UNIVERSITY OF NAIROBI SCHOOL OF COMPUTING AND INFORMATICS (SCI)

Implementation of RFID Technology to Improve Efficiency of Serving Customers-A Kenya Supermarket Case Study

By

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Declaration

The material in this research project is the original work of the candidate except as acknowledged in the text. It has not been previously submitted, either in part or whole, for a degree at this or any other university.

Sign ________________ Date ________________

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This research has been submitted for examinations with my approval as a university supervisor

Sign ________________ Date ________________

Mr. Erick Ayienga

Abstract

Supermarkets in Kenya use the barcode technology in inventory management. This leads to long queues at the till thus adversely affecting efficiency of serving customers. In trying to address this problem, a system was designed based on RFID technology that could overcome the challenges of the existing systems and improve the efficiency of serving customers. The study was about the implementation of RFID technology to improve efficiency of serving customers using a Kenya supermarket as a case study. The objectives of the study were: to design the system, to develop RFID technology shopping cart/basket/till and the Cart Management Module (CMM), to train the supermarket attendants /customers on the new system and to evaluate the system. A prototype called CMM was designed and tested. it worked as the point of sale system as well as collected data on the shopping, queuing, transaction, packing, total transaction and total shopping durations. CMM worked hand in hand with two RFID readers namely the Check in /Checkout and till RFID readers. The data was analyzed using descriptive statistics. Frequencies, means and standard deviations were calculated and the results were: the mean shopping duration of 3.36, mean queuing duration of 1.68, mean transaction duration of 2.73, mean packing duration of 2.63, mean total transaction time of 2.83 and mean total shopping time of 3.96 seconds. All objectives of the study were achieved and it was concluded that RFID technology improves efficiency of serving customers by drastically reducing time spent by customers in the supermarket.

Acknowledgements

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List of Abbreviations

AT : Arrival Time
BT : Basket Time
CIT : Check In Time
CMM : Cart Management Module
COT : Check Out Time
DC : Distribution Center
DFD : Data Flow Diagram
DSDM : Dynamic Systems Development Method
EAS : Electronic Article Surveillance
EPC : Electronic Product Code
EU : European Union
HF : High Frequency
IATA : International Air Transport Association
IC : Integrated Circuit
ID : Identification
ISM : Industrial, Scientific and Medical
ISO : International Organization for Standardization
LF : Low Frequency
PD : Packing Duration
POS : Point of Sale System
QD : Queuing Duration
RET : Receipt Time
RF : Radio Frequency
RFID : Radio Frequency Identification
RT : Read Time
SD : Shopping Duration
TD : Transaction Duration
TST : Total Shopping Time by RFID reader
TT : Transaction Time
TTT : Total Transaction Time
UHF : Ultra High Frequency

CHAPTER ONE

1.1 Introduction

Western and European countries have used Radio Frequency Identification (RFID) technology to successfully enhance customer service and achieve increased profitability. The technology helps them ensure that goods are at the right location when customers need them and their inventories are kept up to date. However, it would be unwise for us to simply adopt such best practices and apply them in Kenya because in our environment, customers have different cultures, traditions and value systems on how they do their shopping. Therefore, it is important for us to fully study and understand how RFID technology can be used to solve typical Kenyan problems. Kwok, et al (2007) as cited by Ting et al (2011) explains that RFID technology is a non-contact and automatic identification technology that uses radio signals to identify, track, sort and detect a variety of objects including people, vehicles, goods and assets without the need for direct contact (as required in magnetic stripe technology) or line of sight contact (as required in barcode technology). RFID technology can track the movements of objects through a network of radio enabled scanning devices over a distance of several meters. This study seeks to find out how the powerful capabilities of the RFID technology can be harnessed and applied in inventory management in a Kenya supermarket situation to the advantage of the customers. It is for this reason that the study focuses on the Implementation of RFID Technology to improve efficiency of serving customers in Kenya supermarket.

1.1.1 Current System of Serving Customers in Kenya Supermarkets

Figure 1.1 below shows the steps that may be followed when a customer buys good from the supermarket in the Kenyan context:

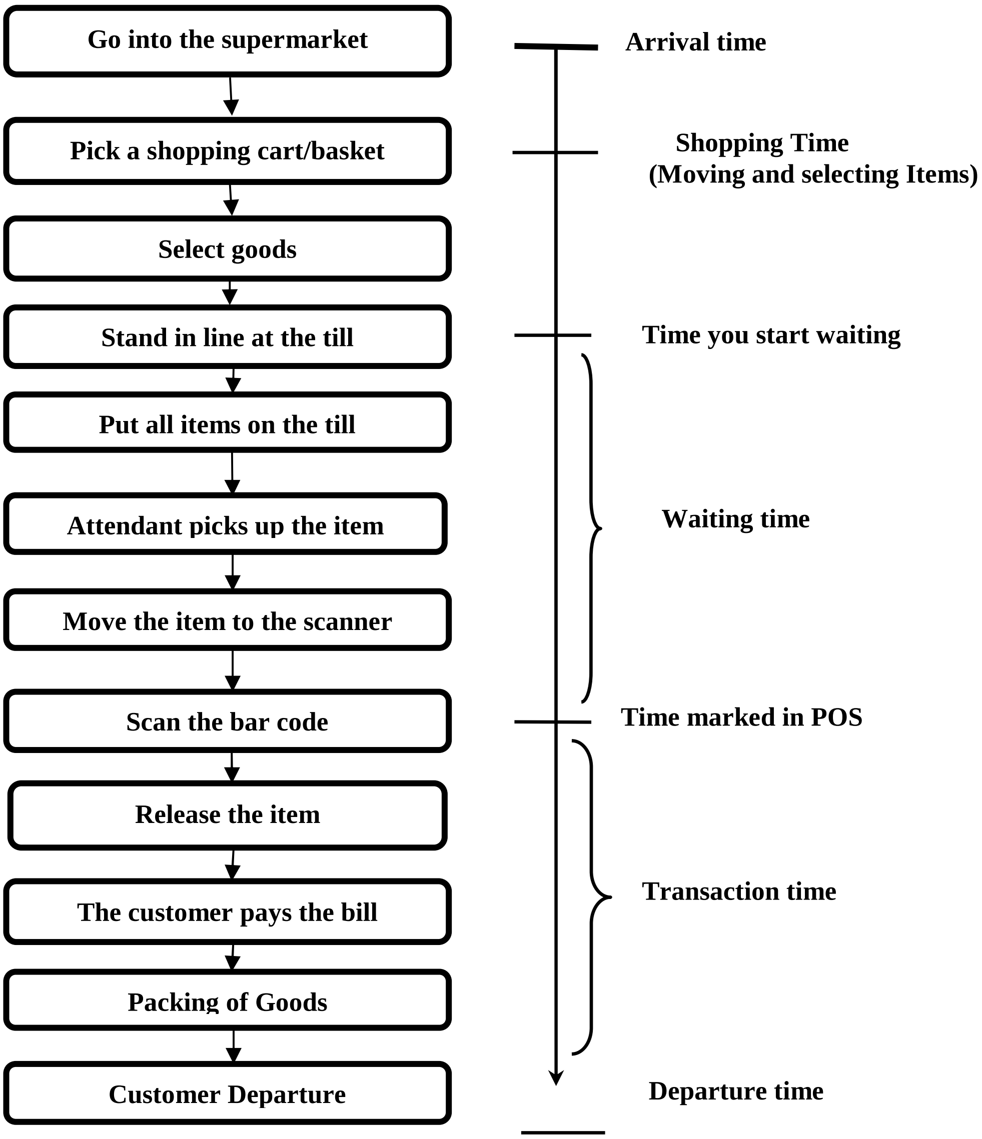


Figure 1.1: Customer Flow in Kenya Supermarket, Adopted and modified from Miwa & Takakuwa, (2008)

1.1.2 Proposed System of Serving Customers in Kenya Supermarkets

In the proposed system of serving customers at the supermarket the following steps have been eliminated from figure 1.1:

1. Put all items on the till
2. Attendant picks up the item
3. Move the item to the scanner
4. Scan the bar code
5. Release the item

The above steps have been replaced with one step where the customer pushes the cart/basket to the till and the content of the cart/basket will be scanned all at once. Figure1.2 below shows the proposed Shopping Cycle in Kenya Supermarket.

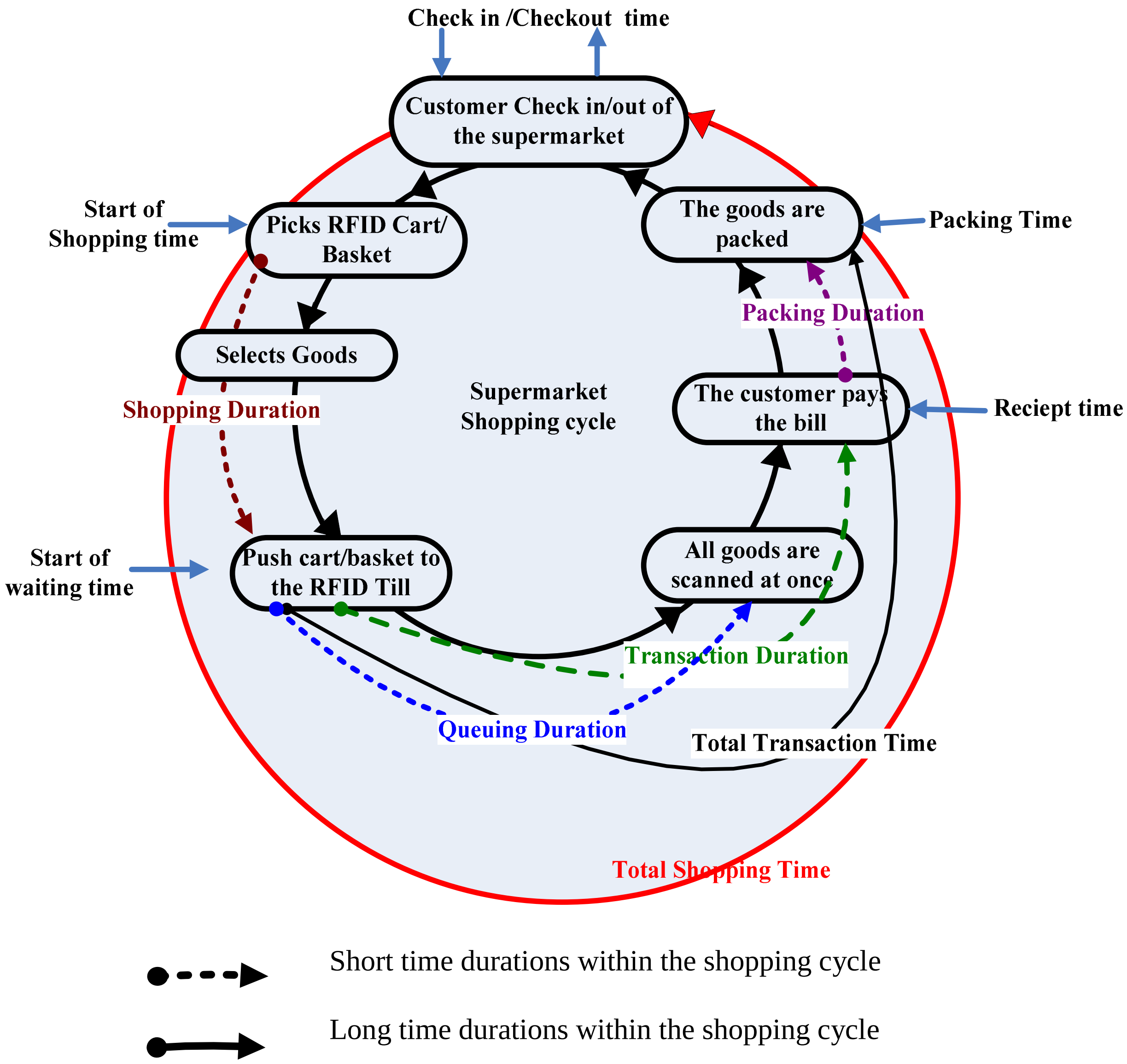


Figure 1.2: Shopping Cycle in Kenya Supermarket using RFID Technology, Adopted and modified from Miwa & Takakuwa, (2008)

1.1.3 Statement of the Problem

In current system a lot of effort is used by the customer and attendant. The customer loads the shopping Cart/basket with the selected goods, pushes the cart/basket to the till and offloads goods on the till. An attendant then picks each item one after another and scans it, the bill is paid and goods are packed by another attendant before the customer leaves the supermarket. In the proposed system less effort might be used because after the customer loads the shopping cart/basket with the selected goods, he/she will push the cart/basket to the till where all goods are scanned at once, the bill paid and goods packed before the customer leaves the supermarket. Secondly in the current system the waiting and transaction time is much longer than the proposed solution's waiting and transactions time. By reducing effort, waiting and transaction time, improvement on efficiency of serving customers will be realized. It is for this reason that this study focused on using the RFID technology to help reduce effort, waiting and transaction time and hence to improve efficiency of Serving Customers.

1.1.4 Research Questions

Does the implementation of RFID Technology enhance efficiency of service to customers?

1.2 Research Hypothesis

The implementation of RFID Technology enhances efficiency of service to customers.

1.3 Objectives of the Study

The objectives of this study will be divided into systems development and research objectives

1.3.1 Research objective

To investigate how the use of RFID Technology has improved customer service

1.3.2 Systems Development objective

The systems objectives are as follows:-

1. To design the system
2. To develop RFID Technology shopping cart/basket, till and the Cart Management Module (CMM)
3. To evaluate the system

1.4 Importance of the Study

First, the findings from this study will contribute to the advancement of knowledge with respect to enhancing efficiency of customer service in commerce and industry. Secondly, the findings can act as a guide in reviewing methods of handling inventories to reduce queues, save time, reduce cost, enhance efficiency of customer service and increase customer satisfaction. Last but not least**,** given that RFID technology is able to uniquely track each and every item in stock, it will improve on the security and inventory management. Finally the system will reduce the number of cases where shoppers, frustrated by staying for long on queues, have taken out their anger on supermarket attendants and failed to return again citing poor service delivery as the cause.

1.5 Constraints of the Study

1. Insufficient electronic components in the Kenyan market hindered the initial success of the study however the problem was solved by importing components from China.
2. The Standard Development Kit provided by the Manufacturer of the RFID readers did not have a kit for java programming hence I was forced to develop the CMM using Visual basic 6.0 which consumed a lot of development time.

1.6 Scope of the study

The scope of system development focused on the baskets register, stock items register, check in, RFID processing and checkout modules. The basket register module was designed to register all RFID labeled shopping baskets in the system. The stock items register module was designed to register all stock items that are RFID labeled in the system. The check in module designed to check in the RFID labeled shopping baskets once picked by the customer when the customer walked into the supermarket. The RFID Processing module was designed to read all stock items on the RFID labeled shopping basket and generate the receipt once the customer places the basket on the till. Last but not least the Checkout module was designed to check out the RFID labeled shopping basket once the customer left the supermarket and the basket was returned where the customer picked it.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Radio Frequency Identification (RFID) is an emerging technology that is capable of automatically identifying, tracking and capturing data from a distance using radio waves. According to Golding & Tennant (2008) , RFID is an automated data-capture technology that can be used to electronically identify, track and store information on groups of products or individual items. According to Sarac et al.(2008) RFID is an automatic identification and data capture technology that uses radio waves to provide real-time communication with objects at a distance, without contact or direct line of sight. This chapter looks at the history of RFID technology and how it has evolved from 1930s to date. It then covers basic components of an RFID system like the transponder, interrogator and middleware and their respective functions. The operating principle of RFID technology and types of RFID systems are expound. Last but not least in this chapter, the applications of the technology are explained and related work from other scholars discussed.

2.2 RFID Technology Evolution

The RFID technology has evolved through various phases from about 1930 to the current times. The 1930s and 1940s saw the development of radio and radar. The 1950s were an era of exploration of RFID techniques. Numerous technologies related to RFID were being explored such as the long-range transponder systems of "identification, friend or foe" (IFF) for aircraft. Other developments of the 1950s include application of the microwave homodyne and Radio transmission systems with modulatable passive responder Landt & Catlin(2001).

Technological advancement in 1960s contributed to RFID explosion in the 1970s. Between 1963 and 1964, Studies like field measurements using active scatterers and theory of loaded scatterers on the electromagnetic theory connected to RFID were done. Several important inventions that contributed a lot to the RFID technology were also made. In 1963, communication by radar beams was invented. In 1967, Interrogator-responder identification system was invented. In 1968, Passive data transmission techniques utilizing radar beams and in 1969, Communication by radar beams was invented. The 1960s also saw commercial application RFID technology. Companies such as Sensormatic, Checkpoint and Knogo developed RFID based Electronic Article Surveillance (EAS) equipment to counter theft. Previously this equipment was developed using microwave or inductive technology Landt & Catlin (2001).

In the 1970s individuals, academic institutions, government laboratories, private and public sector were exploiting RFID technology and improving on it. In 1973 the International Bridge Turnpike and Tunnel Association (IBTTA) and the United States Federal Highway Administration sponsored a conference which concluded there was no national interest in developing a standard for electronic vehicle identification. The decision would later permit the development of a variety of systems because RFID technology was in its infancy. In the same year, large companies such as Raytheon's "Raytag" were advancing RFID technology. Landt & Catlin (2001)

The 1980s were marked by full implementation of RFID technology. In 1987 the first RFID based commercial application for collecting tolls began in Norway and was followed quickly in the United States by the Dallas North Turnpike in 1989. In the same period the Port Authority of New York and New Jersey began commercial operation of RFID for buses.

The 1990's saw the wide scale deployment of electronic toll collection in the United States. In 1991, the world's first open highway electronic tolling system opened in Oklahoma, where vehicles could pass toll collection points at highway speeds, unimpeded by a toll plaza or barriers and with video cameras for enforcement. In 1992 the world's first combined toll collection and traffic management system was installed in the Houston area by the Harris County Toll Road Authority in 1992 Landt & Catlin(2001). In the current times Innovative applications have emerged in many spheres of life. Table 2.1 shows a summary of the History of RFID over Decades.

Table 2.1: History of RFID over Decades

Decade	Event
1940-1950	Radar defined and used. Major World War II development efforts. RFID invented in about 1948.
1950-1960	Early explorations of RFID technology. Laboratory experiments.
1960-1970	Development of the theory of RFID. Early field trials.
1970-1980	Explosion of RFID development. Tests of RFID accelerate. Early adopter implementation of RFID.
1980-1990	Commercial RFID applications enter the mainstream
1990-2000	Emergence of standards. RFID more widely deployed.
2000-2010	Innovative applications emerge. Combination of RFID with personal mobile services. Subcutaneous RFID emerges for animals, humans. RFID becomes part of daily life.

Adopted from Srivastava (2005)

2.3 Components of an RFID System

An RFID system consists of three major components that is a transponder, an interrogator and middleware. The transponder, also called tag, consists of a chip and an antenna. The chip stores the Electronic Product Code (EPC). EPC contains a unique code that provides the unique identification of each object. The interrogator (reader) has an antenna. It emits radio signals and receives in return responses from tags. The distance of the reading range depends on multiple factors; the frequency that is used, the orientation and polarization of the reader and the environment. Finally the middleware bridges RFID hardware and applications Brock(2001) as cited by Sarac, et al (2008).

