UNIVERSITY OF NAIROBI

COLLEGE OF BIOLOGICAL AND PHYSICAL SCIENCES

SCHOOL OF COMPUTING & INFORMATICS

TITLE

TAARA:

A SUPERMARKET SELF CHECKOUT SYSTEM

By

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P15/130005/2018

Supervisor

Professor Daniel Orwa Ochieng

A project report submitted in partial fulfilment of the requirement for the award of Diploma in Computer Science of the University of Nairobi.

July 202

Declaration

This project, as presented in this report is my original work and has not been presented for any award in any other university.

Signed……. Date…….

Kuria Collins Kariuki

P15/130005/2018

Supervisor

This project report has been submitted in partial fulfillment of the requirements of the Diploma in Computer Science of the University of Nairobi with my approval as the University supervisor.

Signed……. Date…….

Prof. Daniel Orwa Ochieng

School of Computing and Informatics

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I sincerely thank everyone who contributed to the success of this project. I thank my supervisor for being available and resourceful as well as providing me with guidance during the undertaking of this project. My parent for financing the purchase of hardware and providing a conducive space to work in.

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Abstract

Retail stores, commonly referred to as supermarkets in Kenya, are a core part of an urban community. A majority of the goods purchased by urban area dwellers are from these stores and their presence in major shopping Centers in the country goes further to prove their significance.

As a result of the continued increase of shoppers visiting these stores, long queues have continued to riddle supermarkets and retail stores that use a traditional cashier operated Point Of Sale systems. To the disgruntlement of the store owners, long queues have become a pain to many customers at major retail outlets. A quick visit to any of the retail stores in the capital to purchase a bottle of soda in the evening will have you queuing for close to twenty minutes awaiting your opportunity to get served by the often-tired cashier. This leaves you with the wish for a faster and more convenient mode of payment.

A Self-checkout mechanism is proposed to try and overcome this problem. the objective of this project is to develop a smart cart that will enable customers to scan and bag items while shopping. This will enable the decentralization of the goods payment process thus reducing the time required to obtain the service.

CHAPTER 1

INTRODUCTION

1.1 Background

Retail enterprise has been one of the sectors that have experienced a dynamic shift over the past years both in developed and developing countries. Retailing occupies an important position, both socially and economically, in the economies of all modern societies.

In Kenya, the retail sector has experienced enormous growth due to the increase in the purchasing power of the general population. The last ten years have seen the coming up of various shopping malls around major towns in the country. This, however, has not been without its fair share of problems.

Supermarkets usually offer a variety of products at relatively low prices by using their buying power to buy goods from manufacturers at lower prices than smaller stores can. This has led to more shoppers preferring to purchase goods from these stores.

The implication of this is the formation of long queues at the supermarkets, Point of sale system. This impacts on customer satisfaction. Recent research conducted by, Qudini, a London based SaaS customer experience management platform has revealed that 26% of customers who walk out of stores due to long waiting times and poor customer service will discontinue their purchase completely, costing British retailers £3.4 billion a year.

Commenting on the findings, Imogen Wethered, CEO of Qudini, said: “With online now allowing consumers to have more choice, convenience, and cheaper prices, they have become increasingly impatient and demanding within bricks-and-mortar retail stores. They expect retailers to deliver a superior service and in-store experience. Poor customer experience and long waiting times are no longer acceptable. As a result, retailers need to ensure that they are reviewing key customer pain points and integrating the right technologies and solutions.”

In a 2015 study of factors that influenced consumer preference for supermarkets in Kissi town [2], an adequate number of cashiers to reduce queuing time was ranked first among the factors.

1.2 Problem definition

Long queues continue to be a bottleneck in the retail stores' business model leading to customer frustration and reduced efficiency. According to a survey by Box Technologies and Intel in the UK, 90% of shoppers actively avoid stores with long queues. 70% even said they might not go back to a store with long lines. Hardware-based self-checkout machines have been proposed, that are similar to the tills cashiers operate, as a solution.

The **high cost of purchasing** a hardware-based self-checkout system has continued to discourage store owners from installing these systems in their retail stores. Being business people, return on investment is always a key factor they consider and there is a concern on the viability of the hardware option. This option is often left to multi-national companies that have the requisite financial muscle.

1.3 Objectives

The following have been designated as the core objectives of this project:

- Research, understand and describe a cheaper solution to queues that is easy to integrate with existing systems.

  Emphasis will be on a hardware-based solution, not just to provide a self-checkout system but also overall efficiency and stability.
- Avail to shoppers a faster way to pay for goods purchased.
- Decentralizing the payment system to reduce time spent in retail stores.

1.4 Justification

The project takes a crack at solving the queue problem in the retail stores. Implementation of this project would see reduced queues in supermarkets. This would lead to enhanced customer experience, thus boosting customer satisfaction that is paramount in the retail sector. The project also cuts down on the cost of current hardware-based self-checkout systems.

