

Capstone Project Final Report

Digital Receipt Mobile Application

by

Law Wen Jun
(19033109)

Bachelors (Hons) of Software Engineering

Supervisor : Dr Chin Teck Min

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Student : Law Wen Jun
Supervisor : Dr Chin Teck Min

Abstract

This document encompasses all the planning and design documentation of the Digital Receipt Mobile Application. This application was designed to be a vendor-neutral and easy-to-use, digital solution to reduce and ultimately cease the usage of paper receipts by enhancing the user experience and convenience at the checkout whilst saving costs for shop owners and reducing environmental impact.

The work done in this document includes researching prior work done in this area, existing solutions and their weaknesses, detailing a development methodology with a system development plan, comparing the implemented interface to its prototype, several types of testing on the system and lastly results and discussion of the project compared to the original goals stated in Capstone 1. With the above work carried out, the reader can have a general idea of the application in terms of its goals, visuals and functionalities and this document can compare how well the deliverables met the goals and objectives stated in the first planning document.

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1 Introduction

This section discusses about what makes up a receipt, the usage of receipts, its pros and cons, and how it impacts the environment. Then, the problem statement would be identified which will then lead to the identification of the project's aim, objective, and scope. This section will kickstart the project and be the initial point on which the project is based and where future development will stem from. Finally, a figure which tabulates the timeline and outcome of the system would be presented in this section to have an overall view of the system.

Background

According to the Cambridge Dictionary, a receipt is an object proving that money, goods, or information has been received. [1] Its main function is to act as proof of purchase, acknowledging that a person has received payment (in form of cash, property, or other forms of payment) following the sale of a product or provision of a service. The term “receipt” is sometimes used interchangeably with the term “tax invoice”.

Since the implementation of GST in 2015, the Malaysian Customs mandated the issuance of receipts for several categories of vendors. [2] These include mini markets and grocery stores, coffee shops, pharmacies, bookstores, and entertainment centres. The receipt provided must be printed via computers that comply with the GST Act requirements. It is also mandated that hand-written receipts will not be permitted for all registered categories.

While there is no international formal definition of what the content of a receipt must contain, according to the Royal Malaysian Customs Department, tax invoices must contain the following [3]:

1. The words “Tax Invoice” in a prominent place
2. Invoice serial number
3. Date of issuance
4. The name (or trade name), address, and GST identification number of the supplier
5. The name and address of the recipient of the supply
6. Description of goods and/or services supplied
7. The quantity or volume of the goods and/or services supplied
8. Any discount offered

9. Total amount payable excluding tax, the rate of tax and total tax chargeable shown as a separate amount
10. Total amount payable including total tax chargeable

The pros of receipts or in this context of the discussion, more specifically printed receipts, are generally a subset of its functions. That is to say, receipts do not have inherent pros other than serving the function that it is designed for. With that in mind, the functions of receipts can encompass a few aspects. First of all, a receipt is a formal proof of purchase that can be used to verify the authenticity of a trade of goods or services. This means that a receipt with all its contents is enough to prove that the customer has made a payment in exchange for some goods or services, hence it is also the basis of most exchange or return policies. Next, a receipt is used to inform the customer about the tax that is collected on behalf of the government from that exchange of goods or services. It shows the rate of tax, the total amount before tax, the total amount of tax collected and the final total amount payable. This ensures that no hidden fee is collected under the guise of tax and that the amount of tax collected is justified properly. A receipt may also contain promotional components placed by the retailer such as discounts for the next purchase, advertisements, or other content but these are not considered part of the formal receipt. Lastly, for the customer, the receipt serves as a reminder or a document that can be kept for budgeting or archival purposes.

Problem Statement

Moving on to the cons of printed receipts, the most obvious one is the fact that printing receipt uses paper which is harmful to the sustainability of the planet. According to a report in 2018, paper receipt production in the United States alone contributed to the felling of over 3 million trees, 9 billion gallons of water and the emission of 4 billion pounds of Carbon Dioxide each year. [4] Moreover, some of the thermal paper used in receipts contain a chemical called BPA (bisphenol A) which is used for its heat-resistant properties. [5] While small traces of exposure to BPA is not expected to cause severe damage to the human body, long-term exposure to BPA can lead to prostate and breast cancer and is found to be contributing factor to reproductive problems and autism. All of this means that the environmental impact of the little piece of paper can add up and cause considerable harm to not just the environment, but also human health. While there is BPA-free thermal paper available, this does not solve the environmental impacts of paper receipts. Irresponsible people may even litter or improperly dispose of receipts which costs taxpayer money to clean up and also affects the beauty and image of the city.

Moreover, the usage of paper receipts involves the logistics of shipping, storing and also filing the receipts, which adds an extra layer of manpower, and potential greenhouse emissions to this inefficient method. There is also the cost of needing a printer and also the recurring cost of buying thermal paper. That is not to mention the weaknesses of keeping receipts physically, which include fading and illegibility after exposure to water or friction, and wear over time. This could mean that a product which will long outlast the receipt could face problems when handling warranty claims, as the receipt is usually the proof of purchase and if it is illegible, then disputes may arise, slowing down the overall after-sales experience.

While digital receipts are not new, most of their implementations are vendor-specific, which is a lot of hassle for consumers as they need to install an app for every vendor, they visit to get their receipts. This is an unsustainable method as the user's phone storage would quickly be bloated with a myriad of apps, an example of such an application is "Setel" by Petronas. [6] While it has other extra features like points redemption and e-wallet functions, the digital receipt function requires a more universal solution that is vendor-neutral. Much like how the "MySejahtera" application unified the contact tracing application nationwide in lieu of state-specific ones like "Selangkah", this mobile application aims to do the same for receipts.

Aim

This project aims to develop a universal mobile application that is capable of wirelessly transmitting receipt data, digital storage of such receipts and ease of use functions that assist users in archiving and exporting the receipts while enhancing user experience. This mobile application will have an accompanying companion application that is capable of generating receipts and sending the information in a realistic manner.

Objective

The objective of this project includes reducing the environmental impact of printed receipts and also helping to innovate and improve the handling of digital receipts. To achieve the aims stated, the following objectives are proposed:

- To investigate how to implement a vendor-neutral digital receipt solution with ease of use and good UX.
- To design the proposed application based on gathered requirements.
- To develop and test the proposed system.
- To evaluate the effectiveness and functions of the system.

Project Deliverables

The Digital Receipt Mobile Application has two parts, one being the emulation of the POS System to generate receipt and upload it to a database; the second part is the actual user application with the functions. Starting with the companion application, it is designed to emulate the POS System, so it has stores (currently developed with three: Adidas, Apple, and McDonald's), that each have unique items with different components such as tax, discounts, prices, descriptions and so on. After that, the companion application is capable of previewing the receipt, checking out with a payment type, then uploading the receipt to the cloud database automatically after the checkout process, and lastly showing a QR code containing the receipt's identifier.

Then moving on to the user application, a user can scan said QR code to link the receipt to their account's receipt storage in the database, and then it will show the receipt to the user. Additional functions to aid in managing receipts digitally include search and filter of receipts, bookmark functions, auto-delete of receipt, export function and some UI/UX feature such as dark mode. The application is designed to be easy to understand, user-friendly and aesthetically pleasing to use while being accessible by accommodating the users' preference for dark or light themes.

Conclusion

Throughout 14 weeks, utilizing Adaptive Software Development methodology to quickly iterate, learn and develop the application, Digital Receipt Mobile Application was able to come to fruition. Starting with the initial plan, requirement gathering, and problem identification following literature

review and several iterations, the foundation and plan of the application were laid out in Capstone Project 1, thus allowing for easier development with proper planning in place.

One of the main technologies used was React Native, a JavaScript library designed to allow developers to make applications regardless of platform and OS restrictions, using a single codebase. It is lightweight and extremely modular, with a myriad of third-party libraries available for almost everything. This made it easy to include just what is needed for the project, without being bogged down with useless libraries that are not needed. As for the backend, Firebase is a Database-As-A-Service, which is an online database that has several functions such as authentication and online analytics, which allowed wireless communication and transfer of data that would otherwise require users to be in proximity to transmit the receipt data.

Testing was carried out after each iteration, the finished module was tested to ensure it is functioning, and after a major milestone, an integration test with regression test was carried out to ensure the entire system functions properly as a whole with the interfaces working as intended, while the previous modules did not have any defects introduced as a result of the iteration. Once the application was complete, a system test was carried out on both the companion app and the user app to check that the application can perform the user flow from start to finish, thus accomplishing the functional requirements stated. Lastly, the User Acceptance Test was conducted with participants that have never used the application before to gather objective feedback and satisfaction ratings.

After the evaluation, it can be proven that the Digital receipt Mobile Application has managed to achieve its objective of developing a vendor-neutral digital receipt solution with ease of use and good UX. This will help the adoption of digital receipts, saving emissions from manufacturing, transportation and waste of paper receipts and help fulfil the Sustainable Development Goals (SDGs).

2 Literature review

Past literature based on digital receipts

In this section, I analysed the past work done on digital receipts and compare the difference in goals and problems faced in the past as times have changed.

2.1.1 “Digital Receipt System Using Mobile Device Technologies” [7]

This paper was originally written back in 2008 and thus many of the views on technology and devices are outdated, nonetheless, some information can still be gathered from this article, especially on the early days of receipt digitalization and which methods managed to gain traction.

The paper first starts by defining what a “digital receipt system” is by saying it consists of 1) an XML schema that is the basis of the paperless receipt and 2) the ability to perform data warehousing and data mining on those receipts. While the first part is still relevant, the second definition in this current day and age raises privacy concerns amidst the age of data misuse concerns and monetization of big data without the consent of the data owner. The paper then goes on to introduce mobile phones which are mainly PDAs and “flip-phones” back then instead of the now ubiquitous smartphones.

Moving onto the comparison of digital receipt systems that existed back then, there were mentions of three systems:

- a) Infor

This method needs the user to fax or scan the receipts that contain a unique bar code which will then be linked with the server. Once linked, the receipt will be available for auditing online. The obvious caveat of this system is that it is not paperless and while the reported benefit of “significant efficiencies from reduced mailing costs, improved accountability, and a more streamlined auditing and approval process” does apply, albeit in this day and age one can do so by omitting the paper scanning entirely and using a fully digital format to transmit the receipt data.



Figure 1.1: The scanning and filing of corporate expense receipts using the Infor system.

b) NeatReceipts

The second method discussed in the paper includes a scanner device accompanied by a “Scanalizer” software which uses Optical Character Recognition (OCR) software to extract the information on the receipt which will then be input into any money management software. This system is IRS approved thus scanned receipts are allowed to be used as proof of purchase, it was initially targeted at business travellers but was then later sold to individual consumers as well who want to organize their purchases into a money management software.

By critically analyzing it, it was a “gimmicky” method to digitalize receipt at best, since it uses OCR technology which requires the paper-based receipt to be legible at the time of scanning. It also means that if the receipts utilize a different design or format, they will not be easily recognized. Compared to modern alternatives which do not require the user to bring around a scanner and plug it into a computer (presumably via a USB interface), it is obvious why NeatReceipts’ solution did not become widespread today.



Figure 1.2: NeatReceipts system to scan and digitalize receipts.

c) AfterBOT, Inc.

The last method was introduced for Smart & Fine Stores Inc, a warehouse grocery retailer based in California. Along with the Association for Retail Technology Standards (ARTS), the company lead a collaborative effort to increase the adoption of the Digital Receipt Schema released by the ARTS IXRetail Group in early 2002. This solution was reported as “the first to give customers the ability to securely view their receipt details” which included registration, rebate information, customer feedback as well as the product warranty and targeted promotions from the retailer’s website.

Qty	Description	Price	Ext. Price
1	Amana Microwave Oven - [305160]	\$354.00	\$354.00
1	Dishwashing Gloves - [100270]	\$2.33	\$2.33
1	Bouillon Spoon - [110339]	\$8.33	\$8.33
1	Bake and Roast Pan - [128340]	\$10.28	\$10.28
1	Bar Blender - [113370]	\$84.95	\$84.95
		Subtotal:	\$459.89
		Tax:	\$32.19
		Shipping:	\$10.00
		Total:	\$502.08

Powered by AfterBot, Inc.

Additional Services:

- [Check Warranty](#)
- [Register Product\(s\)](#)
- [Check Rebate\(s\)](#)

Customer Survey

Thank you for your support
The promotions below are offered directly to you by Amana. Just Click and Go.
www.amana.com

15% off

\$30.00 off rebate

Figure 1.3: AfterBOT’s online ReceiptPLUS™ interface.

Judging from the looks of this solution, it is most likely that modern digital receipt systems have evolved or at least drew inspiration from this system. The addition of ease-of-use functions that extend beyond what a paper receipt can accomplish and add interactivity to a digital receipt was a novel idea back then and is a pro compared to the other two methods.

The paper then moves on to discuss the implementation of Bluetooth for file transfer and define the XML schema of a digital receipt. While using Bluetooth is certainly a possibility, even by today's standards, it is much slower than QR in the sense that pairing Bluetooth devices will require users to authenticate and establish a connection to presumably the POS device to then receive the file. Whereas QR will only require that the user turns on the camera module on the phone and then scan the QR code with the camera to receive the digital receipt. The XML schema is interesting as it is still a digital format that is still in use today, albeit with more popular alternatives such as JSON are used the majority of the time. The basis of the schema does not change much thus it can be referred to when structuring the data of the digital receipt for transmission.

2.1.2 “Case study: A digital solution to receipts” [8]

While not an academic paper, this case study was carried out by UX designer Shreyansh Singhvi and published on Medium.com in 2021. While this case study focuses on building wireframes and UI elements rather than a full-fledged software solution it can be seen that there are still plenty of insights to be gained.

The author began with the design thinking process of “Empathize, Define, Ideate, Prototype & Test”. While the author initially started with a problem statement of “Design a solution to help users better manage receipts for their electrical appliances so that they can avail warranty, etc.”, after conducting secondary research, market studies and user research, the author redefined the problem statement to better match their findings: “Designing a comprehensive digital receipt system that works as a practical and viable alternative to paper receipts and ensure better management of receipts & transactions”.

Design Thinking Process

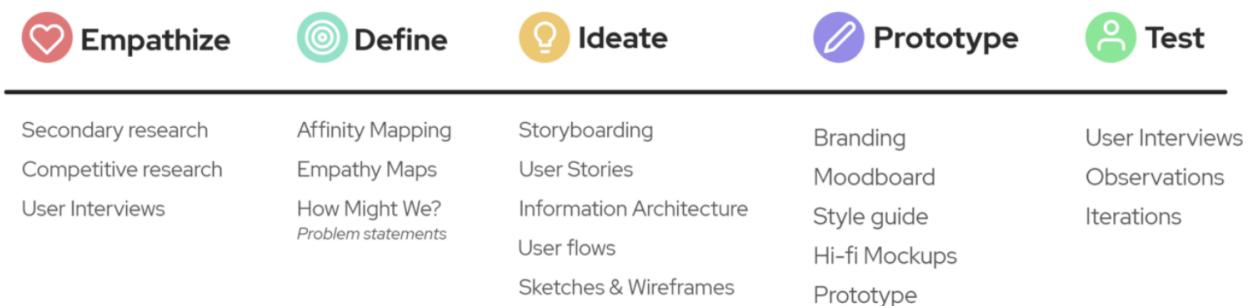


Figure 2.1: Design thinking process of Empathize, Define, Ideate, Prototype & Test.

After the empathize phase, the author began by defining the phase through affinity mapping and empathy mapping. The empathy map is particularly interesting as it summarizes the previous findings by putting the author into the consumers’ shoes by thinking, feeling, saying, and doing.

Think

- › Receipts are temporary
- › Receipts are difficult to store
- › Receipts save time
- › Most receipts are just rubbish

Say

- › Storing receipts are a mess
- › Bad for the environment
- › Warranty related receipts are stored
- › Not many digital solutions available

Feel

- › Paper receipts create trust and get the job done
- › Feel safer with receipts
- › Digital solutions should be there
- › Not completely satisfied with paper receipts

Do

- › Throws away most receipts
- › Only store receipts for warranties.
- › Click Images of receipts for storage

Figure 2.2: Empathy map produced by Shreyansh.

From the above image, we can see that most consumers perceive receipts as negative except for time saving and trustworthiness. This led to them throwing away most receipts with the exception of warranty receipts, even so, they will take pictures of them for storage rather than physically store them. Lastly, we can see the dissatisfaction with current receipt solutions and the want for a better digital solution.

This empathy map led to the last artefact of the define section, goals & “How might we...”. The goals are categorized and identified as such:

Table 1.1: Goals defined for development of solution.

