraddha Tiwari et al. (2018)* focussed on a system that allows the house owner to monitor the door remotely. This system needs to use an internet connection to work as it needs to connect the raspberry pi and the owner's phone. Furthermore, the system contains a camera to snap a picture of the visitor and send notifications using an internet connection through the user's smartphone. Then, the user will decide whether they want to permit the visitor to access it or not.

2.3.10 Smart Door Using Biometric NFC Band and OTP Based Methods

Govindraj et al. (2020) outline a system that uses NFC band and OTP-based method. NFC band is a set of communication protocols that enables the device to transmit information wirelessly. The NFC band is embedded with the fingerprint sensor of the registered user. For guest access, they will undergo OTP authentication and enter their mobile phone number. Then it will be sent to the owner's NFC band by SMS from the Arduino via GSM module. The owner will verify the mobile number and give permission or not. If the owner provides access, the user will receive OTP from the Arduino via the GSM module and can enter the house.

2.4 Critical review of current problem and justification

Based on the research with the previous project, each project's purpose, problem, and solution have been conveyed into a table based on table 2.1. The problem column will represent the issue or problem that undergoes with the previous project. At the same time, the proposed solution is the solution that will overcome the problem to improve the project. Table 2.2 below exhibits the identification of the previous project by state the microcontroller, technology, platform, data representation, and the sensor that was used. Hence, the overall project disturbance has been classified, and the solution to resolve the problem has been recommended.

Table 2.1: Problem and solution propose based on previous work

Research Title / Product	**Purpose**	**Problem / Open Issue**	**Proposed Solution**
Kamelia, L., Noorhassan, A., Sanjaya, M., & Mulyana, W. E. (2014)	This paper proposes a door-automation by using Bluetooth in a mobile device. It also is an Android based and using Arduino platform.	The smart door system that is using Bluetooth has a few limitations. The smart door will communicate with the phone via Bluetooth. If the user phone might have lost, out of battery, or stolen, the user could not unlock their door if they don't have any backup.	The solution to overcome this problem is besides the Bluetooth; the system should give another choice to unlock the door, such as using a biometric identification at the door.
Pandurang, B., Pede, J. D. P. M.	The system proposed to detect the motion of the user. The user motion	The system is using a Bluetooth connection as the module. Bluetooth have few	The solution to overcome this issue, the system can employ Wi-Fi

S., & Rahul, G. A. G. (2016)	will be captured by camera and detect the user then it will give the permission to unlock or lock the door. This project is to create an automated device for locking and unlocking of the door.	disadvantages, such as it can lose connection in a certain condition as Bluetooth technology only allows short-range communication between devices	technology that is much better than Bluetooth. Wi-Fi has a higher bandwidth compared to Bluetooth, and the user can control the door in bigger range communication.
Hasan, Y., Wijanarko, Y., Muslimin, S., & Maulidda, R. (2020).	The paper presents an automatic door lock in a classroom security system that uses the ID Card of students (RFID) as the security key connected to the server. This project aims to keep the security of the classroom by implementing Arduino mega and verifying the classroom door's effectiveness.	The problem in using the RFID in the smart door is that the user cannot access the door if they don't bring the RFID card or damage the RFID card.	The system needs to add another module such as using a keypad to access or change to a different module, such as using a biometric sensor like fingerprints and face recognition.
Park, Y. T., Sthapit, P., &	The paper states that the smart door lock operates over a network's wireless sensor. The system uses a	The problem that occurs using this system is the ZigBee module is low transmission and low network stability compared to other	The system can change the ZigBee module by using the Wi-Fi-based module. Wi-Fi are much faster than

Pyun, J. Y. (2009).	ZigBee module embedded in the digital door lock and acts as the main controller. ZigBee module includes RF communication, and it used digital door lock and sensor modes in the house.	modules. It also does not secure like a Wi-Fi-based secured system.	ZigBee. Wi-Fi networks are also less reliable corresponded to ZigBee network
Maheshwari, K. (2017)	The paper discussed that the method they are used to enhance the smart door's security is by using face recognition and detection method. It also states that the implementation of automatic recognition is using Neural Network.	The neural networks have a few constraints on their algorithm as the process is slow and the result is not accurate. This system also allows only one admin, and it might be one of the problems that occur as it unable to add another person in case of emergency. In addition, the time after successful detection of face is indefinite, thus it should be set according to user needs.	A real time speaking assistant can be deployed to make the system become more friendly and efficient for the user. The database can be linked to the cloud or server in case of power failure or data loss might happen.
R. Dinar Hayu Arifin and R. Sarno (2018)	The paper proposed a friendly system that use speech command and pin.	The problem that occurs in the system is it uses speech command. Thus, anyone who	The system can be improved by modified the authentication method to access the door. The

	This system also used a Bluetooth module.	knows the command to access the door can open it easily.	authentication can use biometric identification like fingerprint or voice recognition so only the user can enter the door .
Lee, C. T., Chung, Y. C., Shen, T. C., & Weng, K. W. (2017).	The paper proposed a system using a novel electronic lock system that can be accessed by using a gesture password. In this system, a smartphone will be used as a communication carrier connected to the development board via Bluetooth.	The problem with this system is it does not have any backup or other way if the user might be lost their phone. If the smartphone is lost or broken, the entire system will become inaccessible.	The system needs to be improved by adding another way for the user to access the door, such as having another software like Telegram bot command to enable the user access the door .
Hadis, M. S., Palantei, E., Ilham, A. A., & Hendra, A (2018)	The paper proposed a smart door lock system that uses a Bluetooth technology as the communication protocol between the lock system and the user.	The obstacle with this system is that it does not contain any user and unauthorized user database trying to access the door at in website application. The website applies only to the user who loses their device and is unable to connect to Bluetooth.	The system can be improved by adding the log and tracking module features to increase the security of the smart door lock system.

S. Tiwari, S. Thakur, D. Shetty and A. Pandey (2018)	The paper focused on a system that can remotely control the opening and closing door by using raspberry pi as the major controlling system at the door. The user need to use an application to gain data of the visitor by using internet connection.	Sometimes, the face recognition might have failure. Hence, the owner needs to open the door manually.	The problem can be resolve when the system implements another backup method to open the door such as using Telegram application.
Govindraj, V. J., Bhat, S. V., & Ramesh, T. K. (2020)	The paper outlines a system that uses NFC Band and OTP Based method. It uses Arduino Uno paired with GSM Module and an NFC reader attached to the door.	The system takes longer to process the action as the visitor needs to put their phone number and send it to the owner for verification.	The system can be improved by linking a software application such as Telegram or WhatsApp that enable the owner to open the door for the visitor quickly.

Table 2.2: Comparison of Functionality of Previous Project

Author / Year	**Microcontroller**	**Communication Technology**	**Platform**	**Data Representation**	**Sensor Type**
Kamelia, L., Noorhassan, A., Sanjaya, M., & Mulyana, W. E. (2014)	Arduino	Bluetooth module	Arduino platform	Android based	-
Pandurang, B., Pede, J. D. P. M. S., & Rahul, G. A. G. (2016)	Android devices	Bluetooth module	Mobile Apps	Android based	Motion detection
Hasan, Y., Wijanarko, Y., Muslimin, S., & Maulidda, R. (2020).	Arduino mega	RFID	Arduino platform	LCD Display	RFID Sensor
Park, Y. T., Sthapit, P., & Pyun, J. Y. (2009).	MCU	ZigBee module	-	TFT touch LCD	Home Detection Sensor Gas Detection Sensor

Maheshwari, K. (2017)	Raspberry Pi 3 Model B+	Wi-Fi module	Windows 10 IOT Dashboard	Display Monitor	Face recognition Detection method
R. Dinar Hayu Arifin and R. Sarno (2018)	Arduino	Bluetooth module	Mobile Apps	Android based	Speech command Pin
Lee, C. T., Chung, Y. C., Shen, T. C., & Weng, K. W. (2017).	Arduino Yun	Bluetooth module	Mobile Apps	Website	Gesture Password
Hadis, M. S., Palantei, E., Ilham, A. A., & Hendra, A (2018)	Smartphone	Bluetooth module	Mobile Apps	Website	-
S. Tiwari, S. Thakur, D. Shetty and A. Pandey (2018)	Raspberry pi 3	Wi-Fi module	Firebase	LCD	Fingerprint Sensor Detection Sensor
Govindraj, V. J., Bhat, S. V., & Ramesh, T. K. (2020)	Arduino Uno	OTP Based method	NFC Band	-	Fingerprint Sensor

2.5 Proposed Solution/Further project

From the previous work, we can observe many problems, such as the limitation of using Bluetooth on a smartphone in *Kamelia et al. (2014*) and *Pandurang et al*., weakness occurs in using the RFID module in *Hasan et al. (2020),* and many more. The previous work using facial recognition module problems happens when the time after successful detection is indefinite. In *R. Dinar et al. (2018),* the problem occurs when strangers know the voice command to open the door. Hence the door will be easy to access. Based on *Lee et al. (2017),* the problem occurs when the system does not have any backup to access the door if the smartphone is damaged or lost.

Furthermore, *the Hadis et al. (2018)* system does not contain any database of people entering the door. Based on *Shraddha Tiwari et al. (2018),* the ninth article states that the user needs to open the door if the face recognition fails remotely. In the last article from *Govidraj et al. (2020),* a problem occurs when the system takes longer to process the door for verification.

The solution proposed in *Kamelia et al. (2014)* from the problem is that the system should give another option to unlock the door, such as using biometric identification. Next, in the second article by *Pandurang et al.(2016),* the system can use Wi-Fi technology that is much better than Bluetooth. The Wi-Fi has a higher bandwidth than Bluetooth, and the user can control the door in bigger range communication. Furthermore, in *Hasan et al. (2020)* system adding another module such as fingerprints and face recognition can be implemented to reduce the weakness of RFID, which is the loss and damage of the card. *Park et al. (2009)* can change the ZigBee module by using the Wi-Fi-based module. Wi-Fi are much faster than ZigBee. Wi-Fi networks frequencies are more stable corresponded to the ZigBee network. Moreover, Wi-Fi can support a large number of users compared to ZigBee. Thus, the Wi-Fi will have more compatible rather than the ZigBee.

The solution to overcome the seventh article, which is based on *Lee et al. (2017),* is by adding another way for the user to access the door to make the system friendlier and efficient. Furthermore, *Hadis et al.* (2018) system can be improved by adding a database linked with the cloud to increase security. Finally, the last article by *Shraddha Tiwari et al. (2018) and Govidraj et al. (2020)* solution can be improved

by linking a software application such as Telegram or WhatsApp that enable the owner to open the door for the visitor quickly.

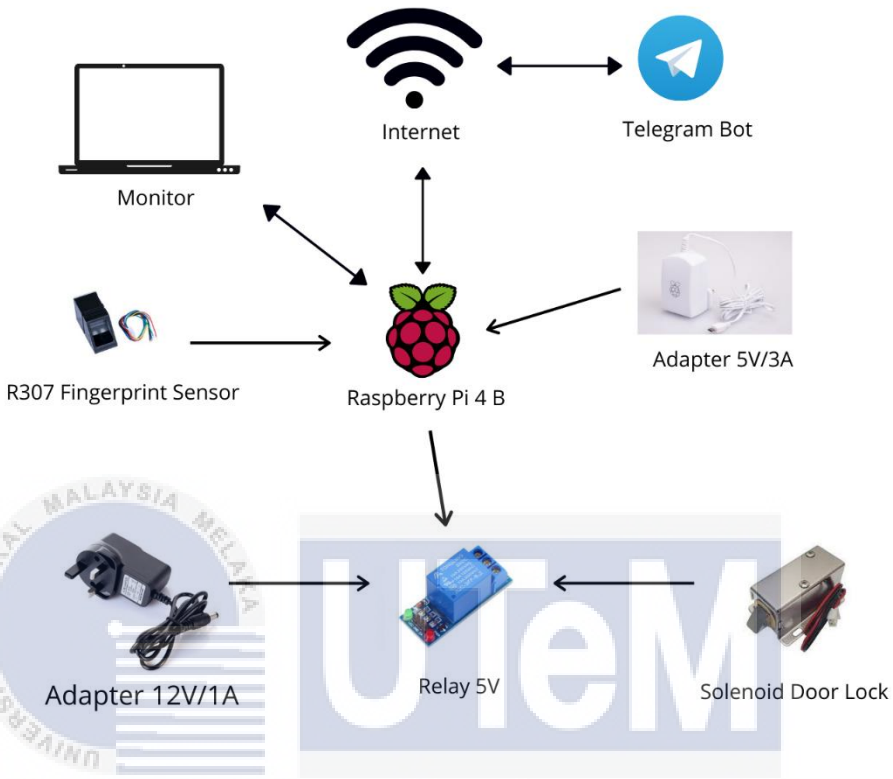


Figure 2.7: Design of door lock fingerprint sensor

The figure shows the component that implements in this project. The Raspberry Pi will act as the main component to manage the system, and it is connected through the monitor. The Raspberry Pi demands a power supply which is the Adapter 5V, to turn it on. Besides, the log and tracking module highlight will be implemented in the MySQL database and display in the Node-RED dashboard. The raspberry pi port will be connected with the R307 fingerprint sensor via CP2102 USB to the TTL converter.

Furthermore, the users can utilize Telegram to control the door by applying telegram command, and Telegram also will act as a smart notification. Smart notifications are implemented in python coding, and the user will receive notification if unregistered fingerprints are attempting to enter the door. The solenoid lock will be connected with the relay module and 12V power supply to energize the coil inside the lock.

2.6 Conclusion

In this chapter, we can identify the purpose of the previous project. Furthermore, we can also acknowledge the project's weakness and the resolution that can overcome the problem. Several problems occur during the last project. There is no other way or backup to access the door if their system is in trouble, using a speech command where anyone can access quickly and need the RFID card to access the door. These problems can commence to the smart door lock system security becoming weak. The problem can be overcome in the smart door lock by using a fingerprint sensor to access the door. Instead of that, the project contains the log and tracking module for the database. If the fingerprint system is down, the user can access the door by using the Telegram application as a backup method. Thus, a the is created to improve and avoid the same problem occur.

CHAPTER 3

PROJECT METHODOLOGY

3.1 Introduction

This chapter will be a focus on the methodology that will be used in this project. The first section will be discussing regarding the software development life cycle. Besides, the project will contain it schedule and milestone in a table form. It can help and explain every activity performed stage by stage during the engagement process.

3.2 Project Methodology

The project methodology is used as the guideline with the right methods and flow of the project. Hence, the suitable approach will be described in detail explanation in this section. A software development methodology can be used to ensure the project produces a stable system.

In this project, the most suitable software development methodology is the prototyping model phase. The prototyping model is one of the software development models where a prototype will be built, tested, and reworked until the prototype is acceptable. The prototyping model contains six system development life cycles (SDLC): requirement gathering and analysis, quick design, build a prototype, initial user evaluation, refining the prototype, and implementing product maintenance.