1.5 Scope

There are various inventory management systems available and in use by retail stores. In light of this, the project shall limit its scope to incorporating the hardware-based self-checkout solution and the supporting software to make it convenient for use by the average supermarket use.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Checkout systems have been in use since the 1900s where manual cash drawers were used. The advent of the computing age brought about the development of point of sale systems that could also perform inventory management roles. The self-service till was invented by David R Humble, inspired by standing in a long grocery checkout line in south Florida in 1984. The tills became popular in the 1990s. By 2013, there were over 200,000 in stores throughout the world.[6]

In the recent years, customers at retail stores have become increasingly impatient and demanding due to technology easing most user needs e.g. instant messaging. This has led to the advent and development of the self-check-out systems such as amazon go.

2.2 Existing systems.

1.Amazon go.

Amazon Go is a chain of retail stores in the United States operated by the online retail company Amazon. The stores are partially automated, with customers able to purchase products without being checked out by a cashier or using a self-checkout station. According to a promotional video published by Amazon, the store concept uses several technologies, including computer vision, deep learning algorithms, and sensor fusion to automate much of the purchase, checkout, and payment steps associated with a retail transaction. However, public rollout of the Seattle Amazon Go prototype location was delayed due to issues with the sensors' ability to track multiple users or objects within the store,[8] such as when children move items to other shelves or when more than one customer has a similar body habitus.[9]

2.Panasonic’s RFID Based Walk-through Checkout Solution.

With this "RFID based walk-through automatic checkout solution," customers can automatically checkout by walking through the checkout lane with the basket containing products with RFID

tags. By scanning information of, for example, prepaid cards in advance, the solution will automatically scan products and complete payment.[10]

3.Walmart's self-checkout stations.

Customers scan their groceries. Shoplifters are prevented from packing items without scanning them by technology that calculates the weight of products. If the weight of the bag does not match the weight the checkout has calculated based on barcodes, staff are alerted. For products without barcodes, customers choose the item from a list of photos on the screen. The item is then automatically weighed and priced. The customer can select the method of payment on the touch screen. This system, however, was faced with a weight measurement problem where the system kept on signaling false positives leading to the embarrassment of most shoppers.

CHAPTER 3

SYSTEM ANALYSIS AND DESIGN

Introduction

The research methodology describes how the research will be carried out so as to accomplish the identified research objectives.

3.1 System Analysis

This is the process of collecting and interpreting facts, identifying the problems, and decomposition of a system into its individual components. It is conducted in order to gain the full understanding of the proposed system and specify what the system should do.

3.1.1 Feasibility Study

This is the assessment of a systems practicality to ascertain the project's likelihood of success.

Economic Feasibility

This study can be compared to a cost/benefit analysis where it aims to evaluate the economic impact the system will have on a business entity. Companies have limited funds that they are willing to spend in any of the companies endeavors thus the expenditure should be justified. The development of this systems aimed to leverage on the cost benefit of open-source hardware and software solutions to relieve the supermarkets of economic burden.

Technical Feasibility

This aspect of the feasibility study aims to check the technical requirements of the system. The design aimed to implement technologies which have a low demand on the technical resources required in development and maintenance.

Social feasibility

This study aims to analyze the acceptance of the people regarding the system design proposed. A user should not find it taxing to use the system. A test, commonly referred to as '*The mom test' [*11], was to guide design of the user interface and user manuals to make onboarding seamless.

3.1.2 Development Methodology

The development methodology is the process of dividing project work into distinct phases to improve product design, resources utilization and meet set deadlines.

Agile (feature driven) development methodology was used. It aims to be iterative, incremental and evolutionary. It breaks the development work into small increments. System development was done in sprints, short timeframes, where a lot of the development work was done.

It was divided into five activities:

1) Developing an Overall model.
   This was a high-level walkthrough of the scope of the system where requirements are elicited,
2) Building a feature.
   Information collected during the modelling sage was used to identify features by breaking down the subject domain into topical areas.
3) Plan by feature.
   This is the phase where feature outlined above were then looked at and a development plan is made.
4) Design by feature.
   A design package was produced for each feature that outlined the design diagrams for the feature in question.
5) Build by feature.
   This was where the system was built after the design was approved by the supervisor.

3.1.3 Data Gathering

Data gathering is the procedural collecting, measuring and analyzing accurate insights for research using standardized techniques to gain insight on the problem statement and proposed solution. This enables the researcher evaluate their proposed solution on the basis of collected data to remain objective

Various techniques were used to collect data on the daily activities of retail stores to identify the system weaknesses and make an educated attempt to propose a suitable solution.

The following were the used methods:

a) **Interviews**

Interviews were conducted on supermarket floor manager and they pointed out the Point of sale as a major bottle neck in their business that slowed down the delivery of service. Customers interviewed expressed their dissatisfaction in the time they spend queueing to pay for goods purchased. They pointed out that after a long day of work the las thing they are willing to think off is the queue at their local retail store.

b) **Existing research papers**

Existing research papers were read to provide helpful pointers on the issue at hand. They were instrumental in scientifically articulating some aspects of retail such as factors that influence consumer ranking of retail outlets in Kenya a case of supermarkets in Kisii town[12] that showed reducing queueing time was an important aspect of consumer ranking.

c) **Review of existing systems**

Existing system, similar to the proposed solution, were looked at in order to gain valuable insight on their merits and the solutions implemented to solve various problems common in the retail sector. Their limitations were also looked at to avoid repeating the same in the proposed solution and to offer solutions.

