

**RESIDENCE PARCEL DROP BOX WITH MULTI-LAYER AUTHENTICATION
USING CYBER PHYSICAL SYSTEM**

**BY
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Finally, I must say thanks to my parents and my family for their love, support, and continuous encouragement throughout the course.

ABSTRACT

This project is development-based for academic purposes. It will provide the Final Year Project students with the methodology planning, concept thinking and design of a residential parcel drop box with multi-layer authentication using Cyber Physical System. The project will be illustrated through the development of a parcel drop box system. The parcel drop box system will be primarily use for residences to solve the issue of failed delivery attempts by courier delivery personnel because of no recipient absent at the delivery address. The courier delivery personnel will be able to deliver parcels conveniently by dropping off the parcel into the drop box system without the recipient to be present to receive the parcel. The parcel drop box can authenticate the parcel, unlock the drop box door, and receive the parcel from the courier delivery personnel. A mobile application is also developed using Flutter to unlock the door of the parcel drop box and to input the tracking number of the incoming parcel. A Raspberry Pi computer is well suited for a project that utilizes digital circuits and software. Therefore, a Raspberry Pi 3 Model B will be utilized in the development of this project. This project aims to reduce failed deliveries of e-commerce parcels to recipient addresses during the non-present period and reduce parcel theft and damages due to parcel throwing into the delivery address compound.

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LIST OF ABBREVIATIONS

| | |
|-------------|------------------------------|
| <i>CPS</i> | Cyber Physical System |
| <i>AWB</i> | Airway Bill |
| <i>QR</i> | Quick Response |
| <i>2D</i> | 2-Dimensional |
| <i>USB</i> | Universal Serial Bus |
| <i>SMS</i> | Short Message Service |
| <i>OLED</i> | Organic Light-Emitting Diode |
| <i>GPIO</i> | General Purpose Input Output |
| <i>CPS</i> | Cyber Physical System |

Chapter 1

Introduction

In this chapter, the background and motivation of the project, problem statement of the project and the contributions to the field will be presented.

1.1 Problem Statement and Motivation

Nowadays, people rely on e-commerce shopping to purchase their everyday necessities due to the cheaper price and convenience it brings. Sometimes it is difficult for e-commerce shoppers to time when the parcel will be delivered to their delivery address. Furthermore, some e-commerce shoppers will not be able to be at the delivery address to receive the parcels when they are at their workplace. When the courier delivery personnel arrive at the delivery address, they will face problems such as the recipient is not at the delivery address to receive the parcel. However, the courier delivery personnel will choose to place the parcel at the gate of the delivery address or throw inside the compound because they must fulfil their commitment to deliver as they are paid by the commission on the number of parcels they deliver in a day. This will discourage them to reattempt delivery on another date when the recipient is present to receive the parcel. This way of handling delivery procedure by the courier delivery personnel will post a higher risk for the parcel to be stolen since the parcel is in reach for the public to steal it. Even though the parcel will be thrown inside to the compound where the public is unable to reach, the products inside the parcel will have a higher chance to be damaged by the impact caused by the throwing especially for fragile products. Besides, when the parcel is left in the open, it will be exposed to the high amount of moisture and high temperature environment. Products that contain inside the parcels such as electronics and food will be easily spoiled as they are not suitable to be exposed to these conditions for long periods of time.

The purpose of this development-based project is to develop an e-commerce parcel drop box device for residential use. The parcel drop box is usually be placed in front of the residence gate or door for easy access by the courier delivery personnel. There are instances where the courier delivery personnel deliver the parcel where the recipient is not at home to receive the parcel, the courier delivery personnel will leave the parcel at the gate or throw the parcel into

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the residence compound where the parcel is exposed to the sun, rain and line of sight from other people. These will create problems such as parcel theft and result in damage products respectively. By having an e-commerce parcel drop box device installed at the residence, the courier delivery personal can drop off the parcel into the e-commerce parcel box without the recipient having the fear of parcel theft and to give convenience to the courier delivery personnel to successfully delivering the parcel safely into the e-commerce parcel box without needing to reattempt delivery.

1.2 Objectives

The main purpose of this development-based project is to produce a prototype of a parcel drop box system for residential use which is simple to operate by the courier delivery personnel to drop off the parcel into the parcel drop box and to be seamlessly used by the recipient of the parcel to retrieve the parcel. Next, a smartphone application will also be developed for the user to input the parcel tracking number and unlock the parcel drop box when needed. This is to protect the parcel from being stolen after it is dropped off by the courier delivery personnel by locking it. Besides, to develop the parcel drop box system that can authenticate the parcel to be placed into. The courier delivery personnel can unlock the parcel drop box by scanning with the tracking number QR code or barcode printed on the AWB.

1.3 Project Scope and Direction

For this development-based project, a prototype of a residential parcel drop box system will be built. This project is to solve problems faced by e-commerce shoppers and courier delivery personnel. E-commerce shoppers will have trouble receiving their parcels when they are not present to collect the parcels when delivery is scheduled. A box with an opening door at the will be built for easy access to the insides of the parcel box enclosure. The scope of the prototype is restricted to only 1 unit of parcel at a time due to the size of the enclosure box.

The parcel drop box will also have authentication features to validate which parcel can be put into the parcel drop box via unlocking solenoid lock. Additionally, an QR code or barcode scanning system will be implemented using a scanner module for the courier delivery personnel to scan the parcel to drop off to the parcel drop box. The process for the courier delivery personnel to drop off the parcel will be automated and will not involve the user to unlock the

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opening door to drop off the parcel. Moreover, a user-friendly Android smartphone application will also be developed using React Native framework. The smartphone application is designed for the user to unlock the front door of the parcel drop box by enabling the solenoid lock, input the tracking number of the receiving parcel that is being used for the authentication of the incoming parcel and to track the delivery status of the incoming parcel.

1.4 Contributions

The development-based project will produce a parcel drop box system for residential use. The parcel drop box can be installed on the front door or the front gate of the delivery address. The targeted consumer that will use this product will be the e-commerce shoppers that is unable to be present to receive the parcels most of the time. The parcel drop box can help them to be less worried about when the parcel will deliver and parcel theft. Besides, the parcel drop box can help to protect the parcel from the external elements such as rain and heat as the parcels will be enclosed inside. Moreover, the parcel drop box system can also help the courier delivery personnel to deliver the parcels to the correct delivery address and prevent the wrong parcels to be put into the parcel drop box. As the parcel drop box needs to scan the parcel's AWB for it to enable to unlock the parcel drop box. In addition, the parcel drop box will only open when the user chooses the option to unlock it.

1.5 Report Organization

This report is organised into 7 chapters: Chapter 1 Introduction, Chapter 2 Literature Review, Chapter 3 System Methodology/Approach, Chapter 4 System Design, Chapter 5 System Implementation, Chapter 6 System Evaluation And Discussion. The first chapter will introduce about the project that has explanations related to problem statement, the objective of the project, the contributions of the project and report organization. The second chapter is the literature review which it reviews on the related works of the Parcel Drop Box System project. Next is Chapter 3, which explains the system design using case diagrams, activity diagram and system architecture diagram. Furthermore, Chapter 4 which contains the block diagram of the system and explains how the system runs with component specifications. Chapter 5 explains how the whole system is implemented with the setup of hardware and software. Chapter 6 will discuss about the system testing and the result and outcome explanation of the project, The final Chapter 7 will summarize the project and recommendations of the project.

Chapter 2

Literature Review

2.1 Parcel Drop Box Systems Past Research



Figure 2.1.1 Smart Box for Receiving Parcel Posts with 2 channels

Based on the research [2] have developed a Smart Box for Receiving Parcel Posts using Arduino. According to Arduino [3], Arduino boards has open-source hardware boards that is readily available to get started in programming of software to control the hardware boards. As in Figure 2.1.1, the Smart Box for Receiving Parcel Posts using Arduino will have 2 channels for delivery, one of it is the mail channel and the parcel post channel.

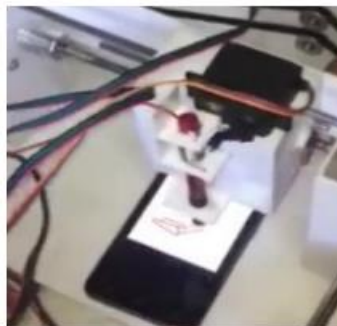


Figure 2.1.2 Mini-CNC with pen for automatically signing

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Additionally, it has an automatic signing channel where the delivery personnel can insert their smartphone to obtain a signature by a Mini-CNC machine. The design of the drop box will have a door at the back for the recipient to retrieve the parcels and mails by using a passcode which is locked by a magnetic lock. The way the parcel drop box system works is when the courier delivery personnel drop the parcel, a motion sensor component will detect that there is a present of parcel being drop into. Therefore, it will notify the recipient via the Line chat application and the automatic signature process will begin.

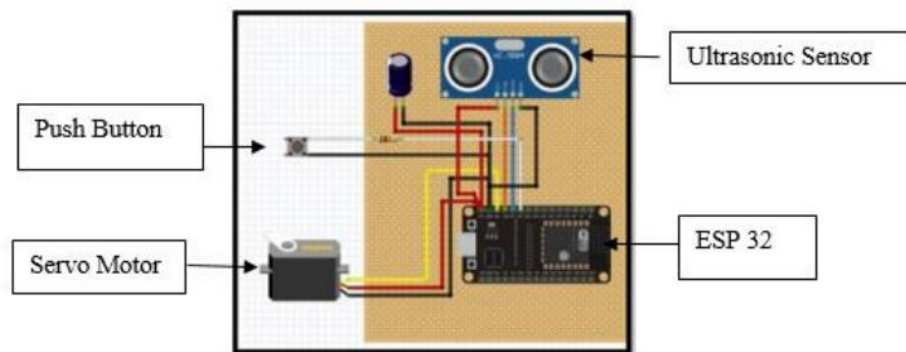


Figure 2.1.3 Circuitry for the Smart Parcel Receiver Box

Furthermore, another research [4] have developed a Smart Parcel Receiver Box. The system uses a ESP32 microcontroller that can communicate instructions to their web application and store information. As shown in Figure 2.1.3, an ultrasonic sensor is also used to detect the item included inside the Smart Parcel Receiver Box. The process of the parcel receiving requires the courier delivery personnel to press the push button located on the body of the parcel drop box. When the courier delivery personnel press the push button, the recipient must unlock the door remotely inside the ESP32 Local Area Network. Once the parcel is placed inside the parcel drop box, the door will be closed and re-locked automatically. Also, the courier delivery personnel will need to scan the QR code displayed to obtain the details about the receiver such as the name, identification card number and telephone number to fill in the details for the courier system to complete delivery. A SMS message will be sent to the receiver's phone after the parcel is detected in the parcel drop box and the courier delivery personnel scan the QR code.