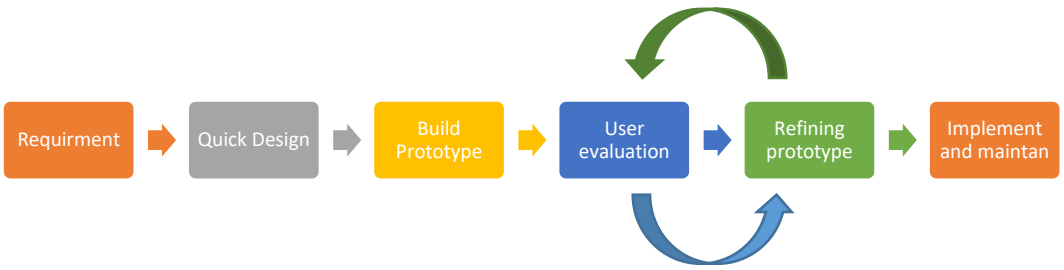


Figure 3.1: Prototyping model

3.2.1 Requirement Gathering

The prototyping model begins with gathering requirements. During this phase, the requirement of the project is defined in detail. Below is the list of requirements that need to be used to build the door lock using a fingerprint sensor according to the hardware and software.

1) Hardware

- Raspberry Pi 4 Model B
- Fingerprint Reader R307 Sensor
- Micro SD card
- Jumper wire
- Solenoid lock
- 12V power supply
- Monitor
- CP2102 USB to TTL converter
- Relay Module 5V
- Adapter 12V/1A
- Adapter 5V/3A

2) Software

- Raspbian OS
- Telepot (Telegram package)
- Node-red
- Python 3
- Tkinter Python
- MySQL Database

3.2.2 Quick Design

In the second phase, a preliminary or quick design, a simple design, is created for the door lock fingerprint sensor. This phase is to give a brief idea of how the system is working to the user. Besides, the quick design can help in developing the prototype. Below is the design that has been created.

In this project, the Raspberry Pi will act as the main component to control the system all the systems, and it is connected through the user's monitor. The Raspberry Pi needs a power supply which is the Adapter 5V, to turn it on. Log and tracking module feature will be implemented in MySQL database, and Node-RED dashboard will show. It will be connected through the R307 fingerprint sensor via CP2102 USB to the TTL converter. Users can use the Telegram application via Internet connection to enable the user to control the door using telegram command and act as a smart notification. The solenoid lock will be connected with the relay module and 12V power supply to energize the coil inside the lock.

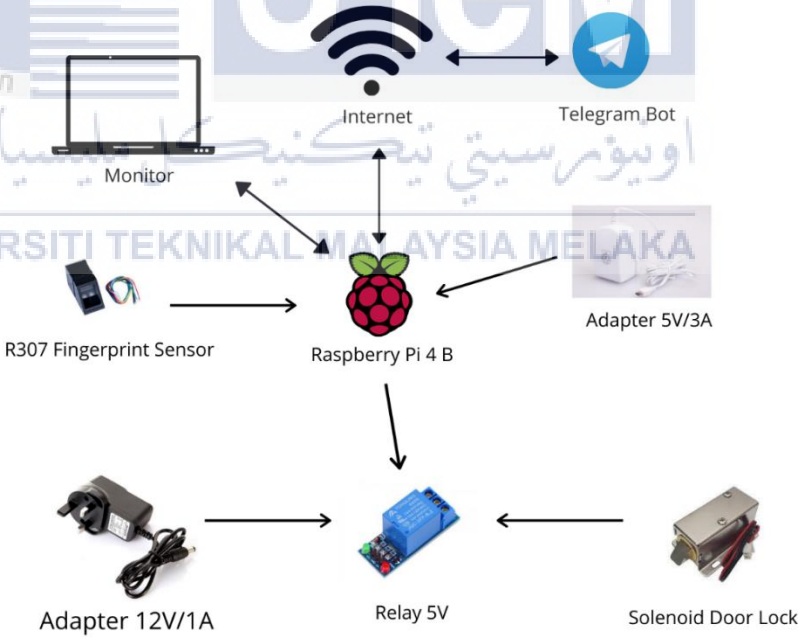


Figure 3.2: Design of door lock fingerprint sensor

3.2.3 Build Prototype

The first prototype will be build based on the plan. All the hardware and software required to be used in the project will be configured and installed. The first software that will be installed is the Raspbian OS which is for the Raspberry Pi 4 hardware. After the OS is successfully installed, all the required packages such as the fingerprint package used in this project will be installed.

3.2.4 User evaluation

After complete the prototype, the evaluator will evaluate the prototype that has been built. The evaluation will comment on the strength and weaknesses and what should be improved on the prototype. Besides, it also will undergo a system usability test (SUS). The SUS testing will have ten questionnaires to measure the usability of the product. The respondent will have the option from strongly agree to disagree strongly. The SUS testing is straightforward to scale to the participant's response. Hence, the evaluation result will be taken for the further analysis process.

3.2.5 Refining prototype

According to the evaluator's feedback and suggestion, the prototype's weakness will be refined from the evaluation result. The refining prototype phase will not be over until the final prototype meets all the requirements and is satisfied.

3.2.6 Implement and maintain

Once the final system is developed and satisfied, the prototype will undergo routine maintenance to minimize any downtime that might occur and prevent a large-scale failure.

3.3 Project Milestones

In this project, the project milestone will be the guideline to ensure the project's timeline. The project milestone is essential to guarantee the continuous running of the project. The table below shows the milestones designed according to the project.

Table 3.1: Project milestones

Activity	Responsibility	Date Start	Date End
Gathering requirement	Student and Supervisor	Week 1	Week 2
Analyze the requirement	Student	Week 2	Week 3
Designing project	Student	Week 3	Week 4
Gathering hardware	Student	Week 4	Week 10
Installing the Raspbian OS	Student	Week 6	Week 10
Building prototype	Student	Week 7	Week 10
Progress evaluation	Student and supervisor	Week 8	Week 10
Testing prototype	Student	Week 9	Week 10
User (supervisor and evaluator) evaluation	Student , evaluator and supervisor	Week 13	Week 12/13

Drafting new design based on evaluation	Student	Week 1	Week 3
Refined prototype	Student	Week 4	Week 5
Progress evaluation	Student and supervisor	Week 4	Week 5
Building full project	Student	Week 6	Week 6
Refined prototype tested again	Student and supervisor	Week 7	Week 7
User (supervisor and evaluator) evaluation	Student , evaluator and supervisor	Week 8	Week 8

Table 3.2: Gantt Chart for PSM1 and PSM2

Week / Method	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Requirement gathering and analysis																							
Quick Design																							
Building Prototype																							
User Evaluation																							
Refining prototype																							
Implement and maintain																							

3.4 Conclusion

The project methodology is essential in developing a project. It is because it can help in focusing the project standardize, structure and organize works in detail. Using the project methodology, this project can be developed in a manageable timeline according to the six stages in the prototype model. Without methodology, this project will face a lot of problems such as delay and failure.

CHAPTER 4

ANALYSIS AND DESIGN

4.1 Introduction

Chapter 4 will be focusing on the analysis and design of the project. This chapter contains a subtopic of problem analysis, requirement analysis, high-level design, detailed design and the conclusion. The problem analysis will be discussing the current problem that might occur indoor security nowadays. Besides, the requirement analysis will cover the data requirement, functional requirement, non-functional requirement, and other related requirements. The high-level design will contain the system architecture, user interface design and database design of the project.

4.2 Problem Analysis

Nowadays, using a physical key or card reader locks is one way that everyone familiarised with. Furthermore, although the way is a common way that people currently applied, it has many flaws. For example, user careless behaviour needs to carry many keys, lose their key, and forget to bring the key, misplaced, or lost. Besides, it also takes a long time to unlock the door by using physical keys. The user is also unable to receive notification if any unauthorised user tries to access the smart door.

4.3 Requirement Analysis

4.3.1 Data Requirement

Nowadays, using a physical key or card reader locks is one way that everyone is familiarised with. Furthermore, although the way is a common way that people currently applied, it has many flaws. For example, users careless behavior needs to carry many keys, lose their key, and forget to bring the key, misplaced or lost. Besides, it also takes a long time to unlock the door by using physical keys. The user is also unable to receive notifications if any unauthorized user tries to access the smart door.

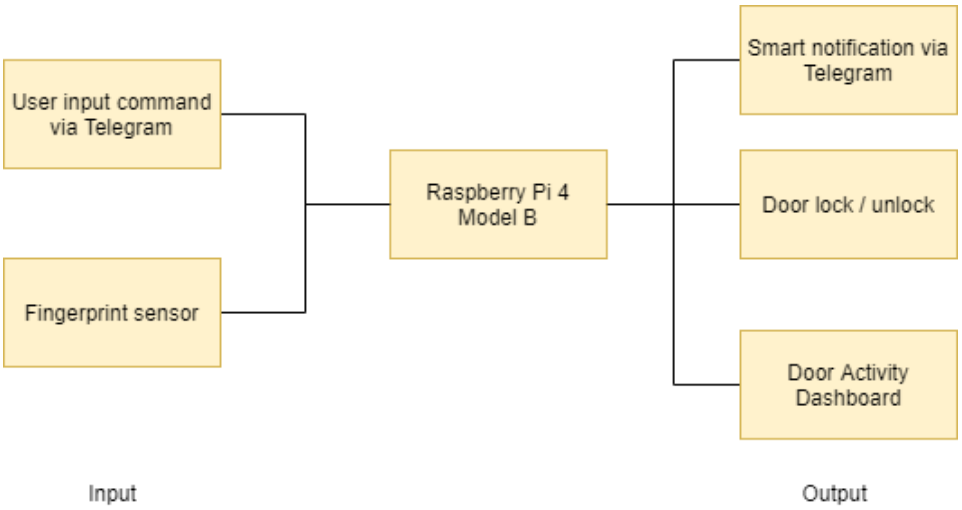


Figure 4.1: Block Diagram of Smart Door Lock

4.3.2 Functional Requirement

In the diagram below, the Raspberry Pi 4 required an Internet connection to enable the device to function smoothly. Furthermore, if any unauthorized user tries to access the smart door, a smart notification will be sent via Telegram. Moreover, the user also can use the Telegram application to control the smart door with command. The door will unlock and lock. The Node-RED dashboard will display the door activity by linking to the MySQL database.

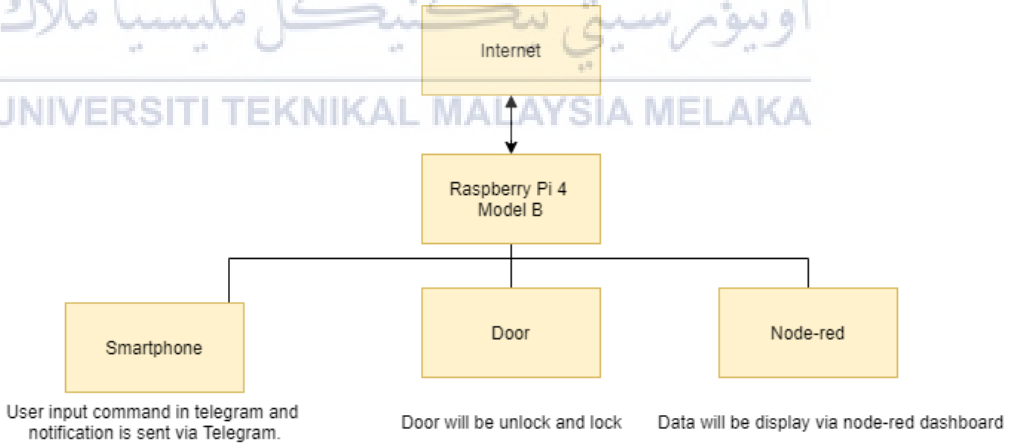


Figure 4.2: Context Diagram of Smart Door Lock

4.3.3 Non-functional Requirement

Table below shows the comparison between The R307 fingerprint sensor comparison with R305 (old) fingerprint sensor. Based on the table below, we have stated why we used the R307 module over the R305 module.

Table 4.1: Comparison R305 and R307 fingerprint sensor

Features	R305 (old)	R307
Storage Capacity (Fingerprints)	250	1000
3.3V Operation	No	Yes
USB Operation	No	Yes
Finger Detect Output	No	Yes

4.3.4 Other Requirement

There is a few equipment that need to be used to complete the project which is the hardware requirement and software requirement.

4.3.4.1 Hardware Requirement

i. Raspberry Pi 4 Model B

Figure 4.3: Raspberry Pi 4 Model B

The Raspberry Pi is stated as a single-board computer that has been created by the Raspberry Pi Foundation. It is a UK charity that aims to educate people in computing and create easier access to computing education. The Raspberry Pi has become a user choice to learn programming skills, build hardware projects, home automation, and indeed use them in industrial applications.

ii. Fingerprint Reader R307 Sensor

Figure 4.4: R307 Fingerprint Sensor

The R307 fingerprint module consists of the optical fingerprint sensor with a high-speed DSP processor, high-performance fingerprint alignment algorithm, and high-capacity FLASH chips. It contains two interfaces which are TTL UART and USB2.0. The USB 2.0 can be connected directly to the computer. The storage capacity fingerprint that can be store in the sensor is 1000 fingerprints. The fingerprint scanner uses a Minutiae-based algorithm method.

iii. Solenoid lock

Figure 4.5: Solenoid Door Lock

The solenoid lock is an electromagnet made by a big coil of copper wire with an armature metal (a slug of metal) in the middle. When the coils are energized, the slug will be pulled into the center of the coil. The solenoid lock is strong and needs a good power supply to drive the solenoid lock.

4.3.4.2 Software Requirement

i. Node-RED

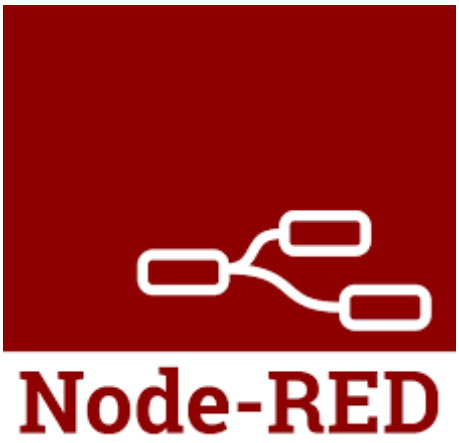


Figure 4.6: Node-RED software application

The Node-RED is a flow-development tool for visual programming development that has been developed by JS Foundation. The Node-RED enables the user to stitch together the Web services and hardware by replacing a common low-level coding task. There is a various component in the Node-RED are connected together to create a flow.

ii. Telegram and Bot-Father

Figure 4.7: Telegram and Telegram BotFather

Telegram application is a free and open-source, cross-platform, cloud-based instant messaging software. The service provided in telegram is end-to-end encrypted call, file sharing and, interaction with bots with many more features. The Bots are simply Telegram account that is operated by the software. It is not controlled by people and

contains AI features. The bots can do anything such as play, teach, search, remind, integrate services, or even pass commands to the Internet of Things.

iii. Python 3

Figure 4.8: The Python language

Guido van Rossum produced Python at the National Research Institute for Mathematics and Science Computer located in the Netherlands. Python is a high-level, interpreted, interactive, and object-oriented scripting language. It has been designed to be readable for the user by using English keywords more frequently. Python 3.0 has been released in 2008. Python 3 is a more upgrade version than Python 2 that has compatible with many features inside.

iv. Tkinter Python

Figure 4.9: The Tkinter GUI for Python

Tkinter is a Python standard GUI framework and commonly comes bundled with Python installation. It is a Python standard interface to the Tk GUI toolkit. Tkinter is famous as it is a very simple graphical user interface and simple to understand.

v. MySQL Database

Figure 4.10: The MySQL database

MySQL is a database system open-source relational database management system that is used on the web. MySQL database is standalone clients that allow the user to interact directly with MySQL. Swedes David Axmark has created it, Allan Larsson and Finland Swede Michael "Monty" Widenius, which is a Swedish company. The data in the MySQL database are stored in tables form that consists of columns and rows.