User Goals	Environmental Goals	Business Goals
A better way to store & manage receipts	A solution to eliminate paper receipts	A digital way to generate receipts
An accessible solution for all ages	Ways to avoid the use of paper to keep records etc.	A practical & viable solution for store owners to adopt
A simple solution to transition into		A way to manage sales, entries and record keeping
Generate trust and safety		

“How might we...” is a list of potential methods to accomplish to goals and the author listed these: How Might We...

- Design a comprehensive digital receipt system to provide an alternative to paper receipts.
- Design a solution to help consumers better manage their receipts & transactions.
- Improve the checkout counter experience
- Create a solution for sellers to better manage & store their sales & entries.

Moving on, the author proceeded to the ideate and prototype stages which included storyboarding (which is similar to user stories in extreme programming), designing the solution, user flow and wireframes. The author then made high-fidelity prototypes for all the use cases which included the checkout, onboarding, view a receipt and seller interfaces.

Lastly, the author tested the prototypes with moderated interviews and gathered feedback for accessibility and visibility issues which was then used to make a new iteration. This cycle reminded me of agile methodologies, especially XP which has user stories, task-based iterations and so on. An example of the prototype produced is shown below.

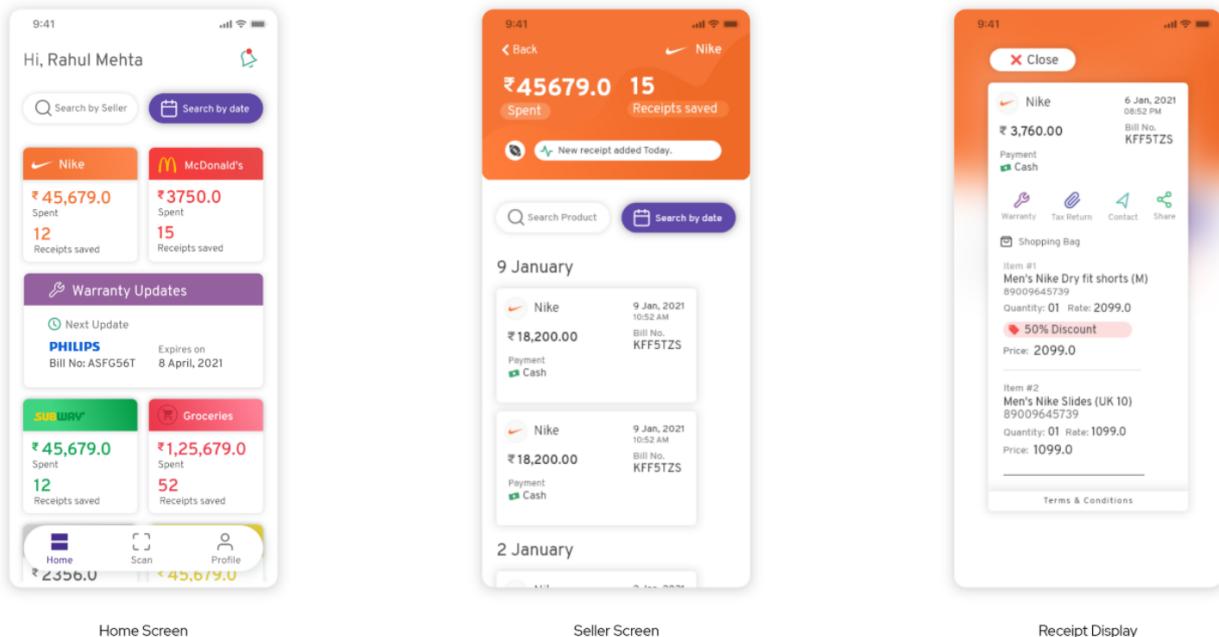


Figure 2.3: Shreyansh’s prototype of the UI produced for the QR digital receipt system.

Looking at existing POS receipt systems

In this section, I will be analysing the existing point-of-sale (POS) receipt systems currently in use at the majority of brick-and-mortar stores. Then, I will critically analyse and identify the problems presented by these technologies.

2.1.3 Point of Sale (POS) System [9]

Online search results yield a definition of a POS system as the “overall hardware and software system used for billing in store”. The site then proceeds to explain the difference between POS systems, hardware, software, and terminals. Since the system encompasses the entire software and hardware system, it includes printers, the display unit, a cash register, a POS terminal and occasionally a barcode scanner.



Figure 3.1: A complete POS System.

The POS Software is custom-built with additional functionalities for specific industries based on the basic POS software, such as those for hotels that will have additional functions for booking, room allocation and guest billing. Some POS software even runs on mobile devices like tablets and smartphones, minimizing the total footprint of the entire POS system.

The POS terminal on the other hand is a hardware device capable of accepting various payment methods. The most common types are credit card terminals which are provided by banks to scan and receive payments. Modern POS terminals can even detect NFC and contactless cards and additional payment methods such as Apple Pay, Google Wallet, Samsung Pay, or e-wallets such as GrabPay and Touch n Go e-wallet. Some terminals have a printer integrated to print receipts as well, these terminals are integrated with the POS software for faster checkout and to retrieve customer orders.

With all the POS terminologies and components identified, I will take a closer look at the printer for the receipt. Assuming that my implementation of the digital receipt system is made to work with POS systems, it should theoretically work with the rest of the system and only requires minor tweaks and removal of the thermal printer to be functional.

2.1.4 Point of Sale (POS) Thermal Printer [10], [11]

There are several types of thermal printers, most of which differs in connectivity. These printers are called thermal printers due to their design which uses no ribbon, ink, or toner, unlike traditional printers. The printhead applies pressure and heat directly to specialized thermal paper, which blackens to produce text or images. There are also thermal transfer printers which function by pressing a wax-coated ink ribbon (or ribbons if multiple colours are involved) onto the material surface, once the wax is melted by the thermal printhead, the ink is exposed and is left to dry on the printed surface. The benefit of a thermal transfer printer over direct thermal printing is that the ink is less likely to fade over time and that multiple colours can be used (assuming the printer supports it), however, the addition of ribbons and additional moving parts means replacement parts and maintenance is going to incur a greater cost.

A page on POSmarket.com.my which is a local distributor of POS Systems contains information on thermal printers specifically, and their different connectivity options. The most basic one is USB, which is a wired interface, the benefit to this is that the computer's OS will most likely automatically detect and install drivers for the printer, however it limits the placement to the length of the cable. Wireless options include Wi-Fi and Bluetooth thermal printers with Wi-Fi being more flexible when setting up the location of the printer while some Bluetooth printers are equipped with batteries to be used portably with mobile devices, allowing for a fully mobile POS System. Both wireless systems also allow multiple POS systems to share a single printer by multiple simultaneous connections, which is said to have become more popular recently in the F&B industry.

Based on CDW.com, thermal printers keep printing costs low as they do not require ink. They are also portable and convenient to bring on the go (the connectivity will be compared separately), they print faster than traditional printers and a thermal printer has fewer moving parts. The same website also lists the cons of thermal printers, which include fading of thermal-printed labels over time, direct thermal printing supporting one colour at a time, thermal-printed labels will turn black when exposed to high heat and lastly thermal printers cost more than traditional inkjet printers.

While the cons listed are true, they are not even close to covering all of the cons that these printers have, and the alternatives available. First and foremost, address most obvious problem is that thermal printers require thermal paper to function. These thermal paper as mentioned in the problem statement emits CO₂, uses a lot of water and contributes to deforestation to produce them. Not to mention older thermal paper uses BPA coating which poses health risks, although the newer thermal paper has since been BPA-free. For thermal transfer printing, the ribbon also presents another problem as it needs to be replaced along with thermal paper, which from a long-term standpoint means ongoing costs are going to add up which affects revenue. There is also a logistics problem when one considers that these woods need to be shipped around to be processed and the end product will need to be routinely delivered to each establishment with a thermal printer.

The legibility of receipts that fade over time has already been mentioned, but there is also the fact that filing these receipts is a challenge because they degrade when exposed to heat, which means that users need to take extra care to file something that is already a hassle. The printer's upfront costs which were mentioned by CDW.com means that it is more expensive to get it over a traditional printer, which might hamper a start-up's ability to purchase one. While the website states that each thermal head is rated for 10 years of endurance, other parts of the thermal printer may break down which poses maintenance costs, some even use proprietary parts which means if the company supplying the printer were to go out of business, the owners will need to find alternatives.

With all of that said, the simplest solution is to remove the thermal printer from the POS System “equation” and replace it with a digital system proposed for the most seamless and painless transition. To the business owner, it means less ongoing cost in the form of paper purchases or maintenance, and more customer engagement through digital receipt solutions (which will be discussed next), while for average joes who uses receipts, this system will remove paper waste, allowing for easy digital archiving of receipts with hopefully lesser time spent at the cashier for faster checkout and pleasant UX.

Comparing existing digital receipt solutions

In this section, I will be comparing multiple existing digital receipt solutions and analysing each of their pros and cons, a table to summarize the findings will be presented at the end of this section.

First of all, I took a look at local solutions in the form of the Setel app by Petronas which have a similar function embedded in it. The Setel app was introduced to provide a seamless and frictionless fuelling experience with cardless and cashless features, allowing customers the convenience of staying in the car.[12] This meant their reward card system with points, and a cashless and cardless payment system is integrated into the application. The function to be discussed happens after the fuelling session, which is the receipt and points summary that is shown to the user. This summary page shows a tax invoice that critically met a few criteria that makes it an actual “receipt”, which are the product description, quantity, total amount, tax amount and other information. This means that this is legally a receipt which is allowed to be submitted for claims and such, thus this should be the best solution to the aforementioned problems right?

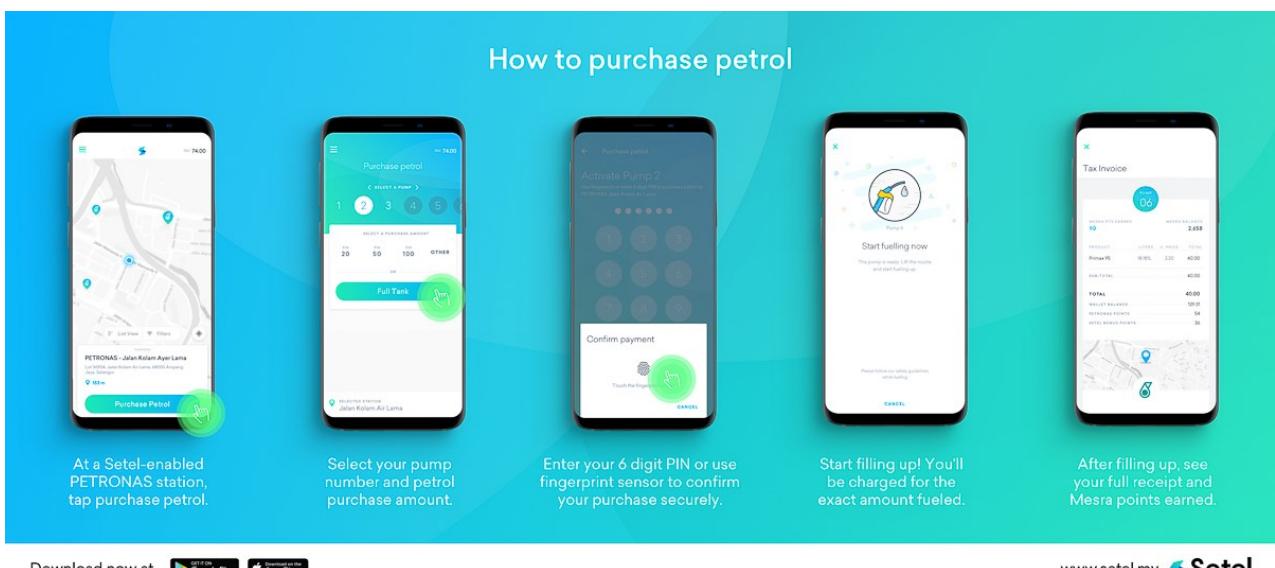


Figure 3.2: The user flow when fuelling with the Setel app.

While this may seem like the best and most “seamless” experience one can get with digital receipts, however, this is a vendor-specific solution, so while as seamless as it is, it is only convenient up to the point the customer walks out of the store, in which case the app becomes another dormant app that will sit and take up storage space, send countless promotional notification until it becomes useful again. Imagine for a moment, if a user were to install a vendor-specific app each time they walked into a store, their phones will be bloated in no time, with most of them being dormant most of the time. How often will you refuel your car at this specific petrol branch? Will the user go often enough that they care to install an app on their phone to save a few seconds on checkout and remove the

paper from the receipts? Unfortunately, from the UX perspective, the time and effort required to install a new app, fill out a sign-up form and login will seldom warrant the “potential benefits” of a few seconds saved, unless a financial incentive accompanies it, which even then this could not apply for every single merchant out there. (Think jewellery stores, clinics, optometrists and more).

If vendor-specific solutions are not feasible, then vendor-neutral solutions will do the job, right? I have compared a few existing solutions and what each of them does differently, and how my proposed solution has drawn inspiration and improved upon these existing designs.

TransactionTree employs a digital receipt solution that is more interactive via email receipts. [13] According to the website: “the act of e-mailing a customer’s receipt as the only action of the process leaves the customer experience as cold and distant as handing unnamed customers a piece of paper as their final act in the store.” Thus, TransactionTree aims to build a two-way relationship with each customer who opts into the program, allowing the marketing department to provide personalized content such as recommendations, repeat previous orders or low stock reminders for liked products.

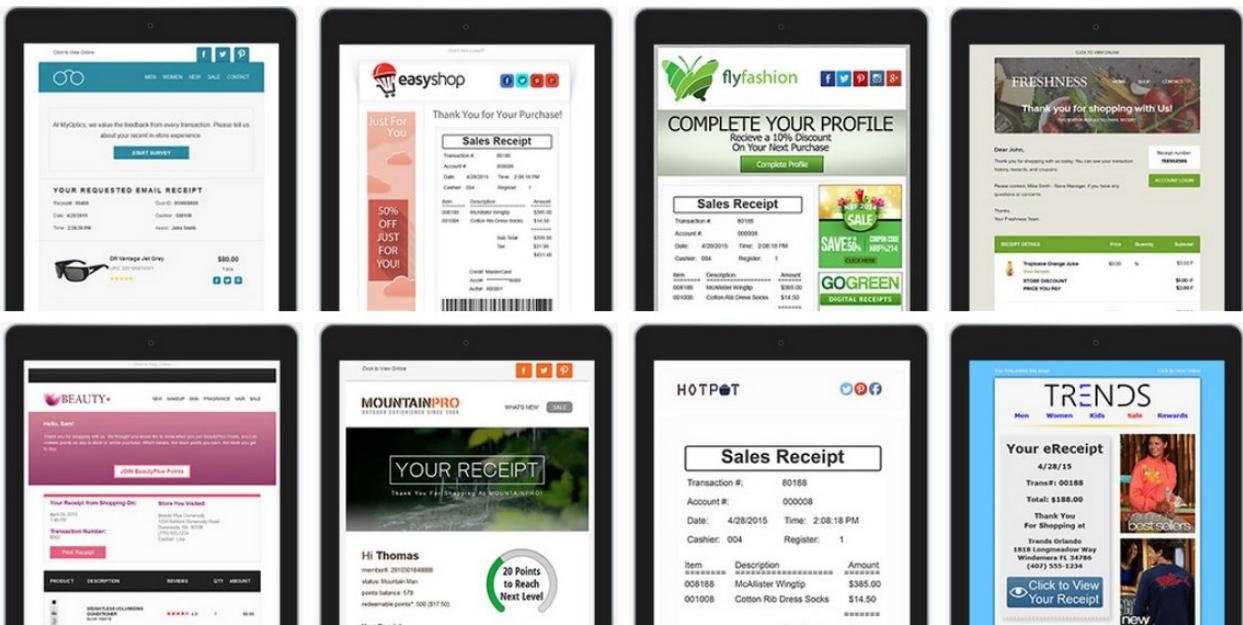


Figure 3.3: Example digital receipts provided by TransactionTree.

While this approach essentially turns receipts into a marketing tool, some might see it as annoying attempts from retailers to push them to make a purchase which might have the opposite effect. A digital receipt should just remain a digital receipt solution and not be meddled with by the marketing team as another advertisement channel. From the example templates provided in the figure above, these emails are not dissimilar to spam mail and advertisements that users might flag as junk mail.

