MAKERERE UNIVERSITY
COLLEGE OF COMPUTING AND INFORMATION TECHNOLOGY

**Ubiquitous Computing for Mobile Based Payments in Localised
Intelligent Transportation Systems**

By
CS23-4

DEPARTMENT OF COMPUTER SCIENCE

A Draft Project Report submitted to the School of Computing and
Informatics Technology For the Study Leading to a Project Proposal in Partial
Fulfillment of the Requirements for the Award of the Degree of Bachelor of
Science in Computer Science Of Makerere University

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Declaration

We Group CS23-4 do hereby declare that this Report is original and has never been published and/or submitted for any other degree award to any other University before.

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Dedication

We dedicate this report to our parents and guardians, whose unwavering and selfless support has been instrumental throughout our entire academic journey at this university.

Acknowledgement

We express our deep gratitude to our project supervisor, Mr. Ggaliwango Marvin. We are sincerely thankful for his continuous guidance and assistance, which have been instrumental in overcoming some of the challenges we encountered during this demanding study.

Furthermore, we extend our special appreciation to our friends and families for their enduring support during the rigorous moments and stressful periods throughout the research project. Their understanding and encouragement have been invaluable.

We would also like to acknowledge the school for providing us with the invaluable opportunity to work as a cohesive team. This experience has not only fostered our teamwork spirit but has also enhanced our communication skills. Additionally, we extend our gratitude to each member of the group for their unwavering team spirit and solidarity, contributing to the overall success of the project.

Abstract

The current system of ticketing and payment for parking at Makerere University in Kampala, Uganda, faces several challenges, such as frequent malfunction of the ticketing machines, fraud by the system employees, difficulty in locating a payment point for motorists, and hefty fines of 50000 Ugandan shillings for lost tickets. These challenges result in inconvenience, inefficiency, as well as revenue loss for both the system's managers as well as motorists using it. To overcome these challenges, we propose a low-cost secure and reliable system that consists of a mobile app that enables cashless digital prepayment of the parking fees using local popular payment platforms such as MTN mobile money. The app interacts with an embedded microcontroller at the gate that scans the QR codes and the motorist access after it verifies their payment. We describe the design and implementation of the app and the microcontroller, and examine its benefits as well as shortcomings. We argue that our system offers a more convenient, efficient, and transparent way of managing toll payments not just in the university context, but other premises with a similar payment system in place.

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Chapter 1

Introduction

1.1 Background and motivation

Access to parking places is a common challenge in many urban areas such as universities, shopping malls, hospitals, where there is a high demand for parking spaces and a limited number of them in availability[1].

Makerere University in collaboration with KSA in 2014 put in a place an automated parking system that allows motorists to purchase tickets and make payments at any of the payment points within the university premises to ensure the smooth flow of traffic, reducing congestion, and generating revenue for the university[2].

The current system of ticketing and payment for parking at Makerere University in Kampala, Uganda, has however suffered from several problems, such as frequent malfunction of the ticketing machines, fraud by the system employees who may sometimes take payments from motorists direct rather than having motorists pay at the paypoints within the university, difficulty in locating a payment point for motorists, and hefty fines for lost tickets. These problems result in inconvenience, inefficiency, and revenue loss for both the system's managers and motorists.

To address these problems, we propose a novel system in the local context that consists of a mobile app that enables cashless digital prepayment of the parking fees using local popular payment platforms such as MTN mobile money, Airtel Money. A study found that in Sub-Saharan Africa, the use of mobile money platforms is promoting financial inclusion, with 548 million registered mobile money accounts in the region. These platforms have seen a 23% growth in transaction value, reaching 490 billion dollars[3]. Another study found that in Uganda, mobile money accounts are held by 43% of the population, compared to

just 11% who have bank accounts[4].This demonstrates how widely used these platforms are in the region.

Our work is also motivated by a growing trend of using mobile apps for parking payment in some cities around the world. Mobile applications offer several advantages over traditional methods of parking payment, such as convenience, flexibility, security, and cost-effectiveness, amongst others. A report by Grand View Research also indicates that the global mobile parking app market size was valued at USD 6.4 billion in 2020 and is expected to grow at a compound annual growth rate (CAGR) of 22.1% from 2021 to 2028[5]. Some examples of mobile parking applications include ParkMobile [6] developed and used in the United States and Flowbird developed in France[7]. Most of these applications are designed for developed countries with advanced infrastructure and technology. There is a need for developing context-specific solutions that cater to the needs as well as limited resources in developing countries like Uganda.

PROCESS DIAGRAM FOR THE EXISTING PAYMENT APPROACH

Receiving ticket at university gates → Making payment at any paypoint within the university → Verifying ticket at exist

PROPOSED SYSTEM

Making prepayment or real-time payment via mobile app → Scanning with ESP32 microcontroller → Rescanning when exiting premises
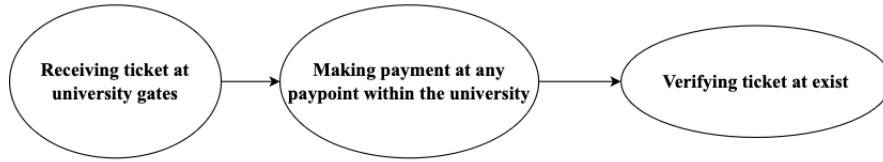
Figure 1.1: High level Process diagram comparing the existing and proposed system

1.2 Problem Statement

Managing access to parking places is a common challenge in many urban public places such as universities, malls where there is a high demand for parking spaces and a limited availability[1].Effective management is crucial for ensuring the smooth flow of traffic, reducing congestion and pollution, and generating revenue for the university. However, the current system of ticketing and payment for parking at Makerere University in Kampala, Uganda, suffers from several problems, such as frequent malfunction of the ticketing machines, fraud by the system employees, difficulty in locating a payment point for motorists, and hefty fines for lost tickets.

These problems result in inconvenience, inefficiency, and revenue loss for both the system's managers and motorists, thus there is a need for developing a novel system that can provide a more convenient, efficient, and transparent way of managing these payments in the university context.

1.3 Objectives

1.3.1 Main Objective

To design and implement a novel system that consists of a mobile app and an embedded microcontroller for cashless parking payment at Makerere University using QR code technology and local popular payment platforms such as MTN Mobile Money. The system aims to provide a more convenient, efficient, and transparent way of managing toll payments in the university context, overcoming the problems and limitations of the current system of ticketing and payme

1.3.2 Specific Objectives

The project's specific objectives include:

- To understand the existing payment approach used at Makerere University toll gates.

- To collect requirements for the digital parking payment system for motorists trying to access Makerere University.

- To design a system prototype for the proposed solution.