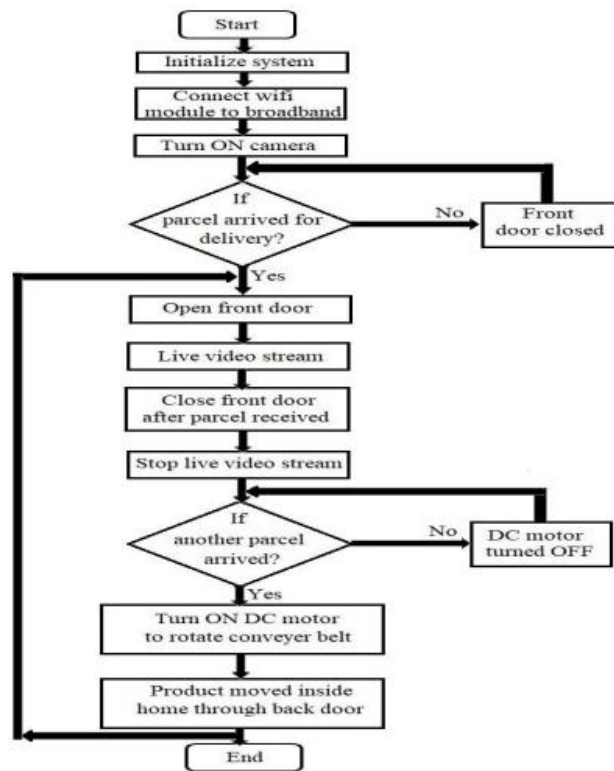


Figure 2.1.4 Flowchart of the Smart Freight Box system

Moreover, based on research [5], a Smart Freight Box is developed using Arduino. It has an Internet Protocol wireless camera that can record while the parcel is being placed into the box. According to the Figure 2.1.4, the flowchart of the Smart freight Box system has a conveyer belt system under the box which can extend from the front side to the back side of the box. When the parcel is placed inside the Smart Freight Box the conveyer belt will bring the parcel into the home through the back door.

2.1.2 Strengths and Weakness

In the previous research there are few strengths, for the previous research [2], the parcel box has a motion sensor to detect the parcel falling when it is dropped into the box. Furthermore, it has rubber door seals at the sides of the door to ensure least amount of water gets into the parcel box when it is placed outside under the rain. From previous research [6], the Smart Freight Box contains a conveyer belt at the bottom of the box. The conveyer belt will move the dropped parcel directly into the house this can be beneficial for the recipient who does not want to collect the parcel manually outside the house.

For weaknesses of the previous research [2], [4], [5] on the development of the parcel drop box system did not implement an authentication method to validate that the correct parcel is being dropped or placed into the parcel drop box. There will be scenarios where the courier delivery personnel make mistakes and deliver the wrong parcel to the wrong address. This could happen where the wrong parcel is dropped into the wrong parcel box. Once the parcel box is locked, the courier delivery personnel is unable to retrieve back the parcel easily. For the research done by [2], the passcode to unlock the backdoor to retrieve parcel is hardcoded which when the recipient forgets the passcode it is unable to unlock the door. Unlike research from [2], [5] has a web application to unlock the parcel drop box door remotely. However, the recipient needs to connect to the local area network of the ESP32 to be able to perform that action. This brings to another limitation where the research [5] needs the recipient to unlock the parcel drop box door when the courier delivery personnel need to place the parcel into the parcel drop box. The recipient needs to interact with the system to unlock it when the delivery is ongoing instead of making the process to be automated. Besides, with the lack of authentication methods, anyone can press the push button and the recipient will unlock the parcel drop box door without knowing the real courier delivery personnel delivers the parcel or a stranger that may steal the parcels that may be inside the parcel drop box previously. In the research based in [5], the Smart Freight Box requires to have direct access from outside the house to inside the house. This will increase the installation cost needed for the user.

Chapter 3

System Methodology/Approach

3.1 System Design Methodology

This development-based project will follow the prototyping process model where has multiple phases, namely communication, construct prototype, evaluation prototype deployment [6]. The requirement of the prototype is identified and gathered during the earlier stage of the development. The gathered requirements are then realized into developing the actual prototype. The prototype is then evaluated to ensure it is suitable to achieve the objective. If there are issues found along the way during evaluation phase, the requirements of the prototype will be modified and developed before deployment.

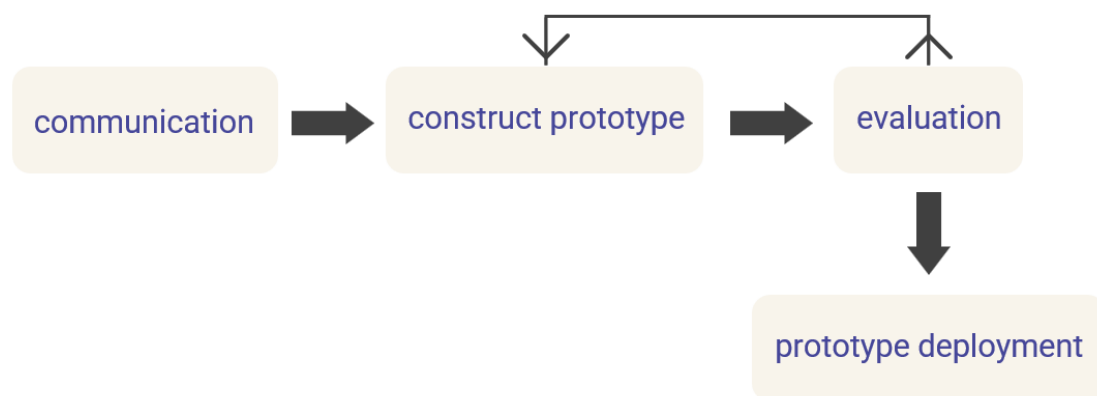


Figure 3.1.1 Flow of the prototyping process model

3.1.1 System Architecture Diagram

The parcel drop box with multi-layer authentication will function together with a mobile application other than its existing on-board system on the parcel drop box. A database is required for the mobile application to communicate between the parcel drop box on-board system and the parcel drop box mobile application. The database also acts as a storage for tracking data to store the tracking information of each individual parcel that is input into the parcel drop box mobile application by the user. Generally, the application user will input the parcel tracking information into the parcel drop box mobile application and the parcel tracking data will be stored into the database to be read by the parcel drop box on-board system to

authenticate and validate the parcel tracking information during delivery by the courier delivery personnel.

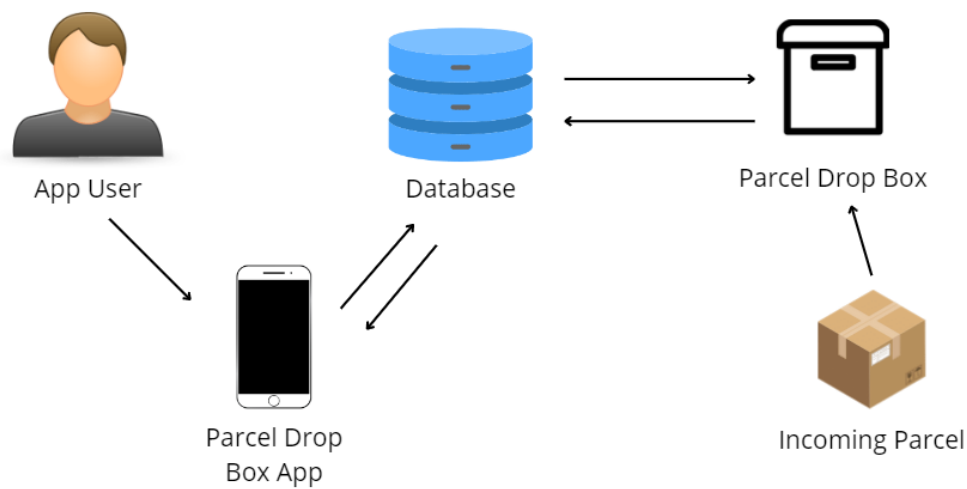


Figure 3.1.1 General System Architecture

3.1.2 Use Case Diagram and Description

According to Figure 3.1.2, the Residence Parcel Drop Box System contains multiple core functions for the user which interacts with the parcel drop box mobile application. Functions such as logging in into the application which allows the user to input incoming parcel tracking information which will be saved into the database. The user can also view the tracking information for each parcel inside the application. Furthermore, there will be a switch which the user can lock or unlock the door of the parcel drop box remotely. When the courier delivery personnel arrive and wants to deliver the parcel, the courier delivery personnel will first scan the QR code or barcode on the airwaybill of the parcel on the scanner of the parcel drop box. The scanned code will authenticate and validate against the parcel tracking data inside the database. Once the code is authenticated and validated inside the database, the door of the parcel drop box will unlock allowing the courier delivery personnel to insert the parcel into the parcel drop box to successfully deliver the parcel to the address. If the scanned code is not found inside the database during the querying process, the transaction will be rejected and the door will not unlock. The courier delivery personnel will have to try the process of scanning the QR code or barcode again with another parcel which its tracking data is existed inside the tracking database of the parcel drop box.

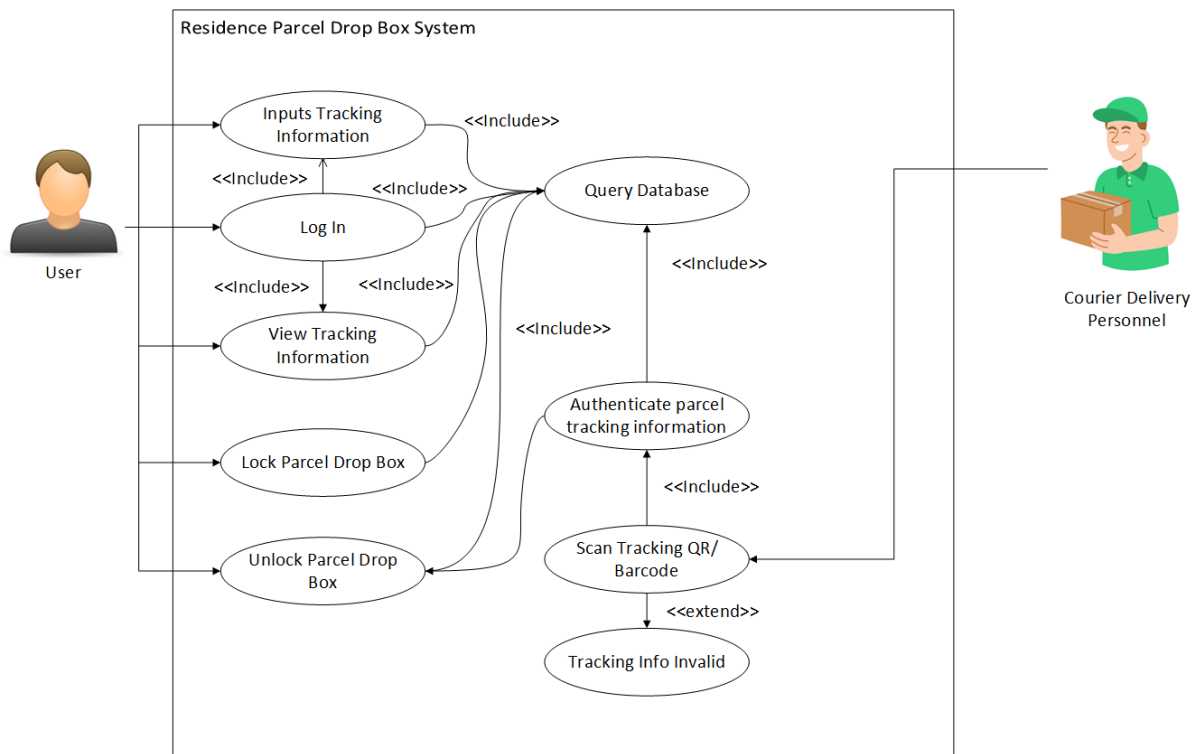


Figure 3.1.2 Residence Parcel Drop Box System Use Case Diagram

3.1.3 Activity Diagram

According to the activity diagram in Figure 3.1.3.1, the user will navigate through the app interface by first logging into the app using user's email and password. Then the app will ask for the parcel drop box identification code. The identification code is a unique string of code assigned for each physical parcel drop box. The identification code enables 1 user to own multiple physical parcel drop box which can be placed at multiple addresses to facilitate its functions. After the user input the unique identification code of the parcel drop box, the account has been tied to the physical parcel drop box. The mobile app will not ask the user again to input the parcel box identification code again unless the user signs out from the mobile application. The user will find itself on the homepage of the mobile application where it has menus to enter to the input parcel tracking page, view parcel data page and also a switch to lock or unlock the parcel drop box door. There is also a profile page which lies the logout feature of the mobile application.