The systems looked at include Amazon Go, Panasonic's RFID Based Walk-through Checkout Solution and Walmart's self-checkout stations.

3.1.4 Requirements Analysis

Functional Requirements

The functional requirements describe:

1. The user should be able to scan goods with little or no assistance from supermarket staff.
2. The user should be able to view goods scanned together with their prices.
3. The user should be able to pay for goods purchased using mobile money b keying in the desired.
4. The system should give status messages to the user where need be to facilitate a positive user experience.

Non-functional Requirements

The non-functional requirements describe:

1. **Performance**

   The Premise that the system is built on is speed of delivery.

2. **Security**

   Security is a priority as the system handles money transactions and user private information.

3. **Availability**

   The system should be available 99% of the time when required by the users. This can be achieved by using robust and tried and tested ways of software architectural design.

4. **Data integrity**

   Data modification and update should only be conducted by authorized personnel. Database updates on the system should be done at appropriate times to maintain the database integrity.

3.1.5 Use Case Model

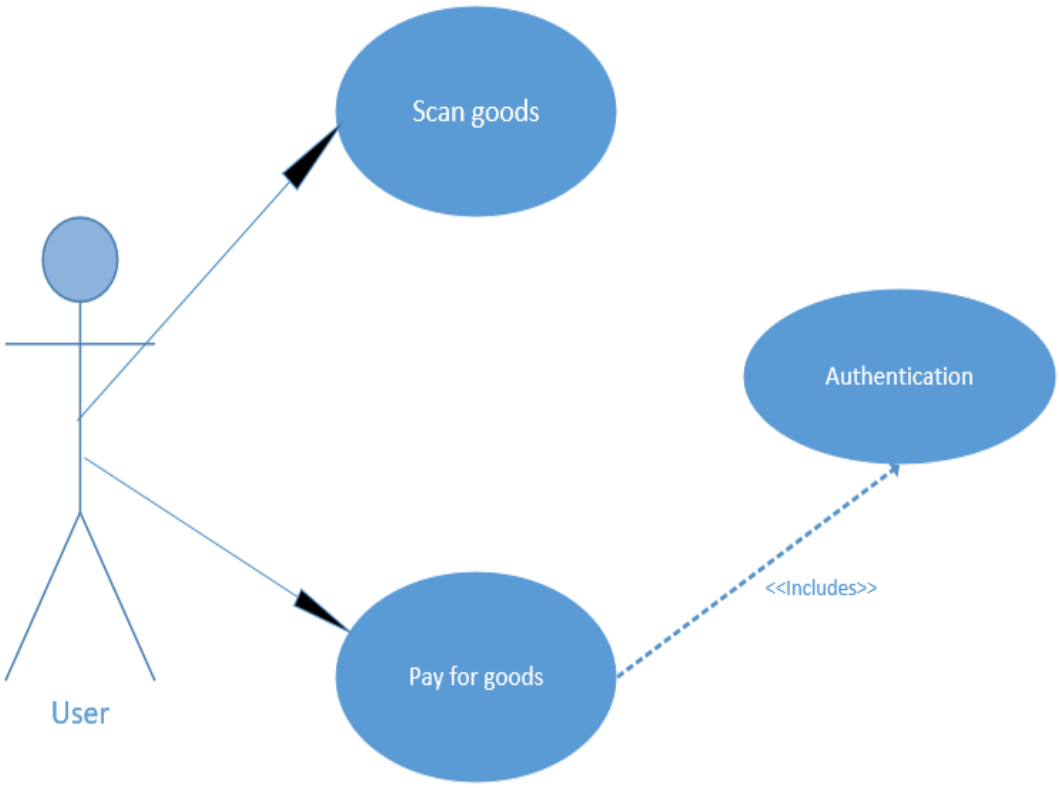

Figure 1

3.1.8 Data Flow Diagram

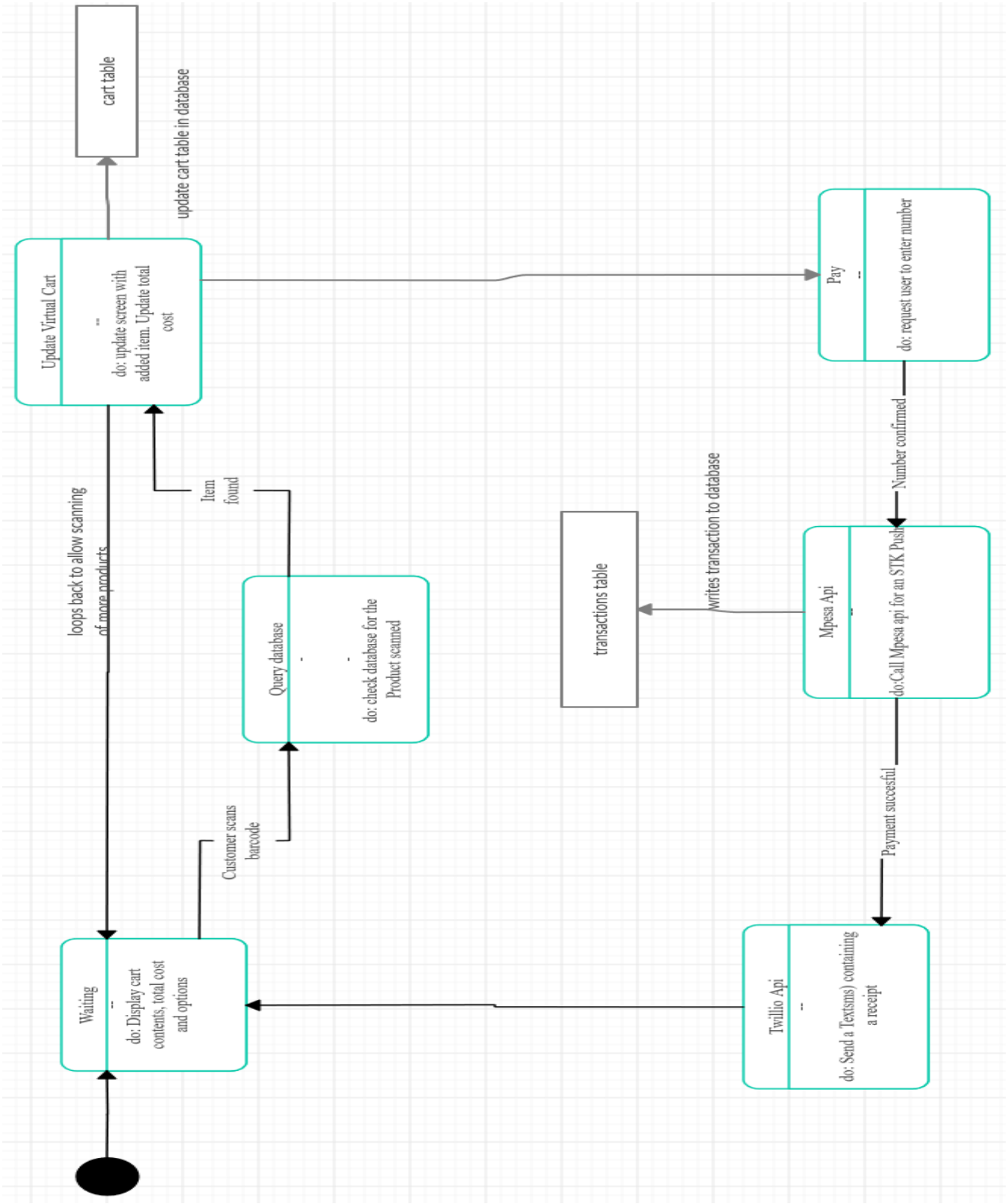

Figure 2

3.2 System Design

Systems design is the process of defining the architecture, modules, interfaces, and data for a system to satisfy specified requirements.