- To implement the proposed mobile application and confirm whether it solves the highlighted problems within the current payment system.

1.4 Scope of the project

The challenges mentioned in the problem statement above affect various parking payment points in the country and even beyond Uganda's borders. However, for this project we focused on Makerere University's main gates. The team

developed the mobile application, programmed the microcontroller to read the QR code values and open the gate. To demonstrate the gate-opening logic, we used a Servo Motor equipment

Figure 1.2: Makerere University main gate where the project will be implemented

Implementation of the project was done for Makerere University setting.

1.5   Significance of the project

In our project, we were able to develop a digital parking payment system eliminating the need for ticket usage when making the payments. The project also addresses a number of issues prevailing in the current system such as difficulty in accessing payment points, fraud by the gate attendants and the issue of hefty fines for ticket loss.

Chapter 2

Literature Review

2.1 Introduction

In this chapter we consider similar projects that have been done and how they relate to the project development and execution in relation to our project. We also look at their shortcomings and how they're addressed in our project.

2.1.1 Makerere University Automated Payment System

This is the existing system in place in our area of study. The project was commenced in 2014 by Makerere University in collaboration with Kenya Airport Parking Services[2] . From our interviews with Mr. Twinomusinguzi Julius, the current manager of the existing system we learned that the system costs approximately 1.5 billion shillings to set up. It consists of a ticketing machine that issues tickets to motorists, as well as various payment points where payments are made and human labour to receive money, give change and manage the systems in case of breakdown. Some of the challenges in this system include:

- Frequent malfunction of the ticketing machines. This occurs due to their wear and tear over time. As previously mentioned, this equipment is costly not just to purchase but maintain as well.

- Fraud by the system employees. A common way this occurs is when a motorist instead of paying at the point, they're granted access by the gate attendants, who then retain the money for themselves. From our interviews, we also determined that students who are exempt from paying the parking fees upon proving their status, sometimes pay the gate attendants to be granted access in case they don't have their student IDs with them. This can be addressed by having a system that automatically detects students and grants them access without the need for human intervention.

- Difficulty in locating a payment point for motorists. The university is large about 300 acres with payment points placed at different points around it. For people visiting the area for the first time, locating these points can be a challenge thus the need for a more convenient way of making payments.

- Hefty fines for lost tickets as motorists who misplace their tickets are required to pay a fine of 50,000 Uganda Shillings. From our interviews we were informed that a high fee was set because with a lower fee, some motorists park for long periods and intentionally lose their tickets to pay a fine that's lower than their actual parking bill.

2.1.2 Uganda National Roads Authority Express Highway

Figure 2.1: Gen. Katumba Wamala showing an UPESI payment card on the launch of the Entebbe Express Highway

The Uganda National Roads Authority in 2022 launched the Kampala Entebbe Express Highway, a Ugandan government project worth approximately 450 million dollars developed to help ease transport flow in Kampala city. Access to the highway is via the tollgates where motorists can make both cash and digital cashless payments. For cashless payments, motorists use an UPESI card.[8]. A motorist purchases an UPESI card that they then load a given amount of money and upon arrival at the tollgate, they swipe the card. The fee is then deducted from the card and the motorist is then granted access.

The main gap with the approach is motorists often resort to only using the cash payments that result in delays and other issues because they find it easier than purchasing an UPESI card. Additionally, the process of loading money onto the card is unnecessarily long.

2.1.3 ParkMobile

Parkmobile is a leading mobile application launched in 2009 in the United States of America that allows motorists to find and pay for parking on their phone. This application is currently used in approximately used in three thousand locations in North America, and also has garnered over 43 million users processing over 113 million parking transactions in 2022.

Parkmobile offers various features and benefits for its users, such as making prepayments and reserving parking points at any given location. It also offers a rewards program that allows users to earn points for every parking transaction and redeem them for discounts or free parking. Parkmobile also supports Google and Apple Pay for a faster and more secure payment process. [6] The project has had good traction since it was launched and in 2022 it generated 9.1 million dollars in revenue , with an average revenue per employee of 52,906 dollars. Parkmobile was acquired by EasyPark Group, a Swedish company that provides smart parking and mobility solutions, in June 2021.

Unfortunately to the best of our knowledge, ParkMobile or any other application of this nature are not available in Uganda thus the need for a local contextualised solution

2.1.4 Use of GPS Software and Cell Towers

Research on how this can be leveraged in easing toll fee payment has been also been done by others. In 2020, Danang Dismantoro, Istas Pratomo and Surya Sumpeno also proposed a mobile application that allowed payment of these fees via GPS software[9, 10]. The system was tested through simulations in Vissim software [11], which they believe was able to simulate the real world condition at tollgates. Cell phone towers and GPS technology are used to identify the motorists location and if the motorist happens to be within the tollgate vicinity, the money is automatically deducted from their personal account.

Research Gaps

- No physical implementation of this system was realised
- The researchers acknowledge the need for a deeper feasibility study and the fact as it has some shortcomings.
- Some scenarios are unaccounted for such as if one is near a cell tower but does not necessarily intend to access the tollgate,theyy will have their money deducted even without actually using the gate.

2.1.5 Use of RFID sensors

Another alternative approach that leverages ubiquitous computing is the use of an RFID system. This system has two main components:
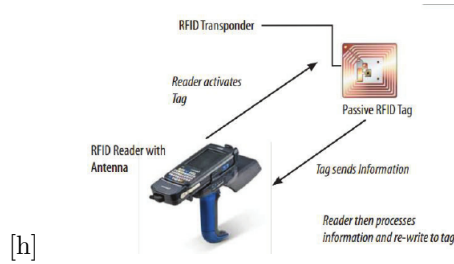
[h]

Figure 2.2: Components of an RFID system

- A transponder: This is the tag that holds information, found on the object to be identified

- A reader/interrogator: This device is able to capture data from the tag.It has a radio frequency module, control unit and coupling element for linking to the transponder. Additionally, an interface is added to pass on data captured from the transponder to a different system

Sabbir Ahmed et al. in 2019 also proposed a similar solution.Their proposed system would simplify toll payment through use of RFID tags placed on digitised license plates of all vehicles.Once the tag is scanned, and the motorist has a sufficient balance on their account, the vehicle is granted access[12].

Another study by Etqad Khan et al. in 2018 proposed a system similar to ours that would ease payment of toll fees using RFID tag that would be linked to motorists' personal accounts where would have a mobile e-wallet on which a given amount would be saved.The system also provides a mobile application to view their past payments[13].

Research Gap

These two identified studies are constrained in our project scopes context, because:

- It would first off require digitisation of all vehicle license plate, an endeavour that has not yet been taken on by the government of Uganda.