2.4 RFID Operating Principles

According to Susy d'Hont (2002) as cited by Kaur, et al (2011) RFID systems consist of three components in two combinations: a transceiver (transmitter/receiver) and antenna are usually combined as an RFID reader. A transponder transmitter/responder) and antenna are combined to make an RFID tag. Kaur et al. (2011) explain that an RFID tag is read when the reader emits a radio signal that activates the transponder, which sends data back to the transceiver. Basic RFID system consists of an antenna or coil, transceiver (with decoder) and a transponder (RF tag) electronically programmed with unique information.

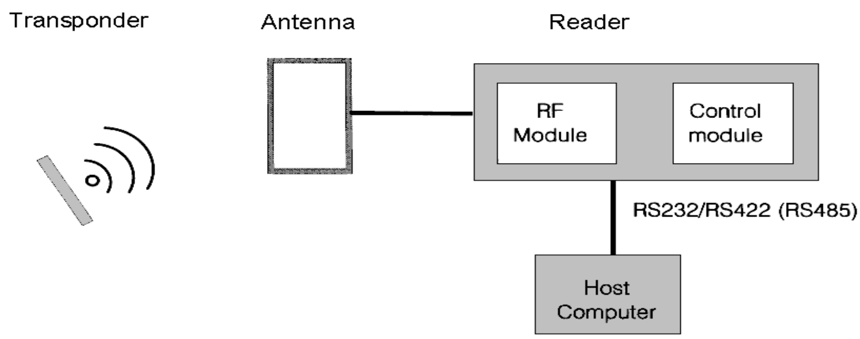


Figure 2.1: Working of RFID, Adopted from Kaur et al (2011)

Kaur et al (2011) further notes that the purpose of an RFID system is to enable data to be transmitted by a portable device, called a tag, which is read by an RFID reader and processed according to the needs of a particular application. The data transmitted by the tag may provide identification or location information, or specifics about the product tagged, such as price, color, date of purchase, and so on. A typical RFID tag consists of a microchip attached to a radio antenna mounted on a substrate. The chip can store as much as 2 kilobytes of data. To retrieve the data stored on an RFID tag, you need a reader. A typical reader is a device that has one or more antennas that emit radio waves and receive signals back from the tag. The reader then passes the information in digital form to a computer system.

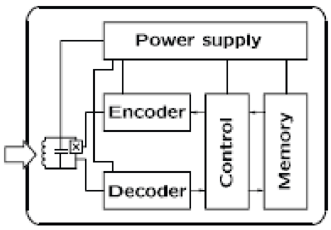
2.3 Classification of RFID tags

There are various types of RFID systems depending on memory embedded in them, communication ranges and how they are powered. On one hand, RFID systems can be classified as passive or semi-passive, read-only or read-write and finally induced or propagated. Various scholars have classified the different types of tags and readers which is reviewed in the section below.

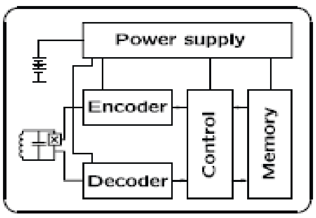
2.3.1 Classification of RFID Tags by Powering Method

According to Ilie-zudor et al. (2006) passive tags also called “pure passive” or ‘beam powered’ obtain operating power from the reader. The reader broadcasts electromagnetic waves that induce current in the tag’s antenna, the tag reflects the Radio Frequency (RF) signal transmitted and adds information by modulating the reflected signal. Semi-passive tags are powered using a battery and communicate in the same way as the active tags do. Figure 2.1 shows passive and semi-passive tag.

Dressen (2004) points out that RFID systems are commonly classified according to the properties of the data carrier, called a transponder or tag. The two major classes are active and passive. Active transponders contain a battery or are connected to an external power source. They are capable of longer communication distance and can perform data collection task without the presence of a reader. He maintains that passive transponders are powered by RF field, are smaller, have lower cost, and require no periodic maintenance. He further breaks them down into Electronic Article Surveillance (EAS), Low Frequency (LF), High Frequency (HF), Ultra High Frequency (UHF) and Microwave systems. This can be seen in figure 2.2. The EAS system simply detects the presence or absence of an EAS transponder in the zone.



Passive Tag



Semi-passive Tag

Figure 2.1: Passive and Semi-passive tag, Adopted from Ilie-zudor et al. (2006)

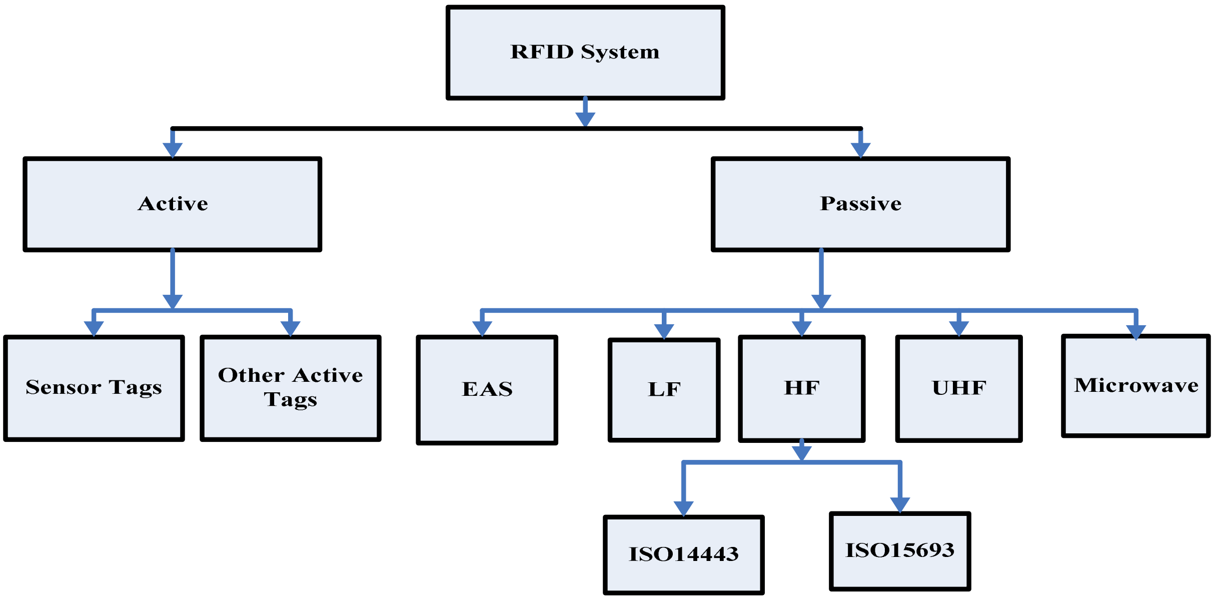


Figure 2.2: The RFID Family Tree, Adopted from Dressen (2004)

Roberti (2012) indicates that RFID Systems can be broken down into three broad categories that is, active systems where tags broadcast signal, passive systems which have no power source and only reflect energy from the reader and battery-assisted tags which have a power source but communicate like passive tags. He further breaks down Active RFID systems into two major types: Conventional active RFID which are woken when they come within range of a reader and Start broadcasting their unique ID plus other data and Real time location systems which tags beacon at set intervals, readers around the perimeter pick up the signal and the software determines the location of the item.

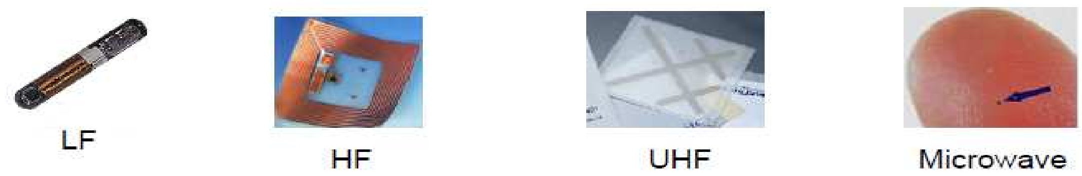


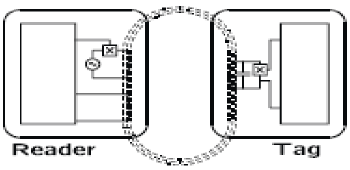
Figure 2.3: Passive RFID Systems, Adopted from Roberti (2012)

2.3.2 Classification of RFID Tags by Memory Type

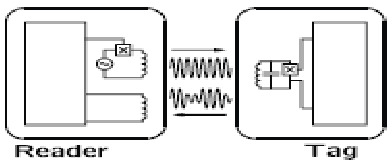
Tags can also be classified according to the memory type. Ilie-zudor et al. (2006) observe that they can be Read-Only or Read-write. Read-Only tags are factory programmed. They have static data hence cannot be modified after manufacturing. The tags have a very limited quantity of data that can be stored, usually 96 bits of information. They can be easily integrated with data collection systems and are cheaper than read-write tags. On the other hand Read-write tags are dynamic in that they can be read and written into. They can store a larger amount of data, typically ranging from 32 kilo bytes to 128 kilo bytes. This type of tags is expensive.

2.3.3 Classification of RFID Tags by Communication Range

RFID systems can also be classified according to their communication methods and frequency ranges. Ilie-zudor et al. (2006) note that RFID systems can communicate by induction or propagation or scatter methods. Induction systems use close proximity electromagnetic or inductive coupling—near field. They operate under LF and HF frequency bands while propagation systems work by propagating electromagnetic waves—far field and operate in the UHF and microwaves frequency bands. Figure 2.4 shows Induction and Propagation RFID System



Induction RFID System



Propagation RFID System

Figure 2.4: Induction and Propagation RFID System**,** Adopted from Ilie-zudor, et al (2006)

LF RFID systems have a communication range of up to 100 cm, HF RFID system can span up to 70 cm while microwave systems span up to 3 meters. This can be seen in table 2.2 and 2.3. Roberti (2012) agrees that passive RFID systems have different frequency ranges that is, Low frequency that operate at 125 kHz or 134 kHz, High frequency that operate at 13.56 MHz, Ultra high frequency that operate from 860 to 960 MHz, Microwave that operates at 2.45 Ghz and Ultra wideband.

Table 2.2: Passive RFID Frequency Bands and characteristics

Frequency BAND	**Common Frequency**	**Coupling**	**Communication Range**		**Data Rate**	**Maturity**	**Reader Cost**
			Typical	**Maximum**			
LF	125 to 135 KHz	Inductive	20 cm	100 cm	Low	Very Mature	Low
HF	13.56 MHz	Inductive	10 cm	70 cm	High	Established	Medium
UHF	868 to 928 MHz	Backscatter	3 m	10 cm	Medium	New	Very High
Microwave	2.45 GHz	Backscatter	3 m	?	Medium	In Development	Very High
	5.8 GHz	Backscatter	3 m	?	Medium	Future Development	Very High

Adopted from Dressen (2004)

Table 2.3 Communication Range of RFID System

		Communication Range						
Frequency Band	**System Type**	**3 cm**	**10 cm**	**30cm**	**1m**	**3m**	**10m**	**>10m**
LF	Passive	Widely Available	Widely Available	Widely Available	Available			
HF	ISO 14443	Widely Available	Widely Available	Available				
	ISO 15693	Widely Available	Widely Available	Widely Available	Available			
UHF	Passive	Widely Available	Widely Available	Widely Available	Widely Available	Widely Available	Available	
	Active	Widely Available	Widely Available	Widely Available	Widely Available	Widely Available	Widely Available	Available
Microwave	Passive	Widely Available	Widely Available	Widely Available	Widely Available	Widely Available	Available	
	Active	Widely Available	Widely Available	Widely Available	Widely Available	Widely Available	Widely Available	Available

Widely Available
Available
Not Available

Adopted from Dressen (2004)

Dressen (2004) expressed that high data transfer rate can only be achieved at relatively short range, and very long range can only be obtained at low data rates. He emphasizes that applications requiring large data transfers or high security must utilize ISO 14443 systems in the HF band. Applications with a very long-range requirement will utilize UHF or Microwave technology. For mid-range systems, either LF or HF may be used. He explains that Active RFID systems are not as widely deployed as passive systems because Active systems are custom designed for specific applications and have not been standardized. He points out that the most popular frequency band for active RFID is UHF due to the obvious range advantages of active UHF RFID and the availability of Industrial, Scientific and Medical (ISM) radio component

2.4 Advantages of RFID Technology

According to Ilie-zudor, et al (2006) the advantages of RFID Technology are:

1. Tag detection does not require human intervention hence no human errors and employment costs
2. As no line-of-sight is required, tag placement is less constrained
3. RFID tags have a longer read range than barcodes
4. Tags can have read/write memory capability, while barcodes do not
5. An RFID tag can store large amounts of data additionally to a unique identifier
6. Unique item identification is easier to implement with RFID than with barcodes,
7. Its ability to identify items individually rather than generically.
8. Tags are less sensitive to adverse conditions (dust, chemicals, physical damage etc.)
9. Many tags can be read simultaneously

10. Automatic reading at several places reduces time lags and inaccuracies in an inventory

2.4.1 Disadvantages of RFID Technology

The limitations of RFID are:

1. Reading several tags at a time may result in signal collision and ultimately to data loss
2. The high price of tags is a hindrance to large scale economic application however, the price keeps on reducing due to the fact that many new manufacturer now producing the same.

2.5 Applications of RFID Technology

The technology has many applications given that it is non contact and has a longer range as compared to the barcode technology. It is being applied in a wide range of security and control applications. Shoewu & Badejo (2006) confirm that many businesses use RFID to control access to hotels and business facilities by attaching a tag to an employee's room card or ID badge. Such technology ensures that only authorized persons are allowed access to particular rooms or entrances. Shoewu & Badejo (2006) further confirms that this application is also becoming more common in nursing homes and hospitals where the management and tracking of individuals is very important. Dressen (2004) says that EAS tags are widely used by retailers in electronic antitheft systems. Leading supermarkets in Kenya like Nakumatt, Naivas, Uchumi, Tuskys, and Jade use EAS anti-shoplifting products and systems to cut down on shoplifting**.** The system is designed to be placed in entryways, doorways and aisles while the tags are placed on expensive goods such as perfumes, cloths etc

Logistics Systems also take advantage of this technology to enhance efficiency of service delivery and reduction of cost. According to Auto-ID Center (2002) and Prater, et al (2005) as cited by Bottani (2008), RFID technology is experiencing an increasing diffusion for the optimization of many logistics systems. Jones et al (2004) as cited by Bottani (2008), further comments that the main reason for RFID adoption is the capability of tags to provide more information about products than traditional barcodes.

RFID is today being utilized in manufacturing industries where production lot, components type, part number, serial number, model are among product data that can be stored into the tag chip and documented in form of an EPC for future reference. Shoewu & Badejo (2006) point out that RFID systems allow the tracking of work-in-progress in automobile manufacturing and in computer hardware manufacturing. Shoewu & Badejo (2006) further points out that such technology allows managers to track goods through the manufacturing process and then the tags can either be reused on other products coming down the assembly line or they may stay permanently fixed to the product to provide a secure serial number. Curran & Laughlin (2011) emphasizes that RFID can be used in the manufacturing industry, tags can be attached to items that are moving through the factory on conveyer belts or being moved around by staff on trucks or forklifts. As the tags move around the factory floor or the warehouse they pass by readers and the tags can be then tracked using a database or a similar data storage system.

In the supply chain industry, goods need to be delivered in the right time at the customer premises. They also need to be tracked when they are being transported for security reasons. According to Li et al (2006) as cited by Sarac, et al (2008), RFID technologies can contribute in different ways in supply chains through their advanced unique identification and real-time communication properties. Through the unique code of each tag and the easiness of scanning, RFID can improve the accuracy and speed of processes and the traceability and the visibility of products throughout supply chains. It can also reduce handling and distribution costs and increase sales by reducing stock-outs. RFID can ameliorate the efficiency of current supply chains, but also may support the reorganization of supply chains to drastically enhance their overall performances.

Items in the library need to be tracked and traced at any point in time so that the users do not waste time searching for them. Golding & Tennant (2008) note that Libraries are fast growing adopters of RFID as the technology promises to relieve repetitive strain injury, speed patron self check, reduce pilferage and provide accurate and timely inventory management.

The retail industry is also applying the technology to ameliorate customer service. Kaur et al. (2011) observe that retailers such as Best Buy, Metro, Target, Tesco and Wal-Mart are in the forefront of RFID adoption. Kaur, et al. (2011) further explains that these retailers are currently focused on improving supply chain efficiency and making sure the product is on the shelf when customers want to buy it. Bottani (2008) points out that larger retail players like WalMart and Target have re-evaluated their mandate for all of their suppliers to use RFID technology.

According to Swedberg (2011) French supermarket company Auchan Group will use radio frequency identification to manage its 1.8 million reusable plastic produce crates as they move from grower to Distribution Center (DC) to store, and through the washing process. The RFID solution, developed and implemented at Auchan's produce DCs over the past two years, is intended to provide the firm with an eye on its leased containers, and with proof that they are being moved in a timely fashion, and washed according to EU requirements.

Owunwanne & Goel (2010) suggests that RFID can be hosted in the cloud to enable its usage by small and medium size organizations or any organization that cannot afford the cost of implementing the entire technology. Since the RFID implementation has been hampered by high costs and unreliable hardware which resulted in many organizations (manufacturers and retailers) being reluctant to invest heavily in the technology, the pay-as-you-go approach and/or the on-demand services approach will enable them believe that the maturity level of RFID is enough to deliver a return on their investments.

In sport RFID technology is used in tracking golf balls so that the balls can be easily located during the game and hence reduce the chances of them getting lost and time being wasted in trying to locate them. The technology is also applied in tracking athletes in order to prevent cheating. According to Yonga (2014) the Nairobi Diamond Run Race Director Barnabus Korir said that 2,000 athletes had registered so for the event that will see the introduction of electronic time equipment. Korir added that every athlete will have a time chip on their running number so as to arrest any cases of cheating and also to get the correct finishing time. The athletes will wear running bibs fitted with RFID technology for the first time in Kenya.

Tracking of valuable goods as they are transported from one airport to another by airlines is an area where RFID is being applied. Baggage applications are becoming very popular in airports. According to Conway (2001) as cited by Shoewu & Badejo (2006) RFID tags could be used to track and identify airline luggage and passengers increasing national security, speeding up luggage sorting and transfer, and decreasing expenditures resulting from heightened security measures. The IATA believes this technology has countless potential benefits for simplifying passenger travel for airports and airlines. According to Mylyy (2007) as cited by Kochar & Chhillar (2010), true benefits of RFID technology can be realized only when the tracking information from RFID components is efficiently included into business applications. It is for this reason that this study seek to improve efficiency of serving customer through the implementation of RFID Technology.

2.6 Related work

Different scholars have come up with different models in trying to solve the queuing problem in retail stores. Miwa & Takakuwa (2008) in their study called simulation modeling and analysis for in-store merchandizing of retail stores with enhanced information technology, proposed and constructed a simulation model of customer behavior. They used the model to examine customer flows, particularly the customer waiting times at the cash register in a retail store. In their model the customer's movements were examined, and then, their movement was simulated. The simulation model was designed and developed to make use of Point of Sales (POS) data. The simulation programs were written in Arena Kelton et al, (2007). The proposed model comprised of three major logical subsystems, that is, Time Control subsystem designed to create entities or customers. Category Allocation subsystem designed to read the location of gondola display and Customer Flow subsystem designed to read a series of stored POS data and to move customers inside the retail store. There preliminary simulation experiments indicated that when customers arrived at the store, customer waiting time became longer, unless the additional cash registers and systems such as RFID were allocated to deal efficiency when lines became backed up. They further proposed scenarios on space allocations of items, IC (Integrated Circuit) tags and layout design as a way to reduce customer waiting time and congestion in a retail store. They explain that it was shown that the advanced information technology including IC tags allows for efficiency in transaction at the register in a retail store.