3.2.1 Conceptual Model

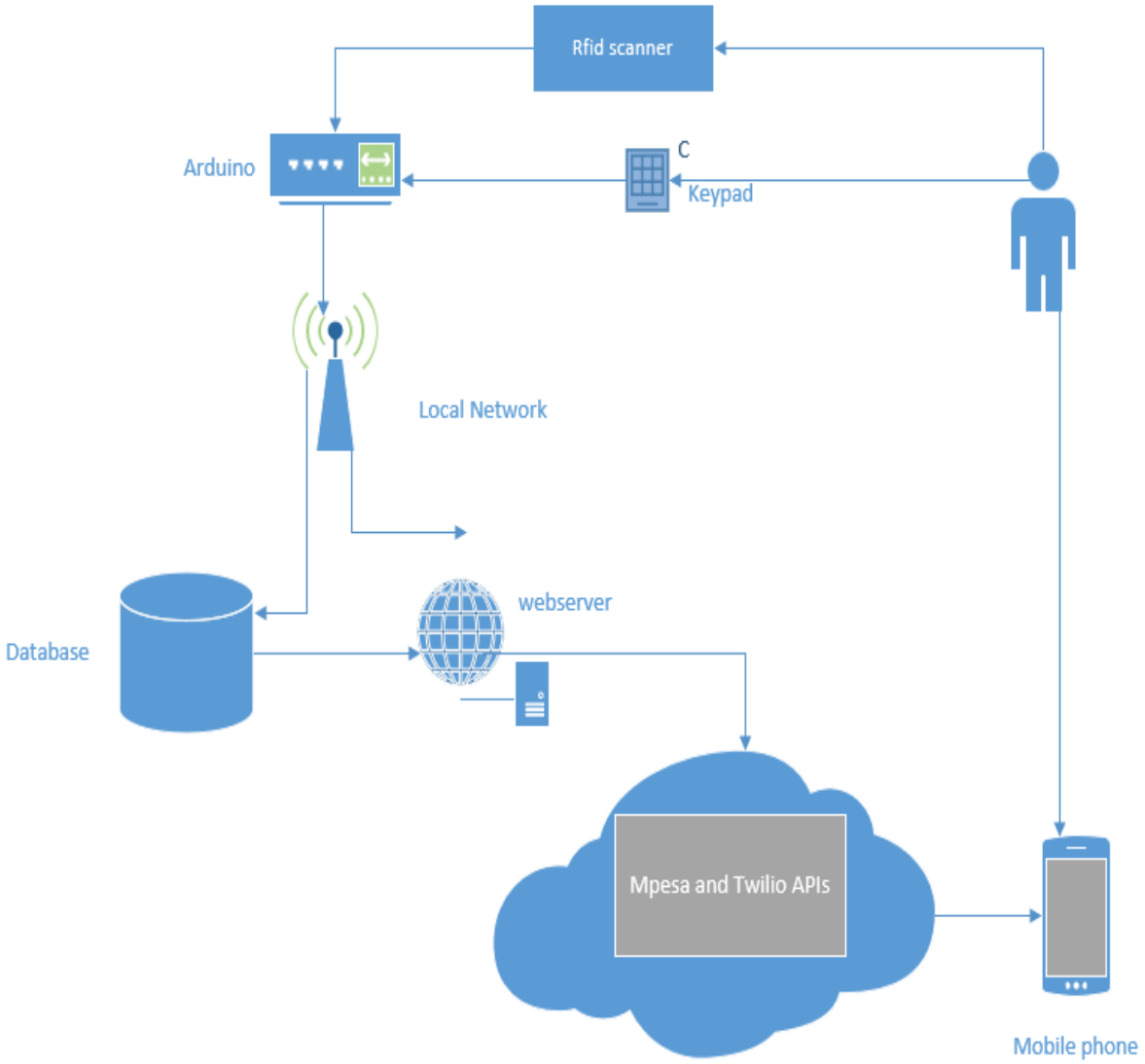

Figure 3

3.2.2 Database Design

3.2.2.1 Entity Relationship Diagram

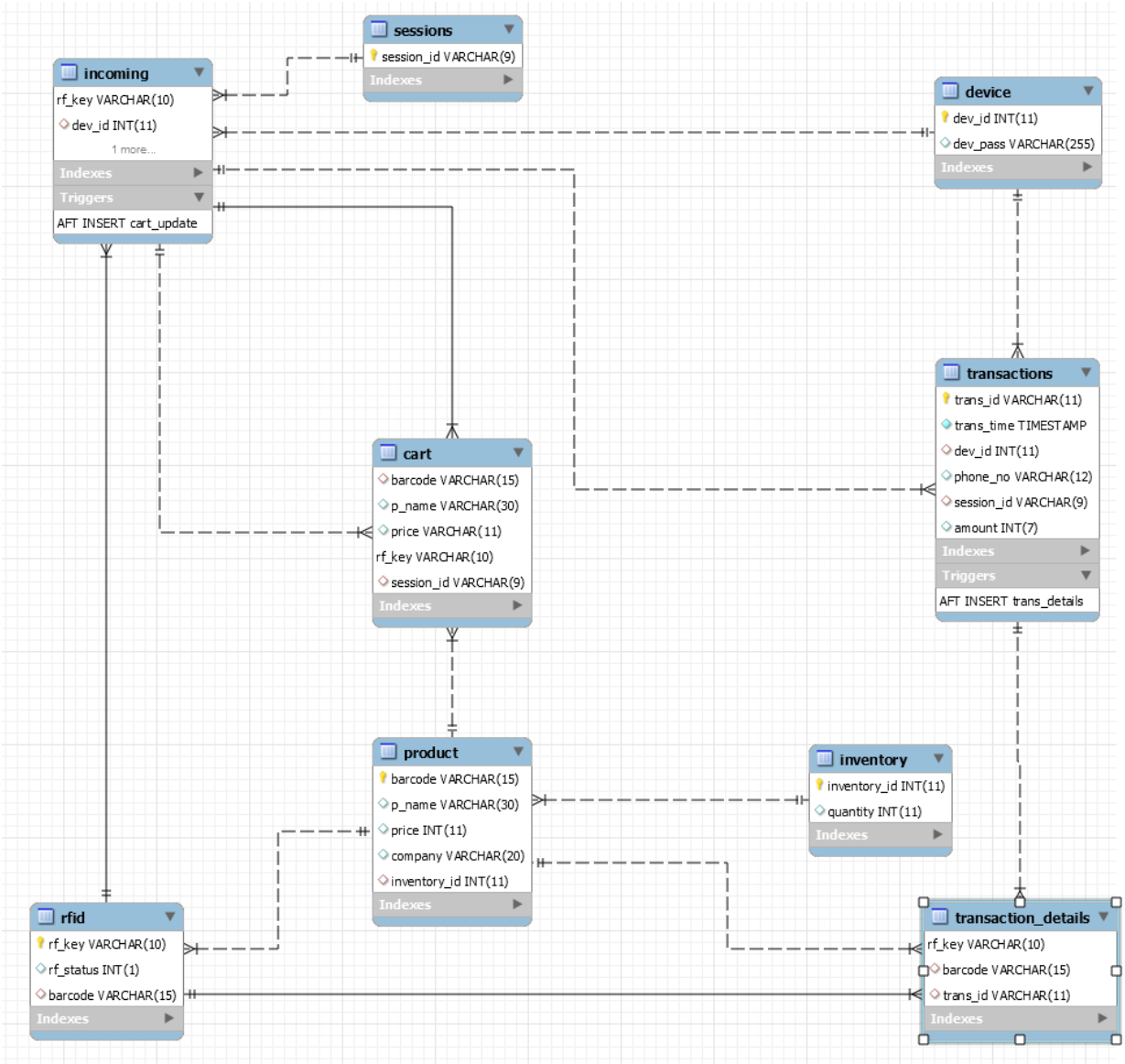

Figure 4

CHAPTER 4

IMPLEMENTATION AND TESTING

4.1 Resources

4.1.1 Hardware Resources

1) Arduino mega 2560.

   This is the brains of the project and processes all data coming from the various components listed below. It contains a software written in C++.

2) Mi-fare RFID reader.

   This is the reader that decodes information stored in RFID cards and stickers and sends it to the Arduino.

3) 16 x 2 LCD.

   This gives output information on the state of the device.

4) 4x4 Keypad.

   This enables the user key in required input such as their M-pesa number.

5) Esp-8266 Wi-Fi module.

   This is the link between the device and the supermarkets Local Area Network.

6) 50k Potentiometer.

   This varies the LCDs contrast to the users liking.

7) 4x RFID cards.

   These were attached to products to enable scanning.

8) Local Area Network.

   Connects the device and the supermarkets servers in a secure environment.

9) Bread board.

10) Jumper wires.

4.1.2 Software Resources.

1) Microsoft VS code.

   This is a code editor that is cross platform and avails various tools to enhance the developer's productivity.

2) Arduino IDE.

   This is a code editor provided by Arduino to run Arduino code and related dependencies.

3) Web Browser – Mozilla Firefox

   This was used to display the Shopping cart contents to the user.

4) MySQL Workbench.

   This was used to create, deploy and manage the database.

5) Microsoft Word 2019.

   This was used to write and compile the project report.

6) Apache web server.

   This was the webserver used to serve the various Php scripts use by the system.

7) Maria db database server

   An open source database similar to MySQL was used to store the systems data.

8) Safaricom M-pesa STK push API.

   The API provided by Safaricom was used to generate an STK push to enable the user pay for goods purchased.

9) Twilio Messaging API.

   This API was used to a receipt to the user after purchase.

10) **PHP** was used for scripting the backend, **C++** the Arduino software, **Html** the shopping cart layout, **JavaScript** the auto refresh feature of the shopping cart and **SQL** to create and query the database.

4.2 System Testing

System testing is testing conducted on a complete integrated system to evaluate the system's compliance with its specified requirements.

The following tests were conducted:

4.2.1 Unit Testing

Unit testing is a level of software testing where individual components of a software are tested. The purpose is to validate that each unit of the software performs as designed.

Each functional part of the system was tested using sample inputs and output analyzed. The software driving the hardware components was written in modules that were incremental in complexity and integration.