While the above point is more of a preferential issue, the following problem is not, however. If one were to analyse the checkout flow of a user at a convenience store, a glaring problem arises: where does the cashier, POS system or even the store get the customer's email to send them the receipt? The most obvious point is after payment in which the customer will have to spell out their email to the cashier letter by letter which as you can imagine is not the quickest nor easiest checkout UX. There is also the privacy concern of giving out their email to random people just for the sake of a receipt, while some people do not mind, more privacy-focused customers will surely not agree to such an arrangement. Thus, while the idea proposed by this solution is novel, it is impractical for our goals of improving the handling of digital receipts.

Next up is the TOGO app, which is very similar to the proposed solutions presented thus far. The app is vendor-neutral with a very logical user flow and UX, the customer first makes the payment, as usual, then the cashier scans the customer's QR code in the app, and then the receipt will be sent over to the customer's TOGO app. If the customer links their payment channel to the app, they even get the receipt without the QR scan when the app detects real-time transaction data from the retailer's POS.[14]

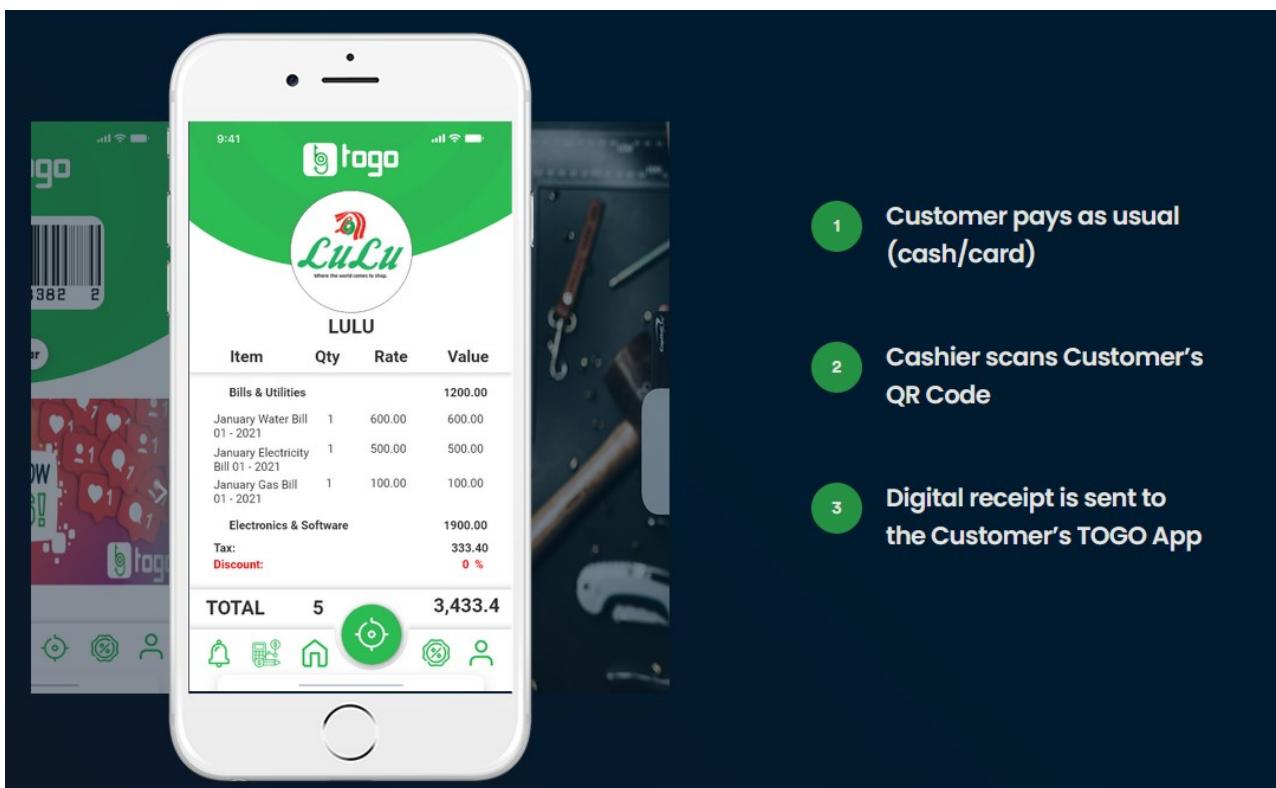


Figure 3.4: Example of a digital receipt provided by TOGO.

This is by far the best solution with a user flow that is intuitive, seamless, and effortless. The integration with seller POS to detect connected payment channels is the ideal scenario however it requires the user to link their payment methods which not all users are comfortable with. The app also requires users to sign up with an account beforehand and claims that “your privacy is our priority”, which contradicts its functions of “make the best use of your data and receive personalized offers” and “know the latest offer that really fit you” which implies that the user’s data is being used to map out spending behaviour so relevant offers can be shown, that means the user’s privacy is being exposed to third parties that are advertising their products and offers.

The last downside to the TOGO app’s implementation of digital receipts is the fact that the cashier will need to scan the QR code on the customer’s phone. Some customers are not comfortable with other people even looking at their phones let alone scanning them. For a more privacy-focused approach, the reversal will be more beneficial, where a device emits a QR code that the user can scan for the receipt. However, the size limitation of the data that can be embedded in a QR code, makes it impractical, especially for long receipts with a lot of items.

3 Methodology

To help solve the problem statement identified, this section identifies two methodologies: one for the project issue and another for the project development. The different methodologies used were discussed in detail, and the tools implemented by the system were also detailed in this section.

Project Issue Methodology

Based on findings from the literature review conducted prior, a few features are proposed to help digitalize receipts in a vendor-neutral, convenient, and privacy-centric manner. A literature review was carried out as it analyses past work and articles about related work done in this area, thus it gives insight into what to expect, the problems faced, and solutions used to solve those problems. With that knowledge, a proper solution can be identified with ease.

Following the literature review, the solutions were compared and the best solution that fits the criteria and objectives was chosen. Then, the list of requirements was generated from the literature review and problem statement. This became the basis on which the development was based and was the goal that the application was aimed at fulfilling. After this phase, the development cycle will begin with the methodology discussed in more detail below. This is accompanied by various testing, including unit tests for every module completion, integration testing and regression testing after each cycle and lastly system and user acceptance tests once the system is fully developed.

System Development Methodology

Adaptive Software Development (ASD)

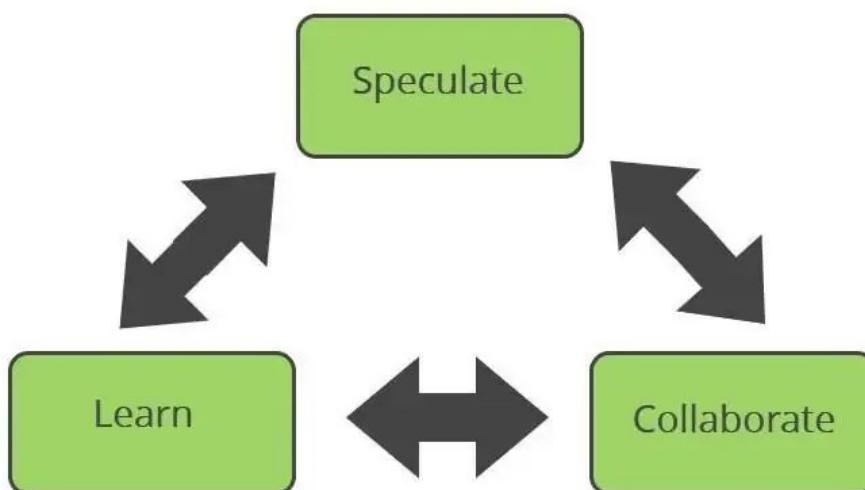


Figure 4.1: The Adaptive Software Development (ASD) iteration. [15]

The software development methodology chosen for this project is an agile methodology, more specifically the Adaptive Software Development (ASD) methodology. As agile methodologies are more popular recently and are replacing traditional waterfall methodologies, this is due to the agile manifesto and principles that are beneficial, iterative and embrace change. ASD was chosen specifically due to the speculate-collaborate-learn phases that suit this project.

In the speculation phase in ASD, it replaces the traditional planning phase as the term “planning” is often too deterministic and confident in the outcome, while “speculation” encourages experimentation and exploration, it allows room for change since there are plenty of unknown variables which was apparent when working with a software library and implementation that I have never worked with before. While the collaboration, phase focuses on teamwork among not just team members but the client, however, due to the unique circumstance of this project having no teammates nor clients, this phase has been adapted into the traditional and more generic “implementation and testing” phase of the SDLC. Last but not least the learning phase was where analysis and reviews were carried out to find room for improvement or identify and rectify mistakes, and the knowledge gained was carried into the following iteration, promoting a continuous learning culture.

Development Tools

a) Library (Language): React Native (JavaScript)

The mobile application will be developed using React Native which is a library based on JavaScript that is used to build user interfaces for Android and IOS devices. [16] This library is selected due to the fact it supports two platforms with one codebase, and developers can modify the platform-specific versions of components while the main UI is shared between platforms, saving time and effort. There are also extensions and libraries to React Native that can provide reusable components in UI design that will speed up and streamline the UI prototyping iterations as developers do not need to rewrite codes between iterations.

b) Integrated Development Environment (IDE)

The IDE used for this project is Visual Studio Code for writing code as it has many helpful extensions and it is well-documented and reliable. Expo CLI QuickStart is a set of tools built on top of React Native to fully allow native apps to be developed without needing to write native codes for each platform.[17, 18] There are two components to Expo, a CLI used to create projects, view logs and publish etc, while the Expo Client allows the app to be tested on a mobile device without needing to use XCode (for IOS) or Android Studio (Android) nor needing to build and send the .apk or .ipa files.

c) Database

For the database, Google's Firebase is selected as it is one of the most widely used online databases hosted by Google. [19] It is free for up to 1GB of storage which is ample for this project. Its built-in authentication helps secure the data to only allow access to permitted users and it is widely tested and integrated with React Native, making it an excellent candidate for an online database that is easy to develop and proven to work.

d) Version Control Software

Lastly, GitHub is selected as a version control software for this project. It allows the developer to rewind code in case of a catastrophic failure or as an online code repository if hardware failure were to occur. [20] The code review and pull requests encourage testing to ensure the code is as reliable as possible before merging into the main branch, this enhances code reliability.

4 Results

The following section details the work done during Capstone Project 2. Diagrams, charts and other documentation were included to aid in the explanation of the system's functionalities and architecture. The analysis of the functional and quality attributes were then discussed, followed by the system testing carried out at the end. Lastly, the complete UI of the system was documented and compared to the original prototype presented in Capstone Project 1.

System Requirements

While most of the system's requirements were similar to the ones stated in the Planning Document, there were some minor revisions as highlighted in the Activity Logs, thus the table below summarizes the system requirements and revisions (if any).

Table 2.1: Functional requirements revision.

ID	Original Requirements	Revised Requirements
F-01	Users should be able to save receipts on their devices.	Users should be able to retrieve receipts from an online database.
F-02	Users should be able to view receipts saved on their devices.	Users should be able to view receipts saved on the database.

F-03	Users should be able to retrieve receipts digitally via NFC.	Users should be able to retrieve receipts digitally via QR Code.
F-04	Users should be able to send receipts digitally from a POS system via NFC.	Users should be able to send receipts digitally from a POS system via QR Code.
F-05	Users should be able to export receipts to PDF format.	Users should be able to export receipts to their gallery in PNG format.
F-06	Users should be able to bookmark important receipts.	(No changes)
F-07	Users should be able to set auto-expiry of receipts.	(No changes)

In terms of quality attributes, there were a few that were identified and they were tabulated in the following table.

Table 2.2: Quality Attributes

	Interoperability	Usability
Source	System	End-user
Stimulus	Exchange of receipt data among system	User adjusting the application
Artifact	The sending and receiving systems	The user interface of the system
Environment	Runtime	Runtime
Response	The receipt is exchanged successfully in the predefined format	The user can adjust their preference in themes.
Response Measure	The success rate of the exchange of receipt is >99%.	User satisfaction with the theme of the system is higher than 3 on a 5-point Likert Scale.

4.1.1 Use Case Diagram

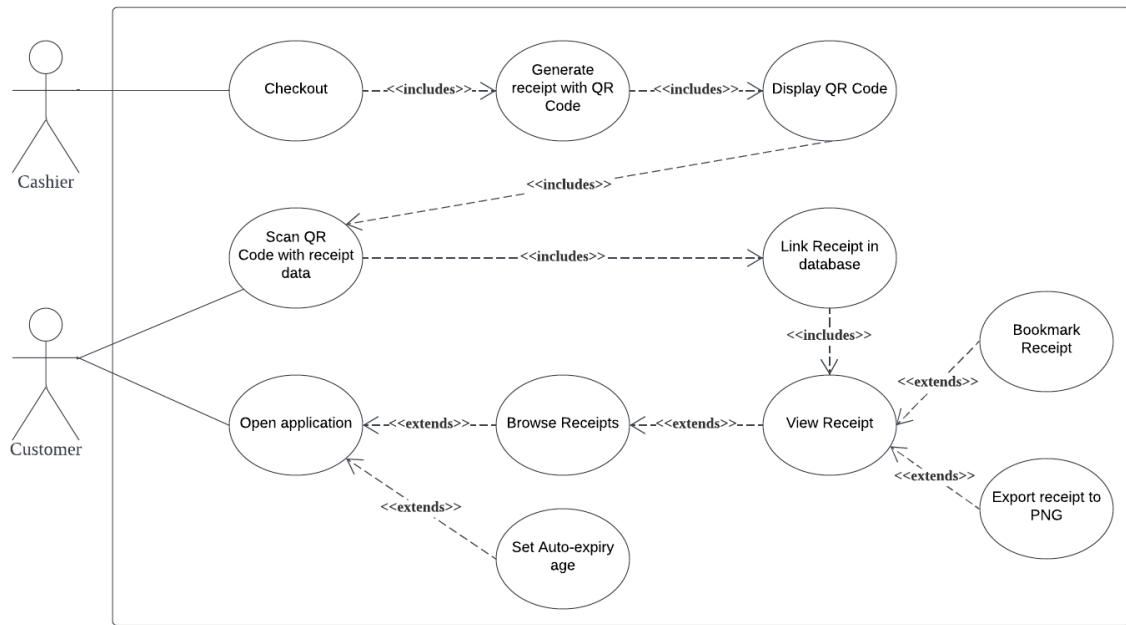


Figure 5.1: The Use Case Diagram for Digital Receipt Mobile Application (created with LucidChart)

From the above diagram, the system involves two users, the cashier and the customer, who are both involved in the user flow of a checkout occurring at a retail store. The use case first begins after the cashier has finished the checkout and confirmed all the goods or services that are being purchased. The cashier will then begin generating the receipt data which will then generate a QR Code containing the receipt's ID and display it to the customer. The customer will then scan the QR code with the mobile application to receive the receipt data which will then be detected and linked to the user's account in the online database. From there, the receipt will be displayed, and the user has the option to export it to PNG and bookmark the receipt.

If the user opens the app outside of a checkout scenario, they will be greeted with the list of receipts stored on their phone, and they can choose to open and view any of the receipts. The app will also have an options page which allows the user to set the auto-expiry age of receipts if they wish to do so.

4.1.2 Functional Requirement Table Specification

Table 2.3: Requirement specification for generate receipt function.

Generate Receipt feature	
Use Case Diagram	<pre> graph LR Actor((Cashier)) --- UC((Generate receipt with QR Code)) </pre>
Actor	Cashier
Trigger Event(s)	The user has completed the payment and checkout procedure
Precondition	<ul style="list-style-type: none"> • The POS System is connected to a display • The receipt data is ready and confirmed • Payment has been completed
Postcondition	<ul style="list-style-type: none"> • The display shows the generated QR Code
Main success scenario	The cashier has a POS System that has an external display, and it is plugged in. The cashier can click to generate receipt data once the payment is completed. Finally, the display will show the generated QR Code containing the receipt ID.
Extensions	<ul style="list-style-type: none"> • The external display is not turned on or connected. • The display is blurry, faulty or unable to clearly display the QR Code. • The POS System is not compatible with the display.

Table 2.4: Requirement specification for Scanning QR Code function.