(Miwa & Takakuwa, 2008) further explain that as soon as a customer puts a basket of all items on the stand of the RFID at the register, the total amount for the items is displayed on the screen. They argue that, by introducing IC tags, time to read barcodes of all items can be eliminated. Through a series of simulation experiments, they examined how much customer waiting time can be minimized by leading the customer to the shortest register line, adopting IC tags, and changing allocation of items on the shelves.

This study borrows, modifies and enhance a lot from the study of (Miwa & Takakuwa, 2008). The customer flow in a retail store diagram is borrowed and modified to suit Kenya supermarket setting. Initially it looked like figure 2.4 but it now looks like Figure 1.1.

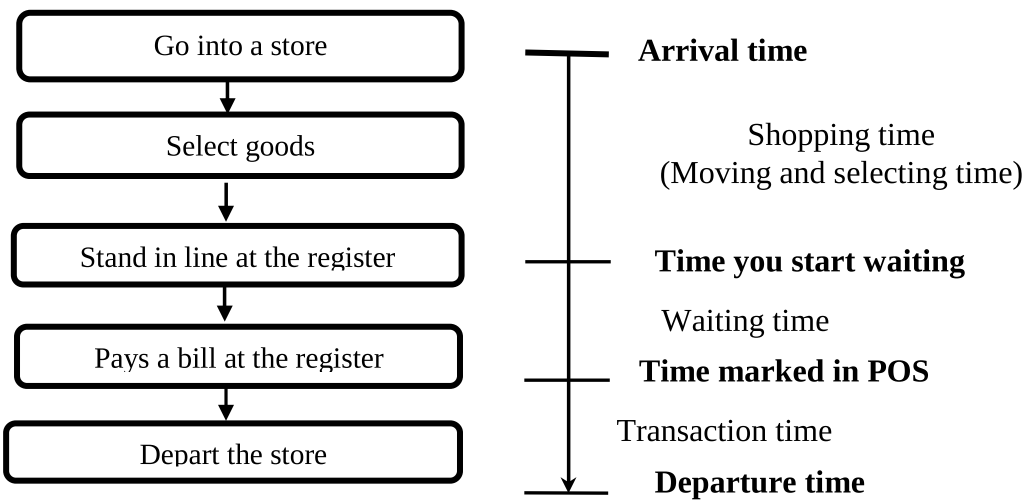


Figure 2.7: Customer Flow in Retail Store, Adopted from Miwa & Takakuwa, (2008)

Miwa & Takakuwa, (2008) view the Customer Flow in a Retail store to be a linear process where a customer goes into a store, select goods, stand in line at the register, pays a bill at the register and depart the store. This study views the Customer Flow as a cyclical process where the customer checks in, picks the RFID Cart/basket, select goods, push the cart/basket to the RFID till, the goods are all scanned at once, the customer pays the bill, the goods are packed and the customer checks out of the supermarket as shown in figure 1.2.

Miwa & Takakuwa (2008) proposed and constructed a simulation model of customer behavior to simulate and analyze how customer waiting time was affected by additional cash registers and systems such as RFID. The simulation programs were written in Arena Kelton et al. (2007). In this study a prototype called CMM was designed, tested and implemented in a supermarket to improve efficiency of serving Customers. The prototype was designed using visual basic 6.0, My SQL 4.1, My SQL ODBC 3.51 driver and Crystal reports 8.5.

Miwa & Takakuwa (2008) point out that it is necessary to obtain “Purchase of Sales” data instead of “Point of Sales” data. Hence, the times marked in POS data themselves cannot be used in the simulation and some modifications to the data should be performed before executing simulation. In this study the prototype collects the correct data including data for each purchased stock item and the customer who purchased it in real time as the customers do their shopping hence no need for modification of data because they provide the real picture on the ground.

Last but not least apart from the customer waiting time which was used by Miwa & Takakuwa (2008) as performance measure, In this study the check in time, shopping duration, basket time, queuing duration, receipt time, packing duration, transaction duration, total transaction time, total shopping time and checkout are all measured to give more detailed information about what happens when a customer checks in and out of the supermarket.

CHAPTER THREE

METHODOLOGY

3.1 Research Development Methodology

The study adopted iterative research designs Wang (2012). It was adopted because it is a cyclic process where a prototype is designed, tested, analyzed, and refined. Based on the results of testing, changes and further refinements are then made on the most recent iteration of a design with a view of ultimately improving the quality and functionality of a design. A prototype of RFID technology Cart/basket and Cart Management Module (CMM) which acted as Point of Sale (POS) was designed, tested, analyzed, and refined. It was then later simulated in a supermarket to obtain results for further analysis. Prototyping was used because of the benefits that prototyping offered which included the designer being able to get valuable feedback, reduced development time, reduced cost and increased user involvement in the research. Dynamic Systems Development Method (DSDM) life cycle was used to ensure. active user involvement, quick decision making , product delivery and fitness for business purpose as the basis for which the product was assessed Chaffey(1998). Lastly, Incremental prototyping was used so that the final product is built as separate prototypes(Kelly & Rector, 1989). The check in, checkout module and, RFID POS module were built as separate prototypes and later combined together to form the system.

3.2 Sampling Technique

In this study purposive sampling technique Calmorin L & Calmorin M (2007), was used due to the nature of items sold in supermarkets and cost of RFID labels. With help of supermarket attendants, the researcher used Judgment to select the samples and decide the sample size. This is because labeling all 400,000 stock items in the supermarket with RFID labels proved to be costly due to the high cost of RFID labels. The unit cost per label was $31.5 exclusive of import duty. To add on that refrigerated stock items needed ruggedness RFID labels which are even more costly than the labels used in the study. Last but not least, some stock items are slow moving yet the study was to be conducted within a limited time frame hence the study was restricted to only a few stock items. For this case sugar, bread, flour and non refrigerated milk were selected to be used for the study. The customers were shown how to use RFID Technology cart/basket and encouraged to shop with it as data was collected by the CMM (POS).

3.3 Data Collection Procedure

The designed RFID Technology cart/basket and CMM were tested and taken to the target supermarket. The supermarket attendants were trained on how to use the new system. Each and every shopping basket was uniquely identified using an RFID label. In general supermarkets have about 400,000 stock items. The study purposively targeted a sample size of 631 stock items that were labeled with 1500 RFID tags and 150 customers. The number of stock items that were labeled was as follow:

Table 3.1: RFID Labels Distribution by Product Category

No	Product Names	Product Category	No of RFID tags per
1	SUPA LOAF BREAD 400G	Bread	150
2	AKIYDA WHITE BREAD 400G	Bread	150
3	UNGA SOKO 2KG	Flour	150
4	UNGA JOGOO 2KG	Flour	150
5	UNGA PEMBE 2KG	Flour	150
6	UNGA HOSTES 2KG	Flour	150
7	KCC GOLD CROWN TFA 500ML	Milk	150
8	FRESHER WHOLE MILK 500ML	Milk	150
9	SUGAR MUMIAS 2KG	Sugar	150
10	SUGAR SONY 2KG	Sugar	150
Total			**1500**

Two RFID readers namely the Check in/Checkout RFID reader and Till RFID reader were placed at the entrance/ exit of the supermarket and at the till. The Check in/Checkout reader clocked the time the shopping basket went passed it after being picked by the customer to shop and later clocked when the basket was returned after the customer left the supermarket. The till reader clocked the time that shopping the basket was brought at the till by the customer including the time that each and every tagged stock item in the basket was read by the till reader.

3.4 Data Analysis

Descriptive statistics , that is measure of central tendency and dispersion was used to analyze the data Sims (2004). The mean was used as a measure of central tendency while Standard Deviation was used to measure dispersion. Descriptive statistics was used to show or summarize data in a meaningful way to allow patterns to emerge from the data. It was chosen due to the nature of data that was being analyzed.

CHAPTER FOUR

4.1 SYSTEM DESIGN

4.1.1 Hardware and Software Requirements

The hardware and software requirements are as indicated below:

Hardware Requirement

i. Pentium III processor and higher with an RS232 port

ii. UHF Medium Range Reader - DL930

Important performance	
Support protocol	ISO18000-6C EPC Gen2 / ISO18000-6B
Working frequency	ISM 902MHz ~ 928MHz, Or 920MHz ~ 925MHz
Customization	860MHz ~ 960MHz
Working mode	FHSS or working mode of fixed frequency pulse transmitting set by software
Transmit power	20dBm ~ 30 dBm (set by software)
Read-Write performance	
Read speed	The average read time for single card is less than 10ms per 64 bits
Read distance	4m ~ 8m (tag and environment dependent)
Write speed	8bits less than 30ms
Write distance	2m ~ 4m (tag and environment dependent)
Read prompt	Buzzer
Data Port interface	
USB Port	Yes
RS232 Port	Yes
RS485 Port	Yes
Weigand Port	Weigand26/34
Trigger port	Yes
TCP/IP Port (RJ45)	Yes
Working environment	
Working temperature	-30°C ~ 70°C

iii. UHF DL9700 Desktop UHF Reader/Writer

Important performance	
Support protocol	ISO18000-6C EPC Gen2 / ISO18000-6B
Working frequency	ISM 902MHz ~ 928MHz, Or 920MHz ~ 925MHz
Customization	860MHz ~ 960MHz
Working mode	FHSS or working mode of fixed frequency pulse transmitting set by software
Transmit power	17dBm
Read-Write performance	
Read speed	The average read time for single card is less than 10ms per 64 bits
Read distance	10cm ~ 15cm (tag and environment dependent)
Write speed	8bits less than 30ms

Write distance	10cm ~15cm (tag and environment dependent)
Read prompt	Buzzer
Data Port interface	
USB Port	Yes
Working environment	
Working temperature	-30°C ~ 70°C

iv. UHF RFID Label -02

Label specifications

EPC Gen 2 UHF RFID Labels used in a wide range of asset tracking applications, such as document tracking, library management, parcel tracking, etc.

Type: Contactless R/W

Operating Frequency: UHF (860~960MHz)

Size: 97*15mm or 101.6*50.8mm (others upon request)

Read Range: 1m ~ 10m (Reader and environment depended)

Housing Material: Paper

Operating Temperature: -40º C to +80º C

Package: 2500 PCS / Roll

Software Requirement

i. My SQL 4.1 or higher
ii. My SQL ODBC 3.51 driver or higher
iii. Crystal reports 8.5 or higher
iv. CMM 1.0