- Long range RFID tags and scanners are costly to purchase which would be needed in this use case are costly ,and would thus the need for a low-cost solution that is accessible to the majority of the motorists.

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2.2   Our Contribution

Alot of work has been done by other researchers to address the issue of digital payments for toll / parking fees. Many of these solutions leverage RFID technology as an alternative to the physical cash payments. This would however require purchasing costly scanners and tags, thus the need for a similar but cheaper solution. The biggest benefits to our proposed system:

- Developing a low-cost and context-specific solution for cashless parking payment using local popular payment platforms such as MTN mobile money

- Designing and implementing a mobile app and an embedded microcontroller that interact using QR codes to facilitate parking access and payment

- Evaluating the performance and usability of the system and comparing it with the current system of ticketing and payment

- Examining the benefits and challenges of the system, such as security, scalability, and user acceptance

Chapter 3

Methodology

3.1   Introduction

This chapter discusses the techniques that were used to achieve the objective of the proposal. It covers the approaches used for data collection, design, final implementation, and system testing.

3.2   Data Gathering and Elicitation

The team collected relevant and appropriate data to determine the requirements of the proposed system. This was done through questionnaires, interviews and physical observation[14].

3.2.1   Questionnaires

Questionnaires contain open or closed ended questions given to a selection respondents to solicit information on a selected research topic[15]. Google forms were be used to create online questionnaires that were shared through social media and emails to targeted stakeholders. Advantages of online questionnaires are that they are relatively easy and quick to distribute. It is also quicker to receive responses and the data can be collected directly into the database for analysis.

3.2.2   Interviews

An interview is a one on one planned conversation with a person with an aim of attaining information. Researchers had interactions with owners of the system currently in place as well as a selection of the motorists in order to get first-hand information on issues faced. This helped us in better defining the system

requirements of the project. The interviews also enabled the researchers to establish relationship with potential respondents as well as owners of the current system and therefore gain their corporation, yielding highest response rates in the survey research.

3.2.3 Observation

Observation involves spending time with stakeholders and keenly monitoring their activities. This will provide unbiased information that will benefit the study. Researchers took a physically closer look at what takes place during the daily activities of motorists trying to access the university and the challenges they face and will entail systematic noting and monitoring of events, behaviors of the motorists as they go on with their activities

3.3 Data Analysis

This was done to remove inconsistencies in the data collected, as well as sieve out useful data that will be used to improve the system requirements.

3.4 System Design

For the system design, context diagrams were created and used to define the scope of the project and its environment as well as the entities who will interact with it.Additionally, there were detailed processes and data modelling[16].

3.4.1 Process Modelling

Here, data flow diagrams were used to demonstrate the processes and entities that interact with the system.

3.4.2 Data Modelling

Entity relationship modelling was done to identify the entities as well as their relationship how they interact with each other This was achieved by use modelling entity relationships. The researchers used a top down approach to identify the entities interacting with the system.

3.5 System Implementation

At this stage the team built the E-Tolls application.A number of tools and technologies were used and these are defined below:

3.5.1 Software tools

- Android Studio.

- Arduino IDE: This will be used to write the code for the microcontroller.

- Flutter mobile framework: This will be used to write the cross-platform code for the application

- DigitalOcean: This will be used to host the remote server.

-

3.5.2 Hardware tools

- ESP32 microcontroller

- Servo motor to demonstrate the opening and closing of the gate

- Camera to be used to scan QR codes

- Wi-FI GSM module to enable internet connection of the microcontroller

3.6 System Testing and Validation

Here, the system is deployed and executed to assess its functionality using carefully planned testing strategies. The system was deployed on a server and released as a prototype for user testing and validation. The purpose of validation was to ensure that the system performs precisely as intended in a consistent and efficient manner.

To validate the system, various methods were employed, including testing the prototype with invalid data and assessing how it handles exceptions. In cases where the prototype failed to handle exceptions satisfactorily, security measures were implemented to address those scenarios. Comprehensive and systematic testing was conducted to identify any flaws in the system and the underlying database structure. The identified faults were documented, and the process was repeated until the system demonstrated compliance with the specified requirements and performance criteria.

3.7 Conclusion

In conclusion, this chapter has outlined the procedures followed in the creation of the E-Tolls Mobile Application. The system we believe will be able to meet not just the requirements of the users but also the objectives of the project.

Chapter 4

System Analysis and Design

4.1 Overview of the System

This chapter consists of the general introduction, the study of the existing system, requirement specification and system design. The study of the existing system includes main findings from interviews, requirements specifications include functional, non-functional requirements, software and hardware requirements. System design comprises modelling the solution from the findings.

4.2 System study

The data gathered using the selected data collection techniques enabled the system developers to garner information which was studied to realise the weaknesses of the existing systems and how the new system would be designed in a better way.

4.3 Study of the existing system

Our case study as previously mentioned was the Makerere University Parking System. We conducted two interviews with the project manager who informed us all the details of the current system and its shortcomings. Some details however such as average revenue garnered by the system,etc. were not shared with us for confidentiality purposes.

4.4 System Analysis

4.4.1 Data Analysis

Below is a summary of some of the main findings from the survey we conducted.

Breakdown of the intended users of the existing and proposed system

Our analysis found that the main users of the system are fall into two categories, each with its own subcategories. These are:

- Frequent users: This comprises users students, lecturers and university staff who are the main users of the system.

- Occasional users: This comprises visitors to the university or ordinary passers-by who wish to use the system quickly perhaps a shortcut to avoid traffic, or a brief visit to the university, among other reasons

The system therefore ought to have a way to discern between these two categories, and frequent users are not expected to make payments while non-frequent users do
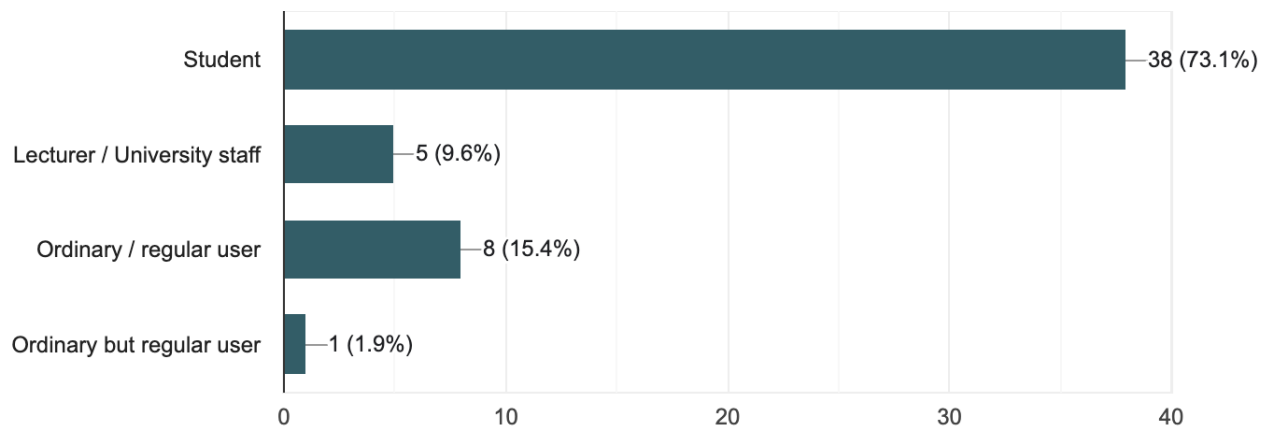