4.4 High-Level Design

The connection between smartphones and Raspberry Pi is really significant. The device will respond with the smartphone by using wireless communication. A smart notification will be sent when there are unauthorized users try to enter the door. The user is also enabled to control the smart door via a command in Telegram. In addition, the node-red dashboard will be used to displaying the door activity.

4.4.1 System Architecture

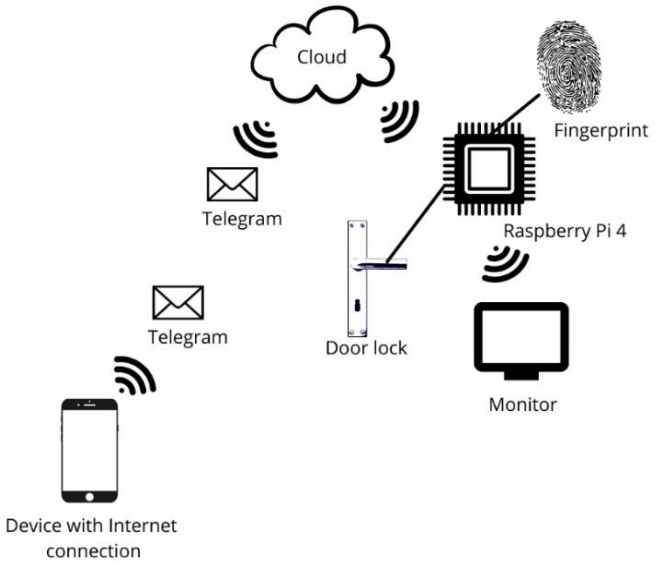


Figure 4.11: Physical Design of Smart Door Lock

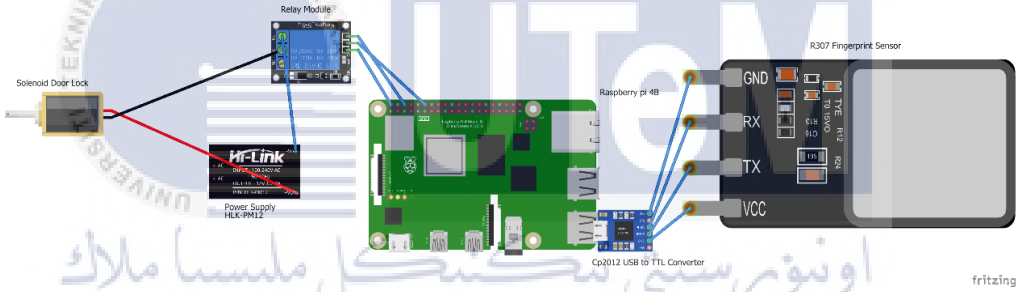


Figure 4.12: Schematic Diagram

Table 4.2: The Component Connected Pin

Raspberry Pi Pin	Relay Module Pin
5V	VCC
GND	IN
GPIO 18	Ground
Raspberry Pi Port	CP2102 USB to TTL Converter
USB Port	USB Port
CP2102 USB to TTL Converter	R307 Fingerprint Sensor
3V3	GND
TXD	TX
RXD	RX
GND	VCC

Solenoid Door lock	Relay Module
GND	COM
Solenoid Door lock	Power Supply Pin
Positive	Positive
Power Supply Pin	Relay Module
Negative	NO

4.4.2 User Interface Design

a) Navigation Design

The flowchart below shows the logic communicating of the system:

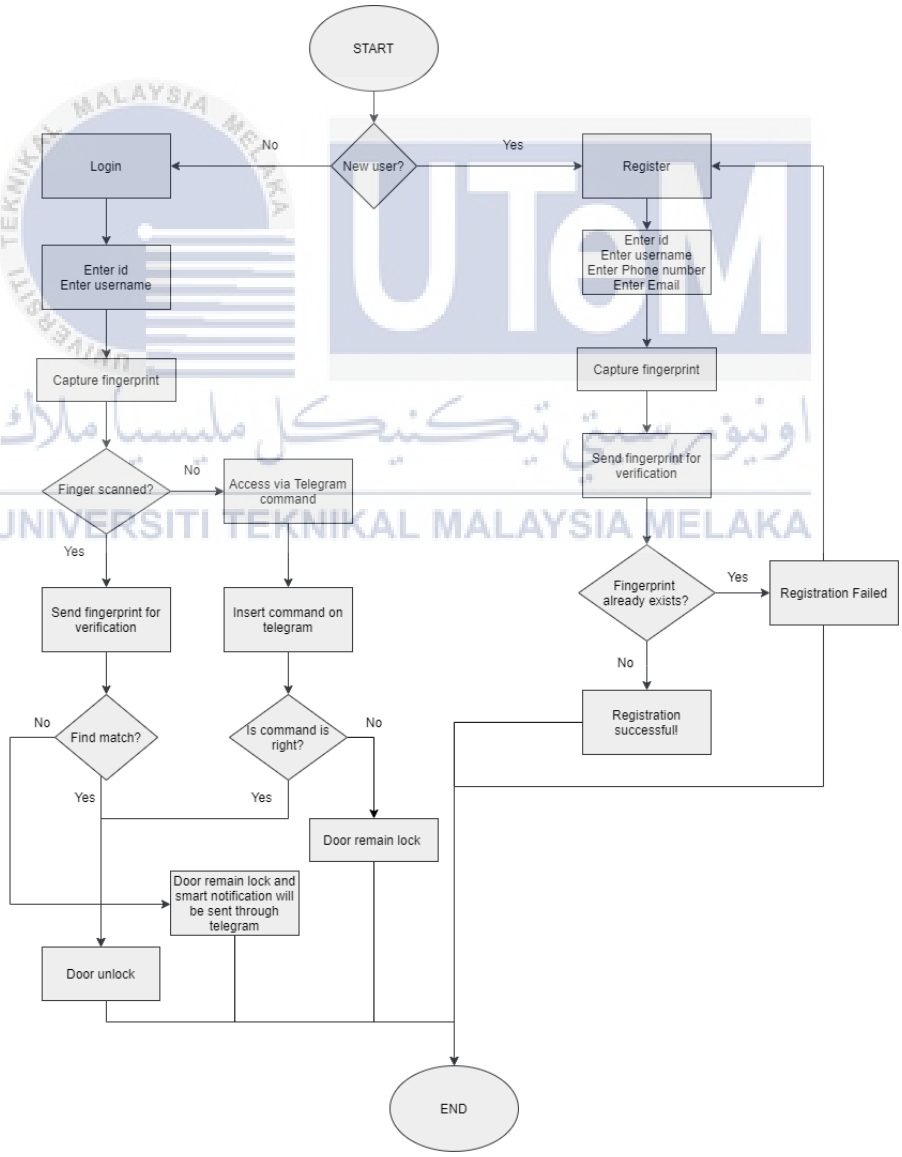


Figure 4.13: Flowchart of Smart Door Lock

b) Input Design

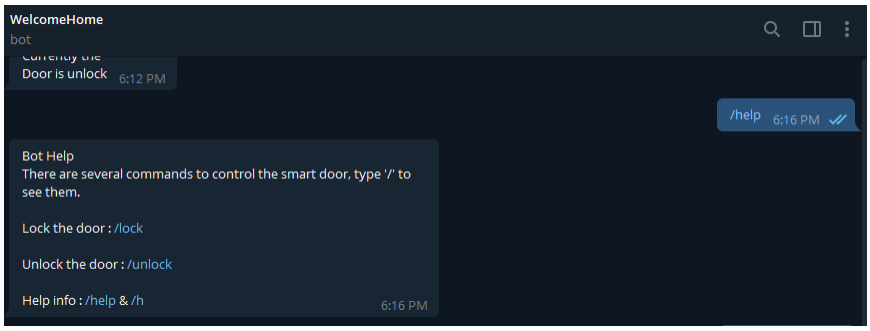


Figure 4.14: Input design from Telegram application

Figure 4.15: User Main Page shown by Tkinter GUI

Figure 4.16: User login input shown by Tkinter GUI

Figure 4.17: User registration input shown by Tkinter GUI

c) Output design

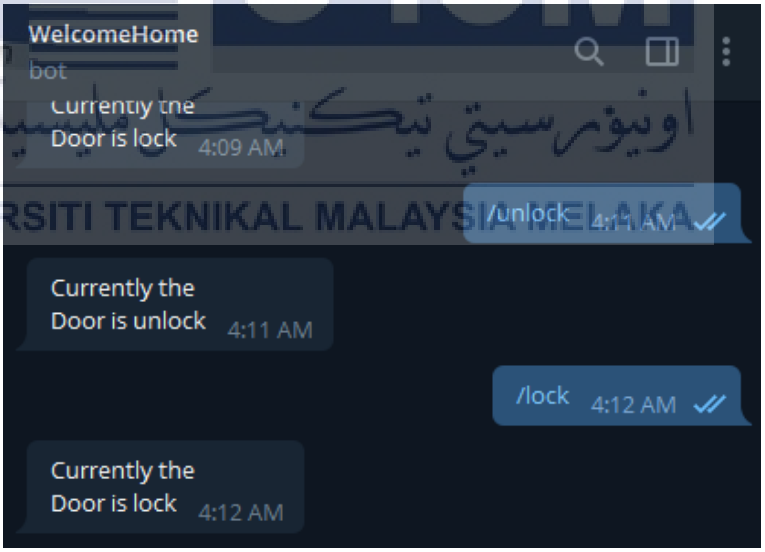


Figure 4.18: The output from Telegram

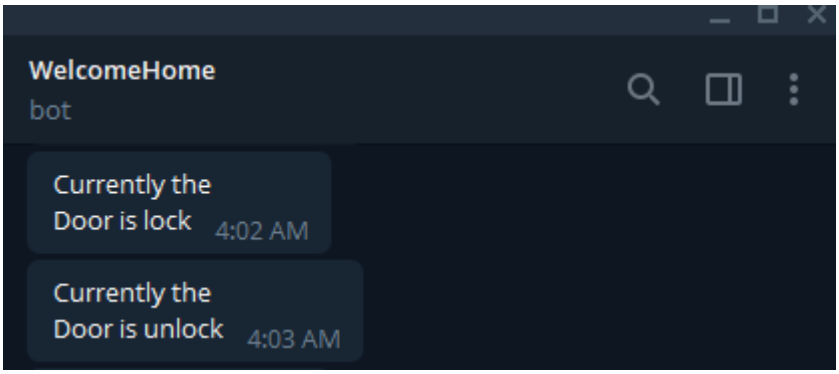


Figure 4.19: The output in Telegram control from node red

Figure 4.20: Smart notification output from Telegram

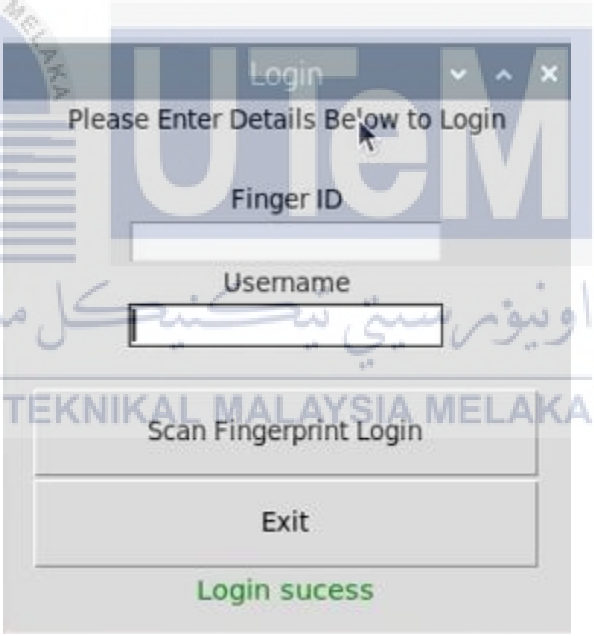


Figure 4.21: User Login success on Tkinter GUI

```
root@raspberrypi:/usr/share/doc/python-fingerprint/examples# python3 main.py
Currently used templates: 7/1000
Waiting for finger...
Found template at position #1
The accuracy score is: 85
The door is unlock
SHA-2 hash of template: caa399a6d63ab62e3a7073067627045d6b58024bdc2b7bb2866bcb
a7de60f512
```

Figure 4.22: User Login output result in terminal at Raspbian OS

Figure 4.23: User Registration success on Tkinter GUI

Figure 4.24: User Register result in terminal at Raspbian OS

4.4.3 Database Design

4.4.3.1 Conceptual and Logical Database Design

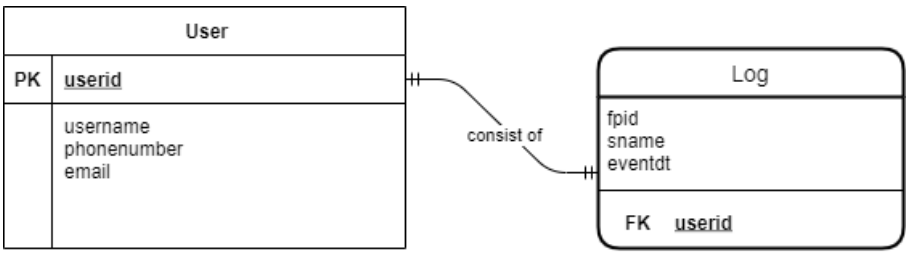


Figure 4.25: ERD of Smart Door Lock

4.5 Conclusion

In conclusion, the analysis and design chapter was really essential in order to gain the success of the project development. In the problem analysis, we have analyzed that the problem of the current automation door is when the careless user actions and the current processing time for the door to unlock with a physical key. Next, in the requirement analysis section, the hardware and software needed to control the smart door lock system are Raspberry Pi 4 Model B and Telegram. Furthermore, the flowchart and ERD of the project have been determined and will be used as a guideline through the development of the project. This analysis and design will be referred to in the next implementation of the project to ensure the smoothness of the project.

CHAPTER 5

IMPLEMENTATION

5.1 Introduction

This chapter will be presenting the implementation of the project. Hardware and software development environment setup will be discussing in the first section. Then, the software configuration setup will cover the configuration used to complete the project, such as the fingerprint sensor detection, Telegram configuration, and the database configuration.

5.2 Hardware and Software Development Environment Setup

5.2.1 Hardware setup

a) Hardware Requirements

- Raspberry Pi 4 Model B
- Fingerprint Reader R307 Sensor
- Micro SD card
- Jumper wire
- Solenoid lock
- 12V power supply
- Monitor
- CP2102 USB to TTL converter
- Relay Module 5V
- Raspberry Pi Power Adapter

b) Hardware Installation

i. The hardware installation such as the R307 fingerprint sensor, relay module, CP02102 USB to TTL converter, power supply and the solenoid lock is connected to the Raspberry Pi 4 Model B.