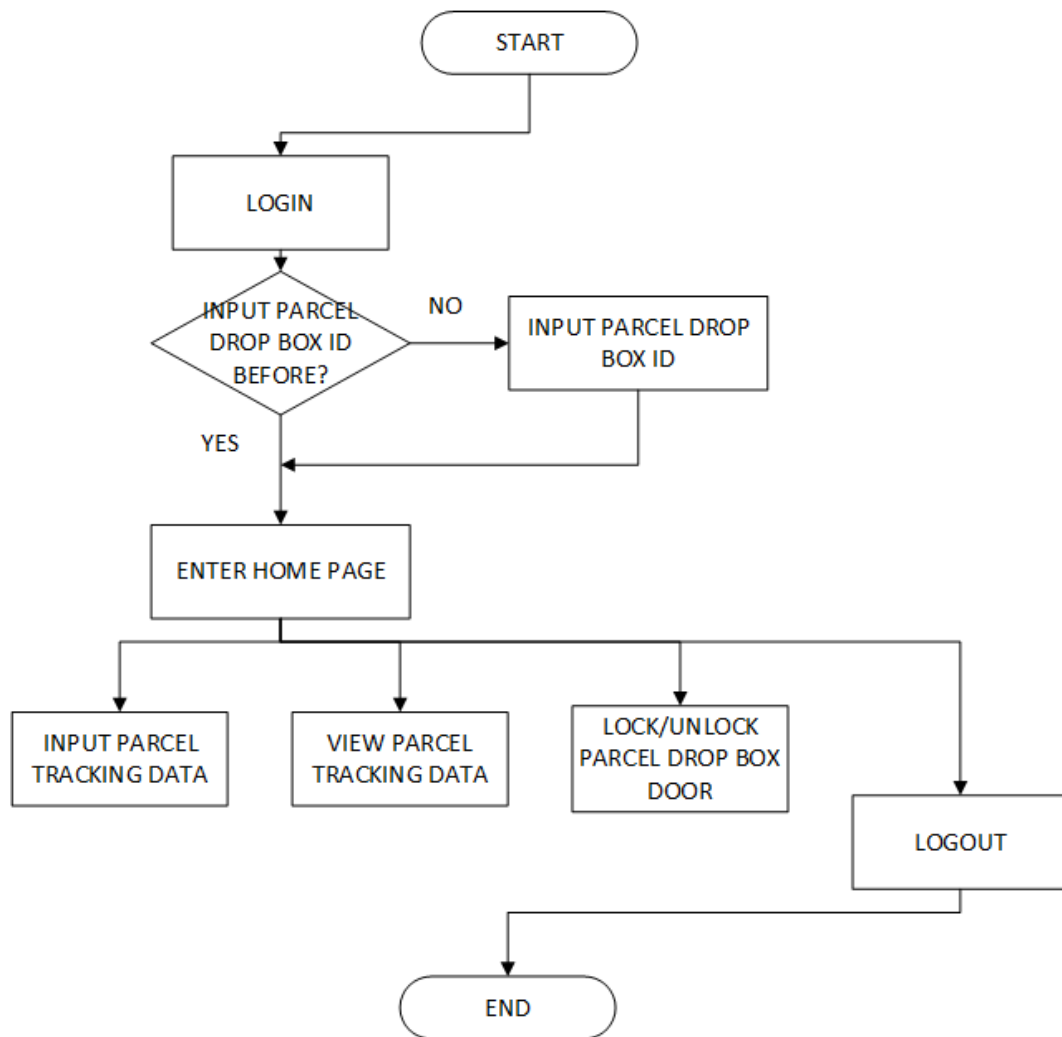


Figure 3.1.3.2 Activity Diagram for User when using Parcel Drop Box mobile app

According to the activity diagram in Figure 3.1.3.1, when the courier delivery personnel wants to deliver the parcel to the parcel drop box. The courier delivery personnel will need to the courier delivery personnel will first scan the QR code or barcode on the airwaybill of the parcel on the scanner of the parcel drop box. The QR code data will be validated with the database, if it doesn't exist in the database, the courier delivery personnel will need to scan with another correct parcel to unlock the parcel drop box door. If the QR code data exists in the database, the parcel drop box will unlock and the courier delivery man will be able too placed the parcel into the drop box enclosure. Once the door is closed, the door will automatically locked.

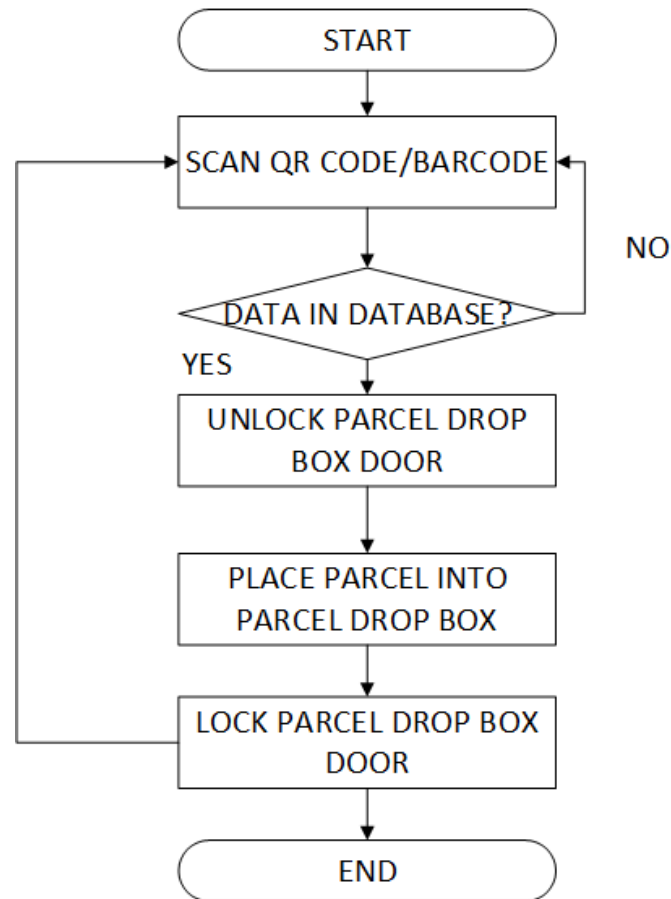


Figure 3.1.3.3 Activity Diagram for User when using Parcel Drop Box

Chapter 4

System Design

4.1 System Block Diagram

4.1.1 Hardware Architecture

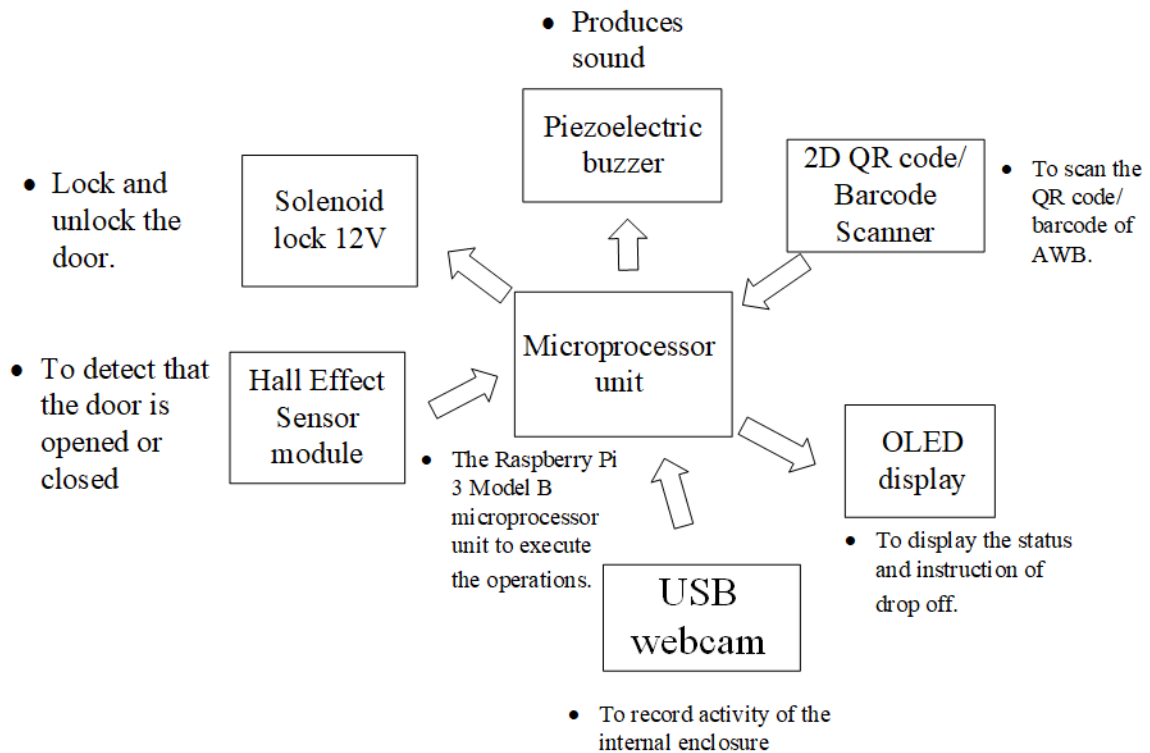


Figure 4.1.1.1 Hardware architecture block diagram

4.1.2 Software Architecture

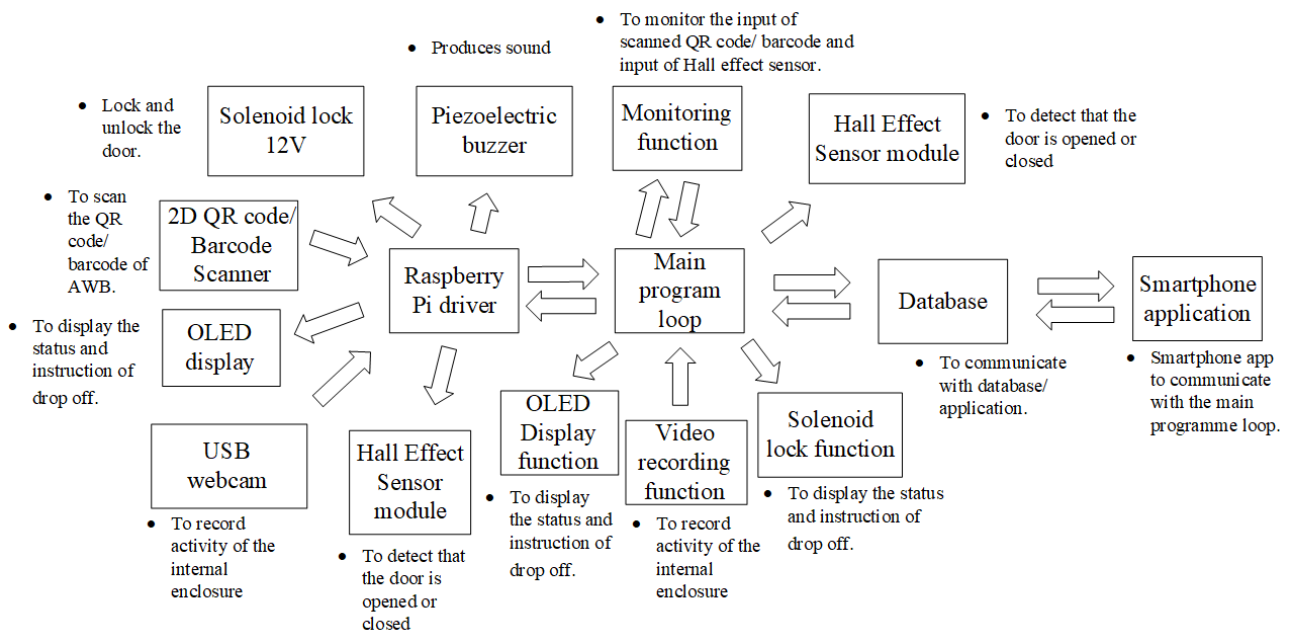


Figure 4.1.2.1 Software architecture block diagram

4.2 System Components Specifications

The parcel drop box with multi-layer authentication will need multiple hardware components and software to develop. The hardware components will include multiple electronic parts and the outer body enclosure, while for the software components includes the smartphone application and the database used to link the main driver of the system with the smartphone application. The parcel drop box system needs to be user friendly to all users including the courier delivery personnel and the parcel recipient.