Scan QR Code feature	
Use Case Diagram	<pre> graph LR Actor((Customer)) --- UC((Scan QR Code with receipt data)) </pre>
Actor	Customer
Trigger Event(s)	The user scans the QR code with the phone camera
Precondition	<ul style="list-style-type: none"> • The phone has a camera • The application is installed on the user's device • Camera permission is granted • The camera is functioning
Postcondition	<ul style="list-style-type: none"> • The application stored the receipt in the database • The application displays the receipt
Main success scenario	The user has installed the application on a compatible smartphone with camera functionality. The camera permission is granted in the device settings. Then the user scans the QR with the camera. After the scanning process, the application receives, parses and links the receipt data to the database. Lastly, the application retrieves and displays the receipt.
Extensions	<ul style="list-style-type: none"> • The phone's camera module is faulty. • The phone's camera function is turned off. • The application was not granted permission to use the camera module. • The user shakes the camera or the QR code is not clear. • The user exits the application.

4.1.3 System Design

In the following section, a system context diagram, data flow diagram and sequence diagram will be used to illustrate and describe the overall flow of information between different segments of the system. The system context diagram will show the high-level and abstracted flow of the system while individual sequence diagrams (and sub-diagrams) will show data flow in more specific features. A class diagram will also be used to show the receipt data structure in more detail.

4.1.4 System Context Diagram

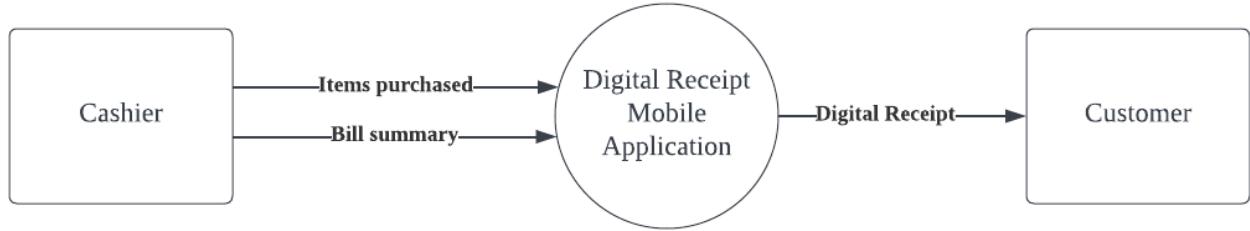


Figure 5.2: The Level 0 Context Diagram. (created with LucidChart)

4.1.5 Data Flow Diagram

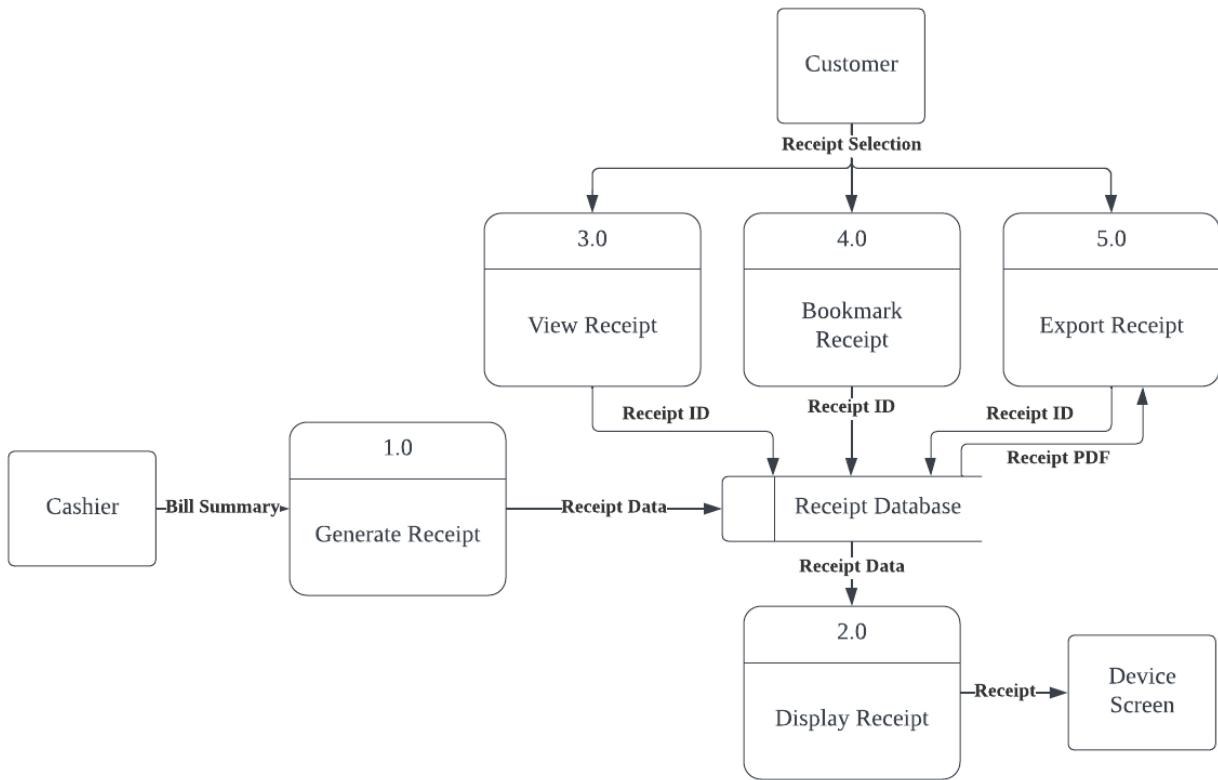


Figure 5.3: The Level 1 Data Flow Diagram. (created with LucidChart)

4.1.6 Main Sequence Diagram

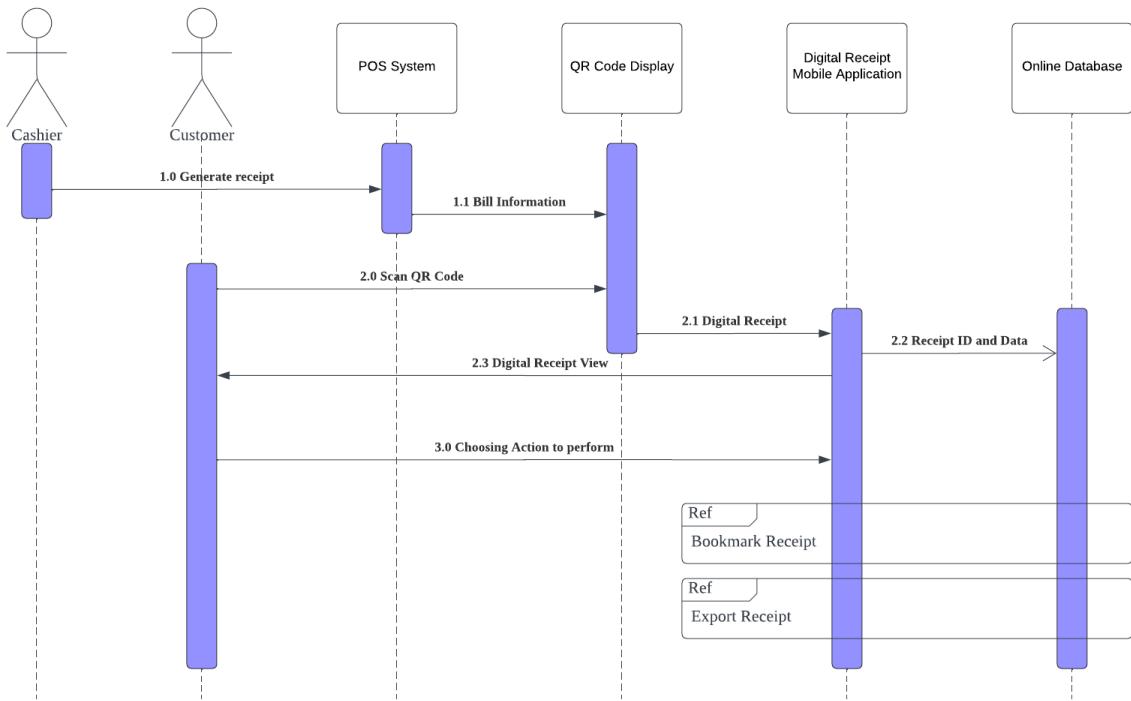


Figure 5.4: The main Sequence Diagram. (created with LucidChart)

Figure 5.5 above shows the revised sequence diagram of the Digital Receipt Mobile Application, which starts with the cashier who generates the receipt on the POS System. The POS System will use the checkout information and payment to generate the bill information which will generate a QR Code that is then displayed to the customer. The customer will then be able to scan the NFC signal to retrieve the digital receipt to the application installed on their phones. The application will detect the receipt data and automatically link it to the online database while simultaneously displaying the bill to the customer by retrieving it from the online database. From then on, the customer is free to close the mobile application or take further action based on their choice, the other features are explained in subsequent diagrams.

4.1.7 Sub Sequence Diagrams for View, Bookmark and Export functions

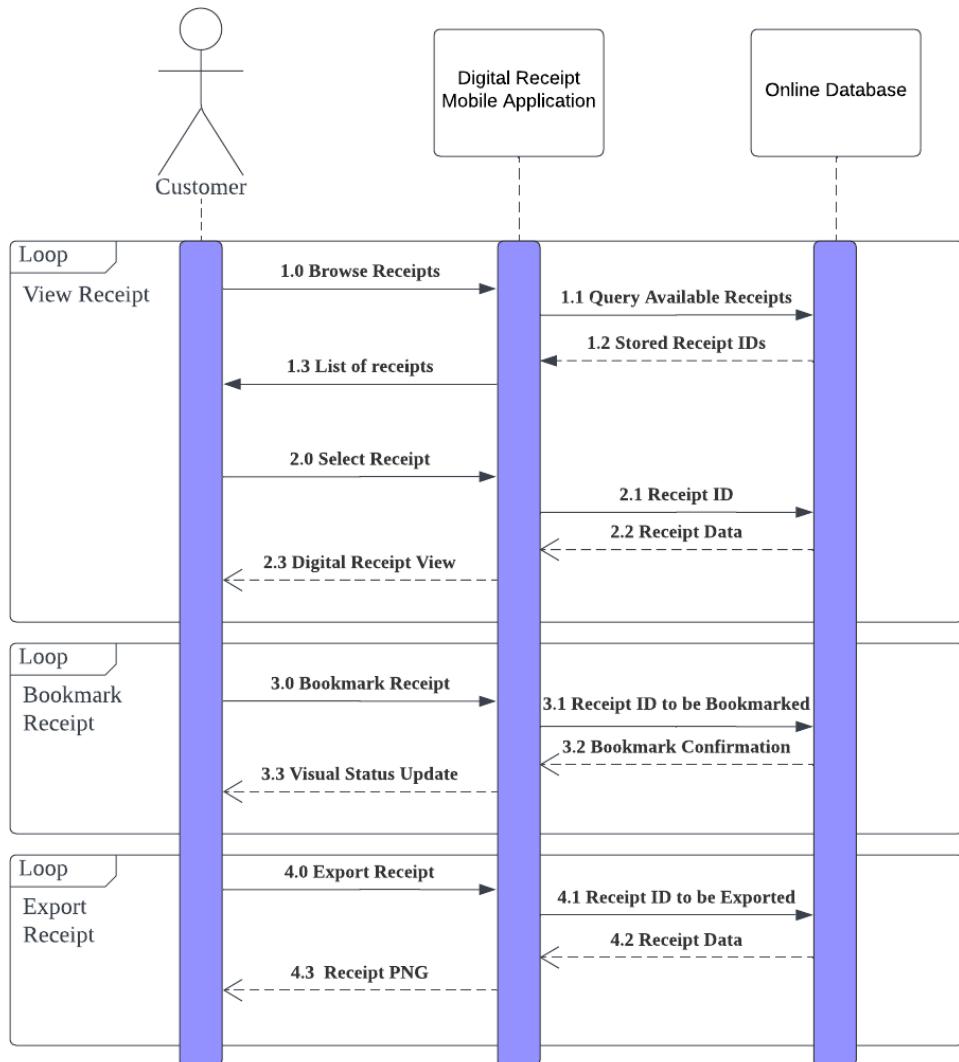


Figure 5.5: The Sub-Sequence Diagram. (created with LucidChart)

Based on Figure 5.6, the user can browse receipts within the application by starting the application which will then query the online database storage for any linked receipts and return them to the user's view in a list form. From the list of available receipts, users can select any of them to view in detail, which will send the receipt ID to query from the database and be returned with receipt data that is then parsed into a digital receipt view for the user to see.

The bookmark function can be used in the digital receipt view to bookmark a specific receipt. The receipt's ID will also be used to identify the receipt in the database and have the bookmark tag activated, a visual confirmation and update will be shown to the user. Whereas the export function

works similarly, using the ID to identify and retrieve receipt data which is then exported into PNG format.

4.1.8 Class Diagram

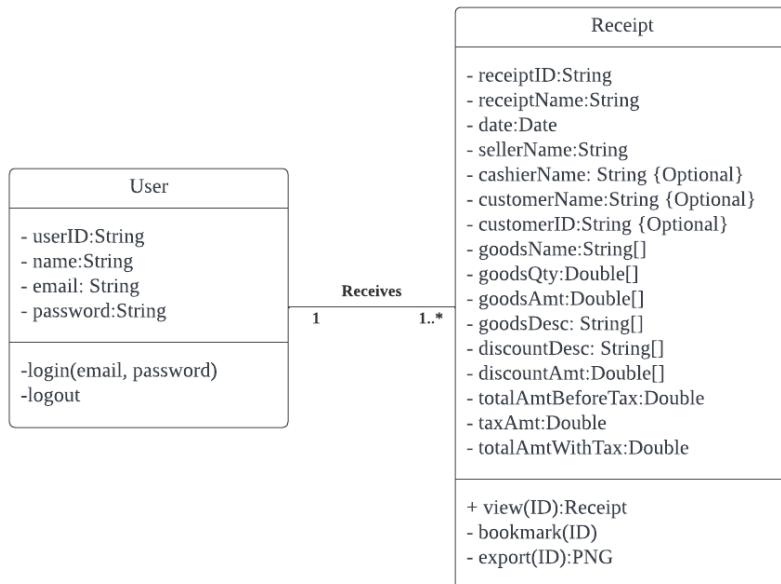


Figure 5.6: The Class Diagram. (created with LucidChart)

The Digital Receipt Mobile Application has a simple class structure, however, while it is simple, many variables need to be stored that constitute a receipt that is legally accepted, these variables must be stored and formatted properly such that they can be arranged and displayed later. Among these variables are receipt name, ID and date of issuance, seller information, optional customer information, a summary of goods or services sold, quantity and amount of goods, any optional discounts, and total before and after tax. The three functions relate to the previously mentioned view, bookmark, and export receipts.

In the implementation of the system, the Cashier class was omitted as the companion application does not require a user login to function. Thus, the receipts can be generated and will automatically be uploaded into the temporary storage in the online database, by passing the need for a Cashier class in the system. Other than that, the rest of the class diagram was adhered to rather closely with some modifications to the class attributes in the receipt that were not needed.

User Interface

The following section shows the mock-up or the prototype of the application's UI designed in Figma, compared to the implemented views of the application on an Android Emulator. There will be light and dark versions of each page for user preference and enhanced UX. Access to view the Figma project and also to use the interactive prototype is available at:

<https://www.figma.com/file/wMUGsbHqbt7h7wIxtezw/CP1-Draft?node-id=0%3A1>

User Interface Mockup	Implemented User Interface
	 <p>Welcome</p> <p>Transforming Digital Receipts one at a time.</p> <p>Login</p> <p>Sign Up</p>

Figure 6.1.1: Landing Page

Figure 6.1.2: Landing Page Revision

The only revisions were the buttons to include the login and sign-up pages.

(None)

← Login

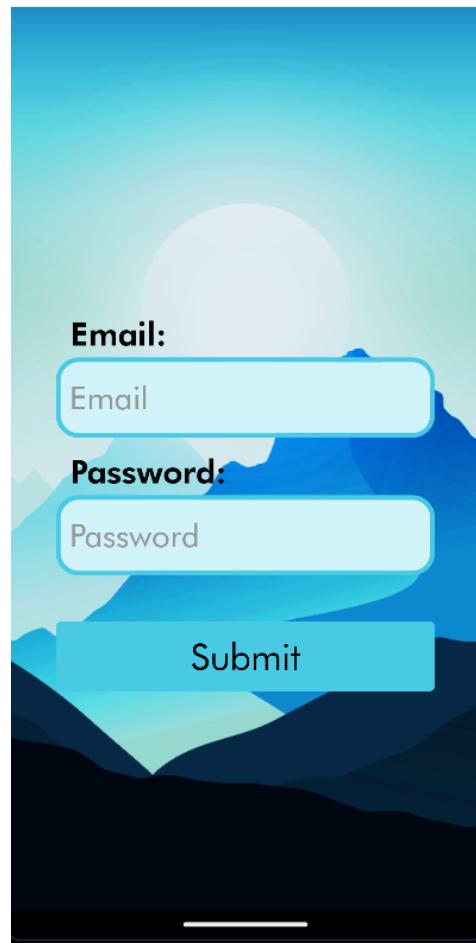


Figure 6.2: Login Page Implementation

The addition of a login page that is powered by Firebase's Authentication API.