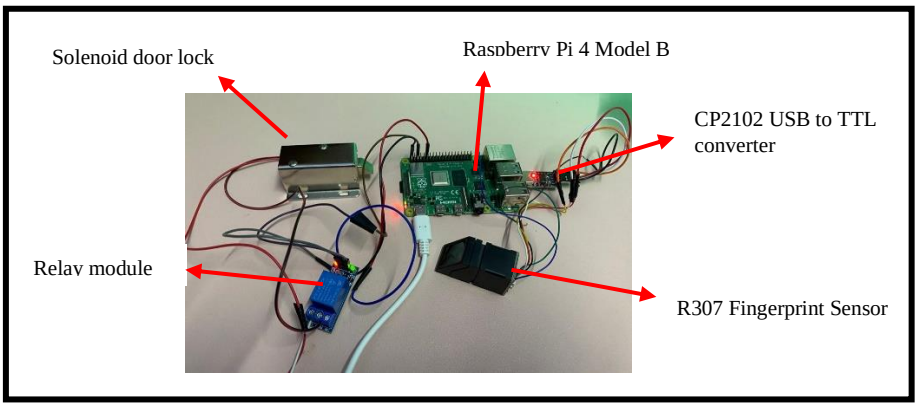


Figure 5.1: Hardware Installation

ii. The Micro SD card need to be format and installed Raspberry Pi imager inside the SD card via Raspberry Pi download page.

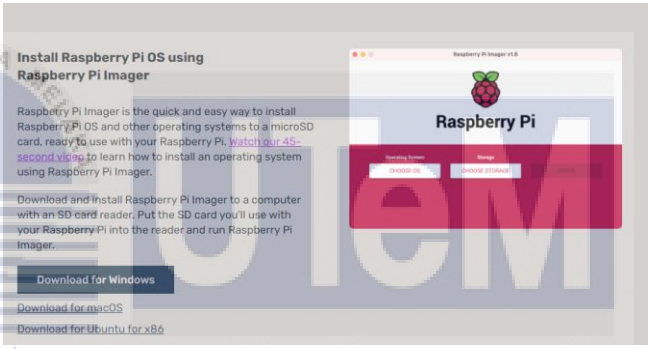


Figure 5.2: Raspberry Pi download page

iii. On the menu click Raspberry Pi OS to install, choose SD card storage and click Write.

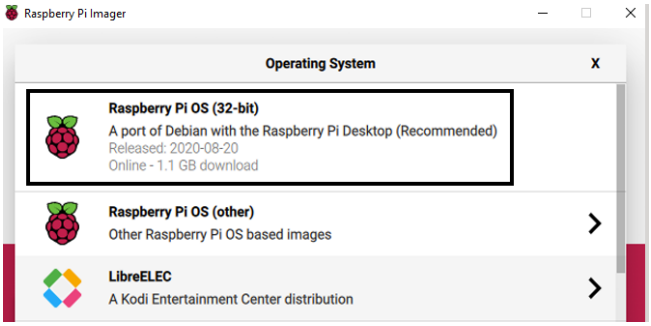


Figure 5.3: Raspberry Pi operating system

iv. The Raspberry Pi will take several minutes to finish the writing process.

v. Then, insert the SD card that already setup with Raspberry Pi OS into the micro SD card slot on underside of Raspberry Pi. Connect your Raspberry Pi with the HDMI port.

vi. Plug the power supply into the provided socket and connect the Raspberry Pi's power port. Then, the Raspberry Pi OS Desktop will be appearing.

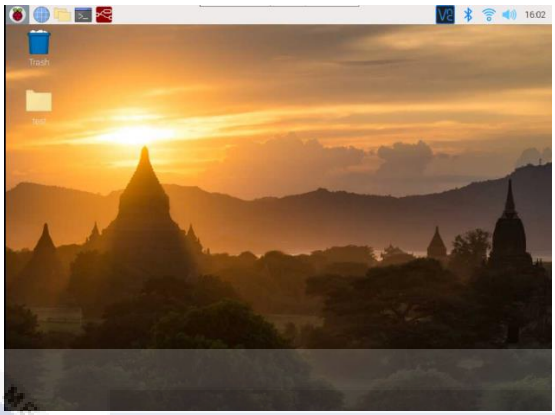


Figure 5.4: Raspberry Pi OS desktop

5.2.2 Software setup

a) Software Installation

The software that needs to be installed in this project is Telepot, Node-RED, Tkinter, MySQL, PhpMyAdmin, Apache and fingerprint. This software will be used to ensure the functionality of each element in the project works well. All the software will be installed through the terminal in Raspberry Pi 4.

i. Firstly, the Raspbian OS need to be upgrade into the latest version by using this command:

```
sudo apt-get update
sudo-apt-get-upgrade
```

```
pi@raspberrypi:~ $ sudo apt-get update
Get:1 http://archive.raspberrypi.org/debian buster InRelease [32.7 kB]
Get:2 http://raspbian.raspberrypi.org/raspbian buster InRelease [15.0 kB]
Hit:3 http://apt.pm-codeworks.de buster InRelease
Get:4 http://archive.raspberrypi.org/debian buster/main armhf Packages [376 kB]
Get:5 http://raspbian.raspberrypi.org/raspbian buster/main armhf Packages [13.0
MB]
78% [5 Packages 9,342 kB/13.0 MB 72%]                              483 kB/s 7s
Fetched 13.4 MB in 1min 14s (182 kB/s)
Reading package lists... Done
```

Figure 5.5: Update command

```
pi@raspberrypi:~ $ sudo apt-get upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
The following package was automatically installed and is no longer required:
  python-colorzero
Use 'sudo apt autoremove' to remove it.
The following packages will be upgraded:
```

Figure 5.6: Upgrade command

ii. Install and upgrading the Node-RED by using terminal by using the following command.

```
bash <(curl -sL https://raw.githubusercontent.com/node-red/linux-installers/master/deb/update-nodejs-and-nodered)
```

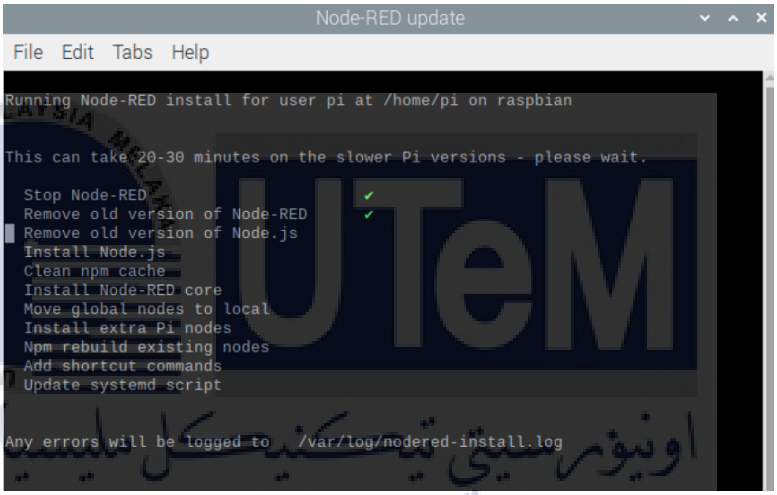


Figure 5.7: Installing Node-RED

iii. The Telepot will be install in Raspberry Pi to enable the connection between Telegram and Raspberry Pi. The following command is insert in the terminal.

```
sudo pip3 install telepot
```

```
pi@raspberrypi:~ $ sudo pip3 install telepot
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting telepot
  Downloading https://www.piwheels.org/simple/telepot/telepot-12.7-py3-none-any
whl (58kB)
    100% |████████████████████████████████| 61kB 510kB/s
Requirement already satisfied: urllib3>=1.9.1 in /usr/lib/python3/dist-packages
(from telepot) (1.24.1)
Collecting aiohttp>=3.0.0 (from telepot)
```

Figure 5.8: Installing Telegram in Raspberry Pi

iv. The telegrambot also can be install in node-red by using this command

```
npm install node-red-contrib-telegrambot
npm install node-red-config-telegrambot --save
```

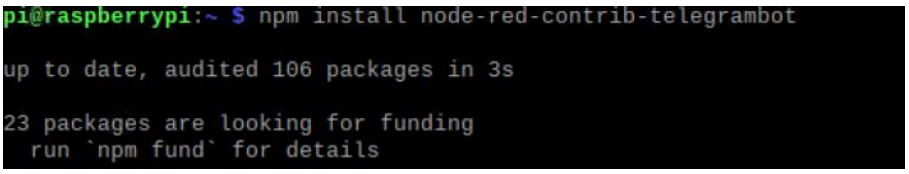


Figure 5.9: Installing telegram in Node-RED

v. The fingerprint sensor also will be installed through the terminal by using the command

```
apt-get install python-fingerprint --yes
```

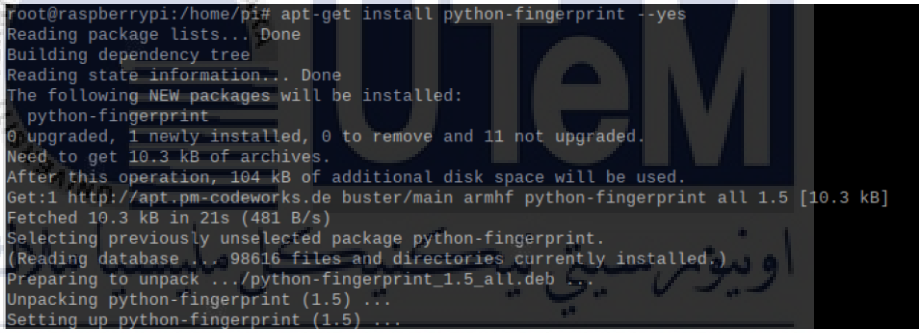


Figure 5.10: Installing fingerprint in Raspberry pi

vi. The smart notification features through Telegram application will be installed through terminal by using command as shown below

```
pip3 install telegram-send
```

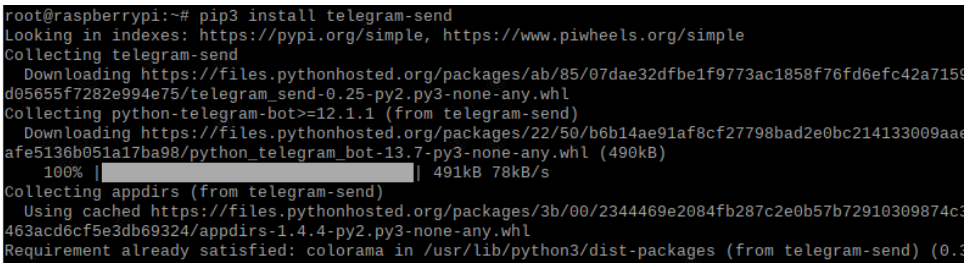


Figure 5.11: Installing smart notification in Raspberry pi

vii. Install Apache2 in Raspberry Pi

```
sudo apt install apache2
```

```
pi@raspberrypi:~ $ sudo apt install apache2
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  apache2-bin apache2-data apache2-utils libapr1 libaprutil1 libaprutil1-dbd-sqlite3
  libaprutil1-ldap
Suggested packages:
  apache2-doc apache2-suexec-pristine | apache2-suexec-custom
The following NEW packages will be installed:
  apache2 apache2-bin apache2-data apache2-utils libapr1 libaprutil1 libaprutil1-dbd-sqlite3
  libaprutil1-ldap
0 upgraded, 8 newly installed, 0 to remove and 0 not upgraded.
```

Figure 5.12: Install apache2 in Raspberry pi

viii. Install PHP in Raspberry Pi by running the command below

```
sudo apt install php libapache2-mod-php
```

```
pi@raspberrypi:~ $ sudo apt install php libapache2-mod-php
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libapache2-mod-php7.3 php-common php7.3 php7.3-cli php7.3-common php7.3-json php7.3-opcache
  php7.3-readline
Suggested packages:
  php-pear
The following NEW packages will be installed:
  libapache2-mod-php libapache2-mod-php7.3 php php-common php7.3 php7.3-cli php7.3-common
  php7.3-json php7.3-opcache php7.3-readline
0 upgraded, 10 newly installed, 0 to remove and 0 not upgraded.
Need to get 2,987 kB of archives.
```

Figure 5.13: Install PHP at Raspberry Pi

ix. Install MySQL database in Raspberry Pi by entering the command as shown below

```
sudo apt install mysql-server php-mysql
```

```
pi@raspberrypi:~ $ sudo apt install mysql-server php-mysql
Reading package lists... Done
Building dependency tree
Reading state information... Done
Package mysql-server is not available, but is referred to by another package.
This may mean that the package is missing, has been obsoleted, or
is only available from another source
However the following packages replace it:
  mariadb-server-10.0
```

Figure 5.14: Install MySQL in Raspberry Pi

x. Install phpMyAdmin

```
sudo apt install phpmyadmin
```

```
pi@raspberrypi:~ $ sudo apt install phpmyadmin
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  dbconfig-common dbconfig-mysql libmcrypt4 libzip4 php-bz2 php-curl php-gd php-mbstring
  php-mysql php-pear php-php-gettext php-phpseclib php-tcpdf php-xml php-zip php7.1-common
  php7.1-mcrypt php7.3-bz2 php7.3-curl php7.3-gd php7.3-mbstring php7.3-mysql php7.3-xml
  php7.3-zip
Suggested packages:
  libmcrypt-dev mcrypt php-libsodium php-gmp php-imagick
The following NEW packages will be installed:
  dbconfig-common dbconfig-mysql libmcrypt4 libzip4 php-bz2 php-curl php-gd php-mbstring
  php-mysql php-pear php-php-gettext php-phpseclib php-tcpdf php-xml php-zip php7.1-common
  php7.1-mcrypt php7.3-bz2 php7.3-curl php7.3-gd php7.3-mbstring php7.3-mysql php7.3-xml
```

Figure 5.15: Install phpMyAdmin on Raspberry Pi

xi. Install MySQL-client on python to allow the connection between MySQL server and python3 by undergoes the command below

```
pip3 install mysqlclient
```

```
root@raspberrypi:~# pip3 install mysqlclient
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting mysqlclient
  Downloading https://www.piwheels.org/simple/mysqlclient/mysqlclient-2.0.3-cp37
-cp37m-linux_armv7l.whl (107kB)
    100% |████████████████████████████████| 112kB 192kB/s
Installing collected packages: mysqlclient
Successfully installed mysqlclient-2.0.3
```

Figure 5.16: Installing mysqlclient on terminal

xii. Installing Tkinter GUI for python to enable the user interface become more friendly by running this command

```
sudo apt-get install python-tk
```

```
root@raspberrypi:~# sudo apt-get install python-tk
Reading package lists... Done
Building dependency tree
Reading state information... Done
python-tk is already the newest version (2.7.16-2).
```

Figure 5.17: Installing tkinter on terminal

xiii. Installing the node-red MySQL to enable the connection of node-red and MySQL for log and tracking module features by select the Palette Manager