Figure 4.1: Breakdown of intended users of the system

Analysis of frequency of usage of the current system

We were also able to analyse the frequency of usage of the current system. We found that the majority of our respondents use the system on a daily basis, with a few using it on a weekly basis. This is expected since the main users of the system are students, lecturers and university staff who are expected to be at the university on a daily basis. The occasional users are expected to be a minority.
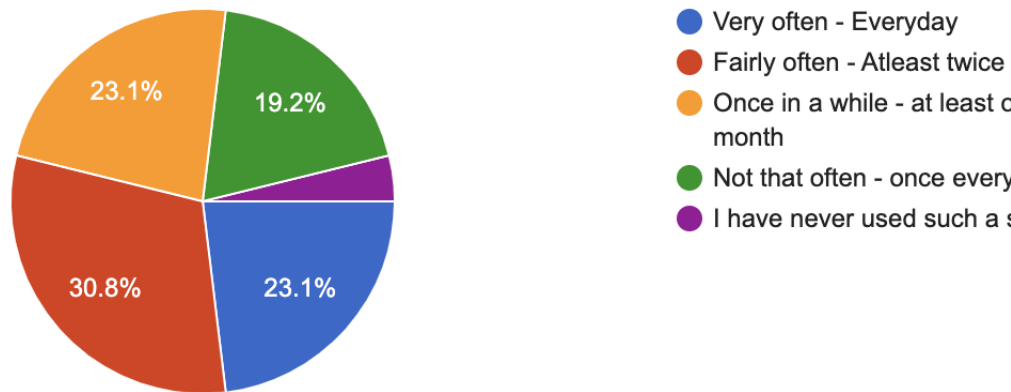
Figure 4.2: Respondents' frequency of usage of the current system

Familiarity with local mobile payment platforms

We believe one of the benefits of our proposed system is that we leverage local mobile money platforms such as MTN Mobile Money and Airtel Money. We therefore sought to find out how familiar our respondents were with these platforms. We found that the majority of our respondents were familiar with these platforms, with a few not being familiar with them. This is expected since mobile money is a popular payment platform in Uganda.
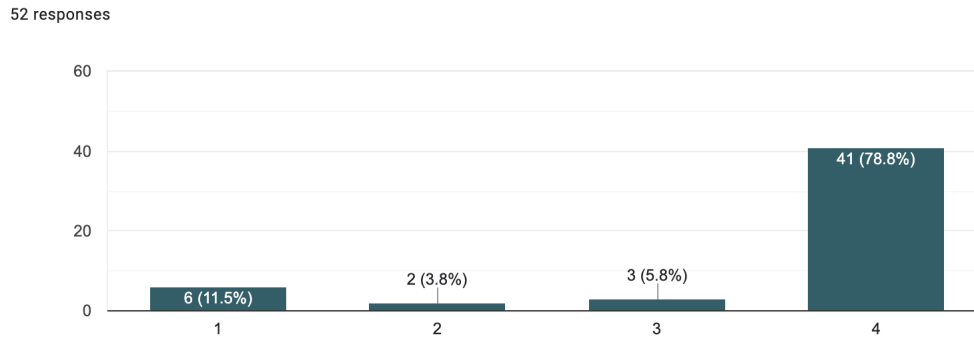
52 responses

Figure 4.3: Respondents' familiarity with mobile money platforms on a scale of 1 to 5

Level of satisfaction with existing system

We also sought to find out how satisfied our respondents were with the existing system. We found that the majority of our respondents were either not satisfied or fairly satisfied with the existing system, with a few being satisfied with it. This is expected since the existing system has a number of shortcomings which we have already highlighted.
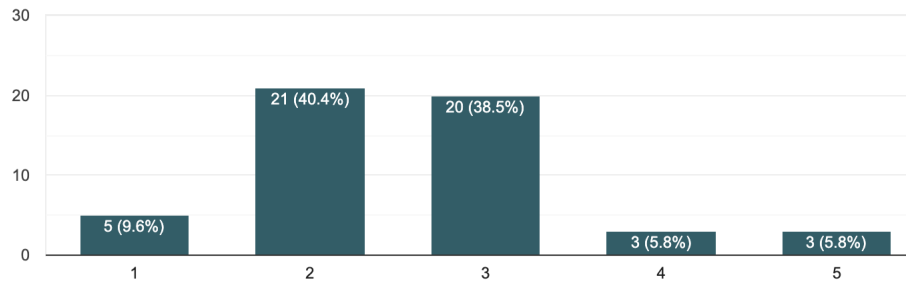

Figure 4.4: Respondents' level of satisfaction with the existing system on a scale of 1 to 5

Frequency of encountering challenges with the existing system

We also sought to find out how often our respondents experienced problems such as malfunction of the ticketing machine, difficulty finding the payment points. We found that the majority of our respondents experienced problems with the existing system occasionally, others frequently and a few never experienced problems with the existing system.
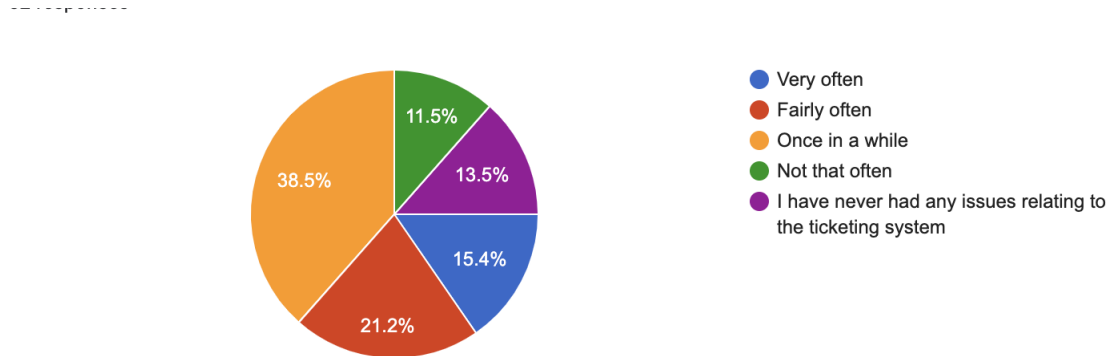
Figure 4.5: Respondents' frequency of encountering problems with the existing system

Opinion on the hefty fine for losing a ticket

The researchers also sought from the respondents their individual opinions on the hefty fine for losing a ticket. All respondents expressed dissatisfaction with the idea, justifying the need for a digital alternative of ticketing that avoid such scenarios.