(None)

← Register

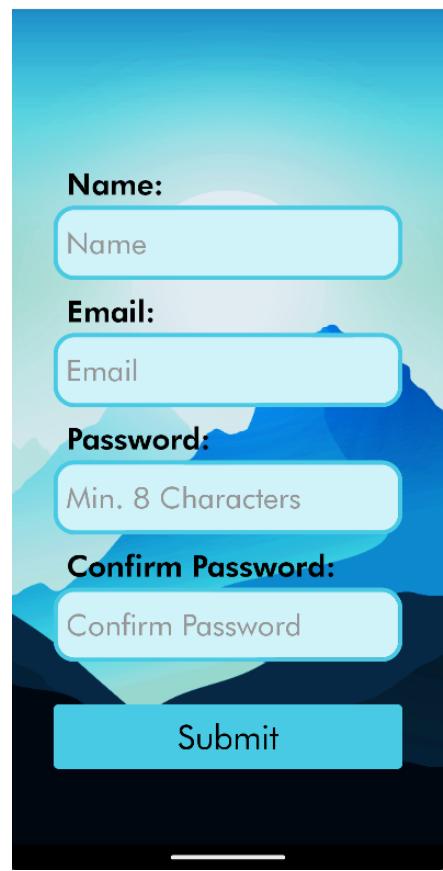


Figure 6.3: Sign-up Page Implementation

The addition of a register page that is powered by Firebase's Authentication API, complete with error checking.

Receipts

Search Name

M Lorem Ipsum RM 1234.67 7 Jul 2022

Bookmark Home Filter

Receipts

Search Name

Adidas
RM 400.00 10 Nov 2022

Apple Inc.
RM 152957.80 10 Nov 2022

McDonald's
RM 8.10 10 Nov 2022

Bookmark Home Filter

Receipts

Search Name

M Lorem Ipsum RM 1234.67 7 Jul 2022

Bookmark Home Filter

Receipts

Search Name

Adidas
RM 400.00 10 Nov 2022

Apple Inc.
RM 152957.80 10 Nov 2022

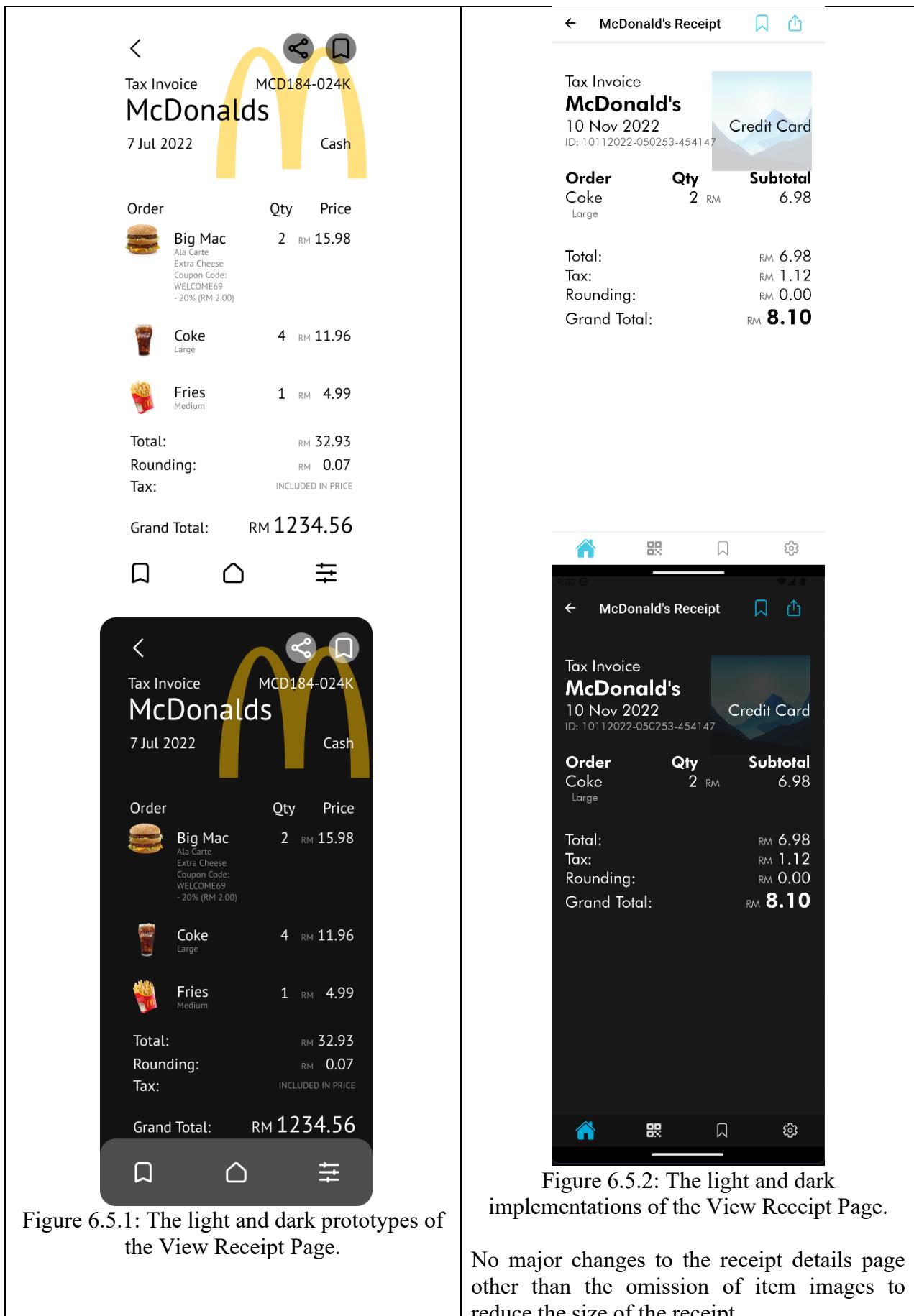
McDonald's
RM 8.10 10 Nov 2022

Bookmark Home Filter

Figure 6.4.1: The light and dark prototypes of the Browse Receipt Page (Home Page).

No major changes were made other than to the design of the bottom navigation bar.

Figure 6.4.2: The light and dark implementation of the Browse Receipt Page (Home Page).



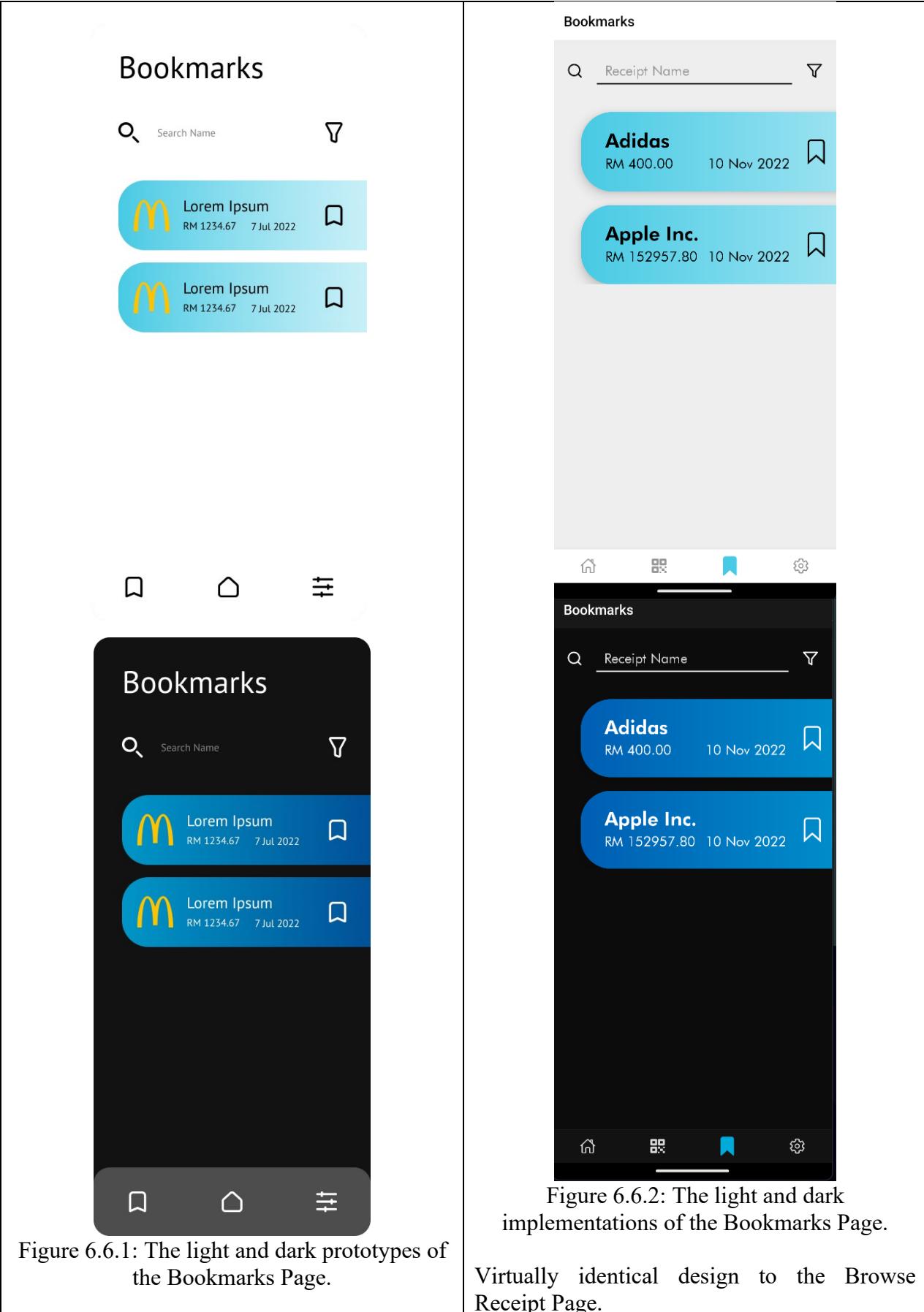


Figure 6.6.1: The light and dark prototypes of the Bookmarks Page.

Virtually identical design to the Browse Receipt Page.

Figure 6.6.2: The light and dark implementations of the Bookmarks Page.

(None)

Scan



Figure 6.7: The implementation of the QR Scan Page.

The implemented look at the QR Scan feature was revised in CP2.

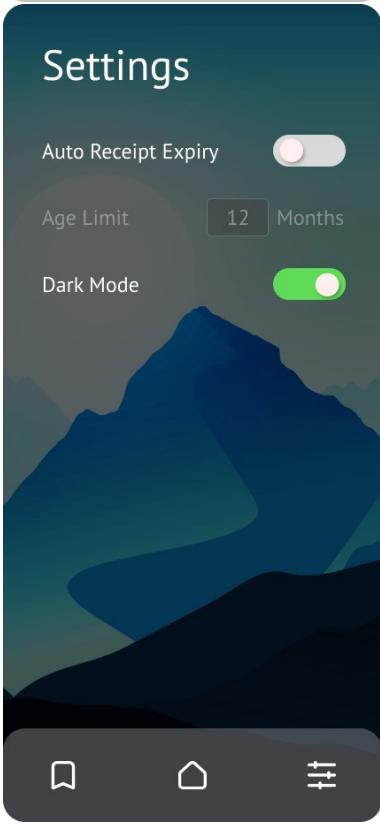
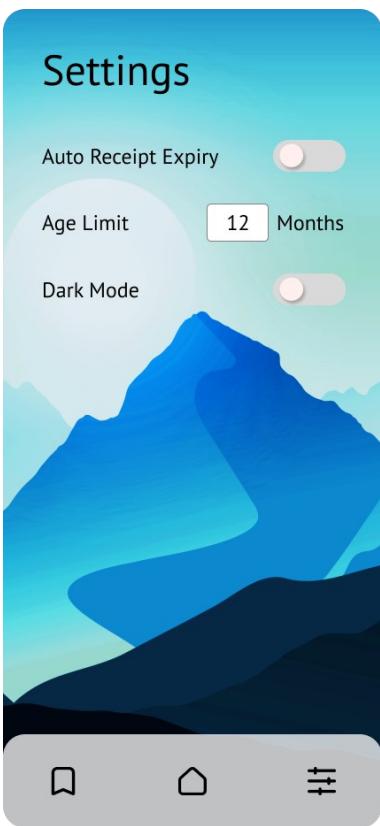


Figure 6.8.1: The light and dark prototypes of the Settings Page.

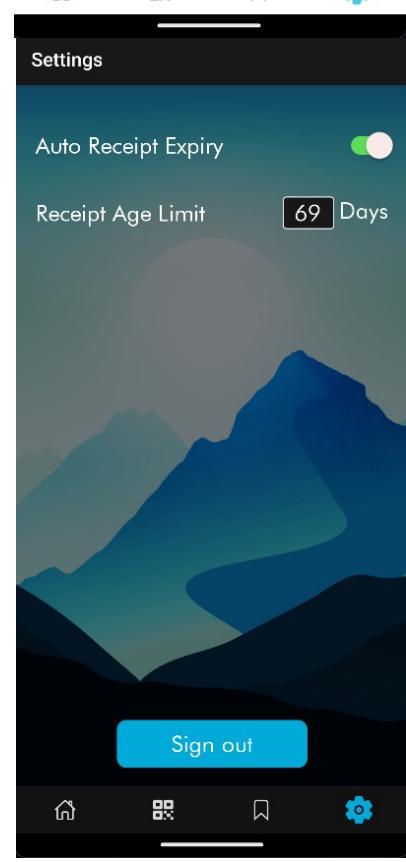
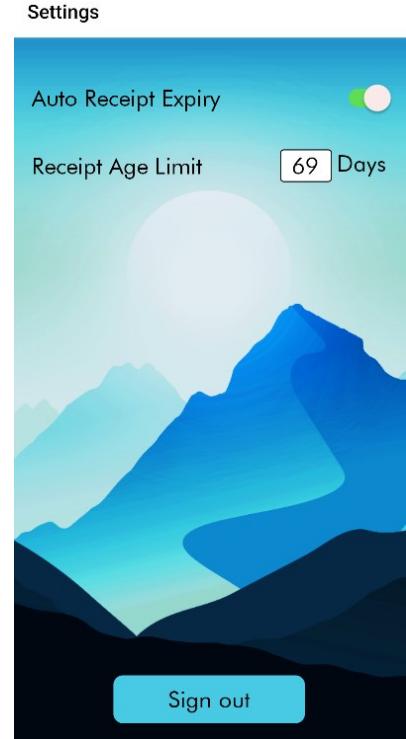


Figure 6.8.2: The light and dark implementations of the Settings Page.

Minor changes include a logout button along with the removal of the dark mode toggle as it is now connected to the OS's theme.

Database Design

The database design is based on Google Firebase's NoSQL design, which organizes data into collections and documents. There are several constraints, such as collections can not store any data type other than documents, and documents can point to sub-collections but not other documents and vice versa for collections and sub-documents. With those constraints, the database was designed into three collections: Temporary Receipts, Users and a sub-collection under Users called Receipts. After the checkout is performed on the companion application, all receipts are automatically uploaded to the Temporary Receipts collection to be linked, and the QR code will contain the ID of said receipt.

If a user scans the QR Code, the receipt will be moved to Users/User_ID/Receipts collection of the user that scanned the code and the receipt will be removed from the Temporary Receipts collection. The database design is illustrated in the diagram below.