4.2.1 Hardware Specifications

- Raspberry Pi 3 Model B



Figure 4.1.1.1 Raspberry Pi 3 Model B

For the hardware part, a Raspberry Pi 3 Model B is used for the microprocessor computer to drive the other smaller electronic components. It is the main brain of the whole parcel drop box system. The Raspberry Pi computer is used because the compute power is suitable enough to drive the overall hardware components. The Raspberry Pi 4 Model B is a Linux ARM based computer with a Quad core 64-bit ARM-Cortex A72 microprocessor and has 28 user GPIO which supports various interfaces [7].

- 2D CMOS QR/barcode USB wired scanner



Figure 4.1.1.2 2D CMOS QR/barcode USB wired scanner

Furthermore, a 2D CMOS QR/barcode USB wired scanner will be attached to the body of the parcel drop box. The scanner is used to scan the QR code or barcode that it printed on the AWB sticker of each parcel.

- USB Webcam



Figure 4.1.1.3 USB webcam

The USB webcam will be placed inside of the enclosure of the parcel drop box. It is used to record the activity when the door is being opened after QR code is being scanned. The USB webcam will be connected to the USB interface of the Raspberry Pi.

- 12V solenoid lock



Figure 4.1.1.4 12V solenoid lock

Additionally, a 12V solenoid lock will be fixed on the opening door of the parcel drop box body. The 12V solenoid lock will unlock while the door is closed by supplying 12V voltage and it will lock by not supplying any voltage.

CHAPTER 4

- 12V relay

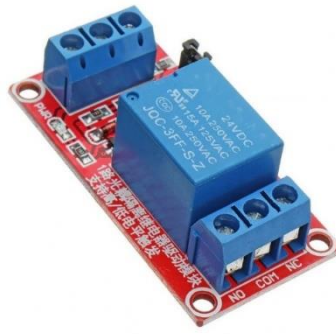


Figure 4.1.1.5 12V Relay

Since the solenoid lock requires 12V of power, the Raspberry Pi device has a limitation where it works on maximum 3.3V logic. Therefore, another electronic component which is called a 12V Relay will be used to control the logic of the 12V solenoid lock.

- A3144 Hall Effect sensor module

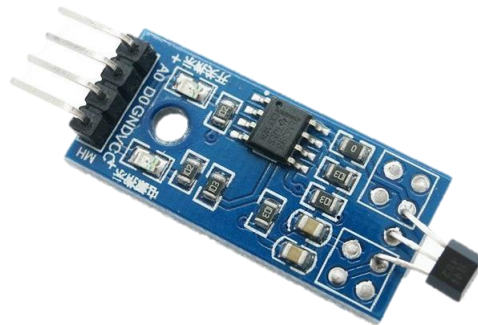


Figure 4.1.1.6 A3144 Hall Effect sensor module

The A3144 Hall Effect sensor module is used to detect if the door is closed or open. When the door is closed it will send a signal to the solenoid lock to lock the door. This is to prevent accidental door lock when the door is swing open.

- OLED display 0.96 inch



Figure 4.1.1.7 OLED display 0.96-inch

The 0.96-inch OLED display will be fixed on the outer part of the parcel drop box enclosure to display the instruction and the status of the parcel drop box for the user especially the courier delivery personnel to read. The OLED display is chosen over other types of display such as the dot matrix display because it can provide a higher readability during exposure of bright conditions. The OLED display will communicate with the Raspberry Pi 3 Model B using the I2C interface.

- Piezoelectric Buzzer



Figure 4.1.1.8 Piezoelectric Buzzer

The Piezoelectric Buzzer will produce a sound when the door is unlocked, locked and when the door is left open for a period. This is to prevent the courier delivery personnel to leave the door unshut fully accidentally to prevent the lock to unable to lock properly,

CHAPTER 4

- 18650 Lithium-ion battery



Figure 4.1.1.9 18650 Lithium-ion battery

A total of 3 units of 18650 3.7V Lithium-ion battery is needed to power the 12V solenoid lock because it cannot be directly connected to the Raspberry Pi due to the limitation of the power can be supplied to be 3.3V only. The lithium-ion battery will be connected to the battery holder in series, the total voltage supplied to the solenoid lock will be 11.1V to power the lock.

- 3-slot 18650 battery holder



Figure 4.1.1.10 3-slot 18650 battery holder

The 3-slot 18650 battery holder is needed for the total of 3 units of 18650 battery to be connected in series. The total voltage supplied to the will be 11.1V.

CHAPTER 4

- Parcel drop box enclosure



Figure 4.1.1.11 Prototype design of parcel drop box enclosure

The wooden parcel drop box enclosure will have a front door opening for access to deliver and retrieve the parcels.

- Dupont jumper wires



Figure 4.1.1.12 Dupont jumper wires

Dupont jumper wires is used to connect the electronic components with the Raspberry Pi GPIO pins.

- Breadboard

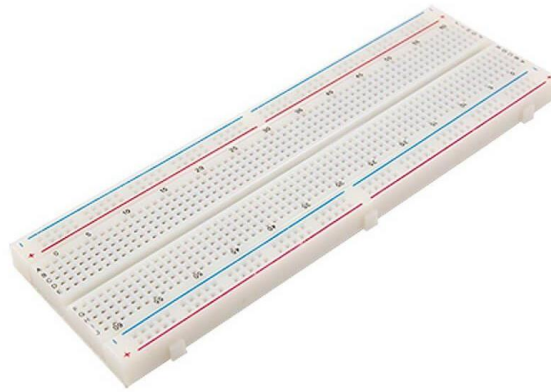


Figure 4.1.1.13 Large Breadboard

The Breadboard is used to connect components with the Raspberry Pi during testing to build a complete circuit.

4.2.2 Software Specifications

A user-friendly mobile application will be developed using Flutter with the following features:

1. Recipient to input the tracking number of the parcel that is needed for the courier delivery personnel to be dropped off into the parcel drop box.
2. Recipient can unlock the door by toggling a switch in the mobile application.
3. The mobile application will have authentication features to increase security of the parcel drop box.

For the database, Google Firebase will be used because it is quick to implement the database model with no SQL structure. It has also Realtime Database feature that can query and update the data from and into the database in real-time with low latencies.

4.3 System Components Operation Design

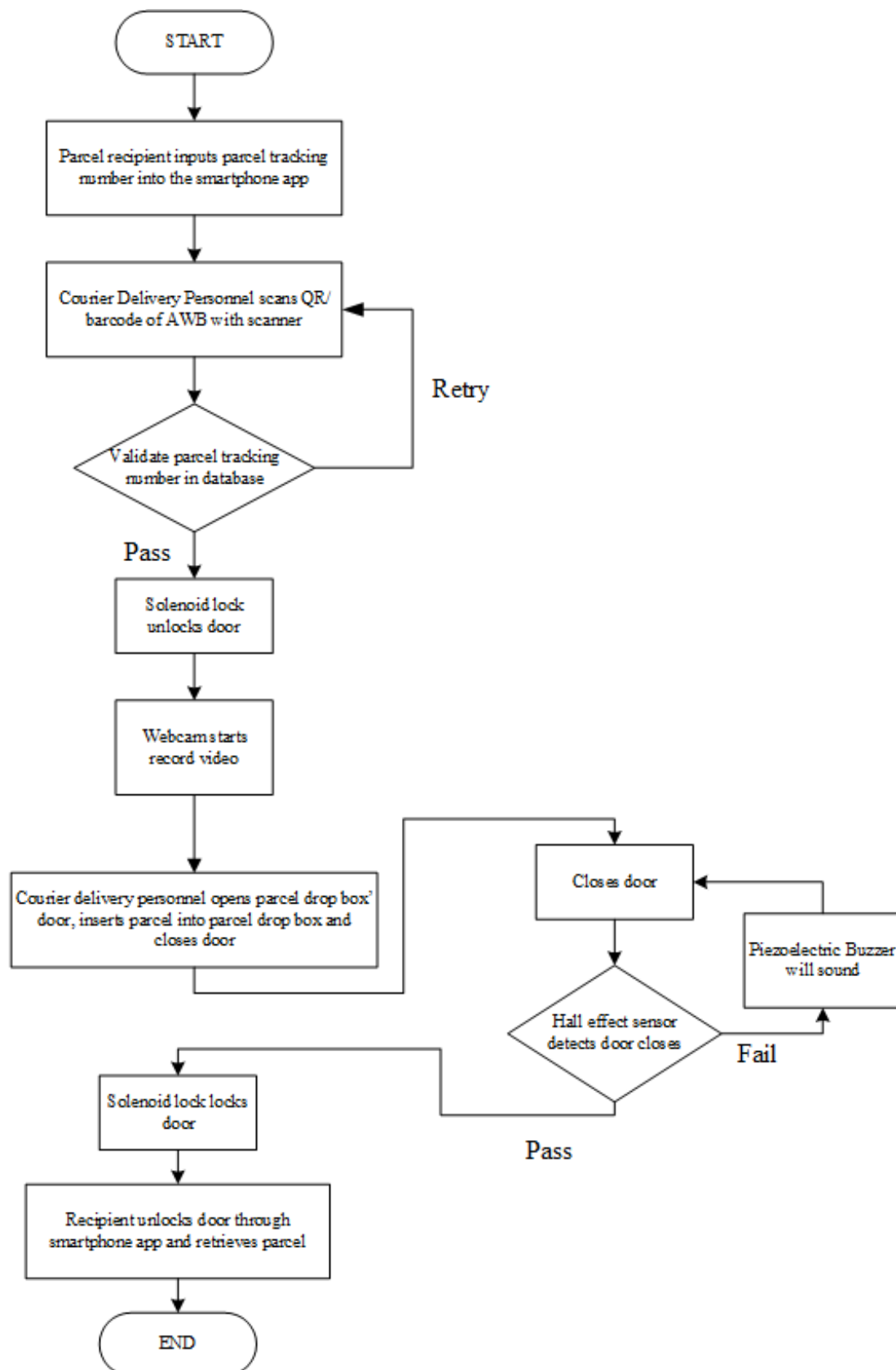


Figure 4.3.1 Operation flowchart

CHAPTER 4

After the parcel drop box is powered on the recipient of parcel inputs the tracking number of the parcel that is generated from the e-commerce website into the parcel drop box smartphone application. The smartphone application will save the tracking number into a database. When the courier delivery personnel attempts to deliver the parcel, the courier delivery personnel will scan the parcel's QR code or barcode tracking number on the AWB to the 2D QR code/barcode scanner. If the tracking number exists on the parcel drop box database, the parcel drop box door will unlock then courier delivery personnel can open the parcel drop box door and drop the parcel into the parcel drop box. When the parcel drop box door is unlocked, the webcam will start to record the video. After done dropping off the parcel, the door will be closed shut. The webcam will also halt recording of the video and save it into the Firebase storage database. Hall effect sensor module will detect the door is closed shut; the solenoid lock will lock the door. If the door is left unshut for a period, the photoelectric buzzer will produce an alert sound to warn for not closing the door fully shut. When the recipient of the parcel wishes to retrieve the parcel, the recipient can unlock the door using the smartphone application and open the door.