4.2 Context Diagram Existing System

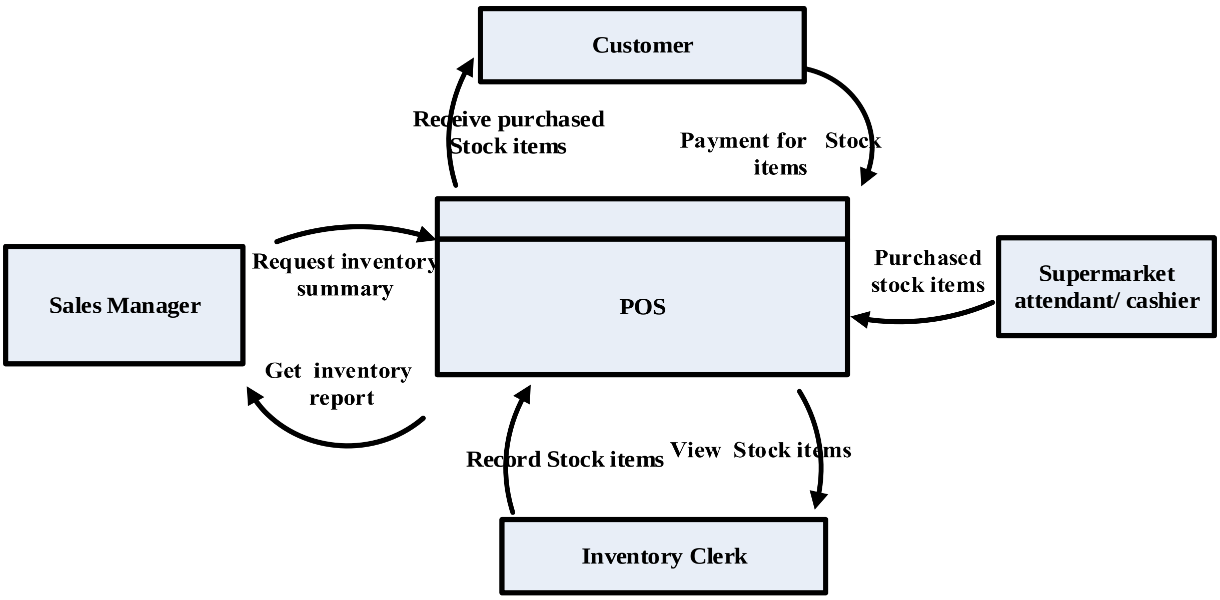


Figure 4.6: Current POS Context Diagram

4.2.1 Data Flow Diagram of the Existing System

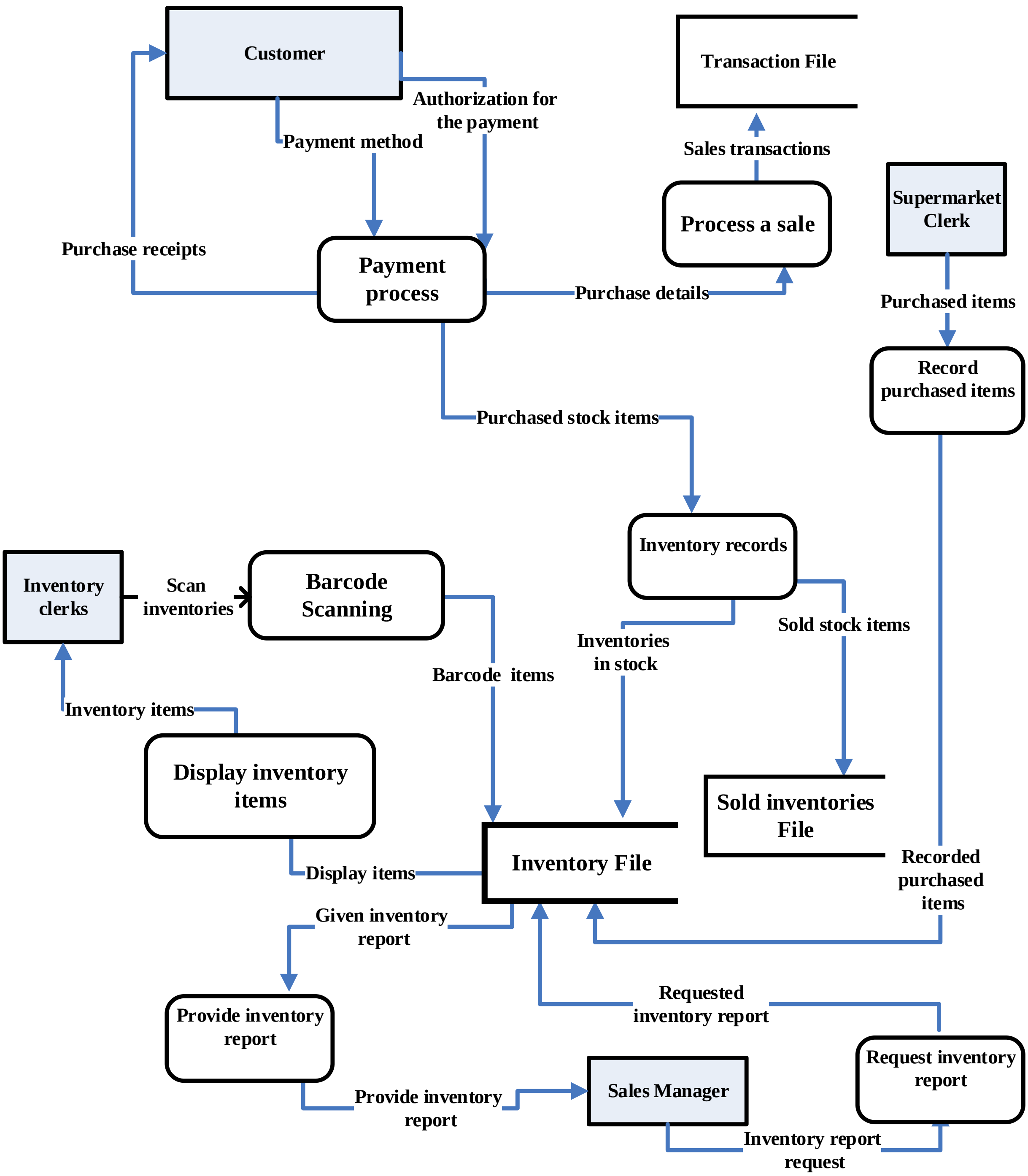


Figure 4.7: Existing System DFD

4.2.2 Data Flow Diagram of the Proposed System

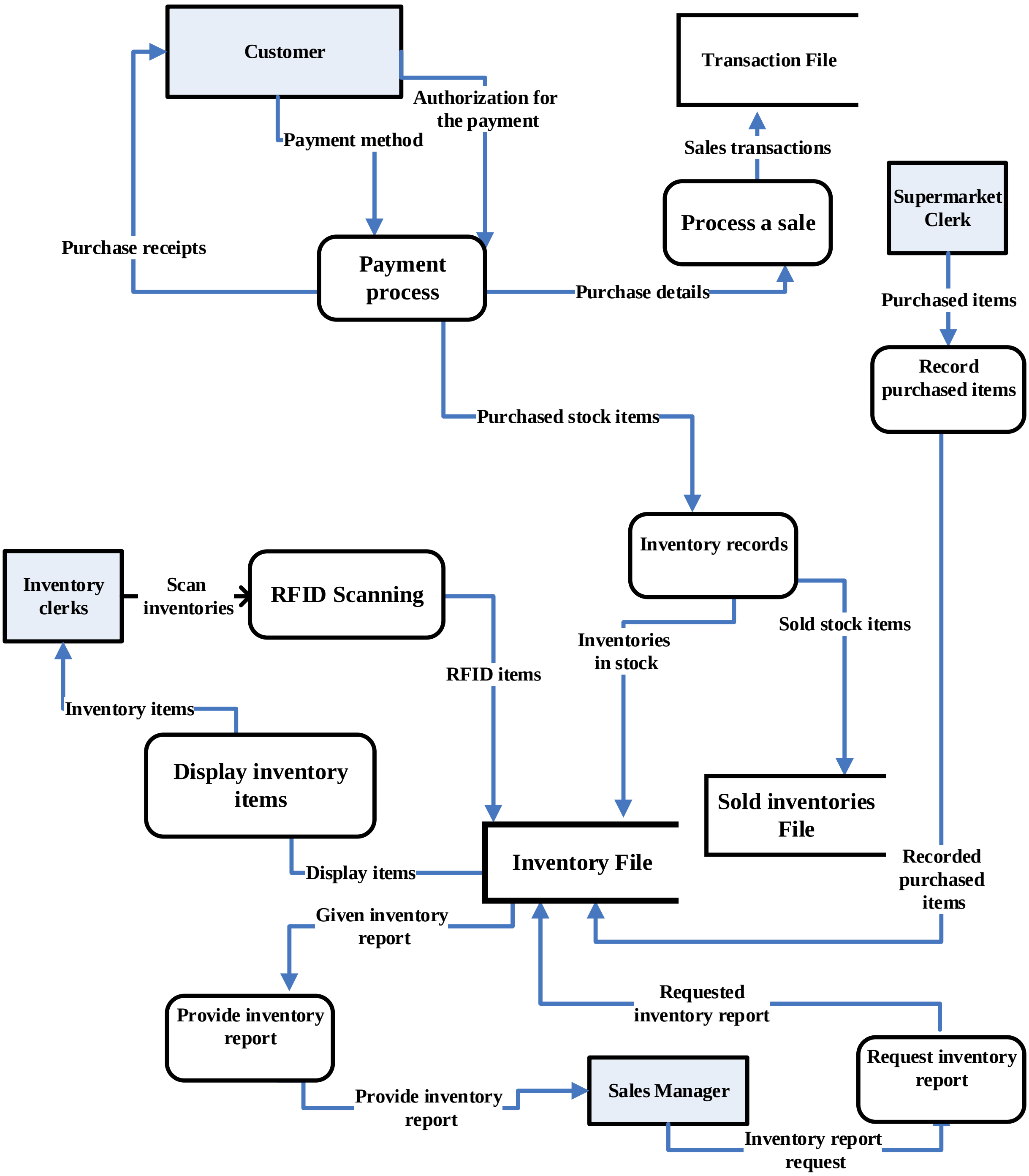


Figure 4.8: Proposed System DFD

4.3 Existing System Program Flaw Chart

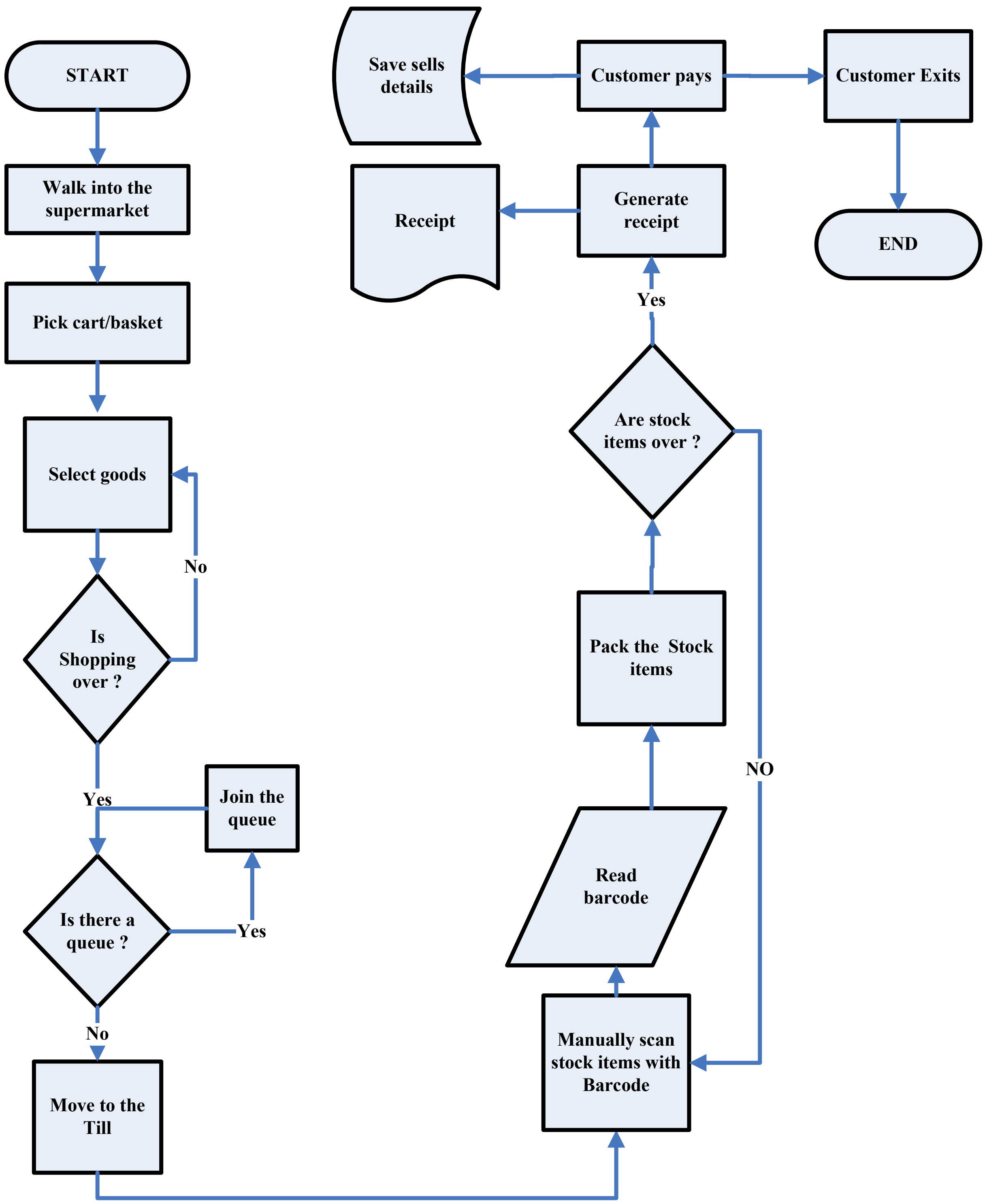


Figure 4.9: Existing System Flow Chart

4.3.1 Proposed System Program Flow Chart

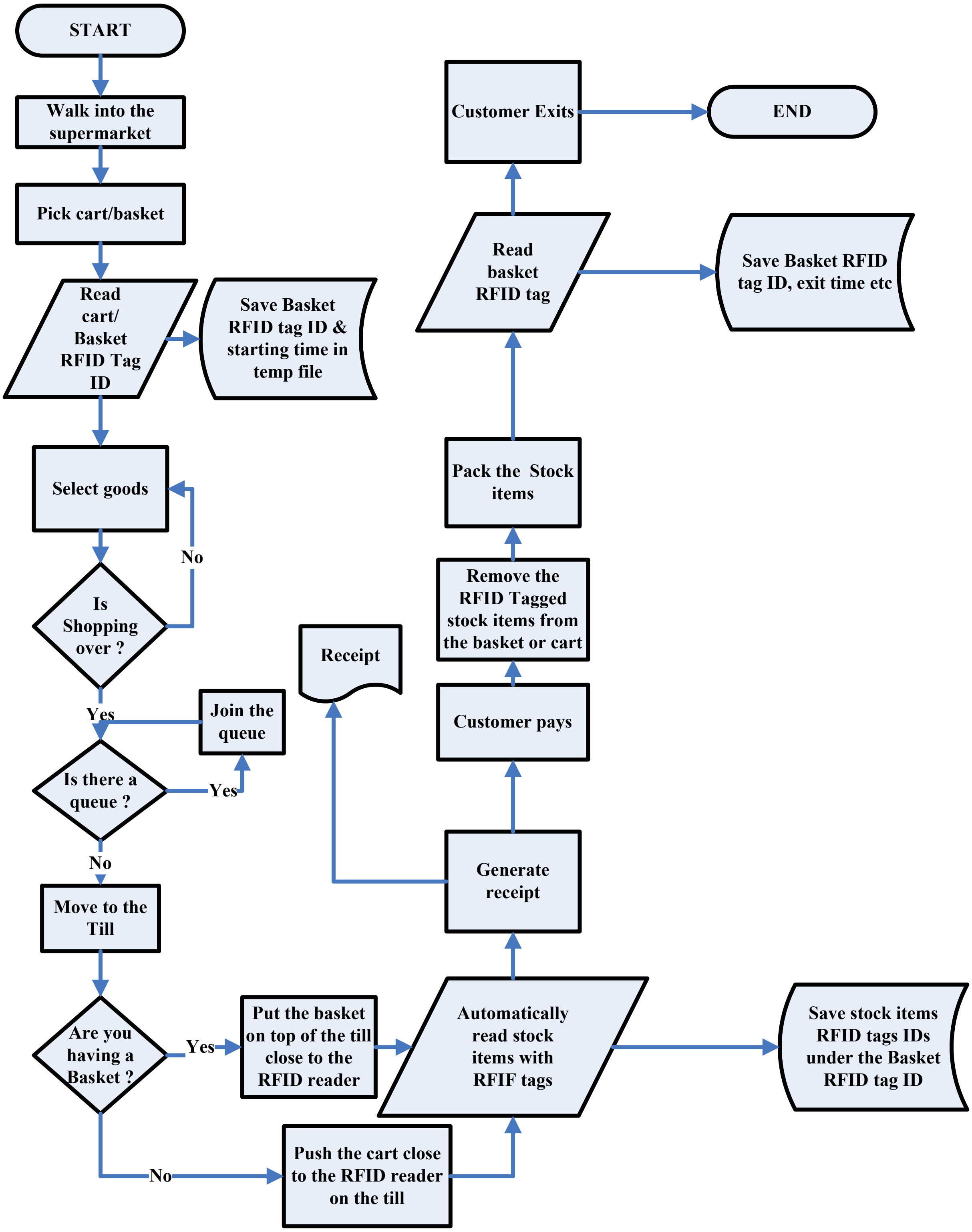


Figure 4.10: Proposed System Flow Chart

4.4 Measurements by Cart Management Module (CMM)

The following data items were collected from the three RFID readers by the CMM:

I. Check in/ Check Out RFID Reader

The Check in reader reads the tag number on the shopping basket and records the check in time. The check in time is assumed to be the time the shopping basket went past the check in RFID reader after the customer picked the basket and commenced shopping. This reader also records the checkout time which is the time the customer left the supermarket after the goods are packed.

II. Till RFID Reader

The Till RFID reader reads and records the tag that uniquely identifies the basket, all the RFID tagged stock items in the basket and the time that each and every stock item was read.

From the data collected by the two readers, the following formulae were derived:

i. Check In Time(**CIT**)= the time that the customer arrived at the supermarket

ii. Checkout Time(**COT**)= the time that the customer left the supermarket after shopping

iii. Basket Time (**BT**) = the Time that the RFID tagged Basket was placed on the till reader for scanning of stock items to start.

iv. Read Time(**RT**) = The Time that each stock item on the basket was read after the RFID tagged basket is placed on the till reader

v. Shopping Duration(**SHD**)= Basket Time(**BT**)- Check In Time(**CIT**)

SHD= BT- CIT

vi. Queuing Duration(**QD**) = Read Time(**RT**) - Basket Time (**BT**)

QD = RT-BT

vii. Receipt Time(**RET**) = the time that the receipt was generated after scanning all stock items on the RFID tagged Basket

viii. Transaction Duration (**TD**) = the time taken for the transaction to be processed by CMM

Transaction Duration (**TD**) = Receipt Time (**RET**) - Basket Time (**BT**)

TT=RET-BT

ix. Packing Duration(**PD**) = Time taken to pack purchased stock items

Check Out Time (**COT**)- Receipt Time(**RET**)

PD = COT- RET

x. Total Transaction Time(**TTT**)= Queuing Duration (**QD**)+ Transaction Duration (**TD**) + Packing Duration(**PD**)

TTT = QD+ TD + PD

or

Total Transaction Time (**TTT**) = Checkout Time (**COT**) - Basket Time (**BT**)

TTT = COT - BT

xi. Total Shopping Time by RFID reader (**TST**) = Checkout Time(**COT**) – Check In Time(**CIT**)

TST = COT – CIT

4.5 System Testing

To ensure that the CMM meets its design requirements and behaves as expected, functional and non functional testing was done Graham, et al (2008). Under functional testing, unit testing was carried out to ensure that individual software modules worked as per requirements, modules that had undergone unit testing were then subjected to integration testing to ensure that when integrated together they would perform specific tasks and activities as required. System testing was then done on the entire system to remove errors and bugs. User acceptance testing was done to ensure that all systems requirements have been met and that end-users and customers have tested the system to ensure that it met all their requirements.

Under non functional testing, usability and compatibility testing was done. In usability testing, the ease in which the users can access modules was considered. User learnability, efficiency, satisfaction, memorability and errors were all considered. Last but not least the new system and it's hardware was tested to ensure that it was compatible with the operation system, hardware and the database system at the supermarket.

4.6 System Implementation

This kind of system is new and has not yet been implemented in Kenyan supermarkets before; hence there was need for risk control in order to avoid a scenario where the supermarket is unable to operate normally due to unforeseen software or hardware issues. In order to mitigate such issues, both pilot and parallel implementation software strategy were used. The pilot strategy is generally used when a new system replaces the old one in one operation but only on a small scale which applies to the proposed system. The parallel implementation strategy was also employed.

CHAPTER FIVE

DATA ANALYSIS

5.1 Introduction

In this chapter, data analysis is carried out on the time taken by the customer to carry out different activities in the shopping cycle. A total of 150 customers and 631 RFID tags where used in the study. The total and mean shopping duration, queuing duration, transaction duration, packing duration, total transaction time and total shopping time were calculated from the data sets that were collected by CMM for each and every Stock item that was purchased during the research.

5.2 RFID tags per Product Category

A total of 631 RFID tags and 150 customers and 1 supermarket were involved in the study. The number of RFID tags used per product category is shown in table 5.1:

Table 5.1: Number of RFID Label Used by Product Category

No	Product Names	Product Category	Quantity
1	SUPA LOAF BREAD 400G	Bread	147
2	AKIYDA WHITE BREAD 400G	Bread	65
3	UNGA SOKO 2KG	Flour	64
4	UNGA JOGOO 2KG	Flour	45
5	UNGA PEMBE 2KG	Flour	59
6	UNGA HOSTES 2KG	Flour	27
7	KCC GOLD CROWN TFA 500ML	Milk	74
8	FRESHER WHOLE MILK 500ML	Milk	59
9	SUGAR MUMIAS 2KG	Sugar	58
10	SUGAR SONY 2KG	Sugar	33
Total	**Stock Items**		**631**

5.3 Analysis of the shopping Duration

The shopping duration (SD) is the time taken by the customer to pick the stock items on the shelves and place them in their shopping basket. SD was calculated by subtracting the Check in Time from the Basket time. The Basket Time was the time the basket was placed on the RFID till by the customer so that the content of the basket is automatically read by the CMM. The SD was measured in seconds and is calculated using following formula:

Shopping Duration (**SD**) = Basket Time (**BT**) - Check In Time (**CIT**)

SD = BT- CIT

Table 5.2.1 show the frequency of shopping duration for customers after the SD is calculated and this frequency table generated. The mean SD and standard deviation (Std. Deviation) of SD were

3.36 and 2.442 seconds respectively. This is shown in Table 5.2.2. The Std. Deviation is small, thus indicating that the data points for the SD tend be very close to the mean and hence to each other. The mean SD was directly determined by customer preference and behavior. Figure 5.1 below, shows that majority of the customers prefer to shop to up to a maximum of between 1001 – 1200 seconds. These indicates that this kind of customers like spending less time shopping. They contributed positively to the mean. However, there was a cross section of customers who preferred to spend up to between 1401-1600, 1601-1800, 1801-2000, 3001-3200, 3201-3400 and 3401-3600 seconds. Table 5.2.1 shows that the sum of their frequencies is meager as compared to the rest. Such customer contributed adversely to the mean SD.

Table 5.2.1: Shopping Duration

SD	Frequency	Percent	Valid Percent	Cumulative Percent
<= 200	23	15.3	15.3	15.3
201 - 400	42	28.0	28.0	43.3
401 - 600	32	21.3	21.3	64.7
601 - 800	22	14.7	14.7	79.3
801 - 1000	10	6.7	6.7	86.0
1001 - 1200	12	8.0	8.0	94.0
1201 - 1400	3	2.0	2.0	96.0
1401 - 1600	2	1.3	1.3	97.3
1601 - 1800	1	.7	.7	98.0
1801 - 2000	1	.7	.7	98.7
3201 - 3400	1	.7	.7	99.3
3401 - 3600	1	.7	.7	100.0
Total	**150**	**100.0**	**100.0**	

Table 5.2.2: Mean Shopping Duration

Mean SD		
N	Valid	150
	Missing	0
Mean		3.36
Std. Deviation		2.442

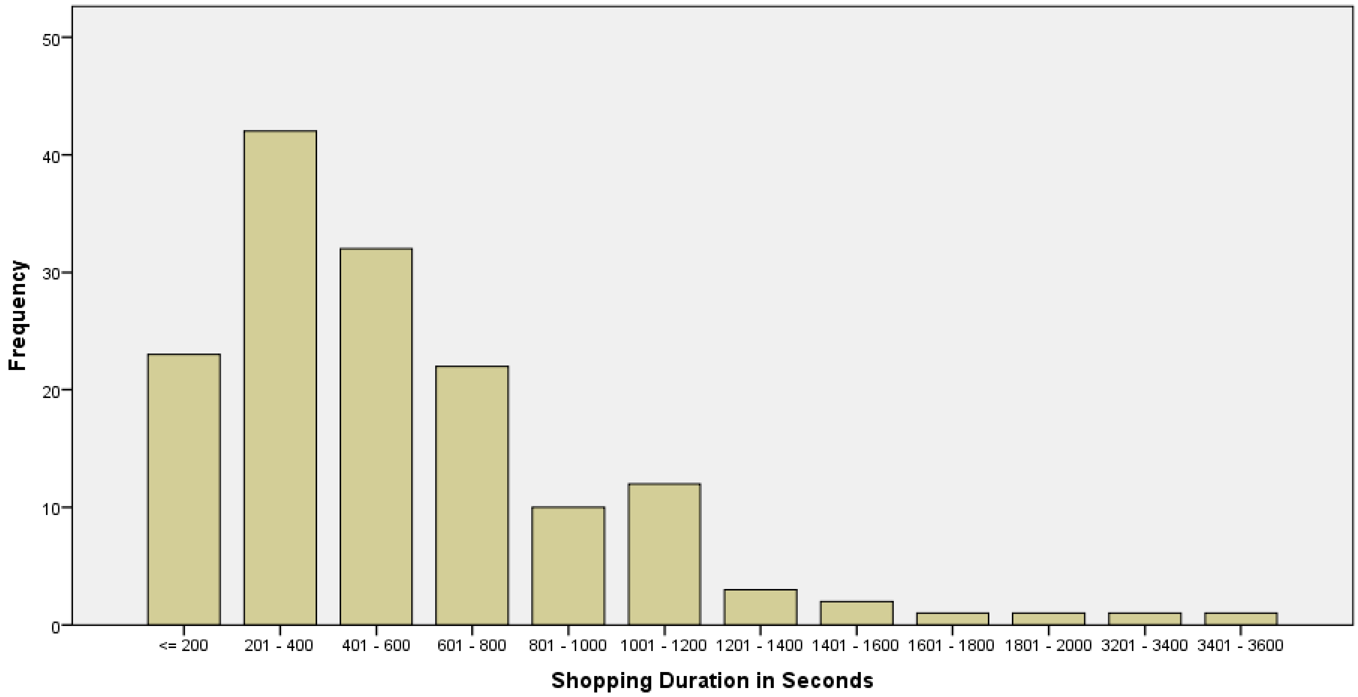


Figure 5.1: Customer Shopping Duration

5.4 Analysis of the Queuing Duration

The Queuing Duration (QD) is the time taken by the customer to stand at the till as the customer waits to be served. QD was ascertained by subtracting the Basket Time (BT) form Read Time (RT). The RT was the time each and every stock was scanned by CMM through the RFID reader. Read Time was directly determined by the RFID Technology. The formula for QD is shown below:

Queuing Duration (**QD**) = Read Time (**RT**) - Basket Time (**BT**)

QD = RT - BT

The result is the time taken by each and every basket on the queue which is equal to time taken by the customer to queue on the line. The QD was measured in seconds. A frequency table of the QD was then created to derive more meaning form the data sets. Table 5.3.1 shows frequency of Queuing Duration for customers. Table 5.3.2 shows that the mean QD and the Std. Deviation were 1.68 and 1.302 seconds respectively. The Std. Deviation is small, thus indicating that the data points tend be very close to the mean and hence to each other. Figure 5.2 shows that majority of customers queued for <=3 seconds hence positively contributing to the mean QD. The remaining customers queued for between 4 and 8 seconds, which was the maximum time taken by the RFID reader to read the content of the basket during the study. This is also attributed to them having many goods on their baskets. A mean QD of 1.68 seconds and a standard deviation was 1.302 seconds indicates that RFID technology improves efficiency of serving customers in the supermarket by drastically reducing the QD to 1.68 second for each and every customer. Miwa &

Takakuwa, (2008) agree that advanced information technology including IC tags allows for efficiency in transaction at the register in a retail store.