Each function and module were tested individually to see if they were working as expected. The functions were made to be highly cohesive, i.e. have only one function and loosely coupled.

4.2.2 Integration Testing

Integration testing is a level of software testing where individual units were combined and tested as a group.

The purpose of this level of testing was to expose faults in the interaction between integrated hardware and software units. Test drivers and test stubs were used to assist in Integration Testing.

Any error arising was traced and a lasting solution sought.

4.2.3 Blackbox Testing

Blackbox testing in which functionality of the Application Under Test is tested without looking at the internal code structure, implementation details and knowledge of internal paths of the software.

This type of testing is based entirely on software requirements and specifications.

The device underwent Blackbox testing and performed as desired.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS.

5.1 Summary of The Project

The overall objective of the project, to design and implement a Self-checkout system, was accomplished and a working prototype was developed. The Arduino platform was immensely resourceful in quickly putting together a prototype due to its simple and opensource nature allowing you to fine tune to your desired application.

The overall objective had specific research objectives that were to be achieved. The first, research and description of a cheaper solution to queues, that is easy to integrate with existing systems was achieved. All components used were existing in the market and readily available. The system was also able to integrate with existing software that is used in development of Supermarket inventory systems.

The second objective was to avail to shoppers a faster way to pay for goods purchased. This was achieved by eliminating the queue process and introducing a self-checkout solution that is user friendly.

The third objective was to decentralizing the payment system to reduce time spent in retail stores. The premise was that this would introduce parallel payment of goods thus leveraging on the merits of a parallel system. The development of a small portable device that can be affixed to a cart achieved this objective by giving the user liberty to process their goods purchased.

5.2 Limitations of The System

Prototyping hardware.

Being a system built on prototyping hardware the prototype is not market ready and could not be efficient if deployed as constructed due to several moving parts.

Documentation of less know Arduino modules.

Documentation of the less known Arduino modules such as the esp. 8266 was difficult to track down and the various firmware developed without version control added to the difficulty of programming the module to function as willed.

The effectiveness direct dependency on individual devices deployed.