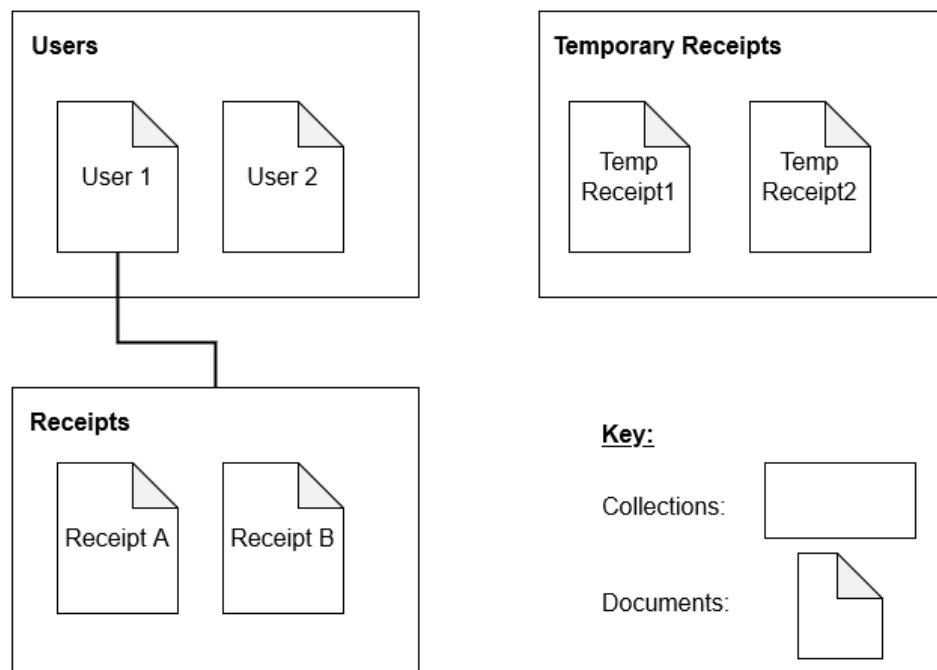


Figure 7.1: The NoSQL database design of the Digital Receipt Mobile App.

Since Firebase does not follow a SQL Schema, thus no database dictionary was formed, but the document contents of a receipt were structured into JSON-like objects with primitive data types as follows:

Receipt :

- ID: "String"
- bookmarked: "Boolean"
- date: "String" (Parsed from a JS Date.Time object)
- time: "Integer" (Stored as milliseconds since the Unix Epoch)
- name: "String"
- lowercaseName: "String" (Firebase does not have a case-insensitive search)
- paymentType: "String"
- tax: "String" or "Double" (Depends on whether tax was included in item prices)
- subtotal: "Double"
- rounding: "Double"
- grandTotal: "Double"
- items: "Array"
 - o discount: "Double" or null
 - o discountPercentage: "Boolean"
 - o name: "String"
 - o quantity: "Integer"
 - o price: "Double"
 - o description: "Array"
 - "String" or null

System Testing

Following the last iteration of the ASD methodology, the testing phase has begun, and before the system test, at the end of each iteration, after a module was developed, unit testing and regression testing were conducted to ensure no new defects were introduced and that each module was functioning properly. Then, after each major milestone, an integration test was conducted. An example of this was after setting up the database, receipt generation from the companion app and scanning the QR code of the user app, an integration test was conducted to ensure the interface between all three components were functional, and that the receipt was able to be sent from the companion app to the database which was then retrieved on the user app.

4.1.9 Functional Testing

The functions that were tested before system testing included:

1. (Companion App) Add item to cart
2. (Companion App) Checkout
3. (Companion App) Generate QR Code
4. (Companion App) Upload receipt to database
5. (User App) Scan QR Code
6. (Database) Link receipt to a user account
7. (Database) Delete receipt from temporary collection
8. (User App) Display Receipt
9. (User App) Browse all Receipts
10. (User App) Bookmark Receipt
11. (User App) Export Receipt
12. (User App) Search and Sort Receipt
13. (User App) Auto-delete receipt
14. (User App) Automatically adjusting the theme to match the operating system's settings

4.1.10 System Testing

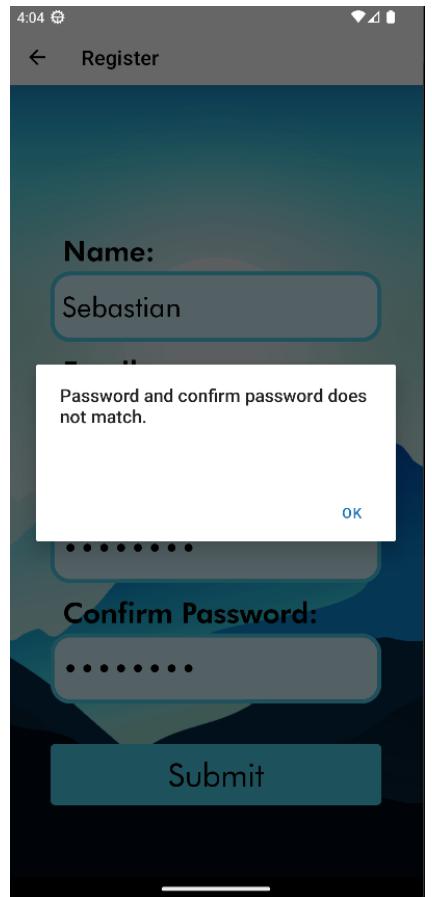
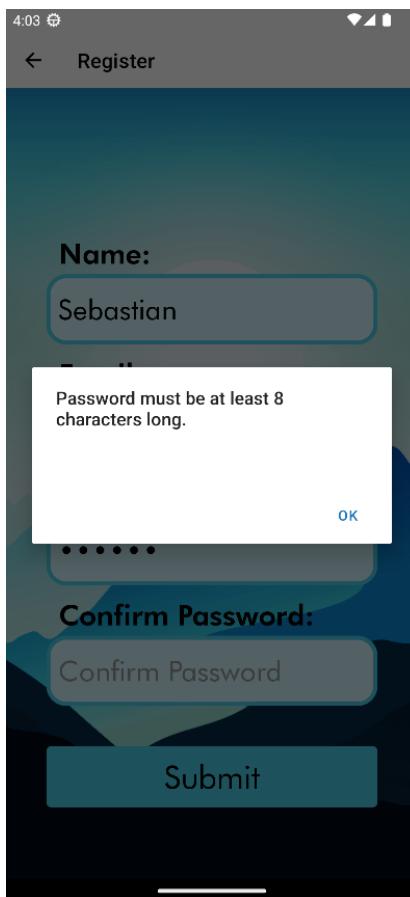
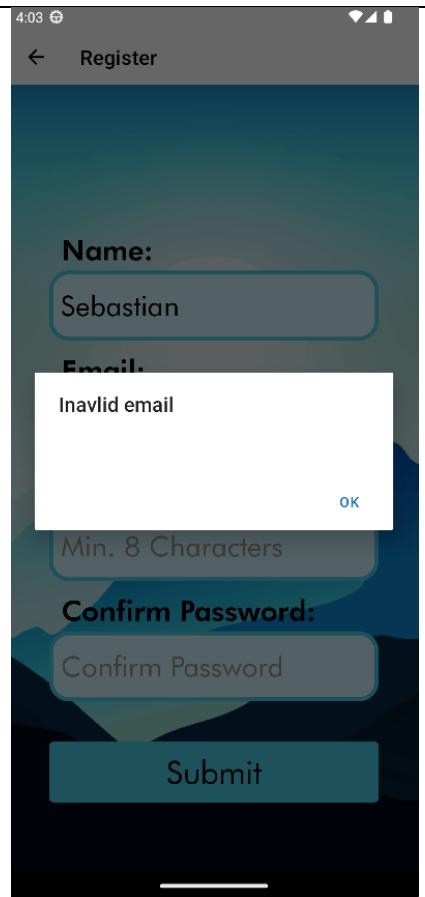
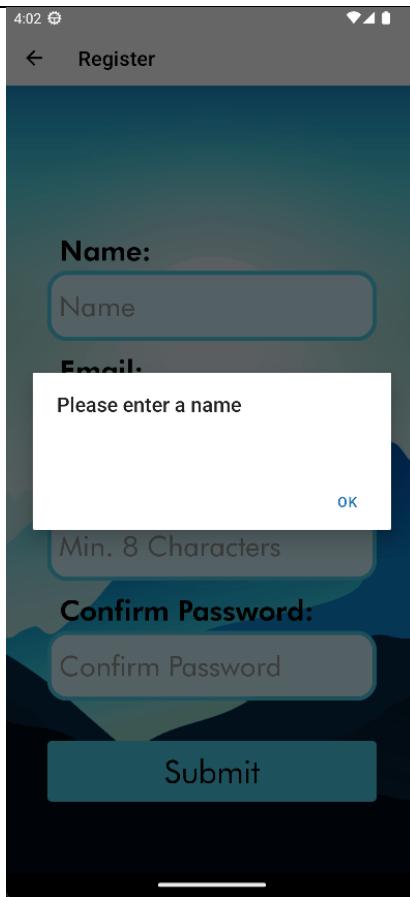
A system test was conducted and the goal was to test the entire system's functionality and user flow after it has been fully developed. This ensures that most defects were weeded out before being sent to customers for User Acceptance Testing (UAT). Below were the test cases for each module tested during system testing.

1. Table 3.1: Test Case 1 – Sign Up

Test Case ID	TC01
Module Tested	Sign Up
Test Procedure	<ol style="list-style-type: none">i. Open the user applicationii. Click on Sign Up buttoniii. Enter Name, Email, Password and Confirm Passwordiv. Click on Submit button
Test Data	<ol style="list-style-type: none">i. Name: Sebastianii. Email: sebastian69@gmail.com (Valid) / test@@@1.com (Invalid)iii. Password: krakenSl@yer (Valid) / abc123 (Invalid)

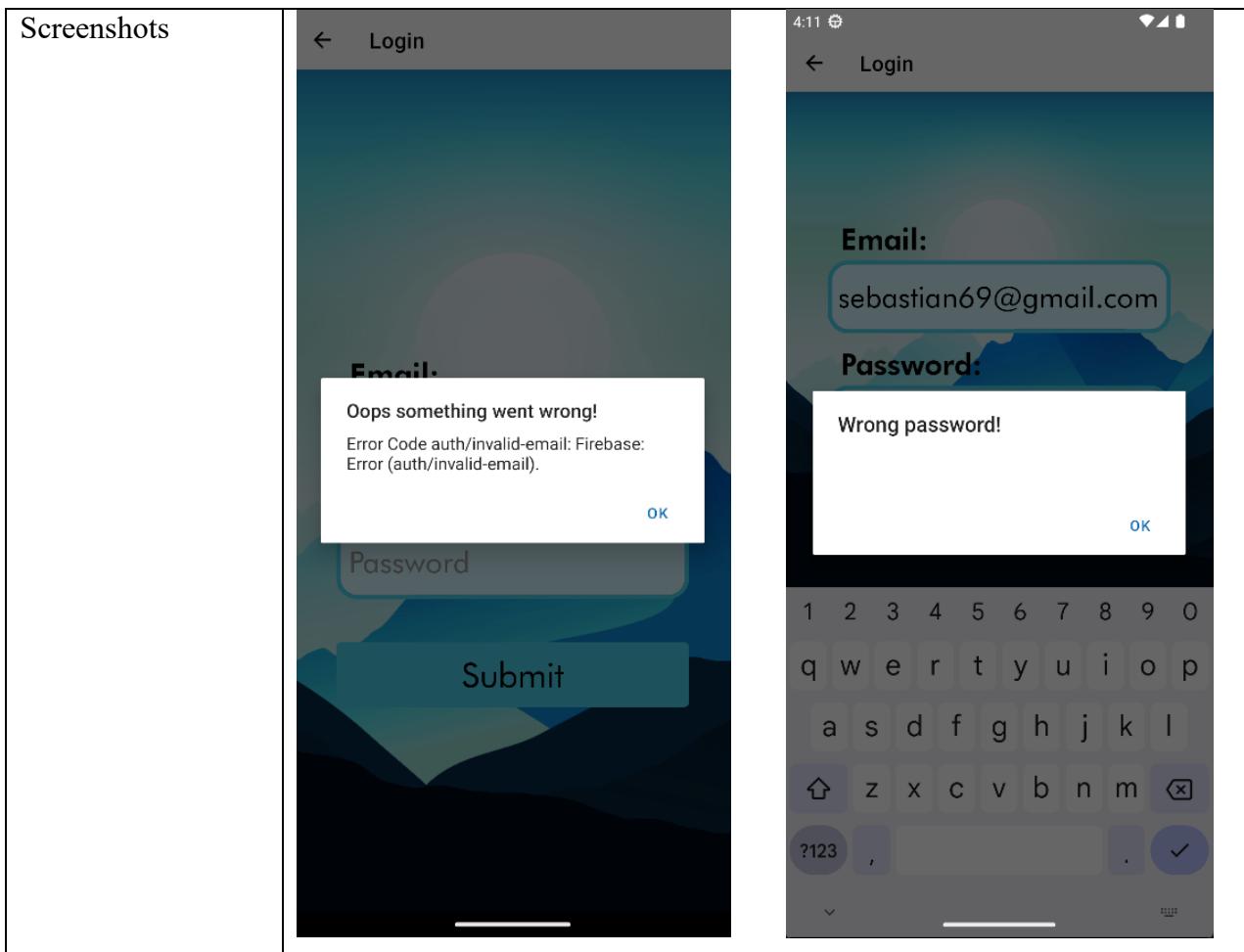
	iv. Confirm password: krakenSl@yer
Expected Outcome	<ul style="list-style-type: none"> • <u>If any field is empty:</u> Alert pop-up to show the user that a field is empty. • <u>If email is invalid:</u> Alert pop-up to show the user that email is invalid. • <u>If Password is less than 8 characters:</u> Alert pop-up to show the user that password must be at least 8 characters long. • <u>If Confirm Password does not match Password:</u> Alert pop-up to show the user that confirm password does not match the password. • <u>If All the above outcomes are false:</u> A user account is created in firebase and the user is logged in automatically.
Actual Outcome	<ul style="list-style-type: none"> • <u>If any field is empty:</u> A pop-up was shown to the user that a field is empty. • <u>If email is invalid:</u> A pop-up was shown to the user that the email is invalid. • <u>If Password is less than 8 characters:</u> A pop-up was shown to the user that the password must be at least 8 characters long. • <u>If Confirm Password does not match Password:</u> A pop-up was shown to the user that confirm password does not match password. • <u>If All the above outcomes are false:</u> A user account was created in firebase and the user was logged in automatically.
Results	Pass

Screenshots



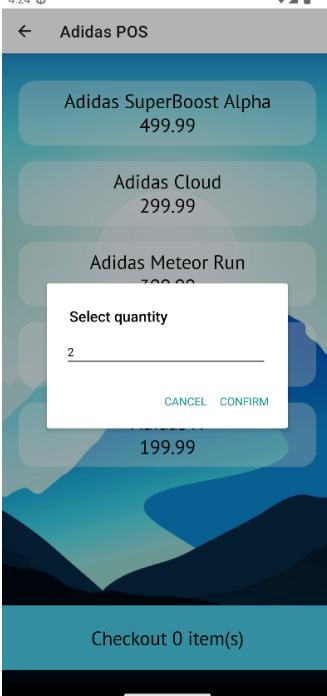
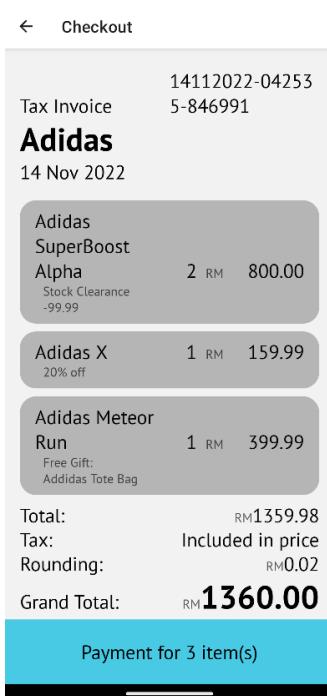
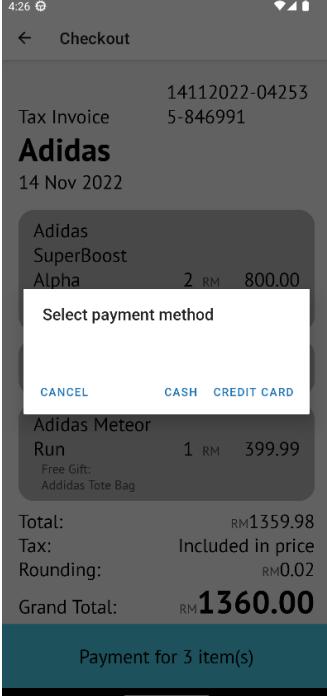
2. Table 3.2: Test Case 2 – Login

Test Case ID	TC02
Module Tested	Login
Test Procedure	<ul style="list-style-type: none"> i. Open the user application ii. Click on the Login button iii. Enter Email and Password iv. Click on Submit button
Test Data	<ul style="list-style-type: none"> i. Email: sebastian69@gmail.com (Valid) / test@test.com (Invalid) ii. Password: krakenSl@yer (Valid) / abc123 (Invalid)
Expected Outcome	<ul style="list-style-type: none"> • <u>If any field is empty:</u> Alert pop-up to show the user that a field is empty. • <u>If email is invalid:</u> Alert pop-up to show the user that email is invalid. • <u>If Password is incorrect:</u> Alert pop-up to show the user that password is incorrect. • <u>If email and password are correct:</u> The user logged in automatically.
Actual Outcome	<ul style="list-style-type: none"> • <u>If any field is empty:</u> A pop-up was shown to the user that email was invalid. • <u>If email is invalid:</u> A pop-up was shown to the user that email was invalid. • <u>If Password is incorrect:</u> A pop-up was shown to the user that password is wrong. • <u>If email and password are correct:</u> The user was logged in automatically.
Results	Pass