Table 5.3.1: Queuing Duration for customers

QD	Frequency	Percent	Valid Percent	Cumulative Percent
<= 0	99	66.0	66.0	66.0
1	28	18.7	18.7	84.7
2	9	6.0	6.0	90.7
3	9	6.0	6.0	96.7
4	1	.7	.7	97.3
5	1	.7	.7	98.0
6	2	1.3	1.3	99.3
8	1	.7	.7	100.0
Total	**150**	**100.0**	**100.0**	

Table 5.3.2: Mean Queuing Duration

Mean QD		
N	Valid	150
	Missing	0
Mean		1.68
Std. Deviation		1.302

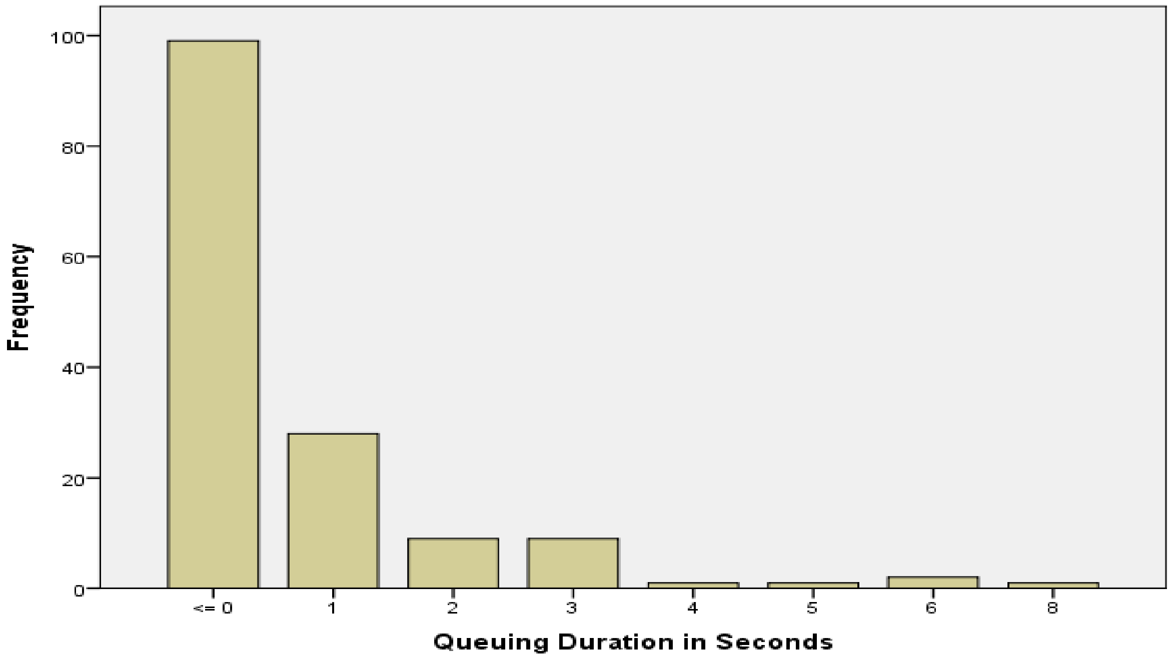


Figure 5.2: Customers Queuing Duration

5.5 Analysis of the Transaction Duration

The Transaction Duration (TD) is the time taken for the transaction to be processed using the CMM from the time the shopping basket is placed on the till until the receipt is printed. TD was calculated by subtracting the Basket Time form Receipt Time. The Receipt Time is the time that the receipt was generated by the supermarket attendant at the till. The formula for QD is shown below:

Transaction Duration (**TD**) = Receipt Time (**RET**) - Basket Time (**BT**)

TD = RET – BT

TD begins just after the QD is over. Figure 5.4 shows that majority of the transaction took place between 6-10 and 11-15 seconds. This continues up to between 31-35 seconds due to the fact that TD is affect by human behavior since it is the supermarket attendant at the till who carries out the transactions with the aid of the computer software and RFID reader. It should also be noted that some customers may delay the attendant from generating the receipt by taking time to get money from their wallets after the bill has been declared by the attendant. Nonetheless Table 5.4.2 shows that the mean TD and the Std. Deviation of TD were 2.73 and 1.181 seconds respectively. This indicates that the data points are very close to the mean and hence to each other. This contributes positively to Improving the Efficiency of Serving Customers in the supermarket. This further Indicates that RFID technology has a short TD which intern improves efficiency of serving customers in the supermarket by drastically reducing time spent by customers on the queue while waiting for the transactions to be completed. A short TD also contributes to the customer spending less time in the shopping cycle and encourages them to come back. Table 5.4.1 show Transaction Duration for customer frequency table.

Table 5.4.1: Transaction Duration for customers

TD	Frequency	Percent	Valid Percent	Cumulative Percent
<= 5	2	1.3	1.3	1.3
6 - 10	84	56.0	56.0	57.3
11 - 15	41	27.3	27.3	84.7
16 - 20	10	6.7	6.7	91.3
21 - 25	7	4.7	4.7	96.0
26 - 30	1	.7	.7	96.7
31 - 35	5	3.3	3.3	100.0
Total	150	100.0	100.0	

Table 5.4.2: Mean Transaction Duration

Mean TD		
N	Valid	150
	Missing	0
Mean		2.73
Std. Deviation		1.181

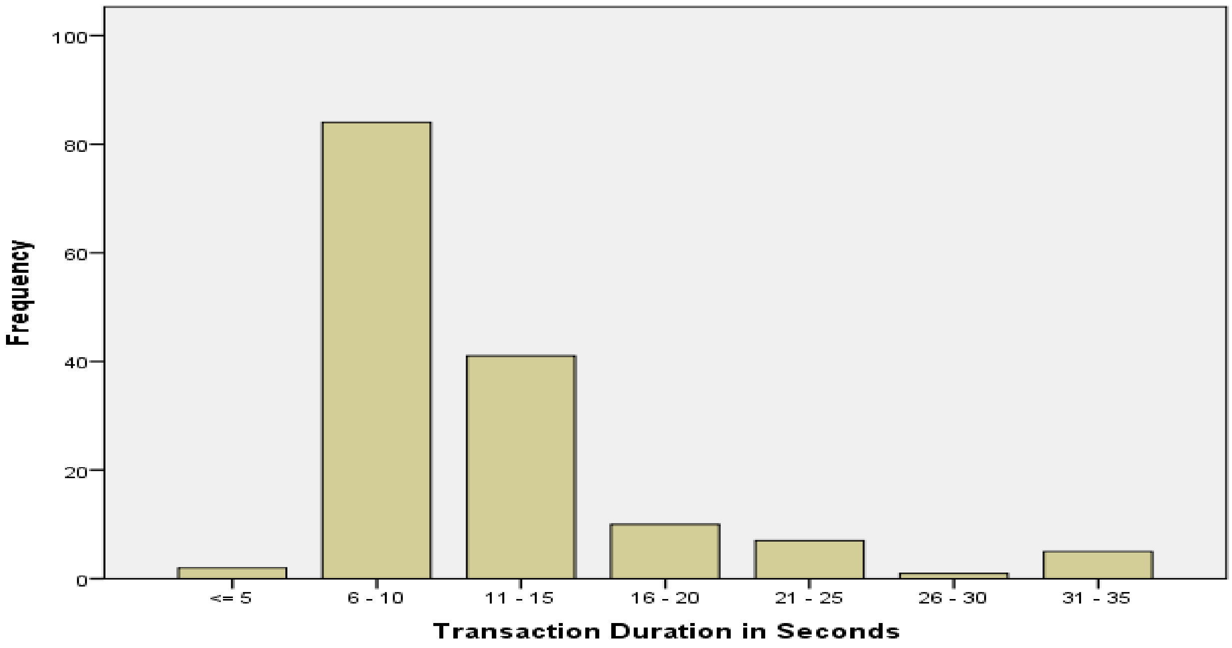


Figure 5.3: Customers Transaction Duration

5.6 Analysis of the Packing Duration

The Packing Duration (PD) is the time taken by the attendant in charge of packing the purchased stock items to pack them in paper bags once the bill has been paid by the customer. This time may be affected by human factors like the fatigue, mood and morale of the packing attendant. PD may also be affected by the number, type and size of stock items purchased by the customer. It should also be noted that PD may not be directly influenced by RFID technology used in this study because it was not used in packing the goods. PD was calculated by subtracting the Receipt Time form Check out Time. It was assumed that immediately the goods are packed, the customer walks out of the supermarket hence this time includes the time taken by the customer to walk from the till to the exit of the supermarket. The formula for PD is shown below:

Packing Duration (**PD**) = Check Out Time (**COT**) - Receipt Time (**RET**)

PD = **COT**- **RET**

Figure 5.4 shows that majority of the stock items were packed between 0-50, 51-100,101-150 and 151- 200 seconds. It is also observed that to pack some stock items, it took up to between 401 to 450 seconds. This is attributed to large quantities of stock items that were being packed. However, the mean PD was 2.63 seconds while the Std. Deviation of the PD was 1.138 indicating that the data points are very close to the mean and hence to each other. Table 5.5.1 Packing Duration frequency table while table 5.5.2 shows the Mean Packing Duration.

Table 5.5.1 Packing Duration

PD	Frequency	Percent	Valid Percent	Cumulative Percent
<= 50	6	4.0	4.0	4.0
51 - 100	81	54.0	54.0	58.0
101 - 150	43	28.7	28.7	86.7
151 - 200	13	8.7	8.7	95.3
201 - 250	2	1.3	1.3	96.7
251 - 300	3	2.0	2.0	98.7
351 - 400	1	.7	.7	99.3
401 - 450	1	.7	.7	100.0
Total	**150**	**100.0**	**100.0**	

Table 5.5.2 Mean Packing Duration

Mean PD		
N	Valid	150
	Missing	0
Mean		2.63
Std. Deviation		1.138

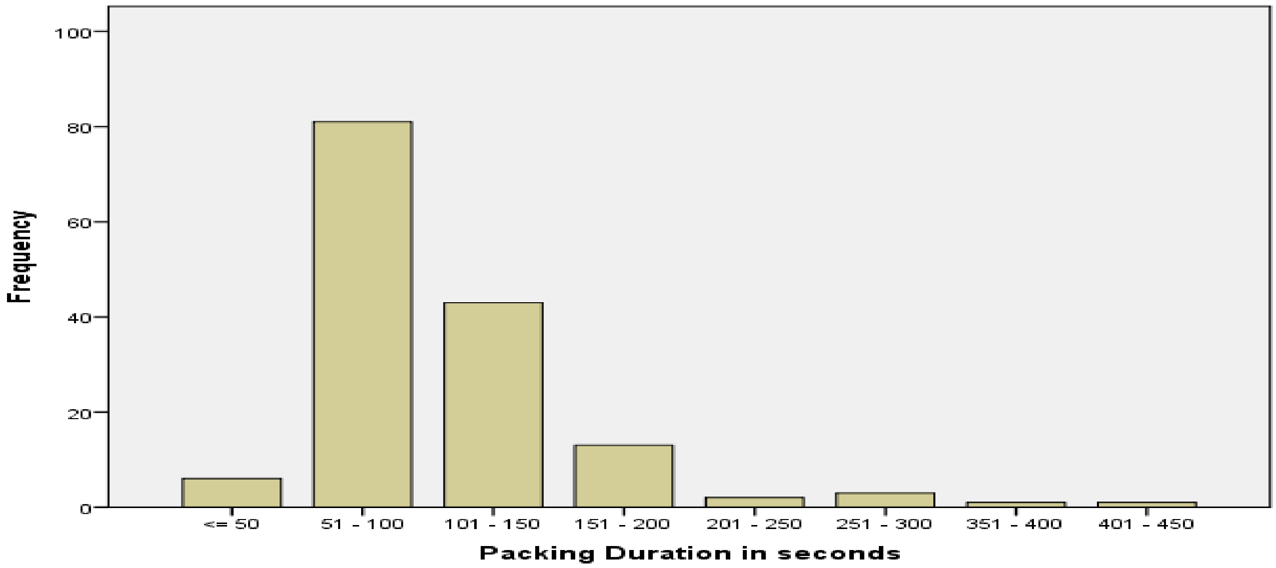


Figure 5.4: Customers Packing Duration

5.7 Analysis of the Total Transaction Time

The Total Transaction Time (TTT) is the time taken for the transaction to be processed using the RFID technology. TTT was ascertained by adding the Queuing Duration, Transaction Duration and Packing Duration. It is also calculated by subtracting the Checkout Time from the Basket Time. The formulae for TTT are shown below:

Total Transaction Time (**TTT**) = Queuing Duration (**QD**) + Transaction Duration (**TD**) + Packing Duration (**PD**)

TTT = **QD**+ **TD** + **PD** or

Total Transaction Time (**TTT**) = Checkout Time (**COT**) - Basket Time (**BT**)

TTT = COT - BT

TTT was determined by the speed of the RFID Technology in use, the speed of customer to paying the bill, the speeds of attendant at the till and the speed attendant packing the goods. Figure 5.5 shows that majority of the TTT took place between ranges of 51-100 and 101-150 second. Table 5.6.2 shows that mean TTT and the Std. Deviation of TTT were 2.82 and 1.204 seconds respectively. This indicates that the data points are very close to the mean and hence to each other. The mean TTT further indicate shopping using the RFID technology has a short TTT hence it improves efficiency of serving customers in the supermarket by drastically reducing time spent by customers on the queue while waiting for the transactions to be completed. Table 5.6.1 shows Total Transaction Time frequency table.

Table 5.6.1: Total Transaction Time

TTT	Frequency	Percent	Valid Percent	Cumulative Percent
<= 50	1	.7	.7	.7
51 - 100	73	48.7	48.7	49.3
101 - 150	52	34.7	34.7	84.0
151 - 200	12	8.0	8.0	92.0
201 - 250	6	4.0	4.0	96.0
251 - 300	4	2.7	2.7	98.7
401 - 450	2	1.3	1.3	100.0
Total	**150**	**100.0**	**100.0**	

Table 5.6.2: Mean Total Transaction Time

Mean TTT		
N	Valid	150
	Missing	0
Mean		2.82
Std. Deviation		1.204

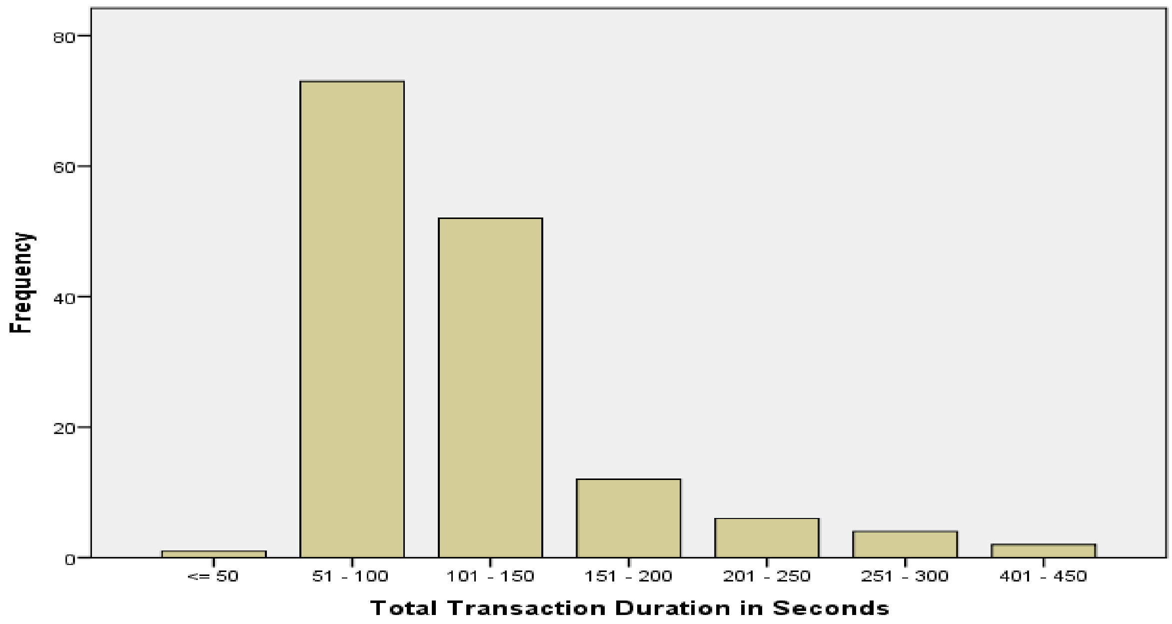


Figure 5.5: Customer Total Transaction Duration

5.8 Analysis of the Total Shopping Time

The Total Shopping Time (TST) is the time taken by the customer to do shopping at the supermarket. This time was ascertained by subtracting the Check in Time from the Checkout Time. The formula for ascertaining the TST is shown below:

Total Shopping Time by RFID reader (**TST**) = Checkout Time (**COT**) – Check in Time (**CIT**)

TST = COT – CIT

A frequency table of TST was then created in order to calculate the mean TST. Table 5.7.1 shows a frequency table of TST. TST was determined by time taken by the customer to shop, speed of the RFID Technology in use, the speed of customer to paying the bill, the speeds of attendant at the till and the speed attendant packing. Table 5.7.2 shows that mean TTT and the Std. Deviation of TTT were 3.96 and 2.517 seconds respectively. This indicates that the data points are very close to the mean and hence to each other. Figure 5.6 below, shows that most of the customers took between a range of 201- 400 and 1201-1400 seconds to do their shopping thus contributing positively to the mean TST. Very few customers continued to shop up to a range of 3401-3600 seconds hence adversely contributing to the mean TST. It is also worth noting that the availability of the RFID technology in the supermarket also contributed to the customers spending less time in the supermarket hence improving the efficiency of serving customers at the supermarket.