4.4.2 Requirements Specification

In order to come up with the end user requirements for the new system, data was collected through interviews with both the project manager of the current system at Makerere University and a survey shared with motorists who use the gates.

The collected data was then analysed in order to come up with the requirements of the new system. This section included the requirements of the new system divided into user requirements and system requirements.

User Requirements

This encompasses the requirements of the system from the user's point of view.

The users identified are gate attendants who can also double as administrators of the system as well as motorists who use the gates. The motorists are split into two further categories: regular users and occasional users.

- **Gate attendants / Administrators**: Manages the ETolls System
- **Motorists**: Uses the ETolls System to make their payment

Functional Requirements

This is to with the services that the system will provide to the users. The system will be able to:

- Allow new users(motorists) to register for the system
- Allow registered users to log in to the system
- Allow users to make payments for parking
- Allow users to view their payment history
- Allow users to view their parking history
- Allow the system administrator to add or delete users

Non-Functional Requirements

These are requirements that are not directly related to the functionality of the system but are important for the system to work properly. These include:

- The system should allow for easy registration of users
- The system should support various payment platforms such as MTN Mobile Money, Airtel Money
- The system should be secure
- The system verifies all user inputs and users must be notified in case of error

4.4.3   System Design

This section defines the physical architectural design and the logical design (showing processes, sub processes and data flows to/from external entities) and database design of the system required to satisfy the specified requirements.

Architectural Design

An architecture diagram is a representation of elements that comprise a given system[17].

The system will comprise a mobile application as well as remote server hosted on the cloud. The mobile application will be used by the motorists to make payments and view their payment history. The remote server will be used to store the data of the users and their payment history. The final component is the microcontroller which will be used to control the gates and communicate with the remote server.

For demonstration purposes, the system will be demonstrated using a microcontroller and a servo motor to demonstrate the logic of opening and closing of gates
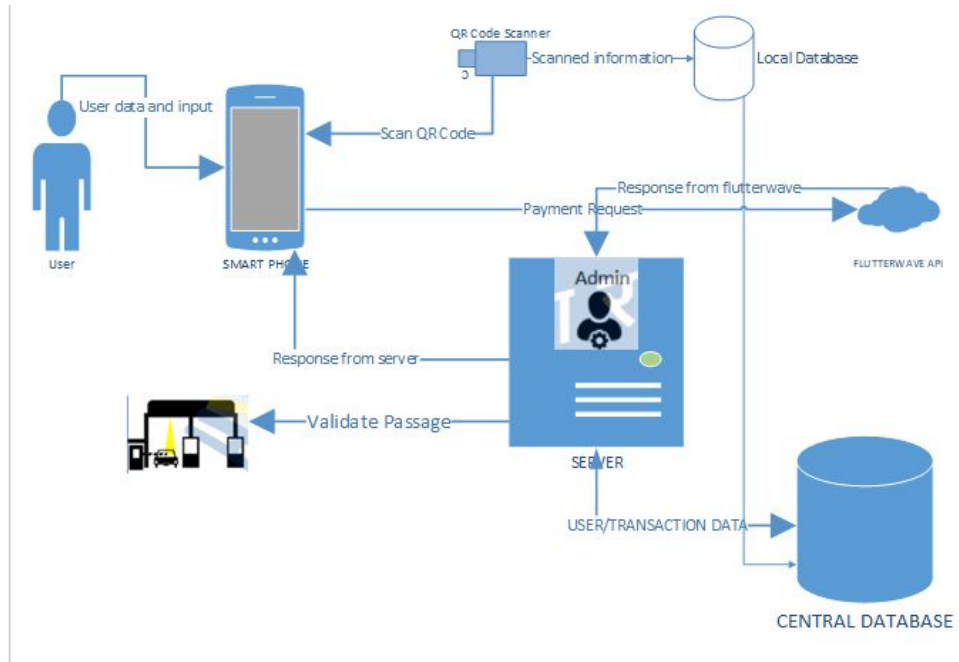