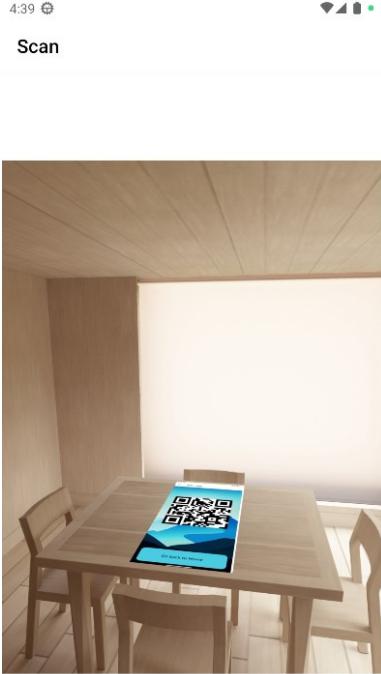
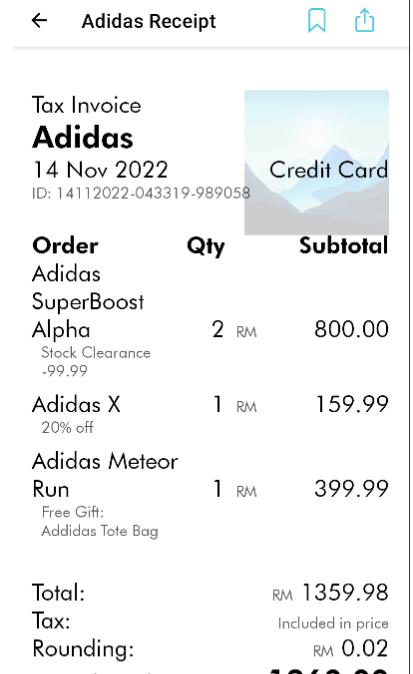


3. Table 3.3: Test Case 3 – Generate Receipt

Test Case ID	TC03
Module Tested	Generate Receipt
Test Procedure	<ul style="list-style-type: none"> i. Open the companion application ii. Click on a store iii. Click on an item and enter quantity, repeat a few times with different items and quantity iv. Click on the checkout button v. Click on the payment button and enter the payment type
Test Data	<ul style="list-style-type: none"> i. Payment type: Credit Card
Expected Outcome	A receipt is generated and uploaded to Firebase automatically and QR Code is generated. Calculations of subtotal, rounding, tax and grand total are accurate.
Actual Outcome	When entering an invalid quantity in the store, the item was ignored and not added to the receipt.

	A receipt was generated and uploaded to Firebase automatically and QR Code was generated. Calculations of subtotal, rounding, tax and grand total were accurate.
Results	Pass
Screenshots	   

4. Table 3.4: Test Case 4 – Scanning QR Code

Test Case ID	TC04
Module Tested	Scanning QR Code
Test Procedure	<ol style="list-style-type: none"> i. Open the user application ii. Ensure the user is logged in iii. Click on the QR Code page iv. Align Camera with QR Code
Test Data	Due to testing with an emulator, the QR Code generated in TC03 was saved to PNG and was uploaded to the camera simulation within the emulator settings.
Expected Outcome	The QR Code is scanned successfully, and the receipt is shown to the user. The receipt is also moved from temporary collection to the user's receipt collection in Firebase.
Actual Outcome	<p>QR Code was scanned successfully, and the receipt was shown to the user. The receipt was also moved from temporary collection to the user's receipt collection in Firebase.</p> <p>When scanning a dummy QR Code, nothing occurs on the user application, but an error was logged with an appropriate error message in the development console, nothing was changed in the database and the application did not crash.</p>
Results	Pass
Screenshots	 

5. Table 3.5: Test Case 5 – Bookmark Receipt

Test Case ID	TC05
Module Tested	Bookmark Receipt
Test Procedure	<ul style="list-style-type: none"> i. Open the user application ii. Ensure the user is logged in iii. Click on the Browse Receipt Page (Home) iv. Click on a receipt v. Click on the bookmark icon on the top bar vi. Check whether the receipt shows up on the Bookmark Page
Test Data	A user account with an existing receipt
Expected Outcome	The receipt is bookmarked successfully and now shows on the bookmarked page.
Actual Outcome	<p>The receipt was bookmarked successfully and now shows on the bookmarked page. A bookmark icon was also present on the receipt page to indicate it has been bookmarked.</p> <p>When the user clicked on the bookmark icon on the header, the icon changed colour to give the user feedback on their action.</p>
Results	Pass
Screenshots	

4:50 ⓘ

← Adidas Receipt ⌂ ⌃

Tax Invoice
Adidas
14 Nov 2022
ID: 14112022-043319-989058

Credit Card

Order	Qty	Subtotal
Adidas SuperBoost Alpha	2 RM	800.00
Stock Clearance -99.99		
Adidas X	1 RM	159.99
20% off		
Adidas Meteor Run	1 RM	399.99
Free Gift: Addidas Tote Bag		
Total:		RM 1359.98
Tax:		Included in price
Rounding:		RM 0.02
Grand Total:		RM 1360.00

Home ⌂ ⌃ ⌄ ⌅

4:52 ⓘ

Bookmarks

Q Receipt Name ⌂

Adidas RM 1360.00 14 Nov 2022 ⌂

Home ⌂ ⌃ ⌄ ⌅

6. Table 3.6: Test Case 6 – Auto-delete function

Test Case ID	TC06
Module Tested	Auto-delete function
Test Procedure	<ul style="list-style-type: none"> i. Open the user application ii. Ensure the user is logged in iii. Click on the Settings Page iv. Ensure auto-delete is turned off v. Add a receipt that is >60 days old via Firebase Console. vi. Restart the application vii. Check whether that receipt was deleted viii. Click on the Settings Page ix. Ensure auto-delete is turned on and set to <60 days. x. Restart the application xi. Check whether that receipt was deleted
Test Data	Due to time constraints, a receipt that is more than 60 days old was added via the console rather than waiting 60 days by tweaking the “time” data field in the receipt. (12 September 2022 or 1662940800000 milliseconds since Unix Epoch)
Expected Outcome	<ul style="list-style-type: none"> • <u>If auto-delete was turned off:</u> The receipt remains although older than the set age. • <u>If auto-delete was turned on:</u> The receipt is deleted when the application starts.
Actual Outcome	<ul style="list-style-type: none"> • <u>If auto-delete was turned off:</u> The receipt remains although older than the set age. • <u>If auto-delete was turned on:</u> The receipt was deleted when the application starts. The user did not need to enter any input nor was the user notified. Firebase has shown that the receipt was removed, and a removal log was shown in the development console.
Results	Pass

Screenshots

The image displays three screenshots of a mobile application interface, likely a receipt management app.

Top Left Screenshot: Settings screen. It shows "Auto Receipt Expiry" with a toggle switch turned off. Below it is "Receipt Age Limit" set to 59 Days. The background features a stylized mountain landscape. At the bottom is a "Sign out" button and a navigation bar with icons for Home, Grid, Bookmarks, and Settings.

Bottom Left Screenshot: Receipts screen. It shows a search bar with "Receipt Name". Below it are two receipts: one from "McDonald's" dated 12 Sep 2022 for RM 51.00, and another from "Adidas" dated 14 Nov 2022 for RM 1360.00. The navigation bar at the bottom is identical to the one in the top-left screenshot.

Right Screenshot: Receipts screen. It shows a search bar with "Receipt Name". Below it is one receipt from "Adidas" dated 14 Nov 2022 for RM 1360.00. The navigation bar at the bottom is identical to the others.

7. Table 3.7: Test Case 7 – Export Receipt Function

Test Case ID	TC07																																							
Module Tested	Export Receipt																																							
Test Procedure	<ol style="list-style-type: none"> i. Open the user application ii. Ensure the user is logged in iii. Click on the Browse Receipt Page (Home) iv. Click on a receipt v. Click on the export icon on the top bar vi. Check whether the image of the receipt was exported into the phone's gallery 																																							
Test Data	A user account with an existing receipt																																							
Expected Outcome	The receipt is exported successfully and now shows in the phone's gallery.																																							
Actual Outcome	<p>The receipt was exported successfully and now shows in the phone's gallery.</p> <p>Longer receipts were not cut off and the exported image's aspect ratio was changed to accommodate the receipt's length. The image on the right was shown from the "Photos" application on the phone.</p>																																							
Results	Pass																																							
Screenshots	 <p>Tax Invoice Apple Inc. 10 Nov 2022 ID: 10112022-044754-197225</p> <table border="1"> <thead> <tr> <th>Order</th> <th>Qty</th> <th>Subtotal</th> </tr> </thead> <tbody> <tr> <td>Apple M2</td> <td>10</td> <td>RM 42000.00</td> </tr> <tr> <td>Macbook Air</td> <td>10</td> <td>RM 42000.00</td> </tr> <tr> <td>Apple iPhone 14 Pro Max</td> <td>2</td> <td>RM 11999.98</td> </tr> <tr> <td>Apple Watch Gen 2</td> <td>4</td> <td>RM 2239.96</td> </tr> <tr> <td>Apple M2</td> <td>11</td> <td>RM 76999.89</td> </tr> <tr> <td>Macbook Pro</td> <td>11</td> <td>RM 76999.89</td> </tr> <tr> <td>Apple Watch Gen 2</td> <td>1</td> <td>RM 559.99</td> </tr> <tr> <td>Apple iPhone 14</td> <td>3</td> <td>RM 10499.97</td> </tr> <tr> <td>Total:</td> <td></td> <td>RM 144299.79</td> </tr> <tr> <td>Tax:</td> <td></td> <td>RM 8657.99</td> </tr> <tr> <td>Rounding:</td> <td></td> <td>RM 0.02</td> </tr> <tr> <td>Grand Total:</td> <td></td> <td>RM 152957.80</td> </tr> </tbody> </table>	Order	Qty	Subtotal	Apple M2	10	RM 42000.00	Macbook Air	10	RM 42000.00	Apple iPhone 14 Pro Max	2	RM 11999.98	Apple Watch Gen 2	4	RM 2239.96	Apple M2	11	RM 76999.89	Macbook Pro	11	RM 76999.89	Apple Watch Gen 2	1	RM 559.99	Apple iPhone 14	3	RM 10499.97	Total:		RM 144299.79	Tax:		RM 8657.99	Rounding:		RM 0.02	Grand Total:		RM 152957.80
Order	Qty	Subtotal																																						
Apple M2	10	RM 42000.00																																						
Macbook Air	10	RM 42000.00																																						
Apple iPhone 14 Pro Max	2	RM 11999.98																																						
Apple Watch Gen 2	4	RM 2239.96																																						
Apple M2	11	RM 76999.89																																						
Macbook Pro	11	RM 76999.89																																						
Apple Watch Gen 2	1	RM 559.99																																						
Apple iPhone 14	3	RM 10499.97																																						
Total:		RM 144299.79																																						
Tax:		RM 8657.99																																						
Rounding:		RM 0.02																																						
Grand Total:		RM 152957.80																																						

5 Discussion

The Digital Receipt Mobile Application aimed to reduce the environmental impact of paper receipts and thermal printers while aiming to improve the user experience of handling and managing receipts digitally. Thus, it was stated that to achieve said aim, several objectives were listed in the first section of this final report. This section summarizes how the delivered application managed to achieve the stated objectives.

Objective 1: Investigate how to implement a vendor-neutral digital receipt solution with ease of use and good UX. (Success)

The efforts of carrying out the literature review and comparing existing solutions while looking at what could be improved, in addition to analyzing the problem statement with sufficient detail lead to the project or system requirements of the Digital Receipt Mobile Application. By addressing the concerns and complaints of the problem statement, while improving upon existing solutions and learning from their mistakes, I have successfully defined requirements so that a solution can be made to fulfil these requirements.

Objective 2: Design the proposed application based on the gathered requirements. (Success)

With the work product from objective one, work continued with this objective where I applied my knowledge in the various areas of software engineering to design a holistic solution to tackle the system requirements from the first objective. A development methodology was chosen first, which was discussed in detail including the motivation and rationale for choosing it in the relevant section. Then came the time to design the system's modules, with the use of diagramming tools such as Draw.io and Lucid Chart, I managed to detail some views of the system which would help stakeholders understand the design of the system, some diagrams included were sequence diagrams, context diagram and data flow diagram. Lastly, the UI of the system was prototyped in Figma to allow an interactive preview of the interfaces and UX of the system, and also served as a blueprint for development.

Objective 3: Develop and test the proposed system. (Success)

Moving onto the third objective, this was where the majority of the development took place in Capstone Project 2, the objective that took the longest time to fulfil. With a JavaScript framework known as React Native and its modularity and myriad third-party libraries, I was able to build the digital receipt app within the stipulated timeframe. In accordance with the development methodology chosen in objective 2, I conducted unit tests after each iteration and for larger milestones, integration tests, this was detailed more in the testing section of this document. The final testing was User Acceptance Testing (UAT) which was to gather feedback and evaluate user satisfaction for this Evolution-type (e-type) system since an e-type system's success is determined by user satisfaction. While some revisions were made to both the UI and system architecture, these changes were well-reasoned and served to enhance the application while adapting to the tools available at disposal to develop the system. These changes were detailed in the accompanying Activity Log.

Objective 4: Evaluate the effectiveness and functions of the system. (Success)

The final objective, the success of this objective as mentioned depends on user satisfaction. Thus the results from the UAT were analyzed and summarised in this section. The full results of the UAT are attached in the appendix. Of the 12 respondents, 58.3% or seven of them are below 25 years old. 11 of these respondents handled receipts on a daily or weekly basis thus making them prime candidates to test the efficacy and usefulness of this app. Most of the concerns of paper receipts from the problem statement were validated, with the reason of "I usually throw receipts away / They are a nuisance" being the main complaint. Only 2 respondents have used any tools to manage receipts before, one of them used folders while the other took pictures of receipts, this meant that people were frustrated with paper receipts but did not have the tools to deal with them.

Moving on to the testing results, all 12 of the respondents found the app easy to use or learn (4 or higher on a 5 point Likert-scale), the app was quick to retrieve receipts, the app was convenient with its ease-of-use features, and the app's design was aesthetically pleasing. 11 of them found the QR scanning method reliable as a way to retrieve receipts, with one's concerns being that their phone's camera was broken, thus being unable to scan the receipt and retrieve the QR Code. In a nutshell, this meant that the aim of the project was fulfilled very well.

In the final part of the survey, I enquired the participants about their concerns what they liked or disliked about the system, suggestions and overall satisfaction. Only one of them had a concern at all, which was the mentioned problem of a broken camera, and their suggestion was to implement a text-based input method for receipts. Most of them applauded the UI of the app about how simplistic and great-looking it is. One of the participants noted that they prefered if they did not have to create an account and suggested that the app could work offline. In terms of suggestions, most of them wanted iOS support or windows support, while others suggested an “archive system”, more vendors participating in the system, “auto link to card so that they do not need to scan QR code”, more themes and backgrounds. To conclude the survey, all of the participants rated 4 or higher in the overall rating of satisfaction towards the system, giving a resounding assurance that this objective has been met successfully.

6 Conclusion

In conclusion, it can be said that the Digital Receipt Mobile Application project was a resounding success as it has achieved its aim and objectives. It is proven that this application does deliver a vendor-neutral solution to managing receipts digitally while being simple, easy to use and sporting good UI and UX. This application can truly make a difference in digitalizing receipts and ending the environmental or health concerns that accompany the usage of thermal paper receipts.

Some work that could be done to improve the system in the future could be implementing the suggestions provided by the respondents such as iOS and Windows support, an alternative text-input method of retrieving receipts, more customizable themes and colours and an offline “accountless” mode.