Table 5.7.1: Total Shopping Time

TST	Frequency	Percent	Valid Percent	Cumulative Percent
<= 200	7	4.7	4.7	4.7
201 - 400	37	24.7	24.7	29.3
401 - 600	32	21.3	21.3	50.7
601 - 800	32	21.3	21.3	72.0
801 - 1000	15	10.0	10.0	82.0
1001 - 1200	10	6.7	6.7	88.7
1201 - 1400	10	6.7	6.7	95.3
1401 - 1600	1	.7	.7	96.0
1601 - 1800	2	1.3	1.3	97.3
2001 - 2200	2	1.3	1.3	98.7
3401 - 3600	2	1.3	1.3	100.0
Total	**150**	**100.0**	**100.0**	

Table 5.7.2: Mean Total Shopping Time

Mean TST		
N	Valid	150
	Missing	0
Mean		3.96
Std. Deviation		2.517

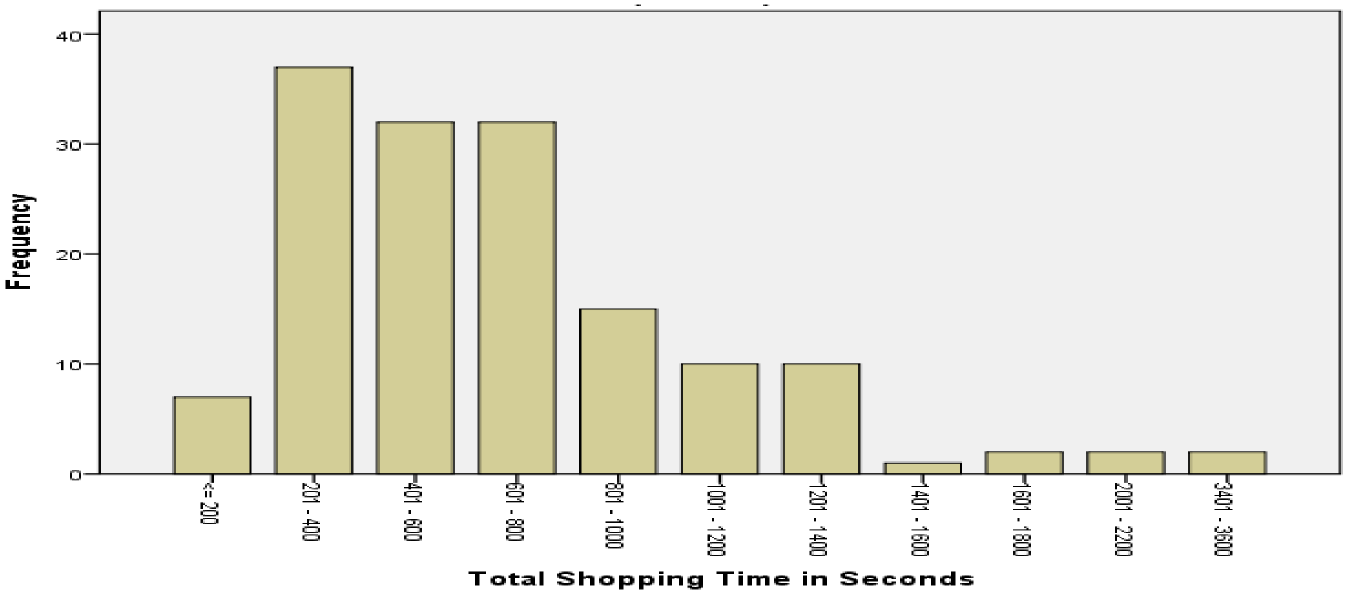


Figure 5.6: Total Shopping Time

5.9 Comparison between the Old and the New System

It should be noted that the old POS system uses the barcode technology and hence it works differently as compared to the RFID POS system used in this study. Unlike the RFID Technology where tracking was possible for each and every individual stock item, in the Old system individual stock items cannot be tracked hence very few parameters can be measured. The system is only able to capture and store the time stamp of when the first stock item was scanned using the barcode reader and the time that the receipt was generated. The difference can be calculated and assumed to the time that the customer queued at the till. Table 5.8.1 show that the old system has a mean QD of 287 second while the mean QD of the new system is 1.68 seconds as shown in table 5.3.2. This shows that the new system performs better than the old system it terms of time. In Figure 5.7 we can see that majority of the customers queued between a time range of 200-299 seconds. Some customers queued up to between time ranges of 700-799 second. When you compare this to the new system, majority of the customers queued below 0 second and the customers who took the longest time on the queue spent only 8 second as shown in figure 5.2.

Table 5.8.1: Mean QD Old System

Mean QD Old System	
Valid	150
Missing	0
Mean	287
Std. Deviation	112.727

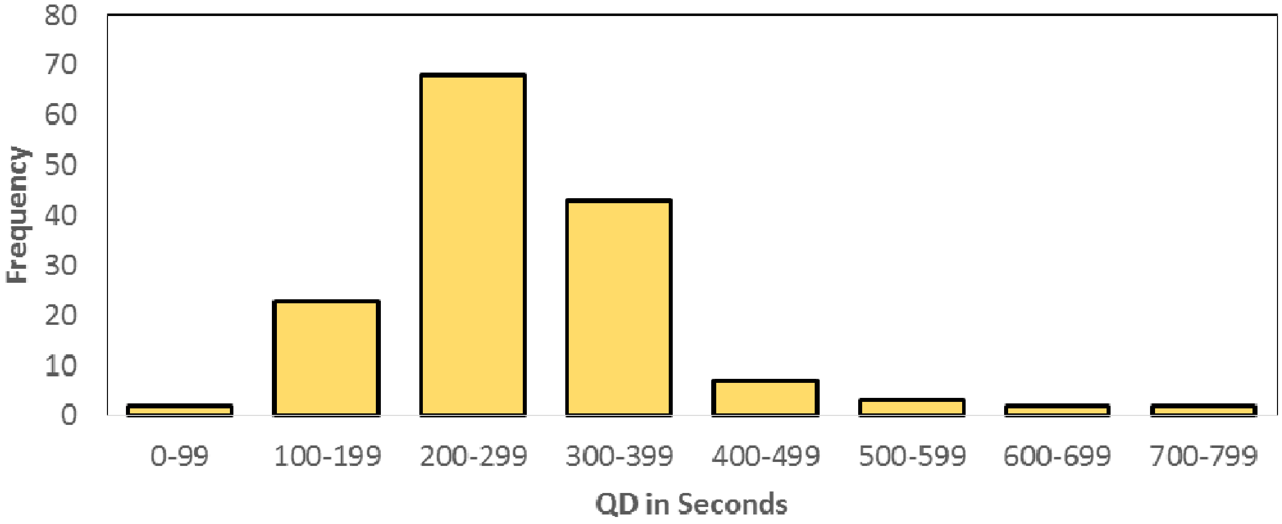


Figure 5.7: Queuing Duration of the Old System

When you compare the old and the new systems in terms of cost, the initial cost of RFID Technology is high as compared to the existing system but the maintenance and running costs remain low, this is because, while using the old system the supermarket owners have to employ staff to be located in different parts of the supermarket apart from the security guards at the entrance so that they can do surveillance on who is shop lifting hence they have to foot monthly bills on security and labour cost. RFID technology monitors and tracks, all stock items electronically which saves a lot on labour and security cost apart from improving efficiency of serving customers. This explains why in Western countries supermarkets are only operated by a single individual who relays on technologies like RFID.

CHAPTER SIX

CONCLUSIONS

6.1 Summary

In this study the objective was to investigate how the use of RFID Technology has improved customer service. To achieve this objective, the researcher set out with an objective of designing a prototype of an RFID POS system (CMM) that uses RFID readers to scan stock items at the till. The researcher drew the context diagram, DFD and program flaw chart of the existing system. The researcher then designed the DFD and program flaw chart of the proposed system. Additionally the researcher came up with the software and hardware requirements of the proposed system.

The researcher also had an objective to develop a prototype of RFID Technology shopping cart/basket, till and the Cart Management Module (CMM). He attached RFID labels to existing cart/basket, decided the best position the till reader and programmed the CMM using visual basic 6.0, My SQL 4.1, My SQL ODBC 3.51 driver and Crystal reports 8.5 or higher

Last but not least the researcher had an objective to evaluate the new system. The results of the evaluation showed that the old POS system that uses barcode Technology has a mean QD of 287 second while the new RFID Technology POS system has a mean QD of 1.68 seconds. The RFID Technology POS system drastically reduces queuing around the till hence it improves Customer service. The results also showed that with the old system, the maximum time taken on the queue is between 700 and 799 seconds, while the new system has a maximum time taken of 8 seconds. This shows that RFID Technology improved customer service by reducing time spent queuing to pay for goods at the till and hence improves the efficiency of serving customers.

6.2 Recommendations

In this study, the modules used to register baskets, register stock items, check in, checkout and RFID processing worked as per the requirement of the designer, end-users and customers. It would recommend that a real system with all modules found in a POS be developed for commercial purposes.

6.3 Suggestion for Future Studies

We would like to recommend that further research be conducted on an algorithm that ensures that RFID labels that have been read by one RFID Reader, cannot be read by any other reader within the same range or surrounding.

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Appendices

Appendix A: Sample Code

New Basket Registration Sample Code

```
  Dim adoRsdata As ADODB.Recordset
  Dim adoRsupdate As ADODB.Recordset
  Dim SQLstr, dateStr, Values, cols As String
  'Block of code used for error management
       If txttag.Text = "" Then
         MsgBox "You have not specified the basket code time correctly.", vbOKOnly + vbInformation, "Unspecified basket code"
           Exit Sub
       End If
       SQLstr = "SELECT BasketName,Basketid FROM cart WHERE Basketid ='" + Trim(txttag.Text) + "'"
Set adoRsFromClientReg = adoCn.GetRecordSet(SQLstr)
    adoRsFromClientReg.MoveFirst
    Err.Clear
      If Not IsNull(adoRsFromClientReg!BasketName) Then
                 txtBasketname.Text = adoRsFromClientReg!BasketName
        If txtBasketname.Text = "" Then
         MsgBox "You have not specified the basket time correctly.", vbOKOnly + vbInformation, "Unspecified basket"
        Exit Sub
     End If
     txttag.Text = adoRsFromClientReg!basketid
     txtCheckintime.Text = Format(Now, "HH:nn:ss") & "." & Right(Format(Timer, "#0.00"),2)
     txtCheckintime.Text = Format(Now, "HH:nn:ss")
     txtCheckouttime.Text = "Not yet"
     dateStr = Format(Now(), "yyyy-MM-dd")
'Block of code is used to register basket

If Len(txttag.Text) <> 0 And Len(txtBasketname.Text) <> 0 Then

 Set adoRs = adoCn.GetRecordSet(SQLstr)
      cols = "Serial,Basketname,Basketid,Checkintime,Checkouttime,DateRegistered"
        Values = "'" + "0" + "','" + addMySQLQuote(txtBasketname.Text) + "','" + addMySQLQuote(txttag.Text) + "','" + addMySQLQuote(txtCheckintime.Text) + "','" + addMySQLQuote(txtCheckouttime.Text) + "','" + dateStr + "'"
        SQLstr = "INSERT INTO checkin(" + cols + ") VALUES(" + Values + ")"
        Set adoRs = adoCn.GetRecordSet(SQLstr)
           MsgBox "Registration successfully made"
Else
    Exit Sub
 End If
    txttag.Text = ""
   Set adoRsdata = adoCn.GetRecordSet("SELECT Basketname,Basketid,Checkintime,Checkouttime,DateRegistered FROM checkin ORDER BY serial ASC")
       Set dtgPositions.DataSource = adoRsdata
   End If
```

Exit Sub

New Stock item Registration Sample Code

```
  Dim res As VbMsgBoxResult
  Dim SQLstr, SQLstr2 As String
  Dim cols, cols2, Values, Values2 As String
  Dim adoRsInsert As ADODB.Recordset
  Dim processDate, EndingDate, StartingDate As String

'This block of code is used in error prevention and saving the stock item
     If Len(txtName.Text) < 2 Then
       MsgBox "You have not specified the Item Name.", vbOKOnly + vbInformation, "Unspecified Item Name"
       Exit Sub
     End If
     If Len(txttag.Text) < 2 Then
       MsgBox "You have not specified the RFID Tag. Please enter the target RFID Tag.", vbOKOnly + vbInformation, "Unspecified RFID Tag"
       Exit Sub
     End If
     If Len(txtBarcode.Text) < 2 Then
       MsgBox "You have not specified the Barcode.", vbOKOnly + vbInformation, "Barcode"
       Exit Sub
     End If
     If Len(txtBin.Text) < 2 Then
       MsgBox "You have not specified the BIN, Shelve or Location. ", vbOKOnly + vbInformation, "Unspecified BIN, Shelve or Location"
       Exit Sub
     End If
     If Len(txtBuyingPrice.Text) < 2 Then
       MsgBox "You have not specified the Buying Price. ", vbOKOnly + vbInformation, "Unspecified Buying Price"
       Exit Sub
     End If
     If Len(txtselling.Text) < 2 Then
       MsgBox "You have not specified selling price. ", vbOKOnly + vbInformation, "Unspecified selling price"
       Exit Sub
     End If
     cols = "Serial,Name,RFID,Barcode,Bin,Date,Buyingprice,sellingprice"
     processDate = Format(dtpprocess.Value, "yyyy-MM-dd")
          Values = "'" + "0" + "','" + addMySQLQuote(txtName.Text) + "','" + Trim(txttag.Text) + "','" + Trim(txtBarcode.Text) + "','" + Trim(txtBin.Text) + "','" + processDate + "','" + Trim(txtBuyingPrice.Text) + "','" + Trim(txtselling.Text) + "'"
     SQLstr = "INSERT INTO productlist(" + cols + ") VALUES(" + Values + ")"
     Set adoRs = adoCn.GetRecordSet(SQLstr)
       res = MsgBox("Do you want to Process another Product? If yes, click yes button.", vbQuestion + vbYesNo + vbDefaultButton2, "Another order confirmation")
     If res = vbYes Then
       Call cmdCancel_Click
       Call Form_Load
```

```
    Else
          Unload Me
    End If
    Exit Sub
err_H:
   MsgBox Err.Description, vbExclamation + vbOKOnly, "General data error"
```

Check In Sample Code

```
 Dim adoRsOrderHist As ADODB.Recordset
 Dim adoRsdata As ADODB.Recordset
 Dim adoRsupdate As ADODB.Recordset
 Dim SQLstr, dateStr, Values, cols As String
 'Block of code used for error management
      If txttag.Text = "" Then
        MsgBox "You have not specified the basket code time correctly.", vbOKOnly + vbInformation, "Unspecified basket code"
          Exit Sub
      End If
      SQLstr = "SELECT BasketName,Basketid FROM cart WHERE Basketid ='" + Trim(txttag.Text) + "'"
   Set adoRsFromClientReg = adoCn.GetRecordSet(SQLstr)
   adoRsFromClientReg.MoveFirst
   Err.Clear

     If Not IsNull(adoRsFromClientReg!BasketName) Then
             txtBasketname.Text = adoRsFromClientReg!BasketName
       If txtBasketname.Text = "" Then
        MsgBox "You have not specified the basket time correctly.", vbOKOnly + vbInformation, "Unspecified basket"
       Exit Sub
    End If
    txttag.Text = adoRsFromClientReg!basketid
    txtCheckintime.Text = Format(Now, "HH:nn:ss") & "." & Right(Format(Timer, "#0.00"), 2)
    txtCheckintime.Text = Format(Now, "HH:nn:ss")
    txtCheckouttime.Text = "Not yet"
    dateStr = Format(Now(), "yyyy-MM-dd")
'Block of code is used to register basket

   If Len(txttag.Text) <> 0 And Len(txtBasketname.Text) <> 0 Then
       Set adoRs = adoCn.GetRecordSet(SQLstr)
        cols = "Serial,Basketname,Basketid,Checkintime,Checkouttime,DateRegistered"
          Values = "'" + "0" + "','" + addMySQLQuote(txtBasketname.Text) + "','" + addMySQLQuote(txttag.Text) + "','" + addMySQLQuote(txtCheckintime.Text) + "','" + addMySQLQuote(txtCheckouttime.Text) + "','" + dateStr + "'"
          SQLstr = "INSERT INTO checkin(" + cols + ") VALUES(" + Values + ")"
          Set adoRs = adoCn.GetRecordSet(SQLstr)
                 MsgBox "Registration successfully made"
   Else
      Exit Sub
   End If
      txttag.Text = ""
```

```
    Set adoRsdata = adoCn.GetRecordSet("SELECT
Basketname,Basketid,Checkintime,Checkouttime,DateRegistered FROM checkin ORDER BY
serial ASC")
        Set dtgPositions.DataSource = adoRsdata
    End If
    Exit Sub
End Sub
```