Figure 4.6: System Architecture diagram for E-Tolls System

Use case diagram

A use case diagram is a graphical representation of a given user's possible inter-
actions with a system. It gives broad view of a system and the different types
of users and use cases within that system [18]. Below is a use case diagram for
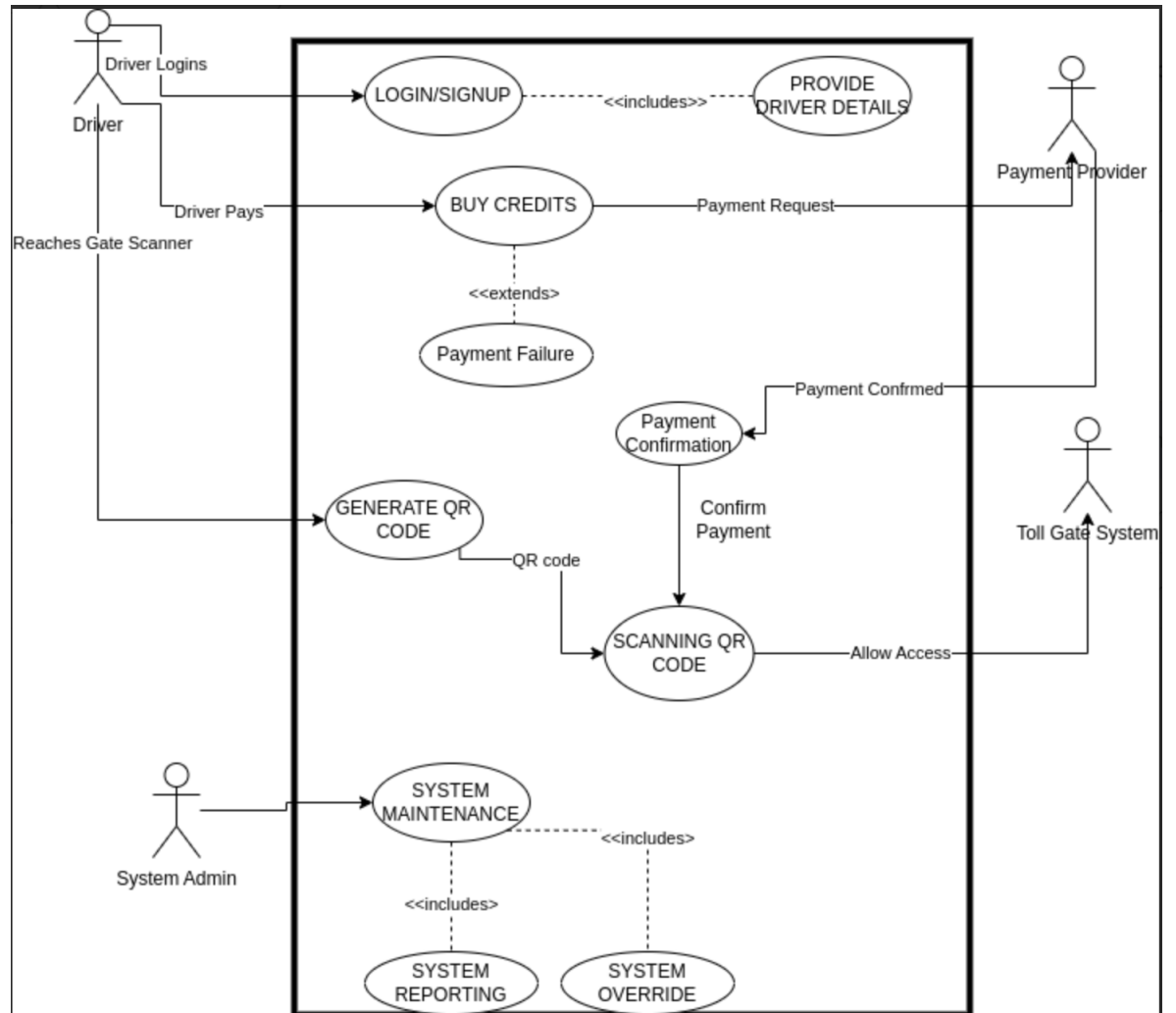our proposed system

Figure 4.7: Use Case diagram for E-Tolls System

Entity Relationship Diagram

An entity relationship diagram (ERD), also known as an entity relationship model, is a graphical representation that depicts relationships among people, objects, places, concepts or events within a system. The diagram below shows the entities and their relationships in our system[19].
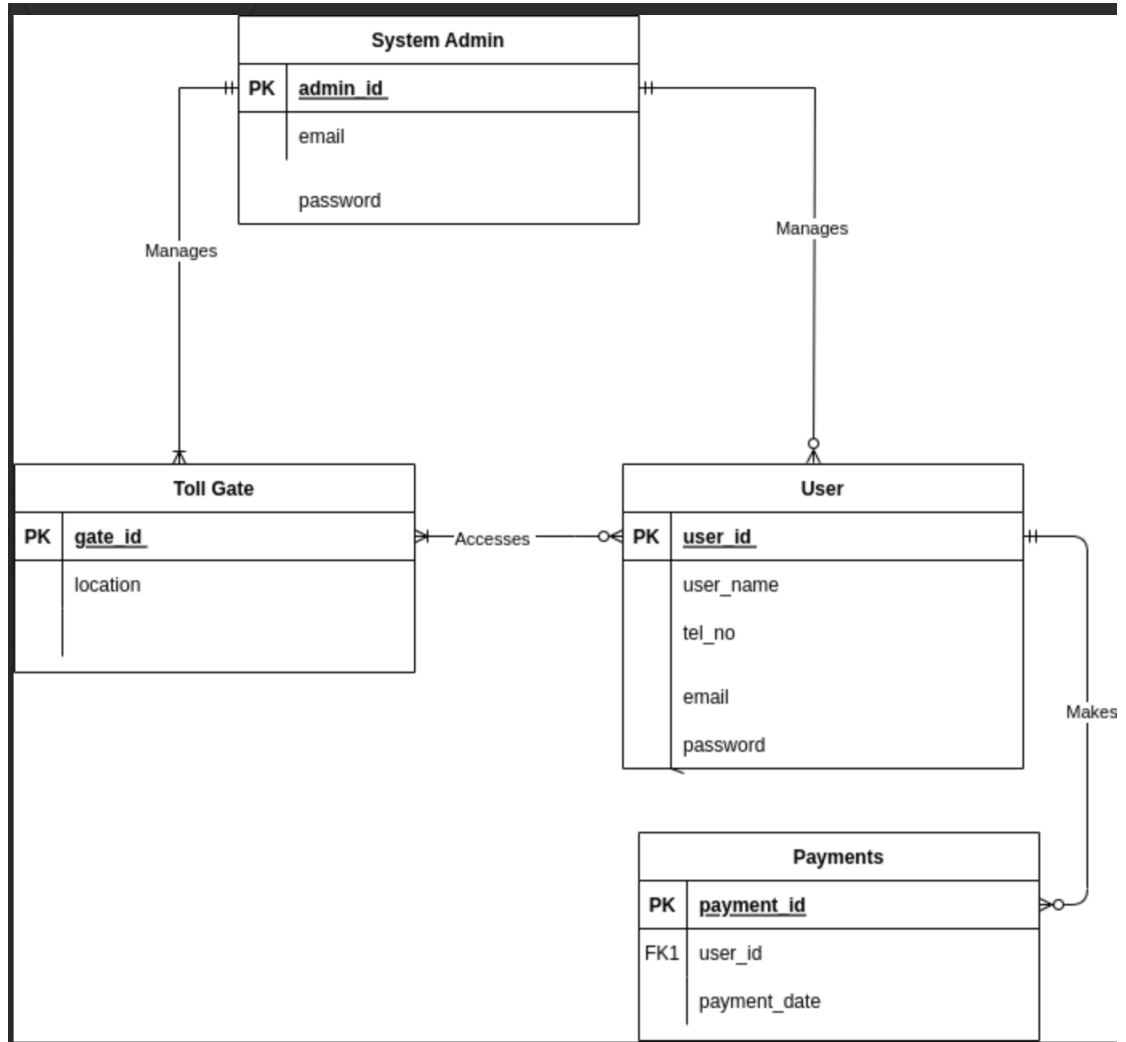

Figure 4.8: Entity Relationship Diagram for E-Tolls System

Flow chart

The flow chart represents the dynamic behavior of the objects and classes that have been identified as part of the system. The flow chart helped us describe the plan in order to perform the different tasks. It showed what was done when the decision was made and when to go to each process as a result. The flow chart helped us build a step-by-step picture of the processes of our system.