Chapter 5

System Implementation

5.1 Hardware Setup

5.1.1 Parcel Drop Box Enclosure

The parcel drop box enclosure is built and fitted with the Raspberry Pi 3 Model B module and the electronic components that is needed for the parcel drop box to function . The final circuitry is connected using the jumper wires. The wires are also managed as much as possible to make sure it does not interfere with the operations of the parcel drop box when in use. From Figure 5.1.1.1, the outcome of the parcel drop box with fitted electronics is presented.

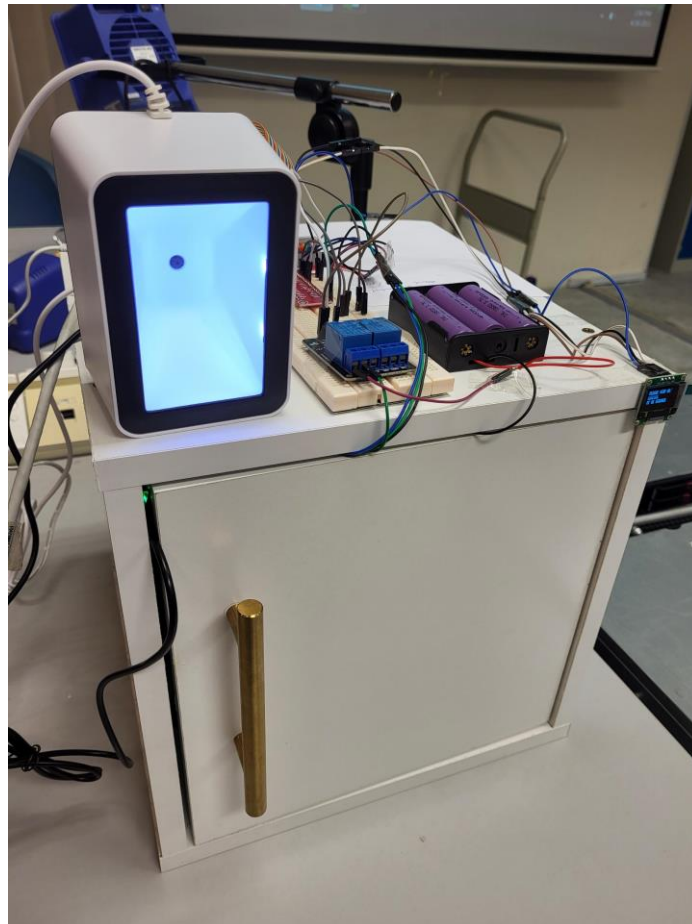


Figure 5.1.1.1 Residence Parcel Drop Box with fitted electronics

CHAPTER 5

From Figure 5.1.1.2, the 0.96 inch OLED display is placed on the front top left corner of the parcel drop box enclosure for the courier delivery personnel and users to read the instructions needed to operate the parcel drop box.

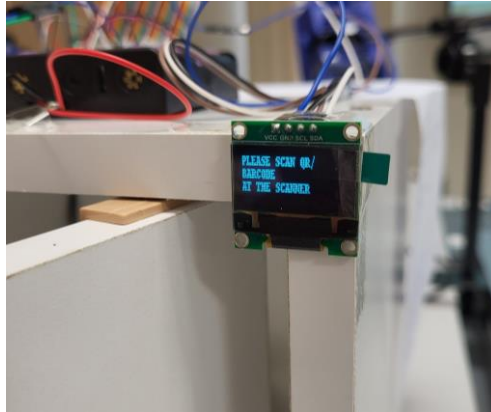


Figure 5.1.1.2 0.96 inch OLED display attached

From Figure 5.1.1.3, the A3144 Hall Effect Sensor module is attached on the wall which is near to the door when it closes. From Figure 5.1.1.4, a magnet is also attached on the door for the hall effect sensor to detect if the door is open or close.



Figure 5.1.1.3 A3144 Hall Effect sensor attached

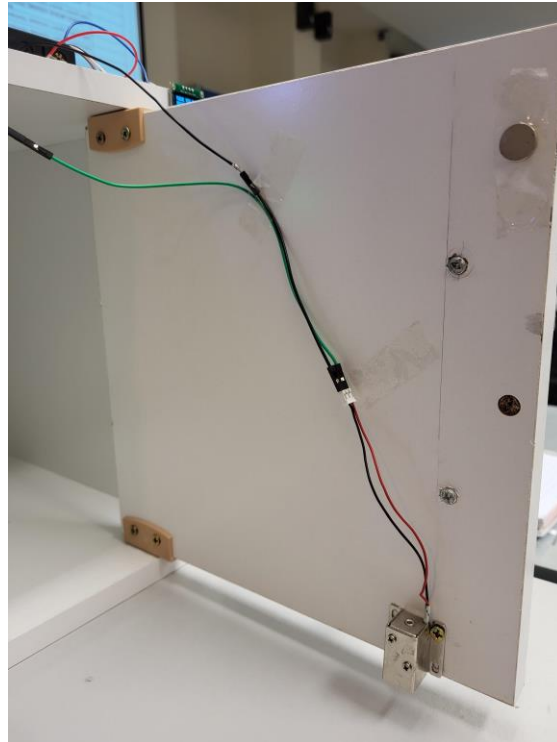


Figure 5.1.1.4 Magnet and 12V Solenoid lock attached to the door

From Figure 5.1.1.5, a USB webcam is also placed inside the parcel drop box enclosure to record video during opening of the parcel drop box door after validation of tracking number in the database.



Figure 5.1.1.5 USB webcam placed inside the parcel drop box enclosure

5.2 Software Setup

5.2.1 Raspberry Pi Setup

Programs that are required to be installed into the laptop to set up the Raspberry Pi 3 Model B:

1. VNC Viewer 6.22.515
2. Raspberry Pi Imager
3. Raspberry Pi OS with desktop (Version Bullseye)

```
sudo apt-get upgrade
sudo apt-get dist-upgrade
```

Figure 5.2.1.1 Terminal Commands to update all packages

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

Figure 5.2.1.2 Terminal Commands to update base system packages

First the Micro SD card is formatted and flashed with the Bullseye version of Raspberry Pi OS desktop using Raspberry Pi imager. After flashing, the Raspberry Pi is booted up. By using VNC Viewer, the Raspberry Pi can be remotely accessed and controlled by using a the VNC viewer laptop client by connecting to the same network subnet without connecting the monitor directly with the Raspberry Pi. Using commands, the packages that functions of the Raspberry Pi is updated using the commands such as in Figure 4.1.1, Furthermore, the base system packages are updated to their latest version using commands such as in Figure 4.1.2.

5.2.2 Firebase Setup

Go to <https://console.firebase.google.com/> by adding a new project to set up the Firebase Database as in Figure 5.2.2.1. After that, enter the project name such as ParcelDropApp and create the project. The Realtime Database, Authentication and Firestore Database is set up by clicking the respective menu at the left side on the Firebase project dashboard as in Figure 5.2.2.2.

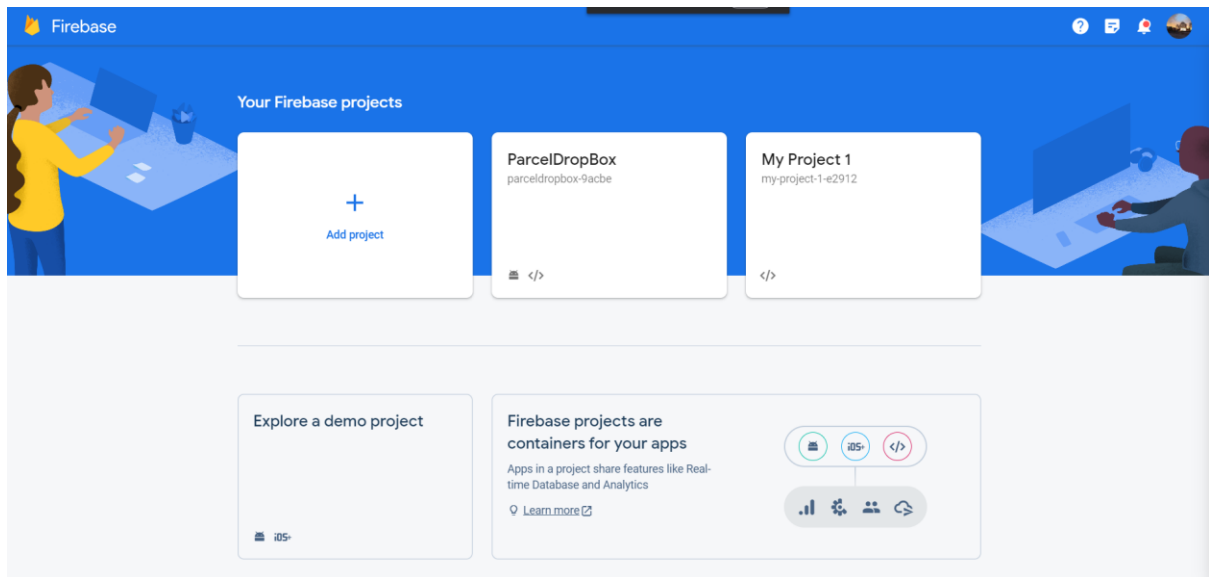


Figure 5.2.2.1 Firebase projects console

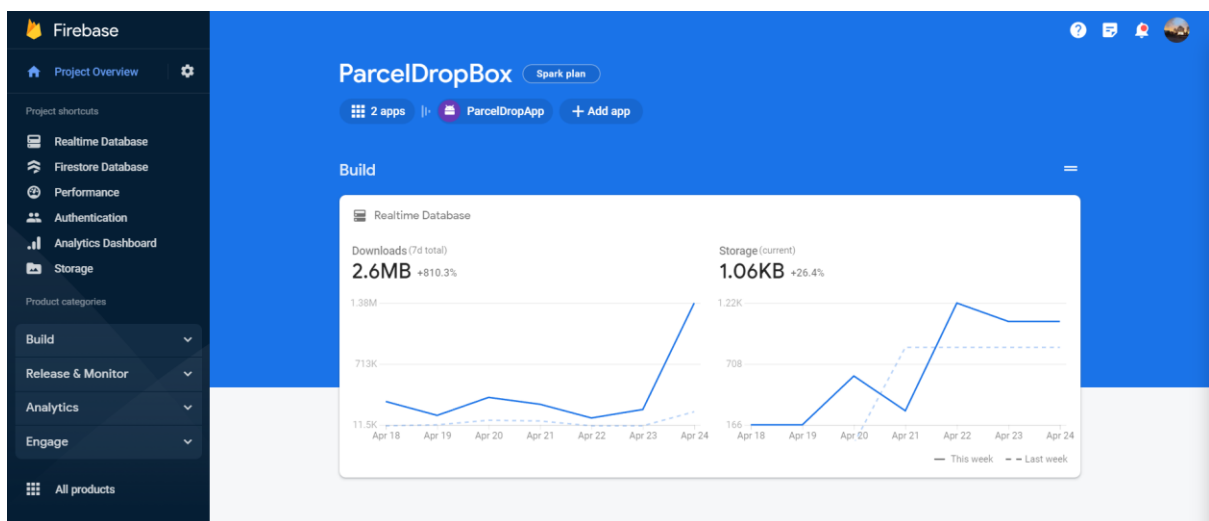


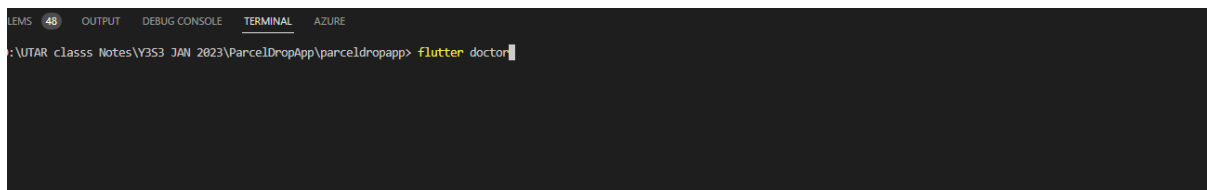
Figure 5.2.2.2 Firebase ParcelDropBox project dashboard