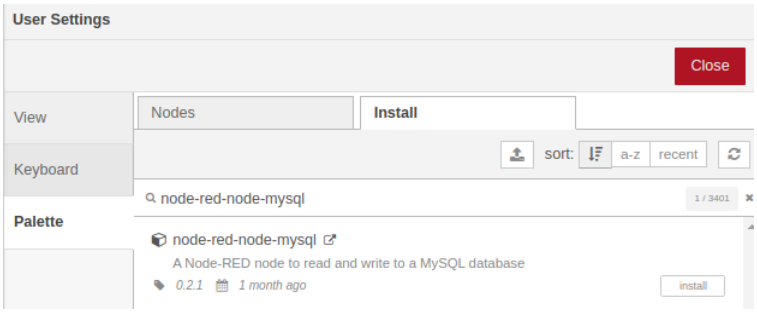


Figure 5.18: Install the MySQL in Node-RED

xiv. Installing the node-red GUI table to ensure the user log and tracking data become more user-friendly by entering the Palette Manager

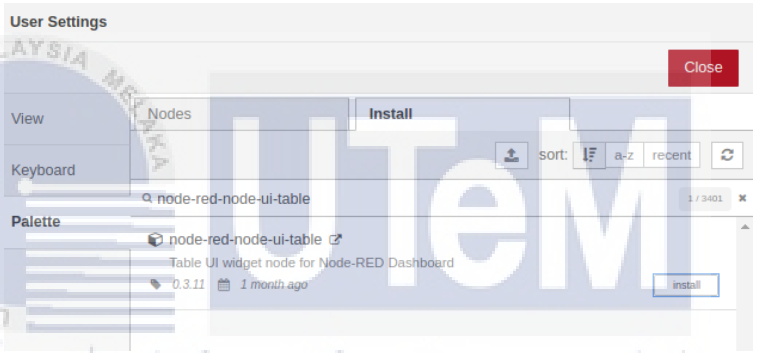


Figure 5.19: Install the node-ui table in Node-RED Palette Manager

xv. Install the raspberry pi node on node-RED by installing it on Manage pallets as shown below:

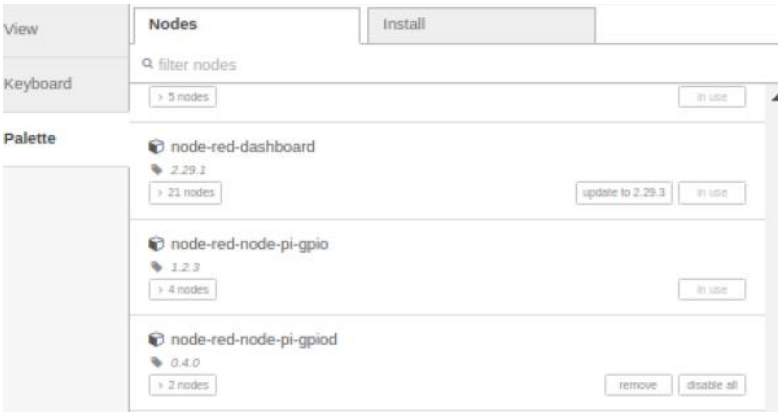


Figure 5.20: Node-RED installation palette

5.3 Software Configuration Management

5.3.1 Telegram configuration

i. Firstly, a Telegram bot needs to be created by using the Telegram BotFather. After creating the bot, the token will be given to the user that will serve as a key to control the telegram bot.

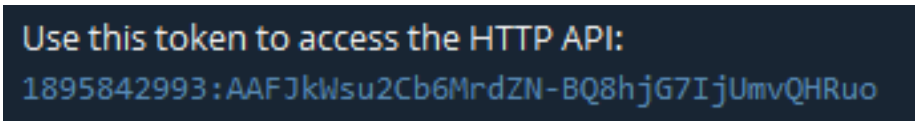


Figure 5.21: Telegram token

ii. Then, insert the telegram node in the Node-RED insert the token and chat ID of Telegram.

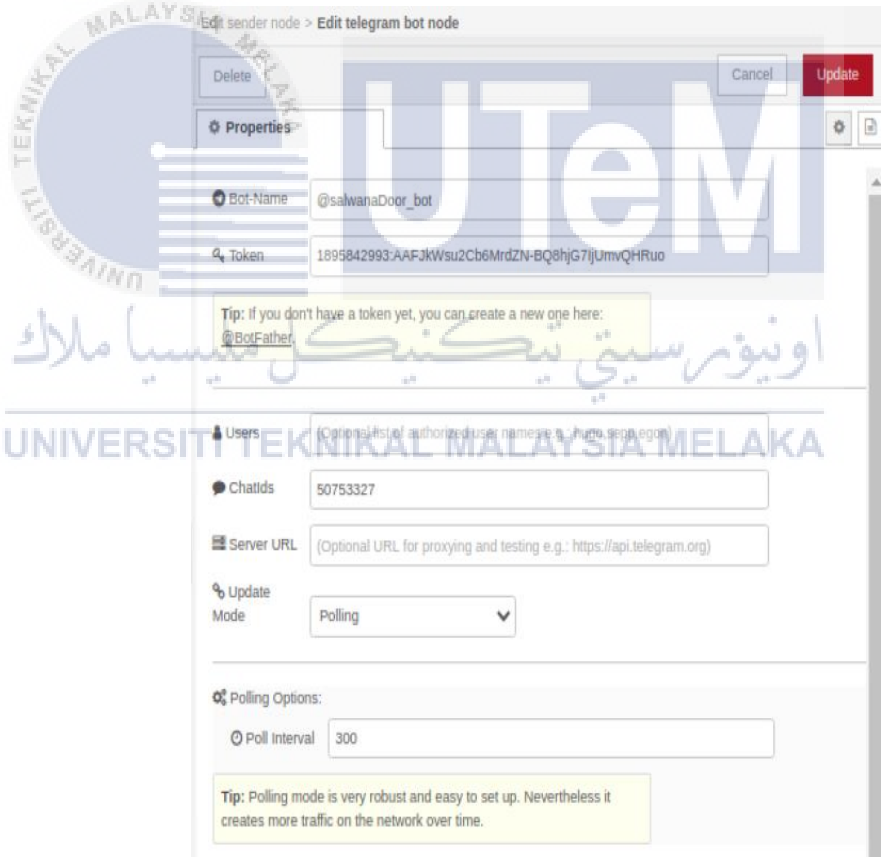


Figure 5.22 Configuration of Telegram token and ID inside Telegram node

iii. Create the flow of Telegram in the Node-RED after install the Telegram-plugins

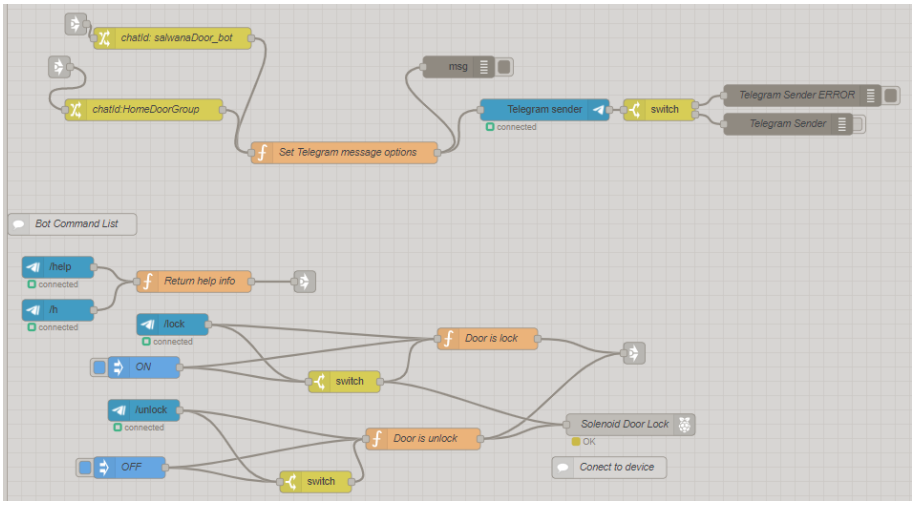


Figure 5.23: Node-RED flow for Telegram

5.3.2 Solenoid Door Lock Configuration on Node-RED

i. After install the raspberry pi node on node-RED the node will available on Manage pallets as shown below:

Figure 5.24: Raspberry Pi node that have installed

ii. Configure the solenoid door lock by setting up the rpi-gpio-out. The solenoid door has connected through a relay module on GPIO18 (PIN 12). Therefore, select the pin

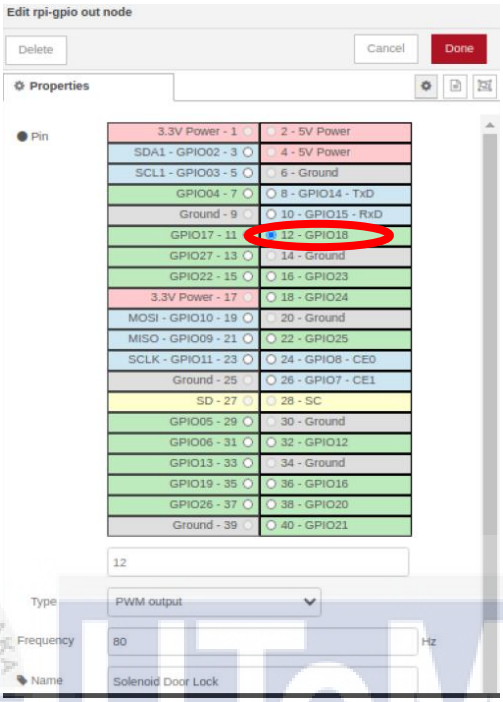


Figure 5.25: : Edit properties Raspberry node

5.3.3 Log and Tracking Module Configuration in Node-RED

i. Configure the MySQL node by adding the MySQL user, password, database. The time zone also need to configure by change it to nodered to avoid different time zone

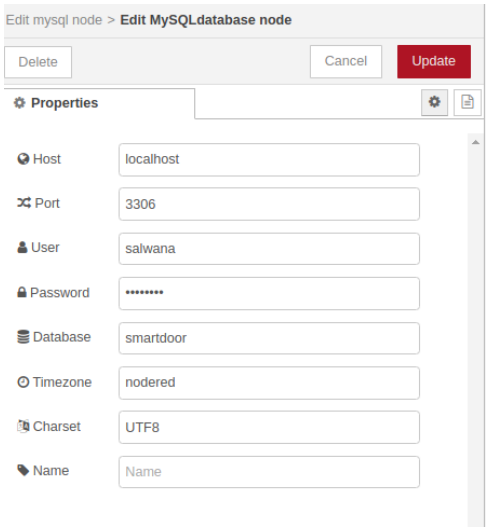


Figure 5.26: Edit MySQL database node

ii. Edit the table node by assign the property and title of each data

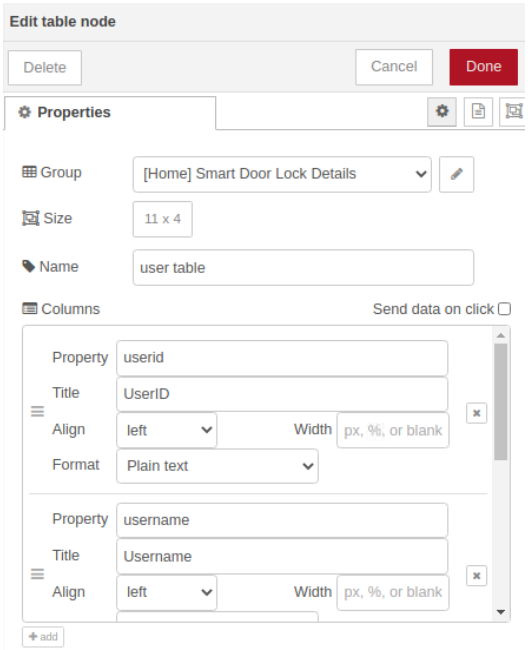


Figure 5.27: Edit the table node

iii. Create the flow of log and tracking module in the Node-RED after installing the MySQL plugins and the node-ui table for the database interface

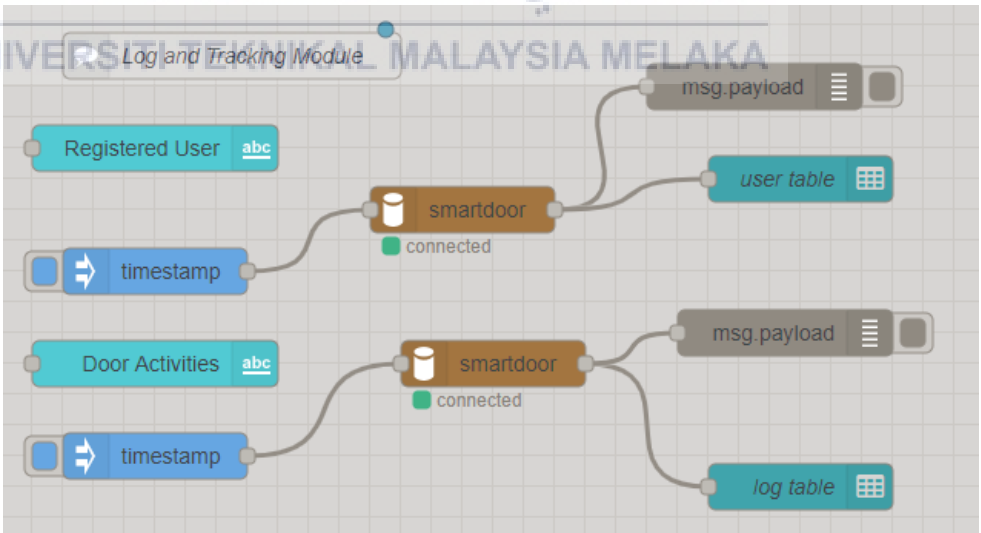


Figure 5.28: Flow of log and tracking module in Node-RED

5.3.4 Fingerprint sensor detection configuration for user login

i. The fingerprint detection configuration is implemented in python coding. For instance, the following code is coding for fingerprint access to enter the smart door.