For the system to be effective a minimum number of individual devices has to be provisioned in a retail store. This is to achieve the decentralized payment system objective. The minimum number of devices is determined by the traffic at the store during the peak times of the day.

System Architecture.

The current system architecture cannot perform optimally when subjected to increased traffic and therefore a need arises to add design features that would ready the device for enterprise deployment.

5.3 Recommendation for Future Work

System architecture.

The current system architecture cannot perform optimally when subjected to increased traffic. Recommendations are made to add a load balancer to different webservers deployed.

A master-slave database architecture is also proposed where all writes are done in the master and reads done from the slave to enable horizontal scaling and deadlocks occurring during writes.

A cache system could be implemented on the read request to serve the most common requests such as popular products to reduce the number of database requests made.

Enterprise hardware

Being a system built on prototyping hardware the prototype is not market ready.

A custom hardware design is recommended to get rid of the many moving parts in the prototype device and make it appealing to the user.

Mass production

Mass Production of the units, would drive the unit price down thus enabling the retailers, overcome the effectiveness direct dependency on individual devices deployed limitation, achieving decentralized payments.

5.4 Conclusion

The self-check out system allows customers in a supermarket beat long queues in the stores.

The project was aimed at designing and implementing a solution that would enable self-processed checkout. To accomplish this a prototype was developed, implemented and tested. This goal was achieved.

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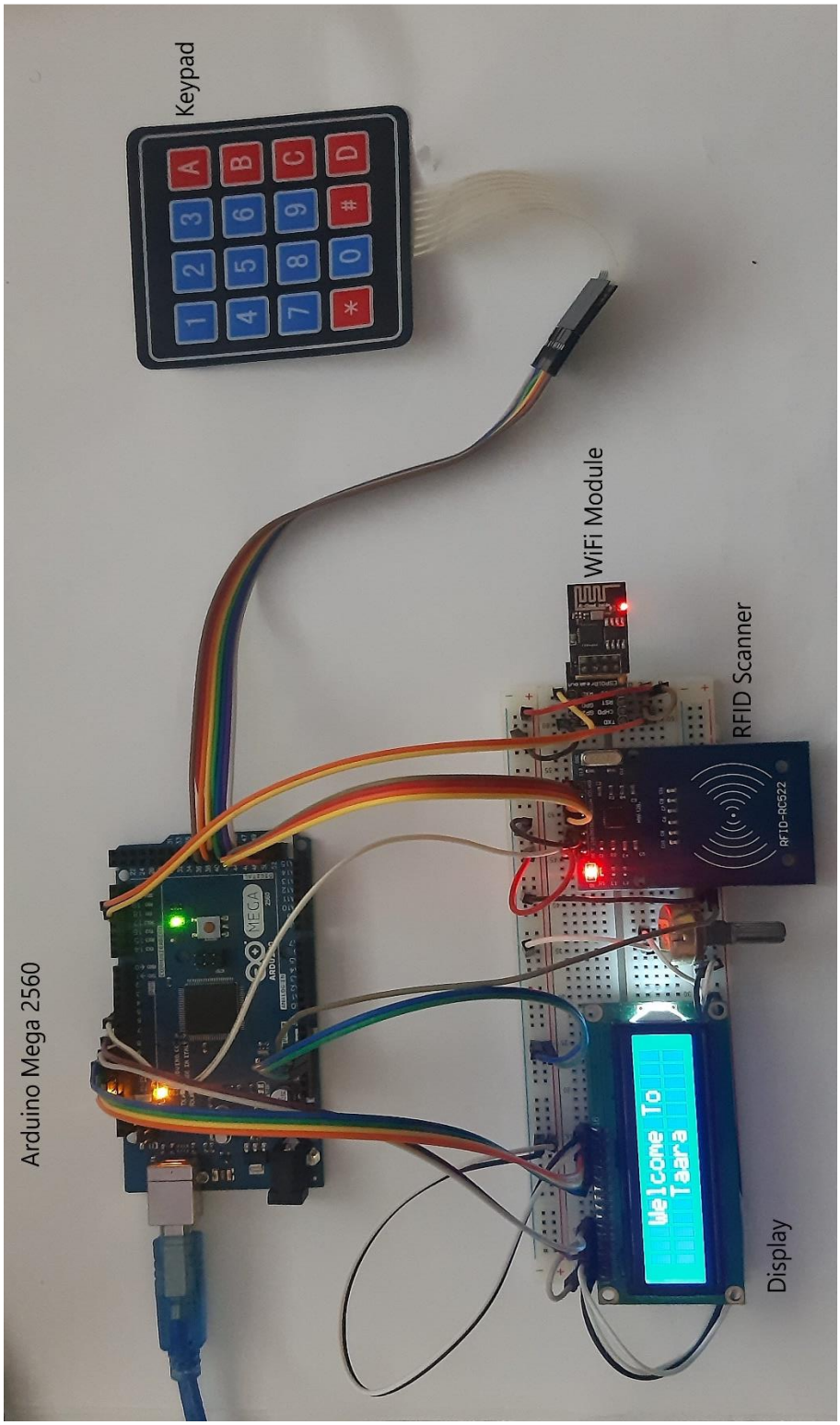
Appendix 1