5.2.3 Flutter Setup

To install the Flutter SDK into laptop, go to <https://docs.flutter.dev/get-started/install> and select windows. Download the Flutter windows SDK zip file and unzip it to install into the laptop. After installing the Flutter SDK, from the Command Prompt window, type the command flutter doctor as in Figure 5.2.3.1. Flutter doctor command will check if Flutter is installed correctly

CHAPTER 5

into the machine before we perform any development with it. If the Flutter SDK is installed correctly, it will not return any error message.



```
LEMS 48 OUTPUT DEBUG CONSOLE TERMINAL AZURE
~\UTAR c\class Notes\Y353 JAN 2023\ParcelDropApp\parceldropapp> flutter doctor
```

Figure 5.2.3.1 Flutter doctor command

Next, install the Flutter Visual Studio Code extension by searching for it in the Visual Studio Code extension marketplace as in Figure 5.2.3.2.

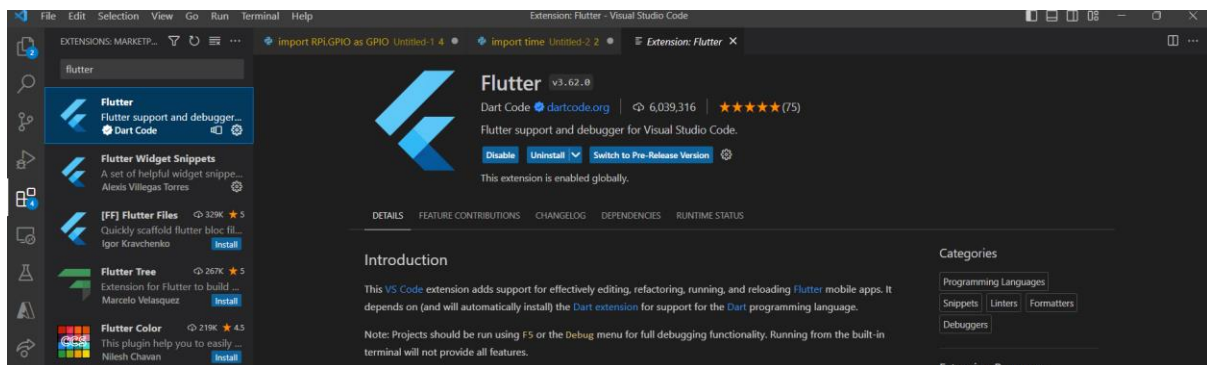
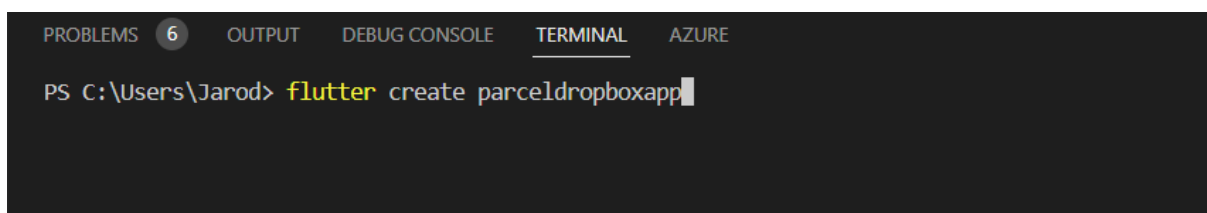


Figure 5.2.3.2 Flutter extension for Visual Studio Code

Next, create an empty project folder and use the terminal in Visual Studio Code and type Flutter create Parceldropboxapp to create a new Flutter project as in Figure 5.2.3.3.



```
PROBLEMS 6 OUTPUT DEBUG CONSOLE TERMINAL AZURE
PS C:\Users\Jarod> flutter create parceldropboxapp
```

Figure 5.2.3.3 Command to create new Flutter project

5.3 System Operation

5.3.1 Mobile Application

The mobile application is named as parceledropbox. There are 5 main pages in the mobile application. The first page which the user will first see is the login page. According to the screenshot in Figure 5.3.1.1, the page requires the user to input their email and password to login to the mobile application. This will increase the security of the app and the controls of the residence parcel drop box.

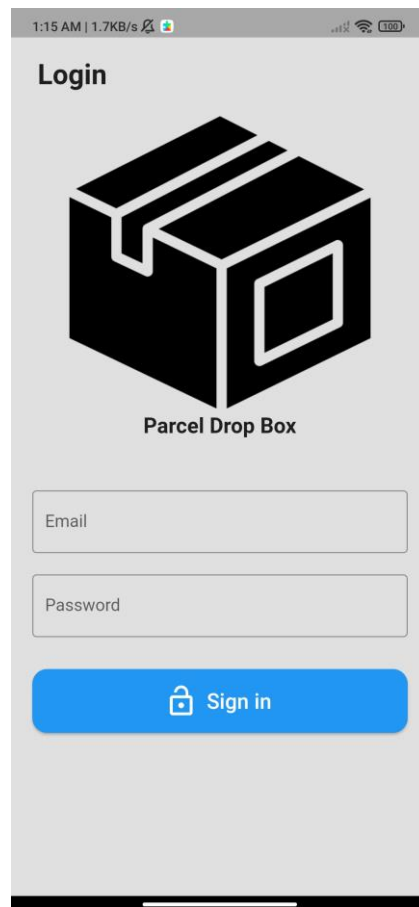


Figure 5.3.1.1 Screenshot for Login page

CHAPTER 5

Next page is the register drop box page, this page allows first time log in users to link their account to the physical parcel drop box just like in Figure 5.3.1.2. Each physical parcel drop box will have a unique code that identifies each box uniquely. This allows the user to control multiple parcel drop box using a single account. The user will have to log out and login again to change the parcel drop box controls.

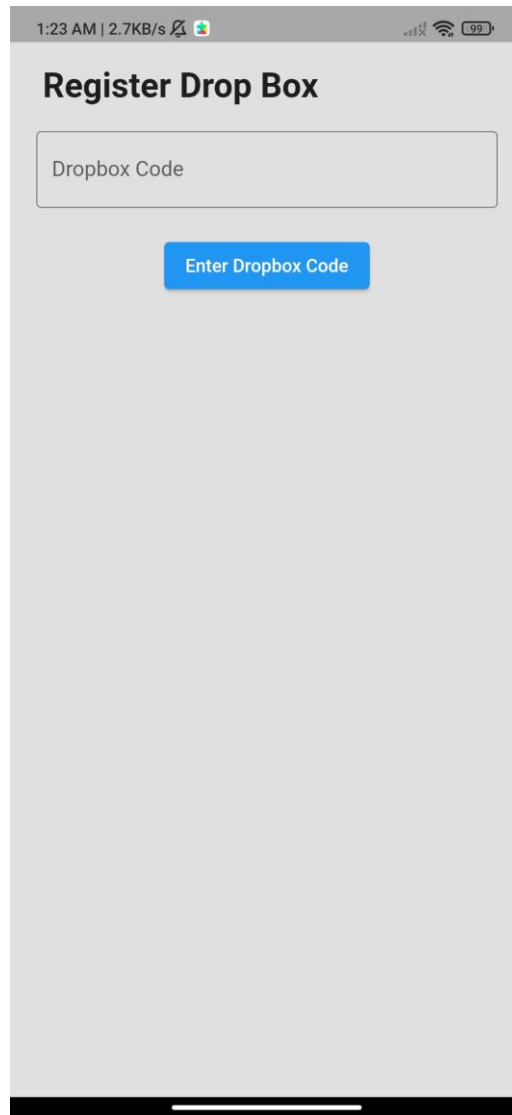


Figure 5.3.1.2 Screenshot for Register Drop Box page

Furthermore, the use of the app will go to the home menu page of the mobile application. In this page the user can navigate to different pages such as new tracking page, profile page through the bottom navigating bar. Such as in Figure 5.3.1.3 there are also menus at the home page such as new tracking menu, tracking list menu and a toggle switch to lock and unlock the drop box.

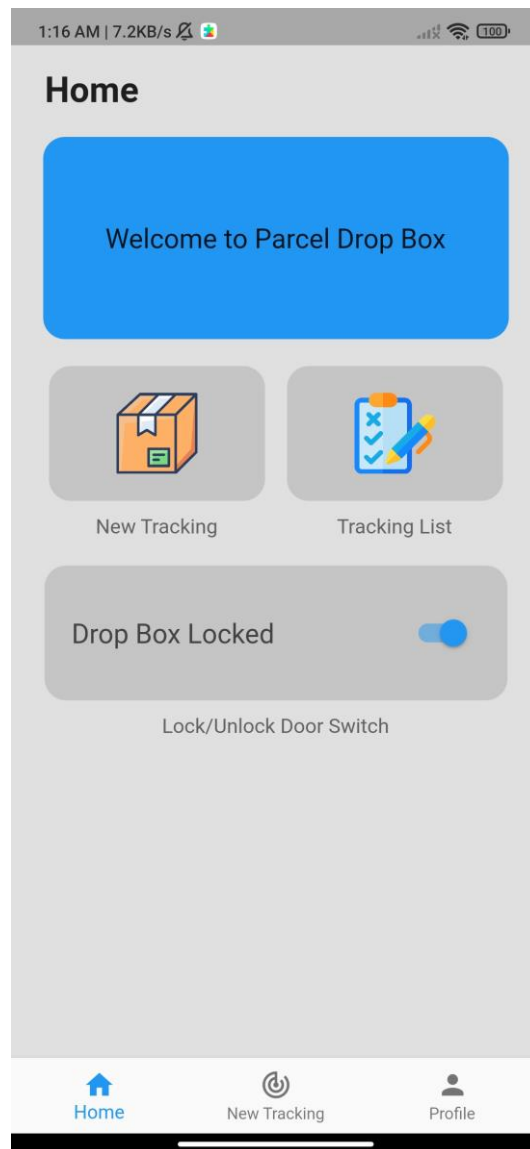


Figure 5.3.1.3 Screenshot for Home Page

Additionally, there is a new tracking page such as in Figure 5.3.1.4 where it allows user to add in tracking and parcel information for the incoming parcel orders to the parcel drop box. The information will be sent to the Firebase Realtime database to be stored and queried during the authentication and validation function to unlock the parcel drop box door.