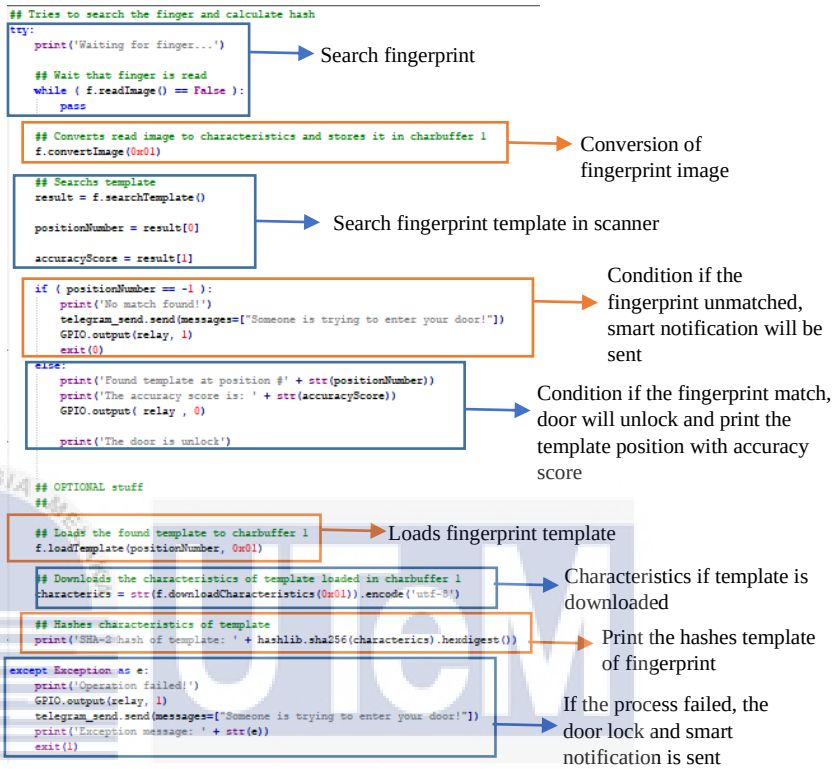


Figure 5.29: Shows the fingerprint python coding for user login

To allow the registered user to access the door, the fingerprint will be scan and will undergo a minutiae algorithm to determine the user fingerprint. If the fingerprint result matches, the solenoid door will be unlocked. Otherwise, the smart notification will send the telegram with a warning, “Someone is trying to enter your door!”

5.3.5 Fingerprint sensor detection for user registration

i. Firstly, the user need to import the fingerprint module. The fingerprint detection configuration is implemented in python coding. For instance, the following code is coding for fingerprint registration to enable new fingerprint user

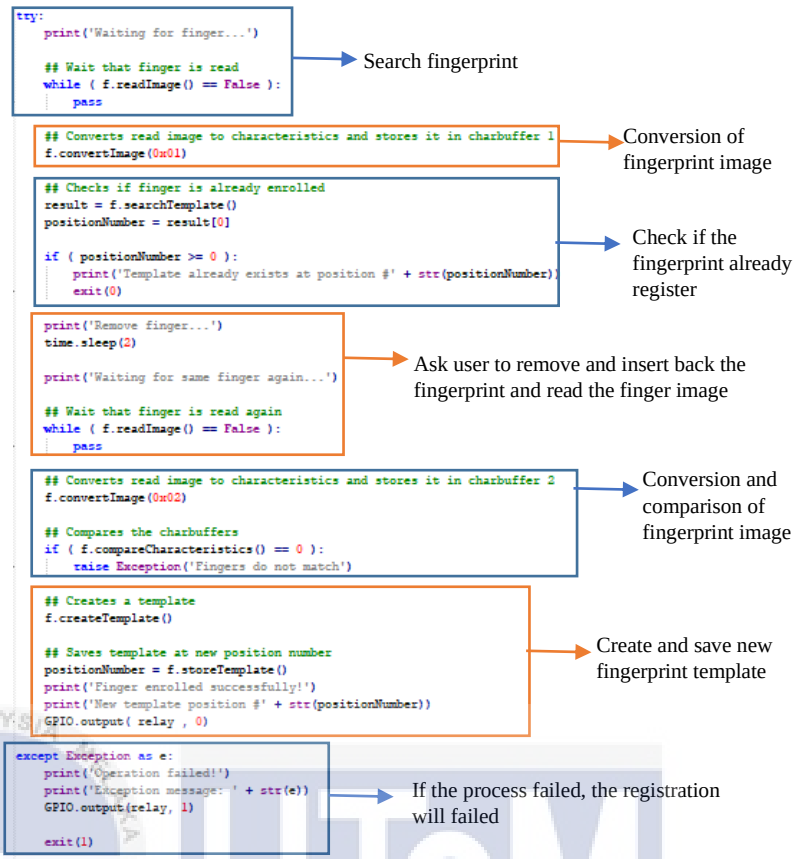


Figure 5.30: Fingerprint registration coding

The new fingerprint can be registered successfully if there are no same fingerprint template are stored in the fingerprint data.

5.3.6 Solenoid door lock configuration

i. The solenoid door lock can be configured in python coding to linked with the fingerprint sensor by import the GPIO module in the python code

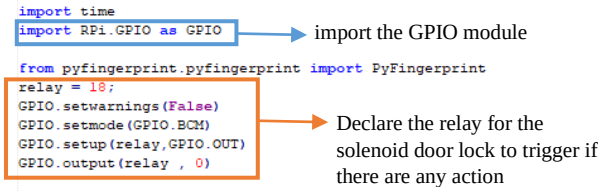


Figure 5.31: The GPIO are import

ii. Then, relay module need to be configured to determine the lock is on or off by entering 0 and 1

```
if ( positionNumber == -1 ):
    print('No match found!')
    exit(0)
else:
    print('Found template at position #' + str(positionNumber))
    print('The accuracy score is: ' + str(accuracyScore))
    GPIO.output( relay , 0)
    print('The door is unlock')
```

Configure relay module by declare 0 and 1

Figure 5.32: The GPIO output are configured

5.3.7 Python Tkinter configuration for user interface

i. After the user successful install the tkinter on the terminal, user can import the tkinter module in python coding to enable the user interface

```
from tkinter import *
import os
import hashlib
import datetime
import time
import mysql.connector
import tkinter.messagebox as tkMessageBox
from datetime import datetime
from pyfingerprint.pyfingerprint import PyFingerprint
from mysql.connector import Error
```

Import all tkinter package in the python coding

Enable the message box in Tkinter GUI

Figure 5.33: Tkinter module is import in python coding

ii. The Tkinter has many widgets such as buttons, labels, frames and many more. The coding below shows the main page code python by implementing the Tkinter interface.

```
def main_screen():
    global screen
    screen = Tk()
    screen.geometry("300x250")
    screen.title("Welcome Home ")
    Label(text = "Smart Door Lock" , bg = "grey", width ="300",font=("Calibri" , 13)).pack()
    Label(text = "").pack()
    Button(text = "Login", height = "2", width= "30" , command = login).pack()
    Label(text = "").pack()
    Button(text = "Register", height = "2", width= "30", command = register).pack()
    Label(text = "").pack()
    Button(text = "Exit", height = "2", width= "30" , command = Exit).pack()
    Label(text = "").pack()
```

Set the screen size of GUI

Tkinter widger at main screen

Figure 5.34: The main screen of python coding by implement the tkinter

5.3.8 Smart notification features Telegram in Python coding

i. After installing the telegram module on terminal, the user can import the telegram send inside the python coding

```
import hashlib
import time
import telegram_send
import datetime
```

Import telegram module

Figure 5.35: Import telegram module in the python coding

ii. Then, set the message under the unauthorised section if the fingerprint does not match with the R307 fingerprint scanner. Hence, the user will get notification from telegram if there are unmatched fingerprint occur.

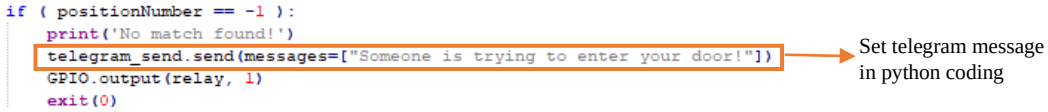


Figure 5.36: Send message to Telegram application from python

5.3.9 Database configuration for log and tracking module

i. After installing the database in the terminal, user needs to import the MySQL client to ensure the connection of MySQL and the python coding.

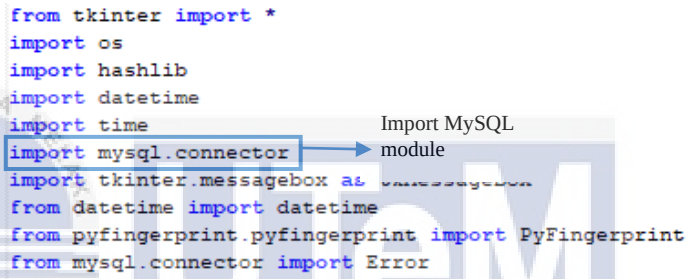


Figure 5.37: MySQL module has been import in python coding

ii. Determine the database connection by declaring the localhost, database name, user and the password

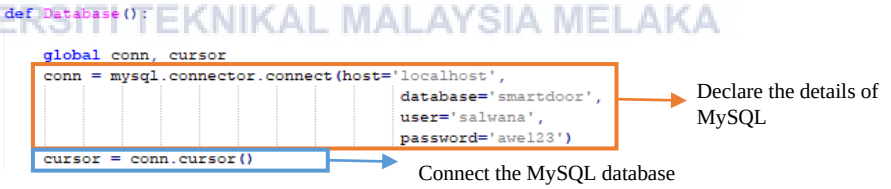


Figure 5.38: The connection of MySQL database in python

iii. Insert database in user table for registration in MySQL database

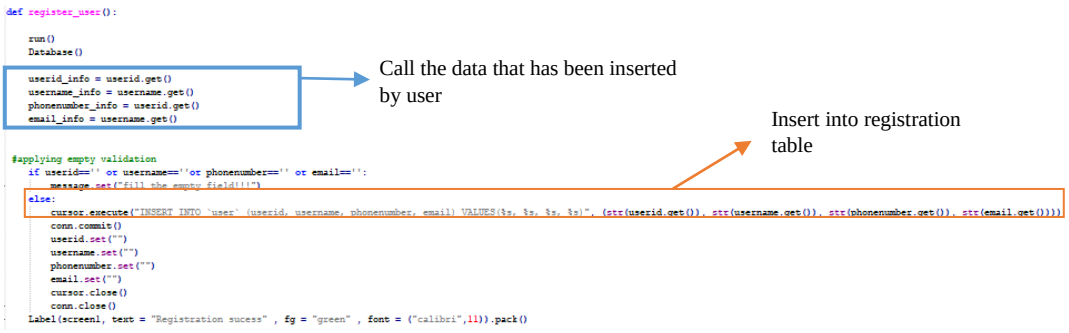


Figure 5.39: Insert data for registration new user in python coding

iv. Insert data inside the log table for the door activity. The database recorded the current timestamp to automatically record the user login to the door every time they access it.

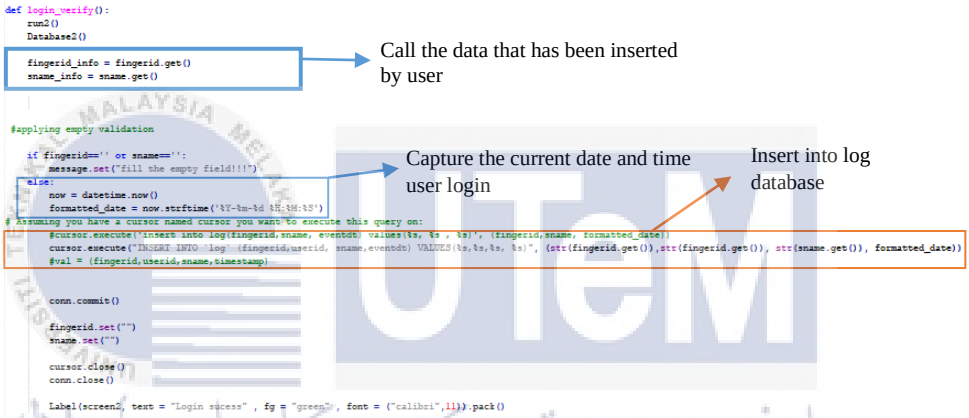


Figure 5.40: User login database

5.4 Conclusion

This chapter has shown the implementation part of the project by embracing the hardware and software configuration in a detailed platform. The software and hardware that have been implemented will be tested once the configuration has been built. This is to avoid any error that might happen while running on the project.

CHAPTER 6

TESTING

6.1 Introduction

Chapter 6 will be reviewing the method testing of this project. The purpose of this testing is to assure the smart door lock system can be running as outlined. The first section in this chapter will be the test plan. The test plan will be described more detail the test activities in the organization, environment, and schedule. Next, the test strategy will be discussed in the next section by discussing the classes of the test. Then, it will be followed by a test design that will contain the description and test data. The test description will be a more specific test in detail as it will have explained more detail about the prototype of the fingerprint sensor, Telegram command with its smart notification and log and tracking module located in Node-RED dashboard. Next, the result and test analysis will show the result of each testing which is the prototype testing, Telegram testing, and log and tracking module testing. It also will cover the functionality and the false test of those modules. Finally, the last part of this chapter will be the conclusion which will summarize the overall chapter in detail.

6.2 Test plan

The basis of each test will be clarify in this section. This part will cover the type of test which is the test organization, test environment and test schedule.

6.2.1 Test Organization

This test will be taken by the developer itself, the user, and several respondents. The prototyping functionality will be tested by the user in a face-to-face situation, while the other features will be tested with video demonstration and Google form via the online user. The developer will be in charge of this testing as only the developer acknowledge how the device will operate.

6.2.2 Test Environment

The test environment will involve the fingerprint sensor, Telegram smart notification, Telegram command to control the door and the log and tracking module

in the Node-RED dashboard. In addition, the test will undergo SUS testing by spread video demonstration and form to the online user.

6.2.3 Test Schedule

The testing process in this project is carried out consistently over a period of time. The errors and problems that were discovered will be solved within the allotted time during the testing phase. There will be a basic implementation process that needs to be revised to solve the project's problems and imperfections. The testing step process will repeatedly undergo until it meets a successful outcome and meet the desired planning. Furthermore, this project has undergone approximately about ten months. Therefore, the testing phase will be conducted out efficiently.

6.3 Test Strategy

The test strategy section will be explaining the flow of the system testing. Test strategy will show how the smart door lock system will be function. First, the Raspberry pi, which acts as the system's main controller, needs to be turned on with an internet connection to enable the system to function smoothly. Then, the developer will run the python coding, and the python Tkinter GUI will be displayed. Besides, the registered user can decide whether they want to login which to access the door, while the unregistered user can register by insert the user id, username, phone number, and password. If unregistered users are trying to access the door, a smart notification will be sent to Telegram. The user also can control the door remotely by using the Telegram command. Furthermore, the log and tracking module that will show the door activity such as time, date, and the user who access the door will show up in the Node-RED dashboard. The Node-RED dashboard application can be access through many platforms such as mobile phones and on the webpage.

6.4 Test Design

The test design has been generated by the developer in executing the testing of project functionality.

6.4.1 Test Description

Specific tests such as the fingerprint sensor test, Telegram test and log and tracking module test will be conducted in this section. The test purpose, test environment, test setup and the expected result from the test will be tabulated in a table form for each data. Besides, all three testing will undergo two ways of test: in-person

testing and SUS Testing. The in-person testing will involve the developer and family. At the same time, the SUS Testing will undergo ten questionnaires with several respondents of different ages to obtain a quick response with different respondent's opinion about the system.

6.4.2 Test Data

The table will show the test perform in fingerprint testing, telegram testing, log and tracking module testing and SUS testing.

Table 6.1: Fingerprint sensor test to access the door

Test	Fingerprint Sensor Test for Login
Test purpose	To ensure the device can detect the user fingerprint to enable the user to access the door
Test environment	This project has been tested in the presence of a developer family member at home to access the door.
Test setup	i. Connect the Raspberry Pi to Internet connection ii. Running the Python code in this project iii. User click on Login on the main page and enter few details such as userid, name and start scanning their fingerprint
Expected result	When the user fingerprint has successful login, the solenoid door lock will be unlock.