1. Project Diagram



2. Code Samples

2.1 Arduino Setup

```
#include <MFRC522.h>

//keypad
#include <Keypad.h>

//lcd
#include <LiquidCrystal.h>

LiquidCrystal lcd(7, 8, 9, 10, 11, 12); //lcd(RS, E, D4, D5, D6, D7)pinout

 //RFID   declaration
#define RST_PIN         5
#define SS_PIN          53

MFRC522 mfrc522(SS_PIN, RST_PIN);  // Create MFRC522 instance
String scanedProd_Uid;
String number;//PhoneNumber


 //keypad declaration
const byte ROWS = 4;
const byte COLS = 4;
char keys[ROWS][COLS] = {
    {'1','2','3','A'},
    {'4','5','6','B'},
    {'7','8','9','C'},
    {'*','0','#','D'}
};

byte rowPins[ROWS] = {40, 41, 42, 43};
byte colPins[COLS] = {44, 45, 46, 47};

Keypad keypad = Keypad( makeKeymap(keys), rowPins, colPins, ROWS, COLS );  // keypad instance

//wifi connection.
char ssid[] = "col";
char pass[] = "collins...";
int status = WL_IDLE_STATUS;

//server connection
char server[] = "192.168.43.177";

// Initialize the wifi client object
```

2.2 Cart Contents

```
<!DOCTYPE html>
<html>
<head>
<link rel="stylesheet" type="text/css" href="style.css">
<script src="JQuery/jquery-3.4.1dev.js" > </script>

<body>

  <h2>Scanned Goods</h2>

  <div id="items"></div>

<script type="text/javascript">
  function display()
  {
    xmlhttp=new XMLHttpRequest();
    xmlhttp.open("GET","select.php",false);
    xmlhttp.send(null);
    document.getElementById('items').innerHTML=xmlhttp.responseText;

  }

display();

setInterval(
  function(){display();},2000
);

</script>
</head>



</body>
</html>
```

2.3 M-pesa API Call

```php


$url = 'https://sandbox.safaricom.co.ke/mpesa/stkpush/v1/processrequest';
$Passkey ='bfb279f9aa9bdbcf158e97dd71a467cd2e0c893059b10f78e6b72ada1ed2c919';
$data = $BusinessShortCode.$Passkey.$Timestamp;
$password = base64_encode($data);

$curl = curl_init();
curl_setopt($curl, CURLOPT_URL, $url);
curl_setopt($curl, CURLOPT_HTTPHEADER, array('Content-Type:application/json','Authorization:Bearer '.$password)); //setting custom header

$Passkey ='bfb279f9aa9bdbcf158e97dd71a467cd2e0c893059b10f78e6b72ada1ed2c919';
$data = $BusinessShortCode.$Passkey.$Timestamp;
$password = base64_encode($data);

$curl_post_data = array(
  //Fill in the request parameters with valid values
  'BusinessShortCode' => $BusinessShortCode,
  'Password' => $password,
  'Timestamp' => $Timestamp,
  'TransactionType' => 'CustomerPayBillOnline',
  'Amount"' => $Amount,
  'PartyA' => $PartyA,
  'PartyB' => $PartyB,
  'PhoneNumber' => $PhoneNumber,
  'CallBackURL' => $CallBackURL,
  'AccountReference' => $AccountReference,
  'TransactionDesc' => $TransactionDesc
);

$data_string = json_encode($curl_post_data);

curl_setopt($curl, CURLOPT_RETURNTRANSFER, true);
curl_setopt($curl, CURLOPT_POST, true);
curl_setopt($curl, CURLOPT_POSTFIELDS, $data_string);

$curl_response = curl_exec($curl);
print_r($curl_response);

echo $curl_response;
?>
```

2.4 Twilio API Call (SMS)

```php

?>
<?php
include "connection.php";
$sql = "SELECT `p_name`,`price` FROM `cart`";
$data = mysqli_query($conn,$sql);

if (! $data){
    echo(failed);
}
$sms = "\nProduct and Price\n";
while($row = mysqli_fetch_assoc($data)){

        $sms = "$sms{$row['p_name']} @ Ksh. {$row['price']} \r\n" ;
}

echo($sms);


require __DIR__ . '/vendor/autoload.php';
use Twilio\Rest\Client;

$account_sid = 'AC17fa4cbfda79b74fec3ba7e47d006241';
$auth_token = 'e02b422e465a783bd7d65b80acb68302';

$twilio_number = "+19283795393";

$client = new Client($account_sid, $auth_token);
$client->messages->create(

    $usernum,
    array(
        'from' => $twilio_number,
        'body' => $sms
    )
);
```

Appendix B

User Manual

The following steps are to be followed for a successful checkout assuming the device is switched on and connected to the local network:

- **Press A** on the keypad to start scanning.
- Scan products on the scanner.
- When finished scanning products **press B** to initialize payment.
- Enter your M-pesa number add **press C** to confirm.
- Wait for a prompt on your phone and enter your M-pesa pin
- Wait for a receipt SMS.
- You are free to leave the store.