Parking Context

Vehicle reaches gate → Toll gate opens and User enters.

User navigates or parks in premises

User buys credits makes payment in the app

Vehicle reaches gate

QR code generated

User reaches gate

QR code scanned

Payment Verification

Verification unsuccessful → Toll gate remains closed

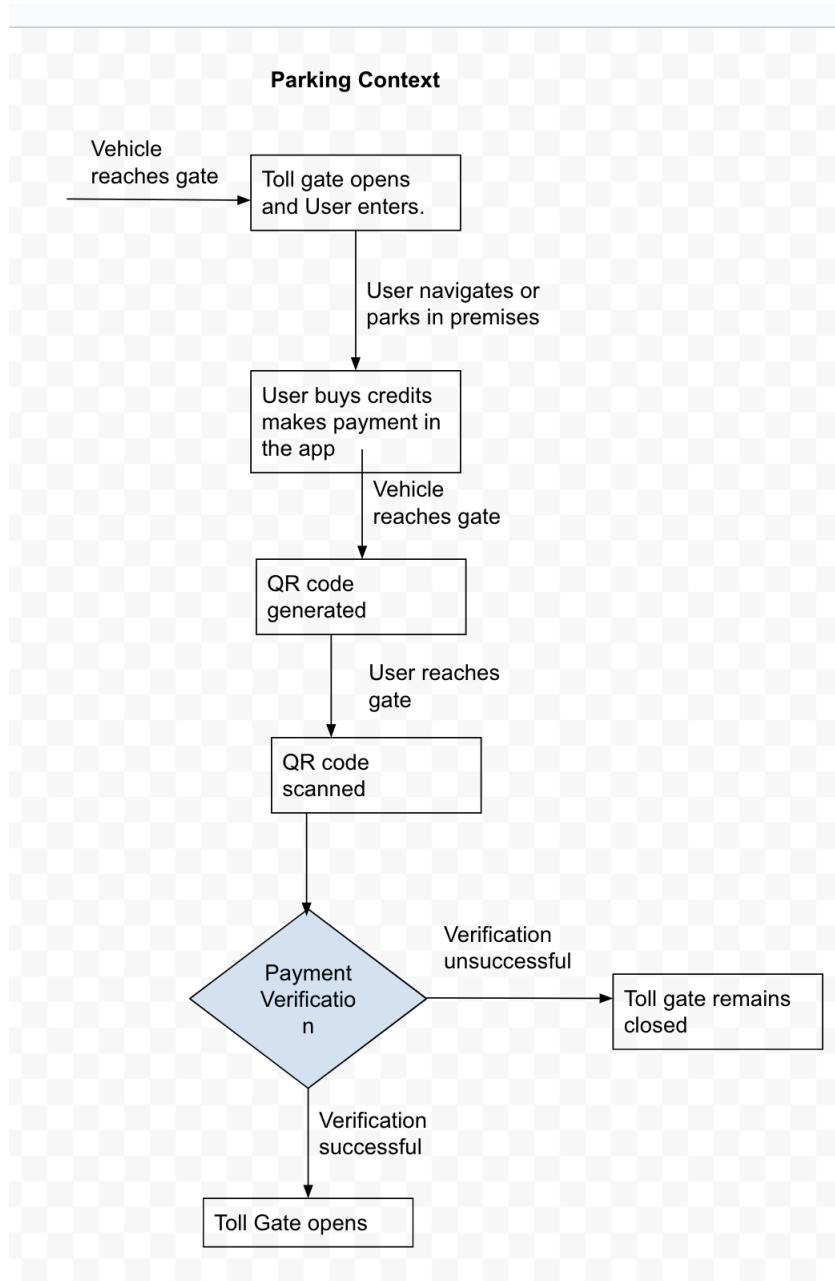Verification successful → Toll Gate opens

Figure 4.9: System Architecture diagram for E-Tolls System

Context Diagram

A context diagram is a visual representation of how external elements interact with a system, such as a project or a software system. It clarifies the interfaces and boundaries of the project or process at hand, and shows the project's interactions with other systems and users[20].
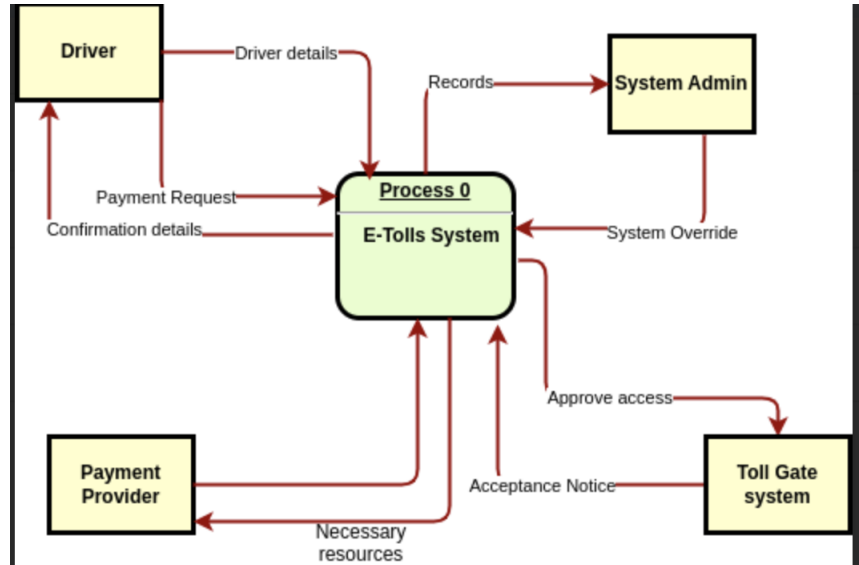

Figure 4.10: Context Diagram for E-Tolls System

Chapter 5

Presentation of Results

5.1 Introduction

This chapter shows screenshots of the system interface and details the programming environment , data manipulation and programming languages used in the development of the system.

5.1.1 Implementing the system

Programming Tools

The system was implemented using the following programming tools:

- **Android Studio**: This is the official IDE for Android development. It is used in the development of the mobile application.

- **Arduino IDE**: This is the official IDE for Arduino development. It is used in the development of the microcontroller code.

- **Digital Ocean**: This is a cloud hosting service. It is used to host the remote server.

- **Flutter**: This is a cross-platform UI toolkit developed by Google. It is used to develop the mobile application.

- **ESP32 Microcontroller**: This is a microcontroller developed by Espressif Systems. It is used to receive data from the mobile application and send it to the remote server.