Table 6.2: Fingerprint sensor test for registration

Test	Fingerprint Sensor Test for Registration
Test purpose	To ensure the device can detect the user fingerprint to enable the user register a new user fingerprint
Test environment	This project has been tested in the presence of a developer family member at home to access the door

Test setup	i. Connect the Raspberry Pi to Internet connection ii. Running the Python code in this project iii. User click on Register on the main page and enter few details such as userid, name , phone number , email and start scanning their fingerprint
Expected result	The new user details and fingerprint will be successfully registered and inserted into the database.

Table 6.3: Telegram command test

Test	Telegram Command Test To Control The Door
Test purpose	To ensure the Telegram command able to control the door remotely.
Test environment	This project need to have Internet connection on the user mobile phone.
Test setup	i. Connect mobile phone to Internet. ii. Running the Node-RED system in Raspberry pi iii. Ensure the Telegram account is logged and activated iv. User enter command /lock to lock the door and /unlock to unlock the door via Telegram chat.
Expected result	Once the command has successfully sent to Telegram, the solenoid door lock will automatically follow the user command , which is lock or unlock

Table 6.4: Telegram smart notification test

Test	Telegram Smart Notification Test
Test purpose	To ensure that the smart notification is received by the user through Telegram application
Test environment	This project need to have Internet connection on the user mobile phone.
Test setup	i. Connect mobile phone to Internet. ii. Ensure the Telegram account is logged and activated
Expected result	Once unauthorized users are trying to access the door, the user will receive a notification through the Telegram application.

Table 6.5: Log and tracking module test

Test	Log and Tracking Module test in Node-RED dashboard
Test purpose	To ensure the door activity that has been stored in the database system will be shown in the Node-RED dashboard
Test environment	To test this project, the user's device can be access to Node-RED with an Internet connection.
Test setup	i. Connect device to Internet. ii. Ensure the Node-RED application has been running from the device
Expected result	The Node-RED dashboard will show the user register list and the door activity, such as the date, time and user who access the door.

Table 6.6: SUS Testing

Test	System Usability Scale (SUS) Testing
Test purpose	To obtain a quick response from respondent in measuring the usability of the system
Test environment	To test this project, video demonstration and ten questionnaires will be given in form with five response options for the respondents, from strongly agree to strongly disagree.
Test setup	i. Deliver the respondents the video demonstration of the project and questionnaire
Expected result	Obtain the respondents view of the system in the project based on the score in SUS testing

Figure below shows the 10 question that has been asked to the respondent in validate the system 's function based on the respondent opinion.

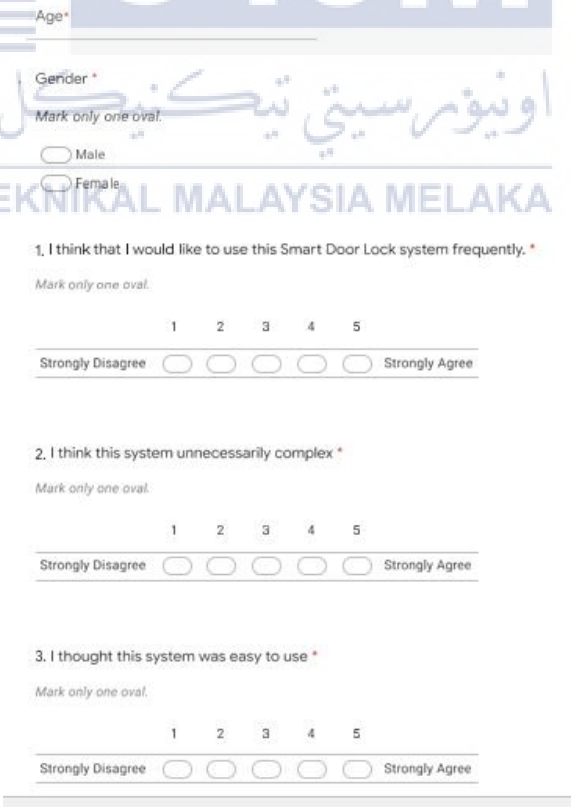


Figure 6.1: SUS Question

4. I think I need technical person assist me to be able to use this system *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

5. I found there are various features in the system and it really well integrated *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

6. I thought there are too much inconsistency in the system. *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

7. I would imagine that most people would learn to use this system very quickly *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Figure 6.2: SUS Question

8. I found this system are really cumbersome/awkward to use *

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

9. I feel really confident while using this system *

Mark only one oval

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

10. I needed to learn a lot of things before I could get along with this system *

Mark only one oval

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Figure 6.3: SUS Question

6.5 Test Result and Analysis

In this section, the testing result from the system will be discussed. In addition, analysis of the result also will be covered.

6.5.1 Functionality Test

The functional test will undergo by testing the fingerprint sensor in detecting the user fingerprint. The test will be performing in the R307 fingerprint sensor, Telegram application, Python Tkinter, and Node-RED dashboard.

6.5.1.1 Hardware Testing

The hardware that will be tested is the R307 fingerprint scanner that is connected to the CP2102 USB TTL converter in USB port of Raspberry PI 4B. The test will be experiencing the fingerprint sensor login and fingerprint registration.

6.5.1.1.1 Fingerprint Sensor Test for Register

The fingerprint sensor test will be done by referring on the table 6.2 above. The result of the testing will be recording about 15 fingerprint with 3 different finger each as shown in below. The recoding result worked well without any error, with the condition of R307 fingerprint sensor is in good condition.

Table 6.7: Testing result of fingerprint registration

Name	Fingers		
	Thumb	Index finger	Middle finger
Salim	✓	✓	✓
Norlida	✓	✓	✓
Salwana	✓	✓	✓
Syima	✓	✓	✓
Syuhaibah	✓	✓	✓

6.5.1.1.2 Fingerprint Sensor Test for Login

The fingerprint sensor test will undergo by referring to table 6.1 above. The result of the testing depends on the accuracy score of the R307 fingerprint scanner. It is carried out about three times per finger. The result will select the mean value of the three accuracy score. Based on the development, the higher the mean score at the

fingerprint sensor, the higher the user's accuracy in entering the door. Based on the paper that has been written by *Hasan et al. (2020*), in the results, the mean or the average timing access of door has taken the average value. Hence, the figure below shows the equation of accuracy score implemented during this project's testing. Therefore, the result shows that only one user has occurred failure about two times while trying to access. It might vary due to the skin texture of the user that might be wet, moist, oily, or dirty.

$$\text{Mean Accuracy Score} = \frac{\text{Sum of Test}}{\text{Number of Test}}$$

Figure 6.4: Equation of Mean Accuracy Score (Hasan et.al, 2020)

Table 6.8: Testing results of fingerprint sensor accuracy

Name	**Total**						The mean accuracy score with R307 fingerprint sensor		
	Thumb		**Index finger**		**Middle finger**				
	Success	**Fail**	**Success**	**Fail**	**Success**	**Fail**	**Thumb**	**Index finger**	**Middle finger**
Salim	3	0	3	0	3	0	134.00	106.33	157.67
Norlida	1	2	2	1	3	0	25.66	39.00	82.60
Salwana	3	0	3	0	3	0	109.33	109.67	80.30
Syima	3	0	3	0	3	0	101.67	88.00	98.33
Syuhaibah	3	0	3	0	3	0	104.67	163.00	186.33

6.5.1.2 Software Testing

The software that will be tested is the Telegram application which is for command and smart notification. Moreover, the Node-RED dashboard also will be tested for log and tracking module features.

6.5.1.2.1 Telegram Command Test

The Telegram test is built in Node-RED with the help of a bot server application. The Telegram test will be conducted based on Table 6.3 above. The figure below shows that Telegram is responding to the command that the user has entered.

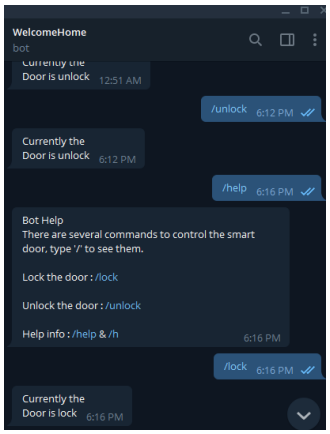


Figure 6.5: Telegram command

Table 6.9: Command list in Telegram

Command	Details
/lock	To lock the door
/unlock	To unlock the door
/help and /h	To show the help info

6.5.1.2.2 Telegram Smart Notification Test

The Telegram smart notification test is built in Python coding by import the package of the Telegram module. Besides, the Telegram test will be conducted based on Table 6.4 above. The figure below shows the notification of Telegram when unauthorized users are trying to access the door.

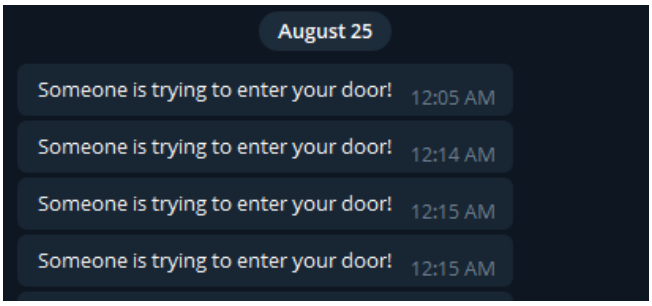


Figure 6.6: Smart notification that received by the user

6.5.1.2.3 Log and Tracking Module Test

The resulting test is to display the door activity on the Node-RED dashboard. This test is done by referring the table 6.5 above. The door details will display the user id, username, date and time when the user access the door. The figure below exhibits

the log and tracking module data of the smart door lock system in Node-RED dashboard.

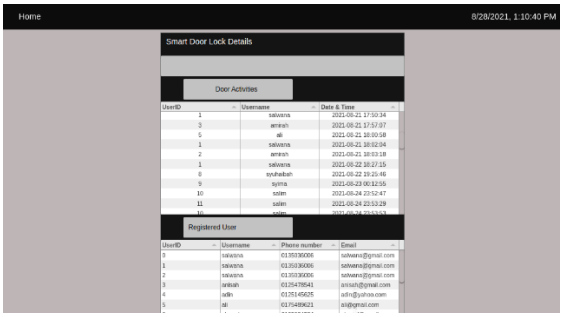


Figure 6.7: The log and tracking module overall page

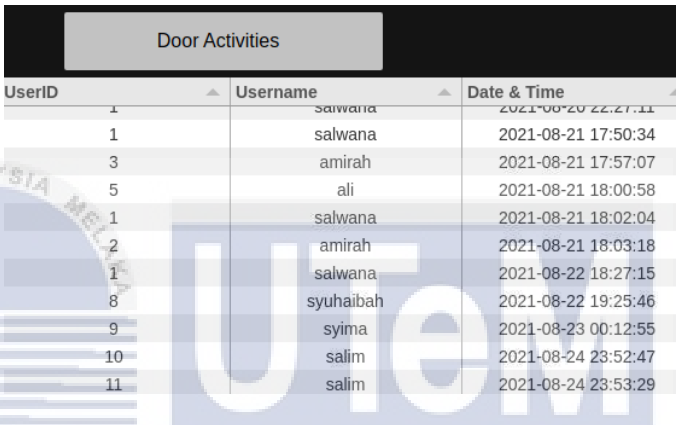


Figure 6.8: The door activities details from user

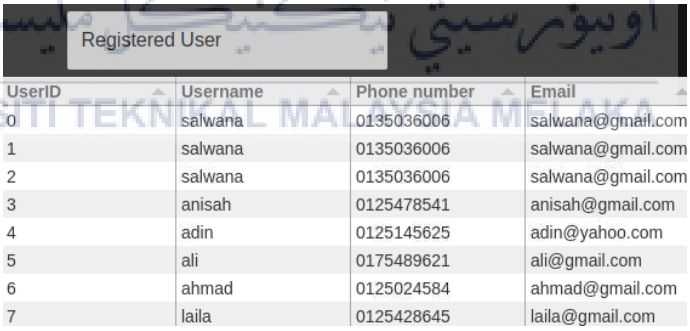


Figure 6.9: The list of registered user

6.5.1.3 System Usability Scale (SUS) Testing

The SUS test has been conducted involving 33 participants in answering the questionnaire. The questionnaire contains ten questions with five responses from the respondents from Strongly agree to disagree strongly. The test is very simple and only required less than 8 minutes for the participant. In addition, the participant is required

to view the video demonstration by the link provided in the form. All the testing conducted is stated based on table 6.6 above.

The method in calculating the SUS score firstly sums the score contributions from each question. Each question score contribution will range from 0 to 4. The total score for questions number 1,3,5,7, and 9, which is the odd number, will be minus 5. For the even questions, which are 2,4,6,8, and 10, which is the even number, 25 will be minus the total score. Finally, multiply the sum of the scores by 2.5 to obtain the overall value of SUS.

The 33 respondents are of various ages, which are 22 until 32 years old, based on the bar chart below in figure 6.10. The highest age that has taken the test is 23 years' old which is about 15 respondents. Therefore, it has revealed that the judgment has come from different viewpoints of people. Furthermore, the pie chart in figure 6.11 below has clarified that most respondents taking the test are females, around 84.8%, while the male respondents are 15.2%.

The results of SUS Testing from 33 respondents have been collected in table form as shown below in Table 6.10. As we can see, the maximum score of the results is above 60. In addition, the average score for total 33 respondents is 69.39. Hence, it shows that the system is in good condition based on SUS scale and from the respondent's view.