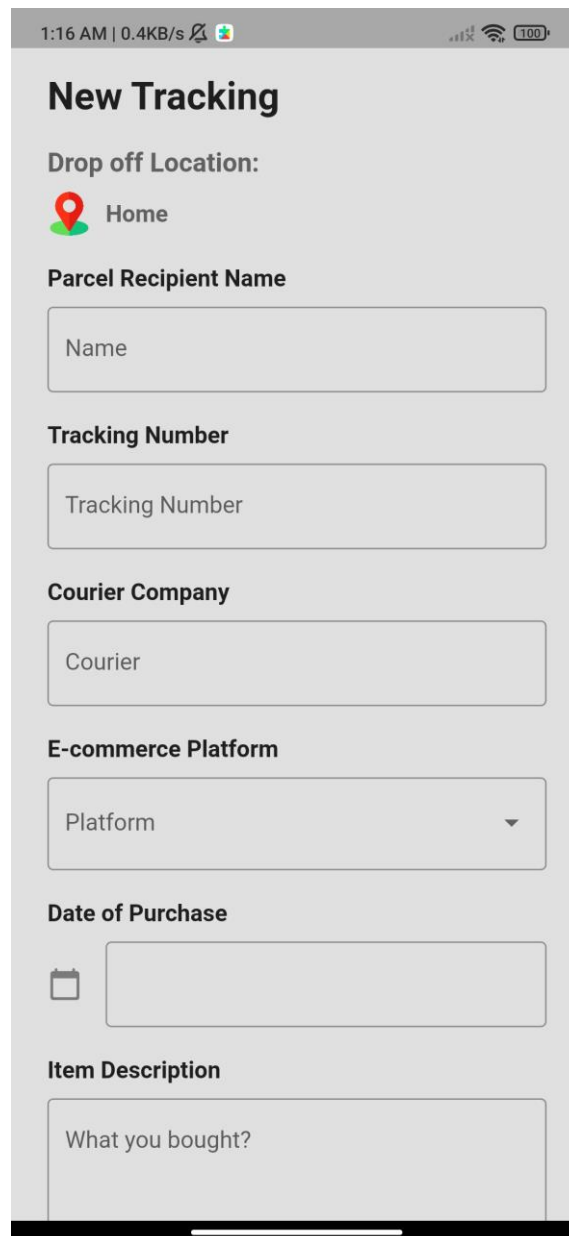


Figure 5.3.1.4 Screenshot for New Tracking page

Lastly, is the profile page which only consist of log out button for use to log out the mobile application such as in Figure 5.3.1.5.

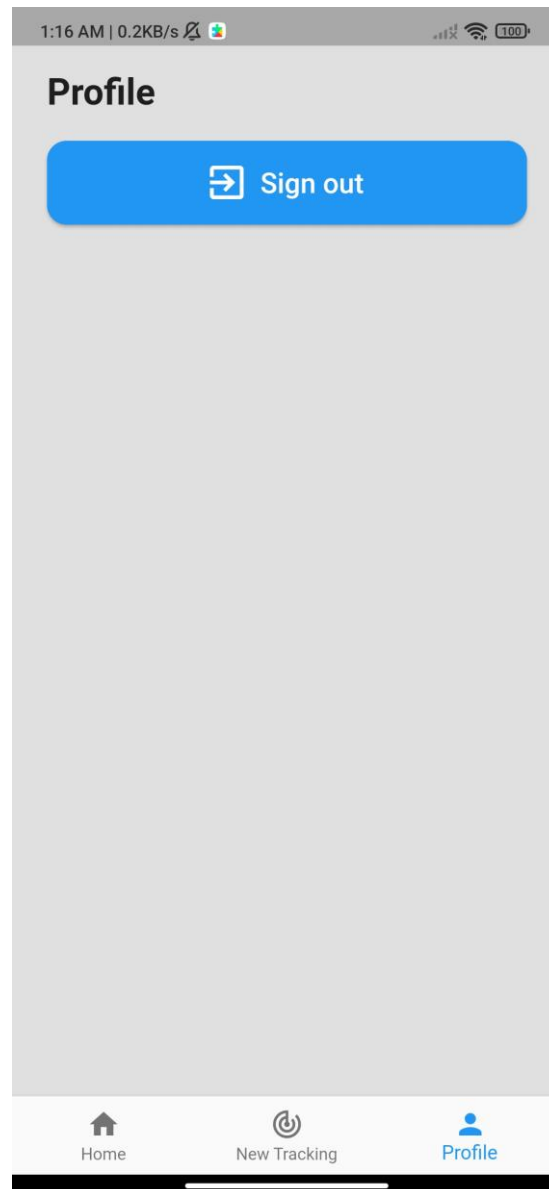


Figure 5.3.1.5 Screenshot for Profile Page

5.3.2 Parcel Drop Box Enclosure

From Figure 5.3.2.1, the courier delivery personnel need to scan the parcel QR code/Barcode on the parcel drop box scanner to input the tracking number into the parcel drop box system to authenticate and validate from the database for it to unlock the door. Once the door unlocks, the buzzer will buzz which the courier delivery man can open the door to drop off the parcel into the parcel drop box. The door should be closed after the parcel is dropped off into the parcel drop box enclosure. The video will also be recorded by the webcam once the door is open and stop recording once the door is closed. The video is uploaded to the Firebase cloud storage.

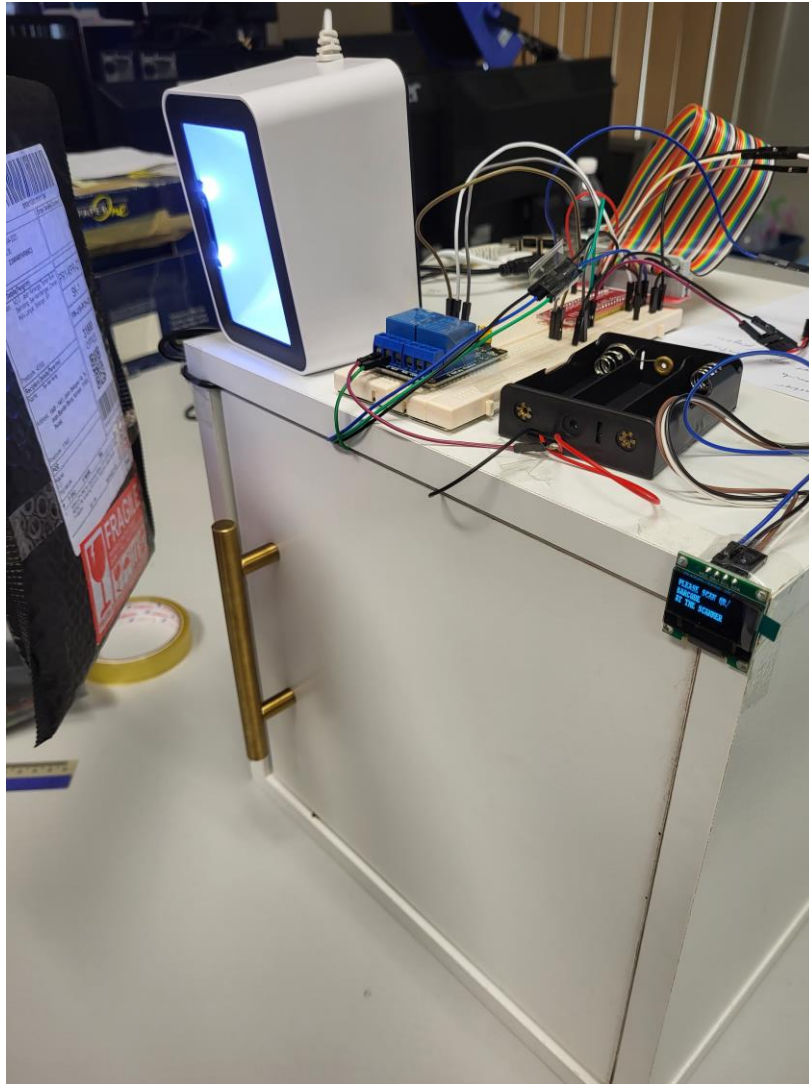


Figure 5.3.2.1 Parcel Drop Box System

5.4 Implementation Issues and Challenges

There are multiple implementation issues and challenges faced in this project. On the hardware configuration and development part of the project, one of the issues faced is faulty components being utilized in the testing phase. Components such as the OLED display doesn't display the output which is intended during the testing. With many rounds of trial and error testing the OLED display is confirmed to be faulty and a new OLED display is repurchased from another reliable supplier to be used. Furthermore, the relay used in this project also faced the same fate as it is faulty after purchase. A new replacement of the component is repurchased and implemented in the project. From the software configuration and development part of the project, the challenges faced is the difficulty in development of the mobile application as it has a steep learning curve to begin with. More time is spent to learn on the mobile application development and connecting the Firebase database to the mobile application. The process of Firebase database integration with the Raspberry Pi and the mobile application has taken out much development time as well because the project has some complexity in it. Another challenge faced is to integrate the code for the whole system using multiple code blocks of individual code components. After integrating, much time is spent to eliminate code bugs where it needs trial and error to find the root cause of the issue.

5.5 Concluding Remark

The overall system can be implemented with the functions run smoothly. Even with the challenges faced, some time is needed to iron out the issues to make sure the features are implemented to meet the project objectives.

Chapter 6

System Evaluation and Discussion

6.1 System Evaluation and Performance Metrics

6.1.1 Mobile Application

For the Flutter mobile application, there are 4 functions for to make sure it is functioning correctly. The first function is the user authentication function, where the user can login into the app successfully or not and the user will not be able to login if the credentials are invalid. Next is the input new tracking function. The user is required to input the parcel tracking details into the app. After inputting and submitting the information, the data should be reflected in the Firebase Realtime database correctly. Furthermore, is the toggle switch for the lock and unlock function for the door of the parcel drop box. When the user toggles the switch in the mobile application, the lock of the parcel drop box door should perform expected results in real-time. Finally, the logout function, the mobile application will need to logout the user correctly and loads the expected interface when the mobile application is launch again.

6.1.2 Parcel Drop Box System

For the parcel drop box system, the system is expected to scan the QR code/Barcode and validate the tracking number scanned against the tracking number inside the Firebase database. If the tracking number is validated, the solenoid lock will unlock and the door will be able to open. Otherwise, if the tracking number is not validated, the solenoid lock will not unlock and will output the warning message appropriate. The program would be expected to produce buzzing sound when the door is not closed after some time when the door is unlocked for courier delivery personnel to place in the parcel. The hall effect sensor is expected to detect when the door is closed or opened for the solenoid to lock. Next, the system is expected to initiate the webcam recording when the door is unlocked after positive authentication validation of the tracking number. Furthermore, the OLED display would be able to display correct instructions for each appropriate step. The system also will loop back at the start after each process iteration so that the next tracking number can be scanned.