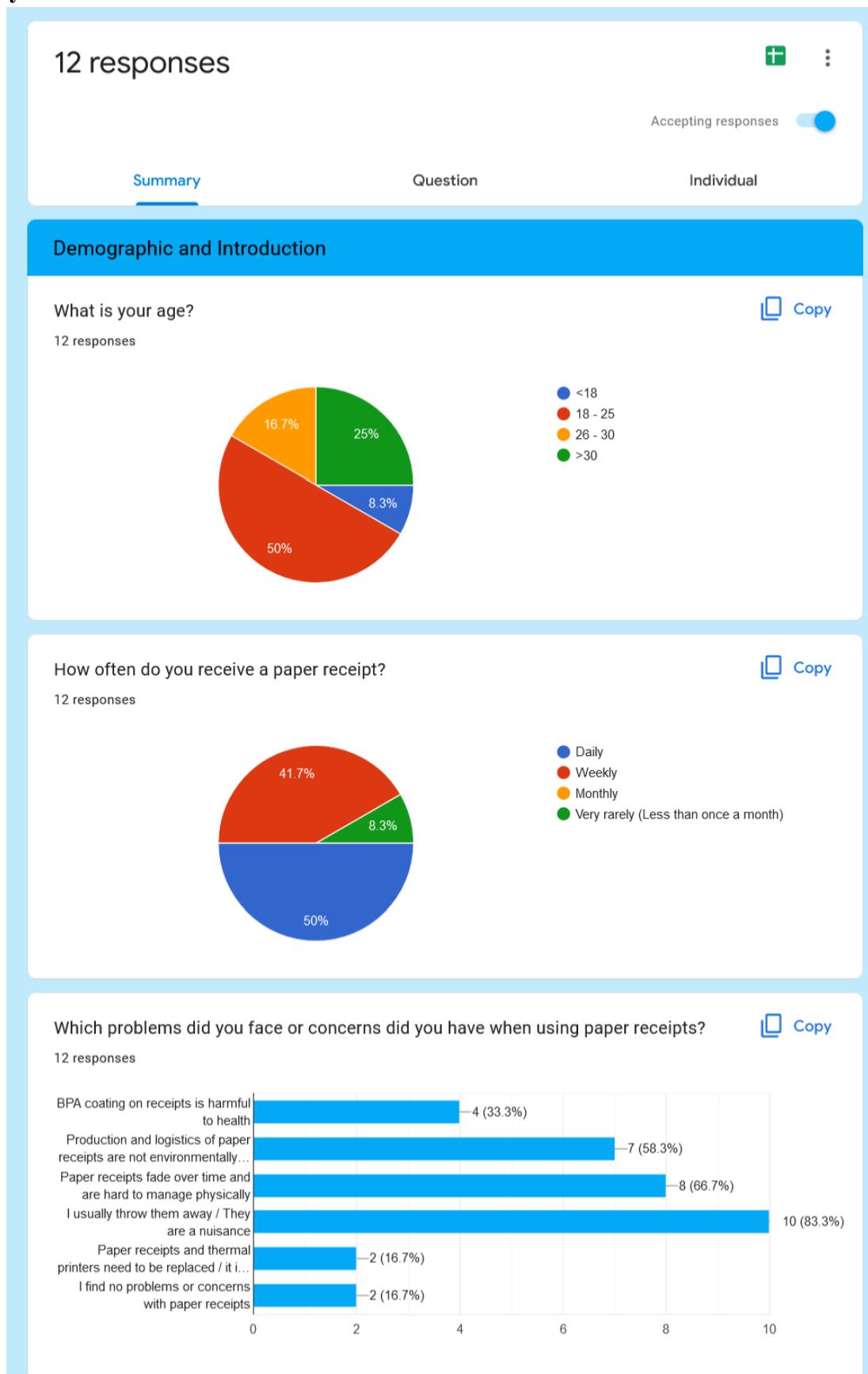
References

- [1]"receipt", Dictionary.cambridge.org, 2022. [Online]. Available: <https://dictionary.cambridge.org/dictionary/english/receipt>. [Accessed: 24- Apr- 2022].
- [2]"Six categories of retailers obliged to issue invoices beginning Oct 1 | Malay Mail", Malaymail.com, 2022. [Online]. Available: <https://www.malaymail.com/news/malaysia/2015/08/17/six-categories-of-retailers-obliged-to-issue-invoices-beginning-oct-1/953441>. [Accessed: 24- Apr- 2022].
- [3]"Issuing Tax Invoices", Customs.gov.my, 2022. [Online]. Available: http://www.customs.gov.my/en/ip/Pages/ip_ti.aspx. [Accessed: 24- Apr- 2022].
- [4]"“Skip the Slip” Report", Green America, 2022. [Online]. Available: <https://greenamerica.org/press-release/skip-slip-report-toxic-paper-receipts-jeopardize-health-millions-waste-12-million-trees-and-13-billion-gallons>. [Accessed: 24- Apr- 2022].
- [5]"Why You Should Switch to Phenol-Free Thermal Paper", Thermal Paper Plus, LLC, 2022. [Online]. Available: <https://thermalpaperplus.com/why-you-should-switch-to-phenol-free-thermal-paper/>. [Accessed: 24- Apr- 2022].
- [6]2022. [Online]. Available: <https://setelappsupport.zendesk.com/hc/en-us/articles/360013301711-What-is-Setel-Apa-itu-Setel->. [Accessed: 10- May- 2022].
- [7]D. Nguyen, "Digital Receipt System Using Mobile Device Technologies", *ScholarWorks@UNO*, 2022. [Online]. Available: <https://scholarworks.uno.edu/td/705>. [Accessed: 16- Jun- 2022].
- [8]S. Singhvi, "Case study: A digital solution to receipts", Medium, 2022. [Online]. Available: <https://bootcamp.uxdesign.cc/case-study-a-digital-solution-to-receipts-b93c0dce4d94>. [Accessed: 22- Jun- 2022].
- [9]"What is a POS? | Definitions, Examples, Types and Inventory in POS", *Primaseller*, 2022. [Online]. Available: <https://www.primaseller.com/knowledge-base/what-is-pos-point-of-sale/>. [Accessed: 22- Jun- 2022].
- [10]"Point of Sales System with Receipt Printer Malaysia | Android Thermal Receipt Printer | Bluetooth WiFi Thermal Receipt Printer | Receipt Printer Software | POSMarket POS System", *POS Market POS System*, 2022. [Online]. Available: <https://www.posmarket.com.my/pos-receipt-printer/>. [Accessed: 22- Jun- 2022].
- [11]"What is a Thermal Printer and How Does it Work?", *Cdw.com*, 2022. [Online]. Available: <https://www.cdw.com/content/cdw/en/articles/hardware/what-is-a-thermal-printer-how-does-it-work.html>. [Accessed: 22- Jun- 2022].
- [12]2022. [Online]. Available: <https://www.setel.com/>. [Accessed: 22- Jun- 2022].

- [13]"Digital Receipts and eReceipt Marketing", *TransactionTree*, 2022. [Online]. Available: <https://www.transactiontree.com/ereceipts/#1469018737376-8ad20a7c-ec9f14690187719802457-b6d2>. [Accessed: 22- Jun- 2022].
- [14]"Retailers - TOGO-Digital receipt", *TOGO-Digital receipt - digital receipt*, 2022. [Online]. Available: <https://www.togoapp.co/retailers/>. [Accessed: 22- Jun- 2022].
- [15]"Adaptive Software Development: A Complete Introduction", *Digite.com*, 2022. [Online]. Available: <https://www.digite.com/agile/adaptive-software-development-asd/>. [Accessed: 04- Jul- 2022].
- [16]"React Native · Learn once, write anywhere", *Reactnative.dev*, 2022. [Online]. Available: <https://reactnative.dev/>. [Accessed: 07- Jul- 2022].
- [17]"Expo", *Expo*, 2022. [Online]. Available: <https://expo.dev/>. [Accessed: 07- Jul- 2022].
- [18]"What is the difference between Expo and React Native?", *Stack Overflow*, 2022. [Online]. Available: <https://stackoverflow.com/questions/39170622/what-is-the-difference-between-expo-and-react-native>. [Accessed: 07- Jul- 2022].
- [19]"React Native Firebase | React Native Firebase", *Rnfirebase.io*, 2022. [Online]. Available: <https://rnfirebase.io/>. [Accessed: 07- Jul- 2022].
- [20]"GitHub: Where the world builds software", *GitHub*, 2022. [Online]. Available: <https://github.com/>. [Accessed: 07- Jul- 2022].

Appendix

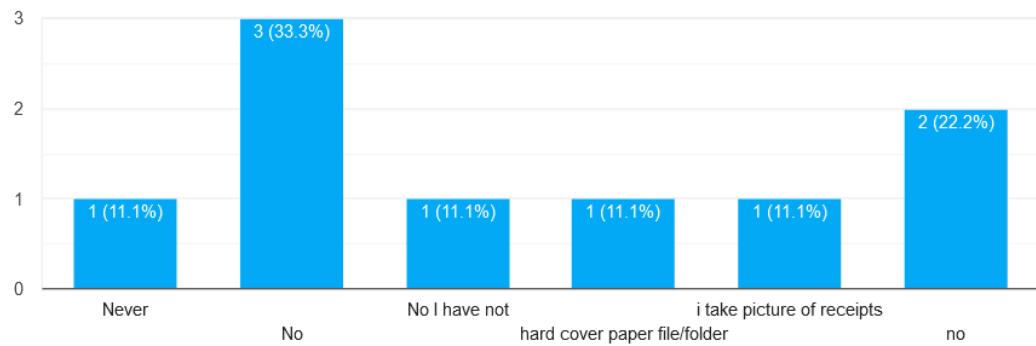
Survey Results



Have you used a tool to manage your receipts before? If so, what tools did you used?

 Copy

9 responses

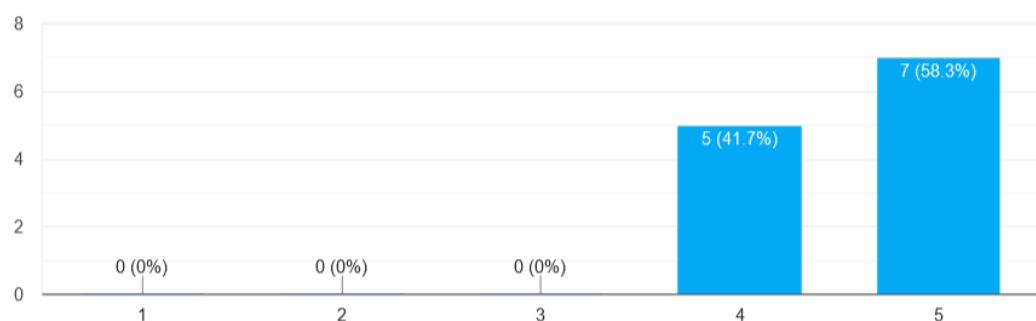


Testing Phase

How easy was the app to use or learn?

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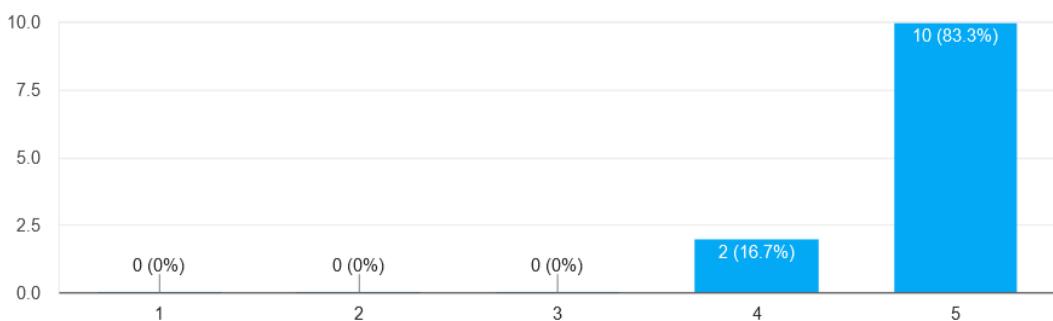
12 responses



How quick was the receipt retrieval process?

 Copy

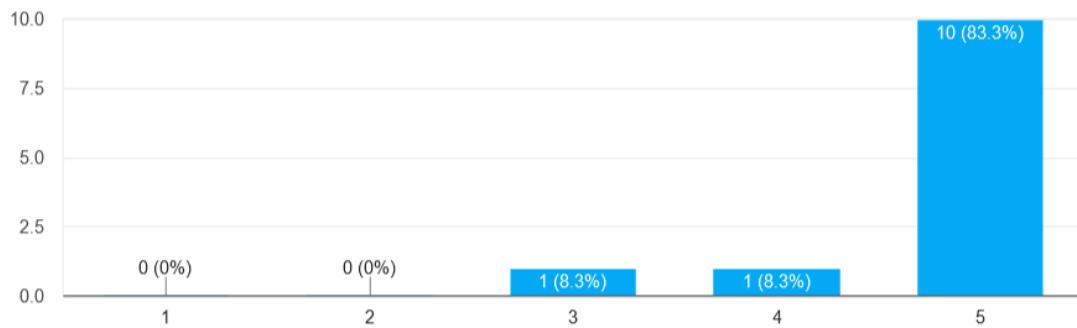
12 responses



How reliable was it to retrieve the receipt?

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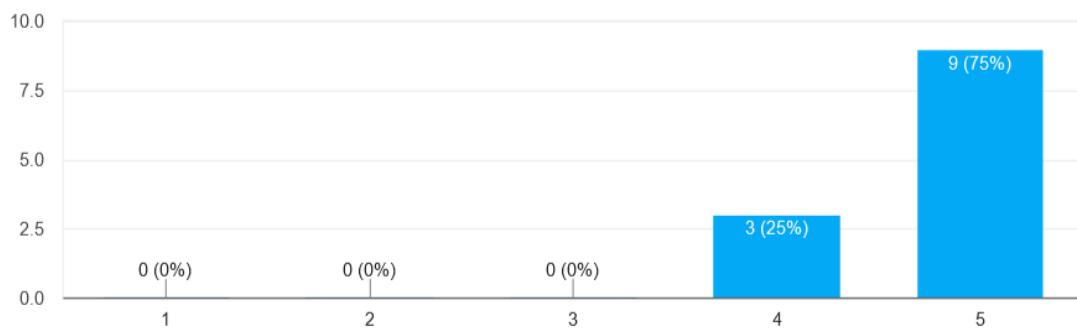
12 responses



How useful do you think, were the ease-of-use features in helping you manage digital receipts? (Export, Search and Filter, Bookmark, Auto-delete)

 Copy

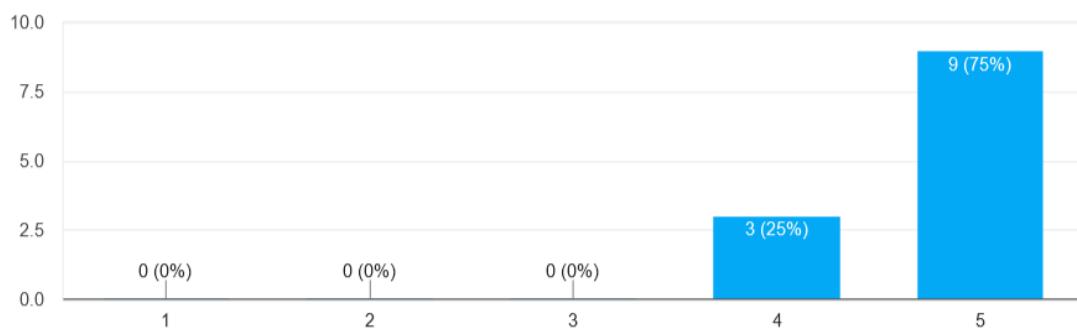
12 responses



How aesthetically pleasing was the app's user interface and design? (Including Dark Mode)

 Copy

12 responses



Post-Testing Phase

Did you face any difficulty or ambiguity when seeing the app in demo? If so, what was your concern?

12 responses

No

Nope

No, the app is perfect and achieved its proposed objectives

No difficulties.

No difficulty, easy and straightforward usage

nope.

Not really.

Yes my phone camera is broken so I cannot scan QR code

What did you like or dislike about the system?

12 responses

I like the look

The ability to generate receipt using QR is pretty impressive and suits the current era of technology

The ability to scan the QR code to retrieve the receipt quickly.

Nothing

I like how simple yet effective the system is.

Dark mode

night mode is very comfort for my eyes.

Simplicity, font choice gave a great viewing experience

DARK MODE IS SO GOOD

What do you wish to see be added to the system in the future?

12 responses

Maybe an implementation on a desktop (to be used in the counters of the cashier system)

Nothing in mind.

iOS support

I would like to see more types of vendors participating in this system.

Archive system

Can try more different background

More themes

can do for ios mou :(i apple user lehhhh

Add receipt by typing instead of scanning

 Copy

Overall, how satisfied were you with the system

12 responses