CMM(POS) Sample Code

```
Dim CardNum As Long
Dim Totallen As Long
Dim EPClen, m As Long
Dim EPC(5000) As Byte
Dim CardIndex As Long
Dim readtime, Baskettime As Long
Dim temps As String
Dim s, sEPC As String
Dim ScanModeData(5000) As Byte
Dim SQLstr, dateStr, checkreadtime, checkbaskettime, Values, X, cols, SQLstr1, SQLstr2, SQLstr3
As String
Dim ScanTime2 As Double
Dim transid As Long
Dim adoRsFromClientReg As ADODB.Recordset
Dim adoRsGetbasket As ADODB.Recordset
Dim adoRsgetcache As ADODB.Recordset
Dim adoRsdata As ADODB.Recordset
Dim adoRsscans As ADODB.Recordset
Dim adoRsTotal As ADODB.Recordset
Dim adoRstransid As ADODB.Recordset
        If (Combo8.ListIndex = 0) Then
        fCmdRet = Inventory_G2(ComAdr, EPC(0), Totallen, CardNum, FrmHabdle)
             If ((fCmdRet = 1) Or (fCmdRet = 2) Or (fCmdRet = &HFB)) Then
                temps = GetHexData(EPC, Totallen)
                fInventory_EPC_List = temps
                m = 1
                    If (CardNum = 0) Then
                    fIsInventoryScan = False
                    Exit Function
                End If
                For CardIndex = 0 To CardNum - 1
                If (fcloseApp) Then
                Exit For
                End If
                    m = m + EPClen + 1
                    If (Len(sEPC) <> EPClen * 2) Then
                        Exit Function
                    End If
                    List1.AddItem (sEPC)
                'call stock details
                txttag.Text = sEPC
                'clear textboxes
                  txtName.Text = ""
```

```
            txtRFID.Text = ""
            txtamount.Text = ""
            txtVat.Text = ""
            txttotal.Text = ""

           'select the basket name
          SQLstr1 = "SELECT serial,BasketName,Basketid FROM cart WHERE Basketid ='" +
Trim(txttag.Text) + "'"
          Set adoRsGetbasket = adoCn.GetRecordSet(SQLstr1)
          adoRsGetbasket.MoveFirst
          txtbasket.Text = adoRsGetbasket!BasketName
          txtBasketId.Text = adoRsGetbasket!basketid
         'select stock item details
         Next CardIndex
            SQLstr = "SELECT name,RFID,sellingprice FROM productlist WHERE RFID ='" +
Trim(txttag.Text) + "'"
          Set adoRsFromClientReg = adoCn.GetRecordSet(SQLstr)
          adoRsFromClientReg.MoveFirst
            txtName.Text = adoRsFromClientReg!Name
            txtRFID.Text = adoRsFromClientReg!RFID
            txtamount.Text = adoRsFromClientReg!Sellingprice
            txtVat.Text = Val(Trim(txtamount.Text)) * 0.16
            txttotal.Text = Val(Trim(txtVat.Text)) + Val(Trim(txtamount.Text))
            txtreadtime.Text = Format(Now, "HH:nn:ss") '& "." & Right(Format(Timer, "#0.00"),
2)
            'txtreadtime.Text = Format(Now, "HH:MM:SS:hh")
            txtCheckintime.Text = Format(Now, "Long Time")
            'txtCheckouttime.Text = "Not yet"
            dateStr = Format(Now(), "yyyy-MM-dd")

 'manage start time
                checkreadtime = Val(Right$(Trim(txtreadtime.Text), 2))
             checkbaskettime = Val(Right$(Trim(txtStarttime.Text), 2))

         'RecieptTime1 = RecieptTime
             If checkreadtime < checkbaskettime Then
                   X = 60 + checkreadtime
                  ScanTime2 = X - checkbaskettime
             Else

                ScanTime2 = checkreadtime - checkbaskettime
             End If
                 QLstr2 = "SELECT count(itemcode) as itemcode  FROM cache WHERE itemcode
='" + Trim(txtRFID.Text) + "'"
            Set adoRsgetcache = adoCn.GetRecordSet(SQLstr2)
            adoRsgetcache.MoveFirst

              If adoRsgetcache!itemcode = 0 Then

'Insert itemdetails in cache
                         cols                                                    =
"RecieptNO,Item,Quantity,Price,VAT,Itemcode,Status,Basketid,basketname,Baskettime,Readtime,
Scantime,date"
```

```
If  Len(txtName.Text) <> 0 And Len(txtbasket.Text) <> 0 Then
        Values = "'" + Trim(txtreceiptno.Text) + "','" + addMySQLQuote(txtName.Text) + "','" +
        addMySQLQuote(txtQTY.Text) + "','" + Trim(txtamount.Text) + "','" +
        addMySQLQuote(txtVat.Text) + "','" + addMySQLQuote(txttag.Text) + "','" +
        addMySQLQuote(txtStatus.Text) + "','" + addMySQLQuote(txtBasketId.Text) + "','" +
        addMySQLQuote(txtbasket.Text) + "','" + addMySQLQuote(txtStarttime.Text) + "','" +
        addMySQLQuote(txtreadtime.Text) + "','" + addMySQLQuote(ScanTime2) + "','" + dateStr
        + "'" SQLstr = "INSERT INTO cache(" + cols + ") VALUES(" + Values + ")"
       Set adoRs = adoCn.GetRecordSet(SQLstr)
 End If
 Else
        MsgBox "You have scanned all stock items in the basket/cart.", vbOKOnly +
        vbInformation, "All items scanned"

  End If

  'populate the grid
  Set adoRsdata = adoCn.GetRecordSet("SELECT Item,Quantity AS
QTY,Price,Itemcode,Basketname as Basket,Baskettime,Readtime,Scantime FROM cache ORDER
BY readtime ASC")
Set dtgPositions.DataSource = adoRsdata
   'count scans
SQLstr3 = "SELECT count(Quantity) as Quantity FROM cache"
 Set adoRsscans = adoCn.GetRecordSet(SQLstr3)
              ' adoRsscans .MoveFirst
                         txtscans.Text = adoRsscans!Quantity

            Next CardIndex
 'calculate final total

            Set adoRsTotal = adoCn.GetRecordSet("SELECT sum(price)as total FROM cache")
            txttotal.Text = adoRsTotal!total

        End If
        If (ListX.listCount > 0) Then
               ListX.ListIndex = ListX.listCount - 1
        End If
      Else
      fCmdRet = ReadActiveModeData(ScanModeData(0), ValidDatalength, FrmHabdle)
      If (ValidDatalength > 0) Then
      temps = GetHexData(ScanModeData, ValidDatalength)
      List1.AddItem (temps)
      End If
       fIsInventoryScan = False
      If (fcloseApp) Then
        Close
      End If
End Function
‘Manage the printing of receipts
Dim adoRsPrint As ADODB.Recordset
Dim adoRsTemp As ADODB.Recordset
Dim adoRsRecieptNo As ADODB.Recordset
Dim Values, SQLstr, SQLstr2, cols, cols2, Values2 As String
```

```
Dim checkreciepttime, checkreciepttime2, X, checkbaskettime, checkbaskettime2, checkbaskettimetot, checkreciepttimetot, RecieptTime, Baskettime As String
Dim TransactionTime As Double
Dim adoRsDelete As ADODB.Recordset
‘block of code for error management
    If Len(Trim(txtpaid.Text)) < 1 Then
        MsgBox "You have not specified the amount paid by the customer. ", vbOKOnly + vbInformation, "Unspecified Amount"
        Exit Sub
    End If
        If Len(Trim(txtBalance.Text)) < 1 Then
        MsgBox "You have not specified the amount paid by the customer. ", vbOKOnly + vbInformation, "Unspecified Amount"
        Exit Sub
    End If
    If Len(Trim(txttotal.Text)) < 1 Then
        MsgBox "You have not Scanned any stock item. ", vbOKOnly + vbInformation, "Un scanned stock item"
        Exit Sub
    End If
    If Val(txtBalance.Text) < 0 Then
      MsgBox "The amount paid is not enough to end the transaction.", vbOKOnly + vbInformation, "Under payment"
      Exit Sub
    End If
      frmRptAllCachedOrders.Show
       Set adoRsPrint = adoCn.GetRecordSet("SELECT RecieptNO,Item,Quantity,Price,VAT,Itemcode,Status,Basketid,basketname,Baskettime,Readtime,Scantime,date FROM cache")
         RecieptTime = Format(Now, "HH:nn:ss") ' & "." & Right(Format(Timer, "#0.00"), 2)
         checkreciepttime = Val(Right$(RecieptTime, 2))
         checkreciepttime2 = Val(Right$(RecieptTime, 5))
         checkreciepttimetot = (checkreciepttime + (checkreciepttime2 * 60))
          Baskettime = adoRsPrint!Baskettime
         checkbaskettime = Val(Right$(Baskettime, 2))
         checkbaskettime2 = Val(Right$(Baskettime, 5))
         checkbaskettimetot = (checkbaskettime + (checkbaskettime2 * 60))
          'RecieptTime1 = RecieptTime
      If checkreciepttimetot < checkbaskettimetot Then
           X = 60 + checkreciepttimetot
          TransactionTime = X - checkbaskettimetot
      Else

         TransactionTime = (checkreciepttimetot - checkbaskettimetot) / 60
      End If
      'Baskettime = Val(Mid$(Trim(adoRsPrint!Baskettime), 8, 2)) * 1000 +
Val(Mid$(Trim(adoRsPrint!Baskettime), 10, 2))
     While Not adoRsPrint.EOF
          cols = "NO,RecieptNO,Item,Quantity,Price,VAT,Itemcode,Status,Basketid,Basketname,Baskettime,Readtime,Scantime, RecieptTime,TransactionTime,Checkintime,Checkouttime,ShoppingTime,Date"
         Values = "'" + "0" + "','" + addMySQLQuote(adoRsPrint!RecieptNO) + "','" + addMySQLQuote(adoRsPrint!Item) + "','" + addMySQLQuote(adoRsPrint!Quantity) + "','" +
```

```
addMySQLQuote(adoRsPrint!Price) + "','" + addMySQLQuote(adoRsPrint!vat) + "','" + addMySQLQuote(adoRsPrint!itemcode) + "','" + addMySQLQuote(adoRsPrint!Status) + "','" + "','" + addMySQLQuote(adoRsPrint!BasketName) + "','" + addMySQLQuote(adoRsPrint!Baskettime) + "','" + adoRsPrint!readtime + "','" + adoRsPrint!ScanTime + "','" + RecieptTime + "','" + addMySQLQuote(TransactionTime) + "','" + "" + "','" + "" + "','" + "" + "','" + adoRsPrint!Date + "'"
        SQLstr = "INSERT INTO bank(" + cols + ") VALUES(" + Values + ")"
      Set adoRsTemp = adoCn.GetRecordSet(SQLstr)
        cols2 = "RecieptNo,BasketName,ReciptTime"
        Values2 = "'" + addMySQLQuote(adoRsPrint!RecieptNO) + "','" + addMySQLQuote(adoRsPrint!BasketName) + "','" + addMySQLQuote(RecieptTime) + "'"
        SQLstr2 = "INSERT INTO reciepts(" + cols2 + ") VALUES(" + Values2 + ")"
      Set adoRsRecieptNo = adoCn.GetRecordSet(SQLstr2)
              Wend
     Call cmdClose_Click
```

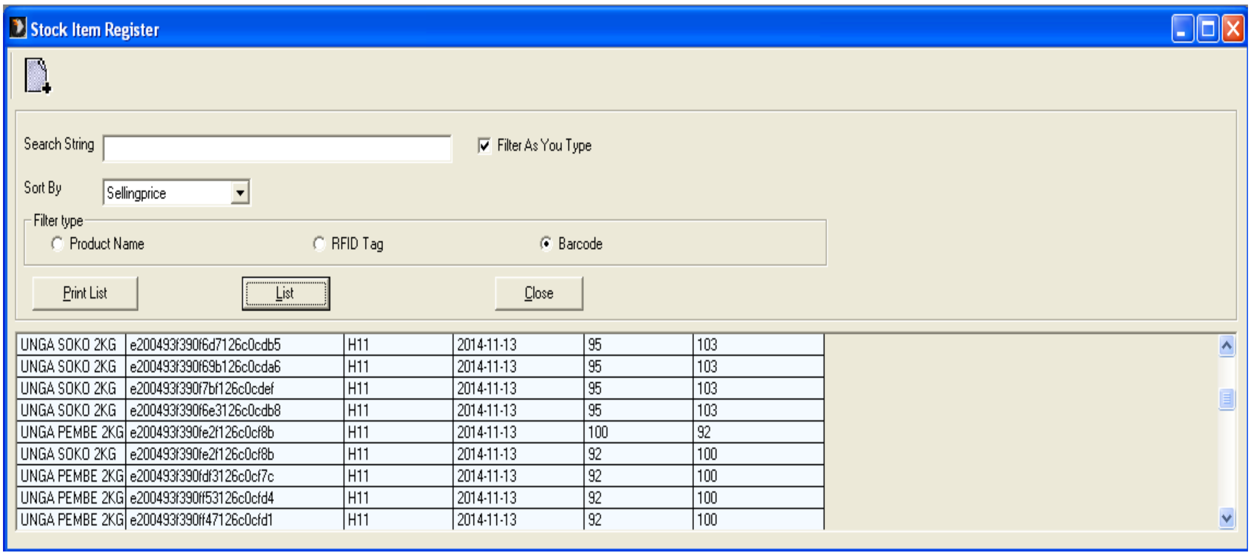
Checkout Sample Code

```
 Dim adoRsOrderHist As ADODB.Recordset
 Dim adoRsdata As ADODB.Recordset
 Dim SQLstr, dateStr, Values, cols As String
 Dim shoppingTime, X, Y, checkin, checkout As Long
 Dim adoRsShoppingtime As ADODB.Recordset
 Dim adoRsCheckintime As ADODB.Recordset
 Dim adoRsDeletecache  As ADODB.Recordset
 Dim adoRsReciptNo As ADODB.Recordset
    SQLstr = "SELECT BasketName,Basketid,checkintime FROM checkin WHERE (Basketid ='" + Trim(txttag.Text) + "' )AND (Basketid LIKE '%" + Trim(txttag.Text) + "%')"
   Set adoRsFromClientReg = adoCn.GetRecordSet(SQLstr)
   adoRsFromClientReg.MoveFirst
   Err.Clear
     If Not IsNull(adoRsFromClientReg!BasketName) Then
             txtBasketname.Text = adoRsFromClientReg!BasketName
      Set adoRsReciptNo = adoCn.GetRecordSet("SELECT RecieptNO FROM cache  where BasketName='" + Trim(txtBasketname.Text) + "'")
       If txtBasketname.Text = "" Then
        MsgBox "You have not specified the basket time correctly.", vbOKOnly + vbInformation, "Unspecified basket"
        Exit Sub
       End If
        txttag.Text = adoRsFromClientReg!basketid
        txtCheckintime.Text = adoRsFromClientReg!checkintime
        txtCheckouttime.Text = Format(Now, "HH:nn")
       End If
        checkout = Val(Right$(Trim(txtCheckouttime.Text), 2))
        checkin = Val(Mid$(Trim(txtCheckintime.Text), 4, 2))
      If checkout < checkin Then
           X = 60 + checkout
          shoppingTime = X - checkin
      Else
        shoppingTime = checkout - checkin
      End If
```

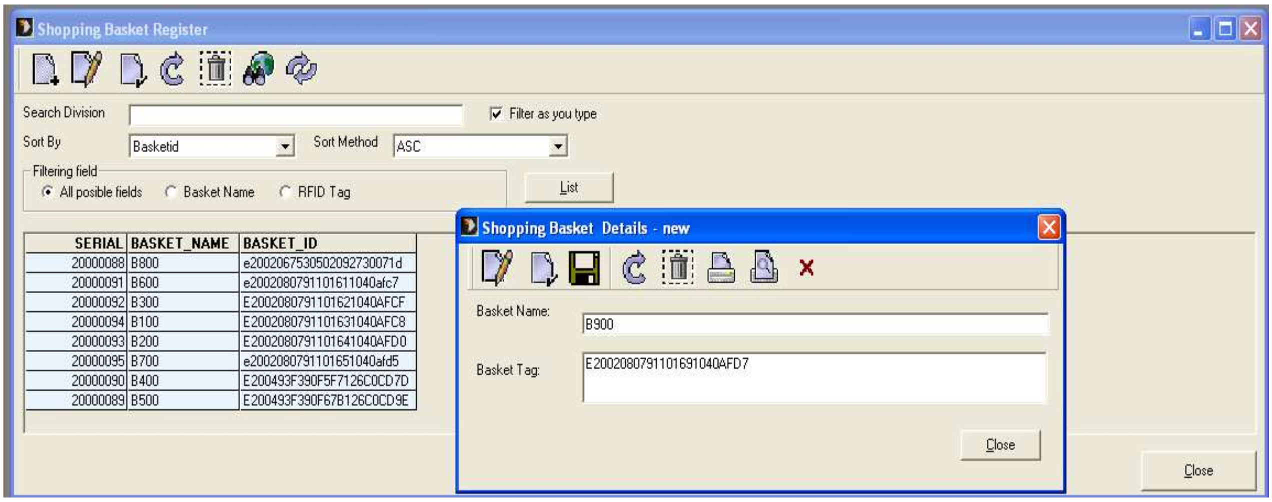
```
    Set adoRsupdate = adoCn.GetRecordSet("UPDATE checkin SET checkouttime ='" + addMySQLQuote(Trim(txtCheckouttime.Text)) + "' WHERE Basketname='" + Trim(txtBasketname.Text) + "'")
    Set adorsupdatebank = adoCn.GetRecordSet("UPDATE bank SET checkouttime ='" + addMySQLQuote(Trim(txtCheckouttime.Text)) + "' WHERE Basketname='" + Trim(txtBasketname.Text) + "'")
    Set adoRsCheckintime = adoCn.GetRecordSet("UPDATE bank SET Checkintime= '" + addMySQLQuote(txtCheckintime.Text) + "'WHERE Basketname='" + Trim(txtBasketname.Text) + "' and RecieptNO ='" + addMySQLQuote(Trim(adoRsReciptNo!RecieptNO)) + "'")
    Set adoRsShoppingtime = adoCn.GetRecordSet("UPDATE bank SET shoppingtime = '" + addMySQLQuote(shoppingTime) + "'WHERE Basketname='" + Trim(txtBasketname.Text) + "' and RecieptNO='" + addMySQLQuote(Trim(adoRsReciptNo!RecieptNO)) + "'")

    Set adoRsDeletecache = adoCn.GetRecordSet("DELETE FROM cache ")
        MsgBox "Your request for updating '" + Trim(txtBasketname.Text) + "' record was successfuly", vbOKOnly + vbInformation, "Update successful"
        txttag.SelLength = Len(txttag.Text)
   Set dtgPositions.DataSource = adoRsdata
    Exit Sub
err_H:
  MsgBox Err.Description, vbOKOnly + vbExclamation, "General series error"
   Resume Next
End Sub
```

Appendix B: Sample Screens Shots

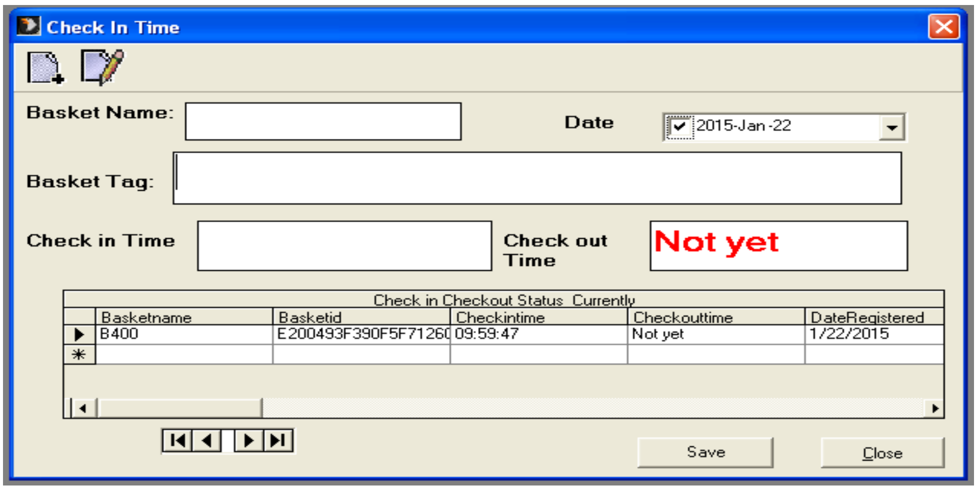
Stock Item Register



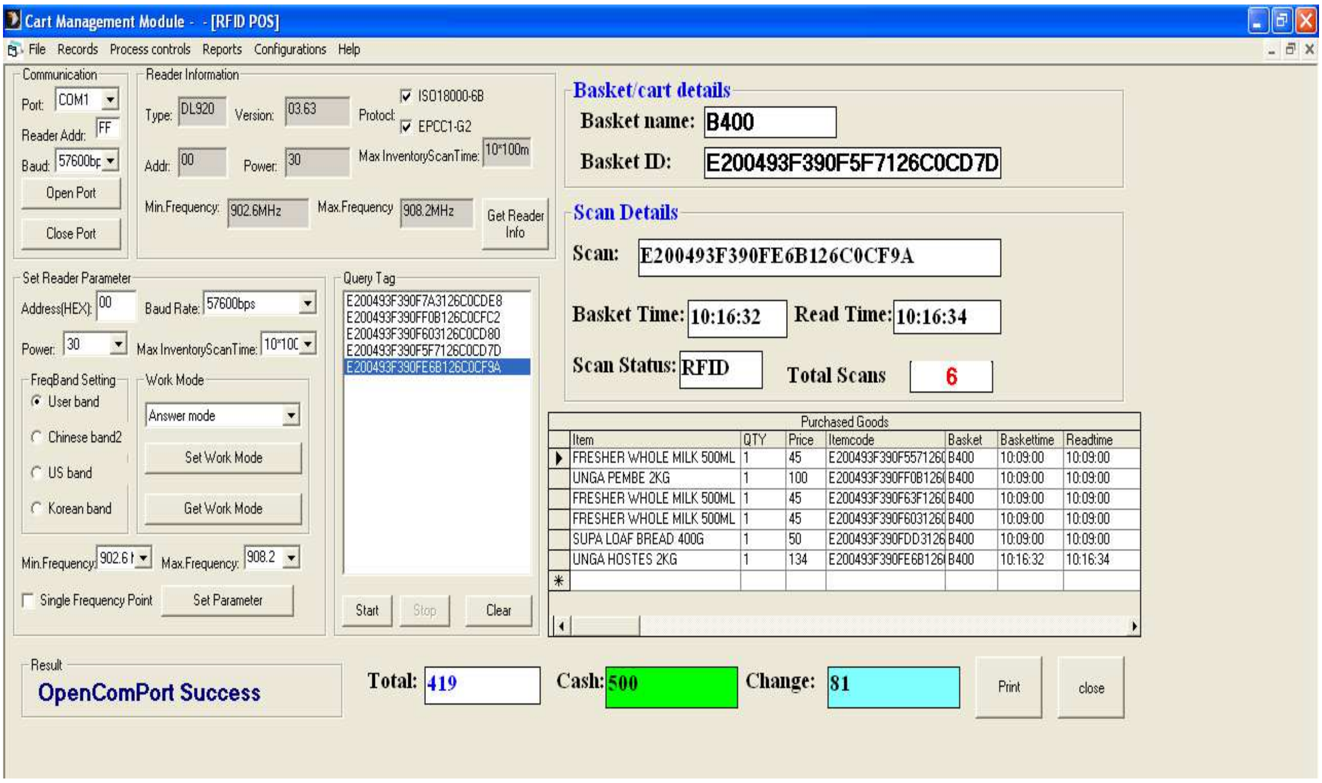
Shopping Basket Register



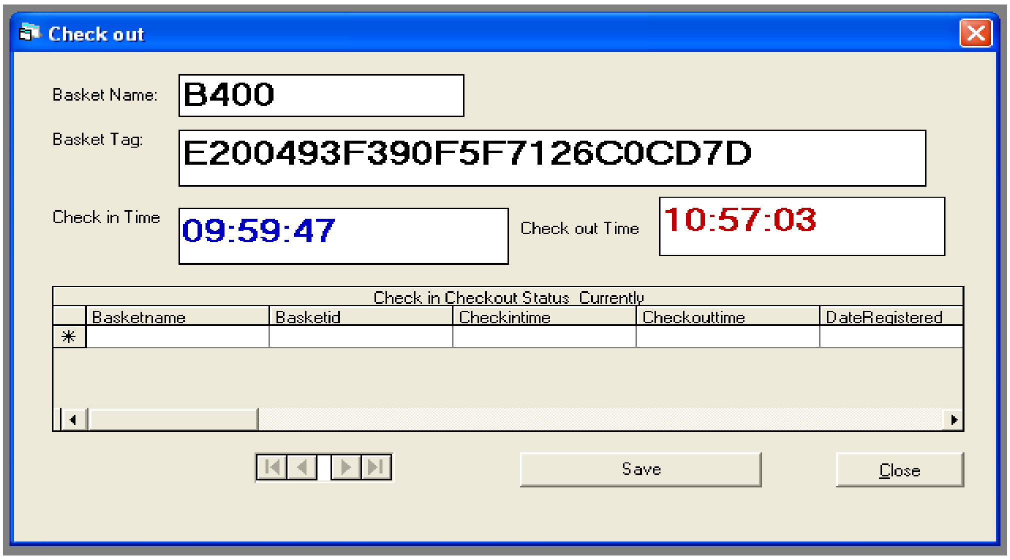
Check in Time Form



Cart Management Module (POS)