Embedded Systems Equipment

The following equipment was used in the development of the system:
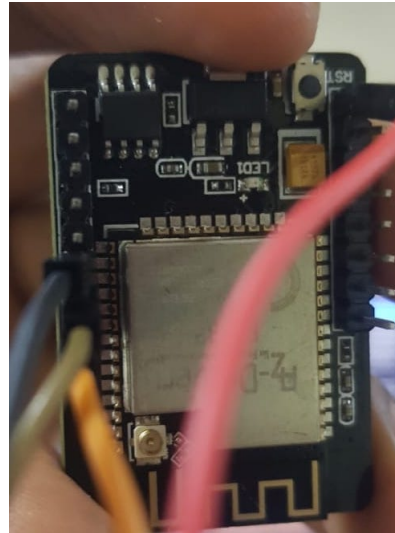
<div align="center">(a)   (b)</div>

Figure 5.1: ESP32 microntroller used to scan the user QR codes

5.1.2   Sample Screenshots

(a)   (b)
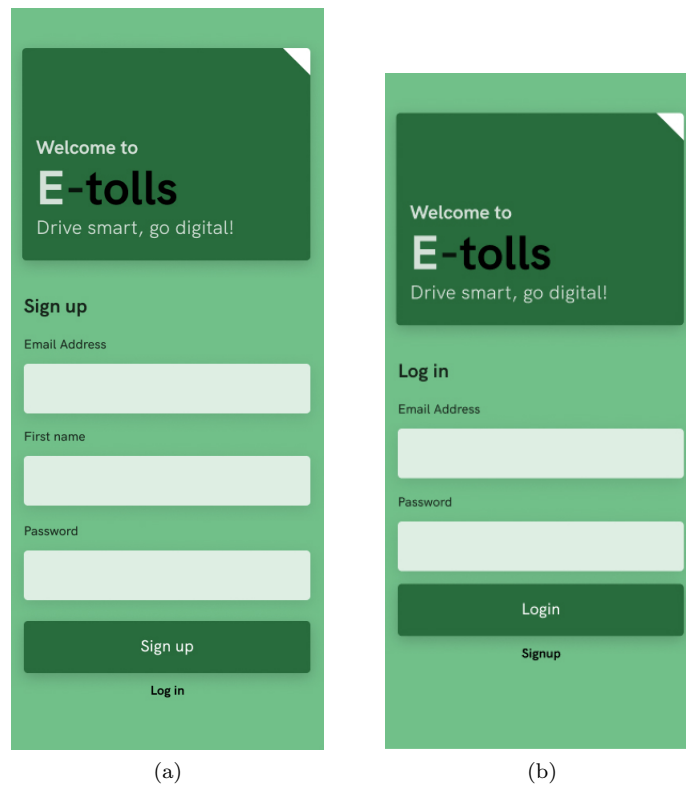
Figure 5.2: Login and Sign Up Screens of the mobile application

Buy credits

Enter Amount

You get

0 credits

Enter mobile money number

Buy Credits

Scan at toll gate

e.tolls

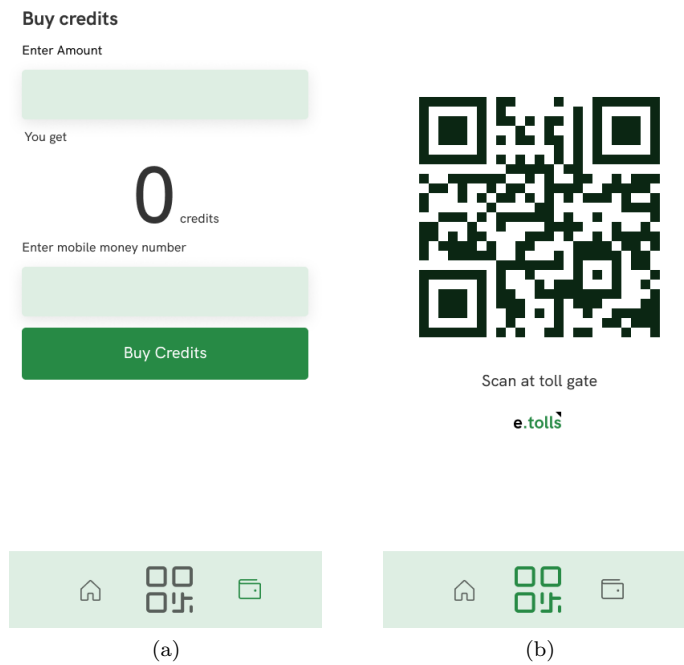(a)   (b)

Figure 5.3: Payment Screens of the mobile application

Chapter 6

Limitations, Recommendations and Conclusion

6.1 Introduction

This chapter discusses the challenges encountered during the implementation of the project, and the limitations of the current project and possible future works.

6.2 Challenges

The researchers encountered a variety of challenges during the implementation of the project. These challenges are discussed below.

- During the interviews, the researchers were not granted some information about the current system for confidentiality purposes. Information such as the detailed costs of the current system, revenue generated by the current system, and the number of tickets issued per day were not disclosed.

- Execution of the project was also dependent on funding to purchase equipment such as the microcontroller and servo motors which can easily be damaged by power surges.

- Majority of the respondents were regular(daily) users of the system and most especially students, leading to some bias in the information gathered. The researchers did not receive a significant number of responses from individuals within the occasional users category as well as university staff.

6.3 Project Gaps and Future Works

Currently, implementation of the project is limited to the university scope and only accounts for users with smartphones with iOS and Android Operating Systems.

Additionally, the researchers were limited to building a demonstration of the project using a servo motor and not a real-world gate. There is a need for a further study where the low-cost esp32 cameras are used at a real world toll / parking gate.

This project can also easily be scaled to various places such as malls and hospitals, and extended to account for non-smartphone users.

6.4 Conclusion

In conclusion, the research's primary objective was to a great extent. An initiative of this nature is worth investing in and taking to the next level of having it publicly available as it would address so many shortcomings in the system currently in place that would benefit various groups in the Makerere University community from students, lecturers and other staff while also generating revenue for the university.

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Appendices

Interview Questions: Motorist

- What are some of the challenges you have faced using Makerere's toll gates?

- Describe the process of payment for toll fee at the ticket stations.

- How frequently do you use the Makerere university gates?

- Motorists who misplace their tickets are expected to pay a fine of 50,000 UGX. Have you ever misplaced your ticket? If yes, how did you resolve the issue? What are your thoughts on the fine?

Interview Questions: Toll Operator

- What was the motivation behind putting in place this system?

- What challenges do you normally face when managing these gates?

- What are some solutions you've put in place to alleviate the challenges you've had?

- Do you believe cashless payments would ease your organisation's work?

Figure 1: The researchers also conducted in person interviews with motorists and the project manager at the toll gate