6.2 Testing Setup and Result

6.2.1 Mobile Application Test

The mobile application is tested by inputting fields and testing by inserting dummy data to evaluate if the expected result is achieved.

| No. | Test Metric | Expected Result | Tested Result | PASS/FAIL |
|-----|---------------------------|--|---|-------------|
| 1 | Login function | Login function handles properly with valid and invalid credentials. | User login successfully with correct credentials and denied login with wrong credentials. | PASS |
| 2 | New tracking function | The input of the new tracking information is reflected in Firebase database. | Tracking information reflected in the Firebase database after submission. | PASS |
| 3 | Logout function | Logout function handles correctly and returns to login screen. | User logout from application properly and application returns to login screen. | PASS |
| 4 | Toggle door lock function | Door lock switch can be toggled appropriately in real time. | The switch is toggled and reflected on the lock in real time. | PASS |

Table 6.2.1.1 Mobile Application Testing Metrics and Result

6.2.2 Parcel Drop Box System

The parcel drop box system is tested by scanning dummy QR codes which has data already input inside the database to validate.

| No. | Test Metric | Expected Result | Tested Result | PASS/FAIL |
|-----|--|--|--|-------------|
| 1 | Scan QR code/Barcode function | QR code/ Barcode scan successfully and input into the system to read. | QR code can be scanned and system can read in the QR code data. | PASS |
| 2 | Tracking number authentication validation function | The tracking number information is validated in the database. | Tracking information scanned is correctly validated to the database. | PASS |
| 3 | Buzzing function | Buzzing function activate when the door is opened after scanning validation. | Buzzer buzz after door is opened when tracking number is validated. | PASS |
| 4 | Door unlock/lock function | Solenoid lock can lock and unlock correctly at each step. | Solenoid lock can function after unlocking and locking step | PASS |
| 5 | Hall effect sensor function | Hall effect sensor can detect magnetic field when door closed. | Hall effect sensor can detect door being closed. | PASS |
| 6 | Webcam Recording function | Webcam can record and saved video to database. | Video is recorded and save into database after unlocking and open door when validated. | PASS |
| 7 | OLED display instruction function | OLED display correct instruction at each process step. | OLED display correct instruction at each process step. | PASS |

Table 6.2.2.1 Parcel Drop Box Testing Metrics and Result

6.3 Project Challenges

In this project, there are a few challenges faced during the development of the parcel drop box system and the development of the mobile application. One of the challenges faced during the development of the parcel drop box system is the integration process of each code block of the individual electronic components. During integration, there are multiple errors popped out which requires a lot of development time needed to integrate the entire system and debug the issues. The other challenges faced is to retrieve the data from the Firebase Realtime Database to the parcel drop box system and the mobile application. It is challenging because the code used keep returning an error and the returned data is null which is not the expected output. The Flutter code syntax to retrieve the data from the database is also complicated. Although having the issues and challenges, with more time to debug and trial and error the challenges has been overcome with a working functional system.

6.4 Objectives Evaluation

The objective of this develop-based project is to develop a prototype of a parcel drop box system for residential use. With the outcome of the project, the objective is achieved. The parcel drop box system can be used by the courier delivery personnel to drop off the parcel to the parcel drop box by scanning the QR code / barcode of the parcel with the scanner attached on the parcel drop box enclosure. The user recipient is able to seamlessly use the mobile app to retrieve the parcel by unlocking the door of the parcel drop box. The smartphone mobile application developed using Flutter is also coded and can provide functions to the user such as add new tracking details and unlock the parcel drop box door.

6.5 Concluding Remark

The overall system can be implemented with the functions run smoothly. Even with the challenges faced, some time is needed to iron out the issues to make sure the features are implemented to meet the project objectives.

Chapter 7

Conclusion and Recommendation

7.1 Conclusion

The trend of e-commerce will be continuing an upward trend, and it will not be slowing down in this digital age. This is certain even after the post-pandemic lockdown has eased where people are back to office and outside of their homes, but the lifestyle of e-commerce purchases are still embedded in their lives. Recipients of parcels will not be available to receive their parcel at their delivery address. The courier delivery personnel will have to throw the parcels into the delivery address compound to prevent theft of parcels if placed outside the house but will be risking damages of the items in the parcels. The implementation of a Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System in recipient's housing gate can ease the courier delivery personnel's worry of the parcel being stolen and being damaged.

The parcel drop box system will have authentication features to ensure that the correct parcels are being placed inside the parcel drop box to prevent mistakes by the courier delivery personnel to drop the wrong parcel into the parcel drop box. The authentication feature of the parcel will be authenticated by scanning the QR code of the parcel AWB that is the tracking number of the parcel. The recipient of the parcel will need to input the tracking number of the parcel that is being delivered into the smartphone application that will be developed. The smartphone app will also enable the recipient to unlock the solenoid lock of the parcel drop box remotely to retrieve the parcel.

7.2 Recommendation

To further improve the residence parcel drop box project, suggested is add more user friendly features in the mobile application such as provide live tracking details to the incoming parcel and add push notifications to the mobile application to notify where are the status and location of the incoming parcel. To add value to the parcel drop box enclosure design, the Raspberry Pi module, wires and also external components should be enclosed in a casing to hide the wires.

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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|--------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 1 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Light research on the development of the mobile application

2. WORK TO BE DONE

Mobile application development and system integration, set up firebase database

3. PROBLEMS ENCOUNTERED

None

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

TEOH

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|--------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 2 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Watch videos tutorial on mobile development using Flutter

2. WORK TO BE DONE

Mobile application development and system integration, set up firebase database


3. PROBLEMS ENCOUNTERED

None

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

TEOH
Supervisor's signature


Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|--------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 3 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Study Mobile app Flutter tutorials

2. WORK TO BE DONE

Mobile application development and system integration, set up firebase database

3. PROBLEMS ENCOUNTERED

None

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

TEOH

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|--------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 4 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Study Mobile app Flutter tutorials

2. WORK TO BE DONE

Mobile application development and system integration, set up firebase database


3. PROBLEMS ENCOUNTERED

None

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

TEOH
Supervisor's signature


Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|--------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 5 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Set up firebase database

2. WORK TO BE DONE

Reports. Integrate firebase database with mobile app and parcel drop box system.

3. PROBLEMS ENCOUNTERED

None

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

TEOH

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|--------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 6 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Integrate the parcel drop box components together.

2. WORK TO BE DONE

Reports. Integrate firebase database with mobile app and parcel drop box system.

3. PROBLEMS ENCOUNTERED

None

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

TEOH

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|--------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 7 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Integrated the parcel drop box system

2. WORK TO BE DONE

Debug the parcel drop box code which is integrated.

3. PROBLEMS ENCOUNTERED

Parcel Drop Box code beings error and unexpected output.

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

TEOH

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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|--------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 8 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Debug the parcel drop box code which is integrated.

2. WORK TO BE DONE

Reports, System integration if the parcel drop box system to firebase database.

3. PROBLEMS ENCOUNTERED

None

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|--------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 9 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Integrated part of the parcel drop box system to firebase database

2. WORK TO BE DONE

Reports, mobile app page such as new tracking and profile page

3. PROBLEMS ENCOUNTERED

None

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|---------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 10 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Integrated parcel drop box system to firebase database.

2. WORK TO BE DONE

Find out how to retrieve Firebase database from flutter and python

3. PROBLEMS ENCOUNTERED

Firestore difficult to retrieve and send data

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|---------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 11 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Mobile app page such as new tracking and profile page

2. WORK TO BE DONE

Reports

3. PROBLEMS ENCOUNTERED

Firebase difficult to retrieve and send data

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work



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FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|---------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 12 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

Report started, firebase bug on Flutter fixed

2. WORK TO BE DONE

Reports and clean up minor bugs for the mobile app

3. PROBLEMS ENCOUNTERED

Firebase difficult to retrieve and send data

4. SELF EVALUATION OF THE PROGRESS

Need to keep up the work

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Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

| | |
|---|---------------------------|
| Trimester, Year: Trimester 3 Year 3 | Study week no.: 13 |
| Student Name & ID: Tan Kah Hsing 19ACB02797 | |
| Supervisor: Mr. Teoh Shen Khang | |
| Project Title: Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System | |

1. WORK DONE

The mobile app development and the parcel drop box system is done.

2. WORK TO BE DONE

Test the whole process flow of the system, complete reports.


3. PROBLEMS ENCOUNTERED

Some minor bugs that have been fixed.

4. SELF EVALUATION OF THE PROGRESS

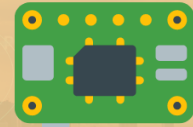
Need clear up reports as soon as possible.

TEOH
Supervisor's signature


Student's signature

POSTER

Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System



Project by: Tan Kah Hsing

Project Supervisor: Mr Teoh Shen Khang

Introduction

To design a prototype of a parcel drop box for residential use which is simple to operate by the courier delivery personnel to drop off the parcel into the parcel drop box and to be seamlessly used by the recipient of the parcel to retrieve the parcel.

Objectives

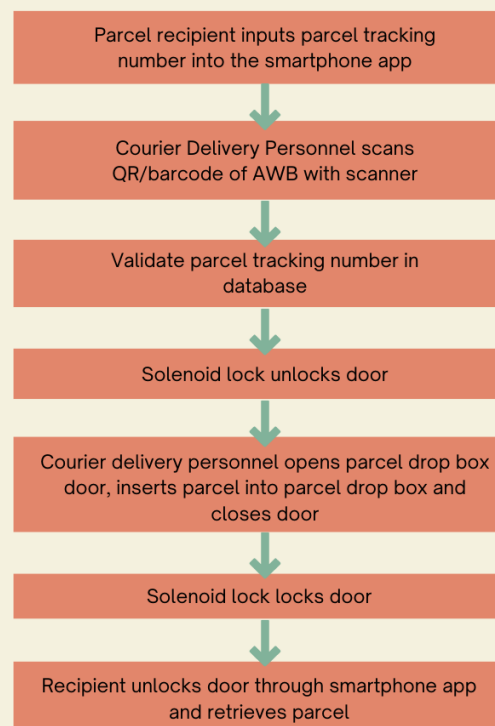
- 01** Develop a prototype of parcel drop box for residential use.
- 02** Develop a system to authenticate the parcel to unlock the parcel drop box.
- 03** Develop a smartphone application for the recipient to control the parcel drop box.

Discussion

How does this project be beneficial to the user?

- Reduce risk of parcel theft.
- Reduce damage of parcel to external environmental elements.
- Ensure parcel is delivered safely by the courier delivery service.

General Flow



Conclusion

At the end of the project, the parcel drop box system can be implemented in residential households for courier delivery staff to deliver the parcel safely to the address when the recipient is not at home.



Faculty of Information and Communication Technology
Universiti Tunku Abdul Rahman, Kampar campus

PLAGIARISM CHECK RESULT

placed into. The courier delivery personnel can unlock the parcel drop box by scanning with the tracking number QR code or barcode printed on the AWB.

1.3 Project Scope and Direction

For this development-based project, a prototype of a residential parcel drop box system will be built. This project is to solve problems faced by e-commerce shoppers and courier delivery personnel. E-commerce shoppers will have trouble receiving their parcels when they are not present to collect the parcels when delivery is scheduled. A box with an opening door at the will be built for easy access to the insides of the parcel box enclosure. The scope of the prototype is restricted to only 1 unit of parcel at a time due to the size of the enclosure box.

The parcel drop box will also have authentication features to validate which parcel can be put into the parcel drop box via unlocking solenoid lock. Additionally, an QR code or barcode scanning system will be implemented using a scanner module for the courier delivery personnel to scan the parcel to drop off to the parcel drop box. The process for the courier delivery personnel to drop off the parcel will be automated and will not involve the user to unlock the opening door to drop off the parcel. Moreover, a user-friendly Android smartphone application will also be developed using React Native framework. The smartphone application is designed

for the user to unlock the front door of the parcel drop box by enabling the solenoid lock, input the tracking number of the receiving parcel that is being used for the authentication of the incoming parcel and to track the delivery status of the incoming parcel.

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| ID Number(s) | 19ACB02797 |
| Programme / Course | BACHELOR OF INFORMATION TECHNOLOGY (HONOURS) COMPUTER ENGINEERING |
| Title of Final Year Project | Residence Parcel Drop Box with Multi-layer Authentication using Cyber Physical System |

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TEOH

Signature of Supervisor

Signature of Co-Supervisor

Name: Teoh Shen Khang

Name: _____

Date: 28 April 2023

Date: _____



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(KAMPAR CAMPUS)**

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