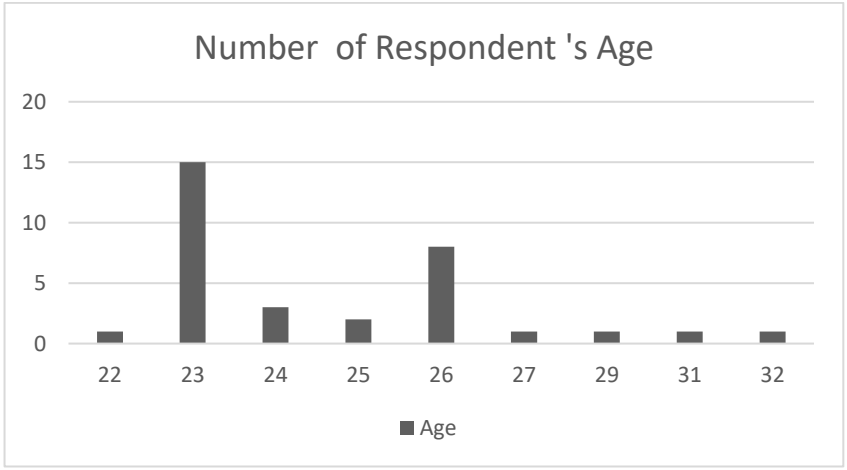


Figure 6.10: The bar chart of respondent's age

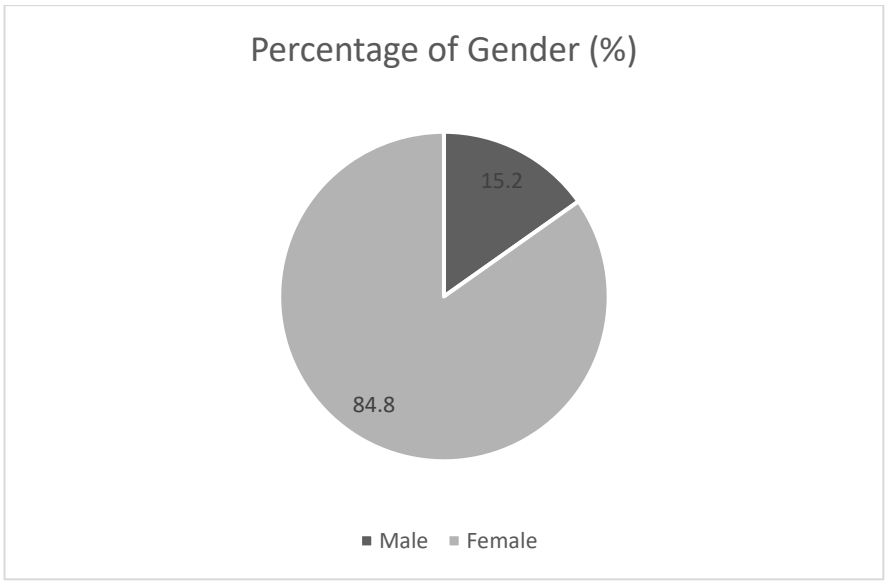


Figure 6.11: The pie chart of respondent ‘s gender

Table 6.10: SUS Testing Results

RESPONDENTS	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	ODD	SUM ODD	EVEN	SUM EVEN	TOTAL
R1	5	5	5	1	5	1	5	1	5	1	25	20	9	16	90.00
R2	5	5	5	1	5	2	5	1	5	1	25	20	10	15	87.50
R3	5	5	5	2	5	1	5	1	5	2	25	20	11	14	85.00
R4	5	5	5	2	5	2	5	1	5	2	25	20	12	13	82.50
R5	5	3	5	3	5	1	5	1	5	5	25	20	13	12	80.00
R6	5	2	2	1	5	2	5	1	5	1	22	17	7	18	87.50
R7	4	3	4	3	4	3	4	3	3	3	19	14	15	10	60.00
R8	5	2	5	5	5	1	5	2	5	4	25	20	14	11	77.50
R9	5	3	5	3	5	3	4	3	4	3	23	18	15	10	70.00
R10	5	1	5	3	4	2	5	1	5	3	24	19	10	15	85.00
R11	4	4	4	2	4	2	5	2	4	3	21	16	13	12	70.00
R12	5	2	5	2	5	1	4	2	3	2	22	17	9	16	82.50
R13	4	3	4	3	4	3	4	2	4	4	20	15	15	10	62.50
R14	5	3	4	5	5	3	5	1	5	3	24	19	15	10	72.50
R15	5	4	4	4	4	4	4	4	4	4	21	16	20	5	52.50
R16	4	2	4	4	4	4	4	1	3	5	19	14	16	9	57.50
R17	5	5	5	2	5	1	4	1	5	1	24	19	10	15	85.00
R18	5	2	5	3	5	2	4	1	4	3	23	18	11	14	80.00
R19	5	5	5	1	5	1	5	1	5	1	25	20	9	16	90.00
R20	4	4	5	5	4	5	4	3	4	4	21	16	21	4	50.00
R21	4	4	4	4	3	3	4	2	4	4	19	14	17	8	55.00
R22	3	3	3	3	3	3	3	3	3	3	15	10	15	10	50.00

R23	5	4	5	5	5	4	4	4	5	4	24	19	21	4	57.50
R24	4	3	4	3	4	3	4	2	4	3	20	15	14	11	65.00
R25	5	1	5	1	5	1	5	1	5	1	25	20	5	20	100.00
R26	5	5	5	1	5	1	5	1	5	1	25	20	9	16	90.00
R27	3	4	4	5	4	3	2	3	3	5	16	11	20	5	40.00
R28	5	5	5	5	5	5	5	5	5	5	25	20	25	0	50.00
R29	4	3	3	4	5	2	3	1	5	5	20	15	15	10	62.50
R30	4	3	4	5	3	4	5	5	3	5	19	14	22	3	42.50
R31	4	4	5	4	5	4	4	2	4	4	22	17	18	7	60.00
R32	5	5	5	5	5	4	5	1	5	5	25	20	20	5	62.50
R33	4	4	3	5	4	3	3	2	4	5	18	13	19	6	47.50
AVERAGE SCORE OF SUS FOR 33 RESPONDENTS															69.39

6.5.2 False Test

6.5.2.1 Unregistered Fingerprint for Login

In this test the user will insert unregistered fingerprint. The python coding shows the result in terminal as shown in figure 6.12 below:

```
root@raspberrypi:/usr/share/doc/python-fingerprint/examples# python3 main.py
Currently used templates: 18/1000
Waiting for finger...
No match found!
```

Figure 6.12: The result in python terminal

6.5.2.2 Same Fingerprint for Register

In this test the user will insert unregistered fingerprint. The python coding shows the result in terminal as shown in figure 6.13 below:

```
root@raspberrypi:/usr/share/doc/python-fingerprint/examples# python3 main.py
Currently used templates: 18/1000
Waiting for finger...
Template already exists at position #0
```

Figure 6.13: The result in python terminal

6.5.2.3 No Internet Connection

In this test, if there is no internet connection, the Raspberry Pi 4, Node-RED and Telegram will not engage with each other. The figure below shows the Telegram that doesn't have any response when there is no Internet connection in Raspberry Pi.

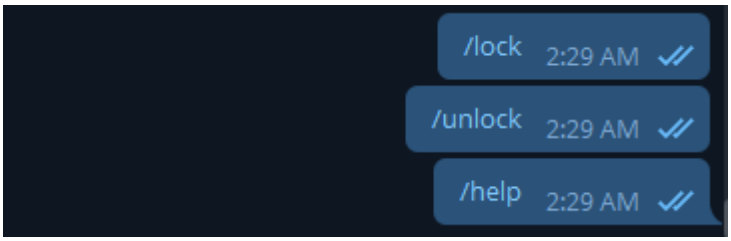


Figure 6.14: Telegram not respond to the command

6.6 Conclusion

As the conclusion in this chapter, the testing phase is really important to determine whether the project functionality meets the success. The test plan has covered the activities involved in the test, while the test strategy will guide how to implement the test. From the test design, we can use it as the guideline to performing the specific test. As a result, we can know that the device is working really well or not.

CHAPTER 7

PROJECT CONCLUSION

7.1 Introduction

As this chapter concludes, the testing phase is significant to determine whether the project functionality meets the success. The test plan has covered the activities involved in the test, while the test strategy will guide how to implement the test. From the test design, we can use it as the guideline to performing the specific test. As a result, we can comprehend that the device is working well or not.

7.2 Project Summarization

7.2.1 Project Objective

The three objective that has been established and act as the guideline in this project is

i. To identify the current technology in smart door which are using biometric sensor
ii. To develop the fingerprint sensor for smart door that enable the user to control the door
iii. To validate the functionality testing of the prototype

7.2.2. Project Weakness and Strength

7.2.2.1 Project Weakness

Several weaknesses are undergoing in this system. Firstly, regarding the health issue that involves in touching of a single scanning sensor device by the individual can occur spread of disease. Consequently, it is a serious implication during this pandemic situation, such as the COVID-19. Next, the system needs to have an Internet connection to enable the Raspberry pi and the Telegram to operate smoothly. Besides, the user needs to have a 24/7 internet connection to enable the features in the system can operate, such as the smart notification in Telegram or the control command to running.

7.2.2.2 Project Strength

There are several project strengths in the system that we can testify to. Firstly, the project is economical to develop compared to the market price for door installation fingerprint, which can cost RM1000 to RM2000 compared to the system that only costs around RM400. Besides, the system is embedded with the smart notification features available via Telegram. Furthermore, the log tracking module features for the user to view and access the door activities are also available via the Node-RED dashboard. Finally, the user is also able to control the door remotely via the Telegram application.

7.3 Project Contribution

This project enables help the user to enhance the security of smart door locks by introducing biometric identification, which is the fingerprint. The security also has a smart notification feature if there are unregistered fingerprints trying to access the door. Furthermore, there are also log and tracking modules for the user to examine the data of their door activity. The summary of the project contribution is stated in table 1.4 above in Chapter 1

Table 1.5: Project Contribution

PS	PQ	PO	PC	Project Contribution
PS_1	PQ_1	PO_1	PC_1	Help the user to increase the security by using smart door and propose a faster processing time to open the door with accurate details of the door activity
	PQ_2	PO_2		
	PQ_3	PO_3		

7.4 Project Limitation

There are several limitations in this project which we can distinguish. Firstly, the project demanded an Internet connection. The internet connection is essential to ensure the Raspberry Pi 4 B, Telegram application, and the Node-RED enable them to communicate well. Next, the solenoid door lock and the Raspberry Pi are quickly hot, and the developer needs to give the hardware to rest a particular time. The user is incapable of deleting the fingerprint that has been registered. Else the developer itself needs to delete it by entering the MySQL database. Finally, the system fingerprint will

depend on the skin texture of the user where it can affect the accuracy score of the fingerprint sensor.

7.5 Future Works

In the future, there are several upgrades that can be implemented in this project to enhance a better feature with the greatest function. Below is the upgrade that can be implemented in the project in the future:

i. Upgrading the smart notification function by installing the camera to capture if there is an unauthorized user
ii. Live streaming from the camera to the monitored front door area
iii. Integrated the sensor with alarm sound to enhance more security function for the door
iv. Installing the door status features for the user to know the door condition whether it lock and unlock

7.6 Conclusion

In conclusion, this project is successful as it meets the objective that has been proposed. This chapter represents the overall summarization of the chapter in the project. Furthermore, in this chapter, we have collected several weaknesses of the project which need to be improved in the future to develop a better system. The strength of this system has enhanced the user that the system is very accommodating in controlling the door and easy to be used. Besides, the project contribution and project limitation also have been addressed in this chapter. Still, the project is completed, many upgrades can execute to feel a better system with the most prominent feature.

REFERENCES

Kamelia, L., Noorhassan, A., Sanjaya, M., & Mulyana, W. E. (2014). Door-automation system using bluetooth-based android for mobile phone. ARPN Journal of Engineering and Applied Sciences, 9(10), 1759-1762.

Pandurang, B., Pede, J. D. P. M. S., & Rahul, G. A. G. (2016). Smart lock: A locking system using bluetooth technology & camera verification. International Journal of Technical Research and Applications, 4(1), 136-139.

Hasan, Y., Wijanarko, Y., Muslimin, S., & Maulidda, R. (2020). The automatic door lock to enhance security in RFID system. The automatic door lock to enhance security in RFID system. In Journal of Physics: Conference Series (Vol. 1500, No. 1, p. 012132). IOP Publishing.

Patil, B. S., Mahajan, V. A., Suryawanshi, S. A., & Pawar, M. B. (2018). Automatic Door Lock System Using Pin on Android Phone. International Research Journal of Engineering and Technology (IRJET), 5(11), 1007-1011

Park, Y. T., Sthapit, P., & Pyun, J. Y. (2009). Smart digital door lock for the home automation. In TENCON 2009-2009 IEEE Region 10 Conference (pp. 1-6). IEEE

Maheshwari, K. (2017). Facial recognition enabled smart door using microsoft face API. arXiv preprint arXiv:1706.00498.

Verma, G. K., & Tripathi, P. (2010). A digital security system with door lock system using RFID technology. International Journal of Computer Applications, 5(11), 6-8.

R. Dinar Hayu Arifin and R. Sarno. (2018). Door automation system based on speech command and PIN using Android smartphone. 2018 International Conference on Information and Communications Technology (ICOIACT), Yogyakarta, Indonesia, pp. 667-672, doi: 10.1109/ICOIACT.2018.8350715

Lee, C. T., Chung, Y. C., Shen, T. C., & Weng, K. W. (2017). Development of electronic locks using gesture password of smartphone base on RSA algorithm. In 2017 International Conference on Applied System Innovation (ICASI), pp. 449-452. IEEE.

Hadis, M. S., Palantei, E., Ilham, A. A., & Hendra, A. (2018). Design of smart lock system for doors with special features using bluetooth technology. In 2018 International Conference on Information and Communications Technology (ICOIACT), pp. 396-400. IEEE.

S. Tiwari, S. Thakur, D. Shetty and A. Pandey. (2018). Smart Security: Remotely Controllable Doorlock.2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), Coimbatore, India, 2018, pp. 979-984, doi: 10.1109/ICICCT.2018.8473161.

Govindraj, V. J., Bhat, S. V., & Ramesh, T. K. (2020). Smart Door Using Biometric NFC Band and OTP Based Methods. In 2020 International Conference for Emerging Technology (INCET), pp. 1-4. IEEE

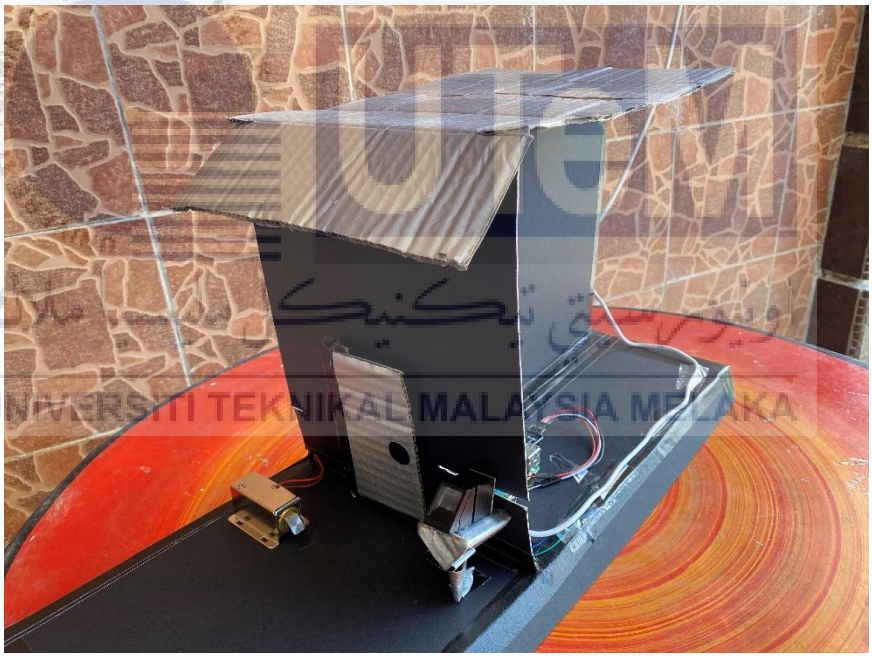
W. Chen and Y. Gao. (2007). A Minutiae-Based Fingerprint Matching Algorithm Using Phase Correlation.

Jeff Sauro, P. (2021) Measuring Usability with the System Usability Scale (SUS) – MeasuringU, Measuringu.com, accessed 26 August 2021, <https://measuringu.com/sus/>

Statistic How To. (2021) Sample Mean: Symbol (X Bar), Definition, Standard Error, accessed 9 September 2021, <https://www.statisticshowto.com/probability-and-statistics/statistics-definitions/sample-mean/>

APPENDIX

The image above shows the front side of prototype



The image shows the right side of prototype

The image shows the left side of prototype