Checkout Form



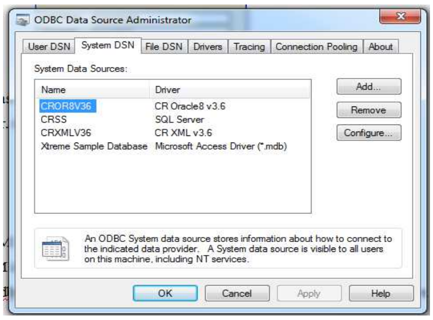
Appendix C: CMM 1.0 Prototype Installation and Configuration Manuals

To install the CMM prototype you will need My SQL 5.1 or higher, My SQL ODBC 3.51 driver or higher and CMM 1.0 setups. MySQL and MySQL ODBC can be downloaded from http://dev.mysql.com/downloads/mysql/

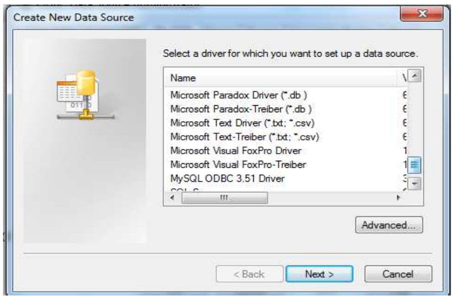
Install My SQL and My SQL ODBC 3.51 driver following the guideline given by mysql.com

MyODBC 3.51 driver configuration Manual

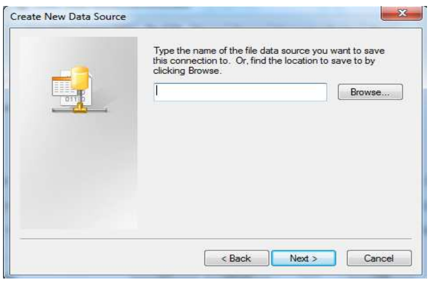
1. Before using this CMM 1.0, you will need to install and configure MySQL MyODBC 3.51 driver or higher so that CMM connects connected to the via the driver CMM database. In my case I am using MySQL MyODBC 3.51 and MySQL 4.0
2. After installing MySQL MyODBC 3.51 using the instructions from mysql.com, click on start button then click on control panel. Click on Administrative Tools then click on ODBC Data Source and the following form will open:



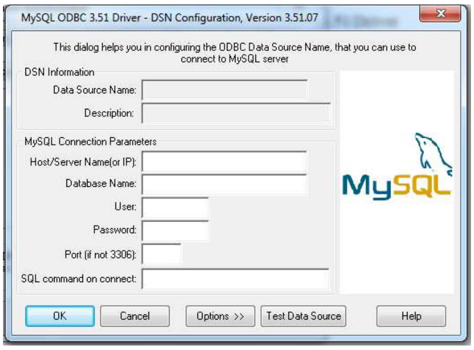
3. Click on File DSN tab then click on Add. The following form will open



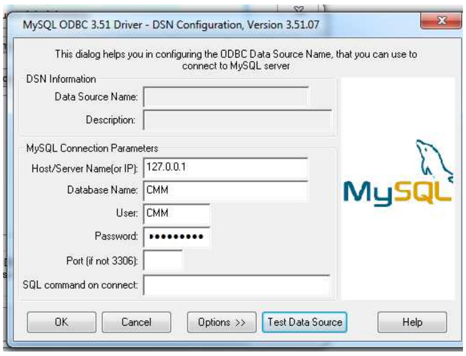
4. Scroll down using the vertical scroll bar until you get to MySQL ODBC 3.51 Driver and click on it then click next. The following form will open:



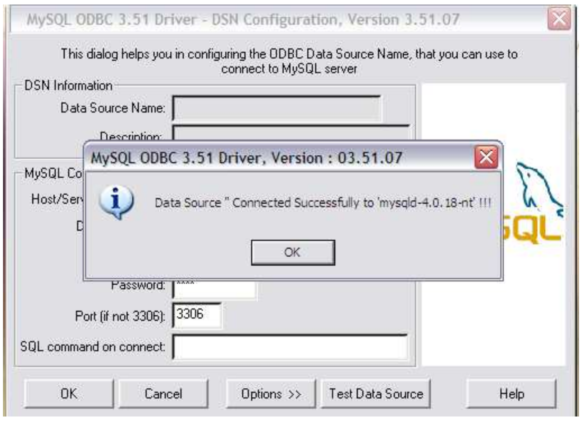
5. Enter CMM then click next button and the click finish button and the following form will open:



6. Enter the Host/Server Name (OR IP) should be localhost or 127.0.0.1 if you intend to install both the database and CMM on the same machine. Otherwise input the IP address of the server where Mysql database has been installed.
7. Input **CMM** as the Database Name and Password as **administrator.**



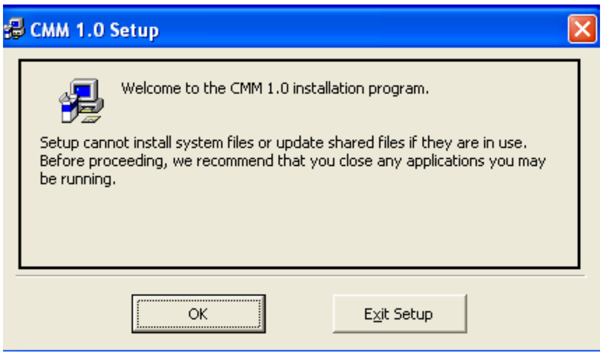
8. Click on Test Data source Button to make sure that you have connection to the data source. The following form will open.



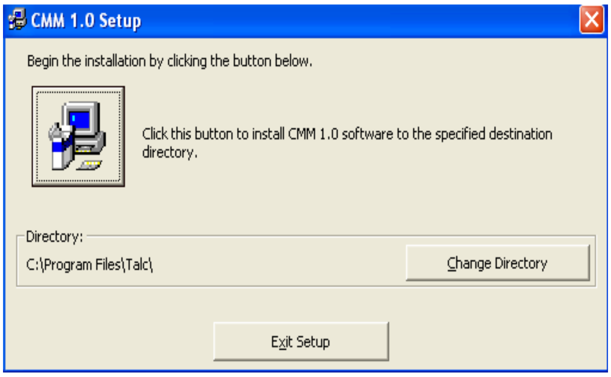
9. Click ok to finish.

CMM 1.0 Prototype Installation Manual

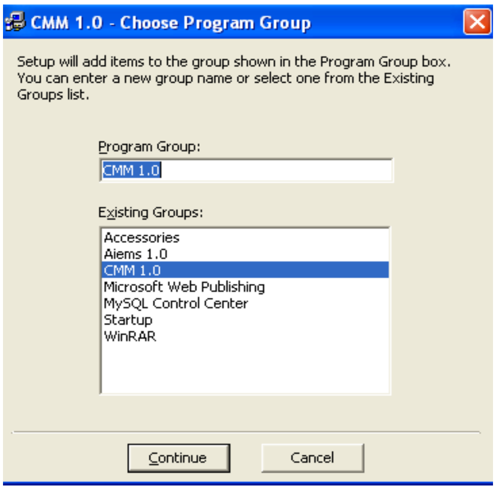
1. To install the CMM 1.0, double click on CMM setup. The following will be displayed on your monitor.



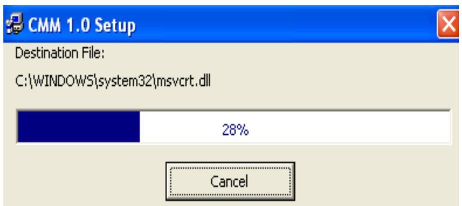
2. Click OK and the following will appear on your display.



3. If you wish to change the directory where you want to install the CMM you can change it by clicking on change directory. If not click the button above it to continue setup.

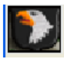


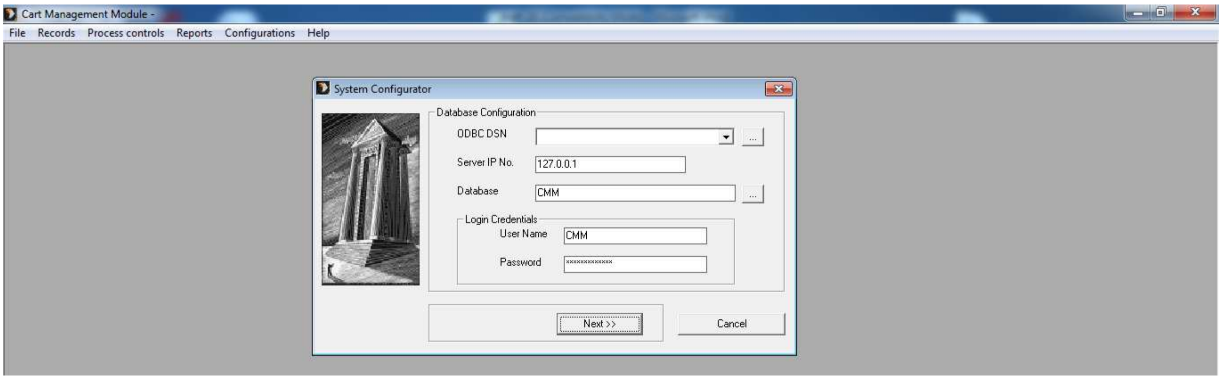
4. Click on continue button to continue with the setup process.
5. The following progress bar will appear on the display.



6. Once setup is complete, the following message box will appear on the display indicating that setup completed successfully. Click OK.

CMM 1.0 Prototype Configuration Manual

1. Double click on the click on this Button on the desktop and the following form will open:



2. Click on the ODBC DSN dropdown arrow and select CMM as the DSN.
3. Enter the following details:

   Server IP NO: **127.0.0.1**

   Database: **CMM**

   User Name: **CMM**

   Password: **Administrator**

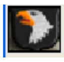
4. Click next then Enter supermarket name and the initials.
5. The click next to finish the configurations.

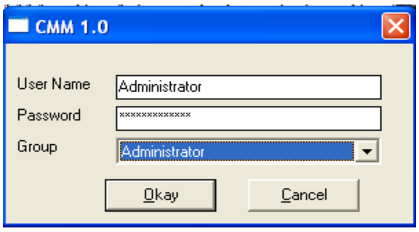
CMM 1.0 Prototype Administration manual

In **CMM 1.0 Prototype** Users are organized into groups and each group has specific rights and privileges to access only those controls that have been granted to them by the Systems Administrator. The Administrators has rights and privileges to access any controls in the system. But they are not able to know passwords of system users since they are hashed. This part will be divided into three parts which are as follows:-

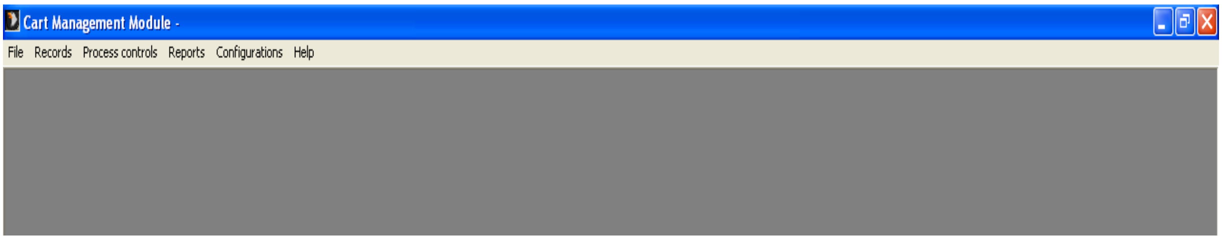
1. Managing user Groups.
2. Managing Users.
3. Changing User Passwords.

Managing User Groups

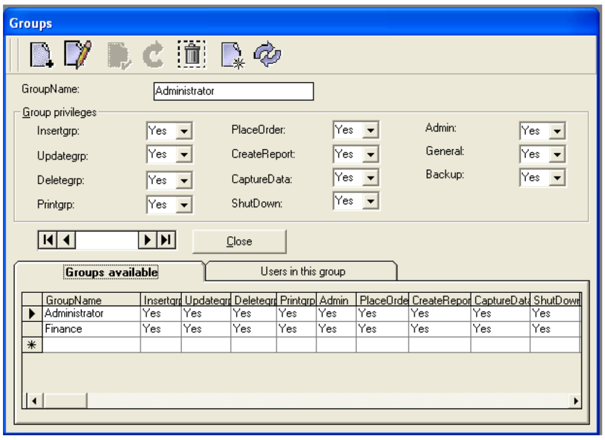
1. To login into the CMM 1.0 Prototype as the Administrator , click on this  Button on the desktop and the following form will open:



2. Input your user name as **Administrator**, Your password is **Administrator** and your group is **Administrator**. One you login, you must change your password.
3. Click on OKay button and following form will appear on the desktop:



4. On the main Menu, click **Configurations** then click **User Groups.** the following form will open:-



A user group must have a group name and Group privileges. Privileges in this system are as follows:-

a. Insertgrp which allows a user group to be able to insert records.

b. Updategrp which allows a users group to update records (save).

c. Printgrp which will allows a user group to be able to Print records and reports.

d. Use RFID POS which allows a User Group to be able to use RFID module

e. Create report which allows a User Group to be able to create reports.

f. CaptureData which allows a User Group to be able to capture data.

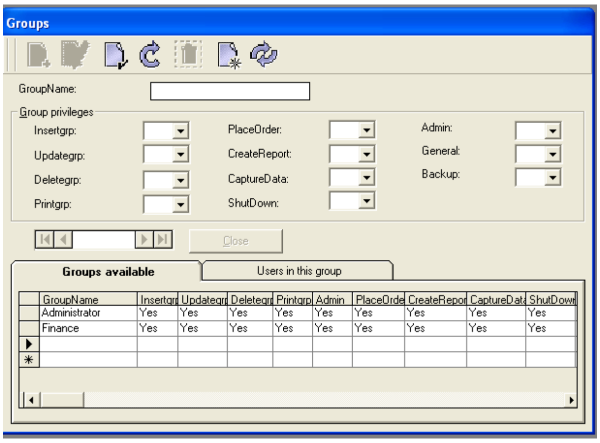
g. Shut down which allows a User Group to be able shut down the system.

h. Admin which allows a User Group to be able to be System Administrators.

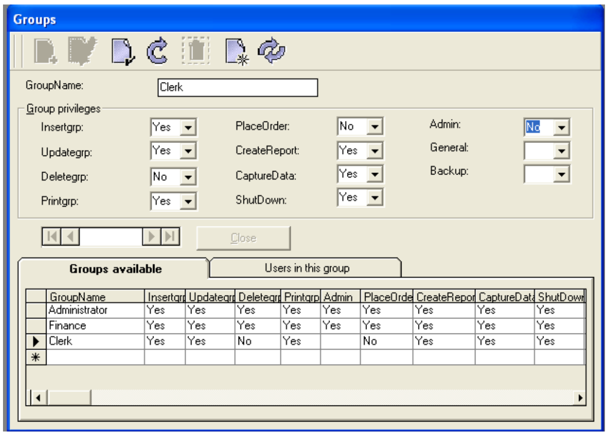
i. General which allows a User Group to have very minimal rights and privileges.

j. Backup which allows a User Group to be able to Backup data?

5. To create a **User Group**, click on this  button on the tool bar.



6. Input a **Group Name** and allocate it **Rights** and **Group privileges** according to the explanations that have been given above. **Save** your record by clicking this  button on the tool bar.



To Delete a Group

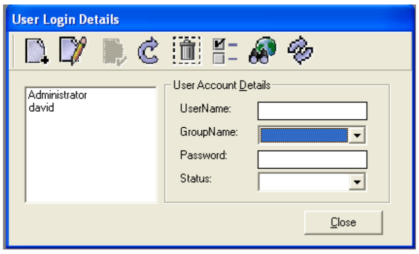
Highlight the group and **DELETE** it by clicking this  button on the Tool bar. The system will notify you if you surely want to delete the record, choose yes.

Managing Users

After creating user groups, you will now be required to create users accounts under your respective groups.

To Add a User Account

1. On the main Menu, click **Configurations** then click **Users.**
2. To **ADD** a new user, click  on the Tool bar



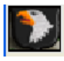
3. Enter the following details as follow:-
    a. User name e.g. Smith, Tom, Jerry etc.
    b. Select the Group name under which the User should fall under from the drop down list that you created.
    c. Input the User name as the password and ask the user to change it after there first Login. ***Please note that Blank passwords are not acceptable by this system.***
    d. Select the account status as either Enabled or Disabled.
4. To save the record, click this  button on the Tool bar.

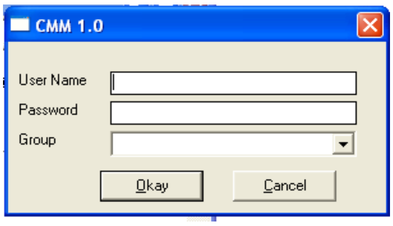
To Delete User Account

1. Click the user account that you wish Delete from the list.
2. Click this  button on the Tool bar. The system will prompt you if you surely want to delete the record, choose
3. Click on the yes button and the user will be deleted from the system.

Appendix D: User Manual

Logging into the CMM

1. To login into the CMM as a normal user, click on this  Button on the desktop and the following form will open:



2. Input your user name, password and select your group then click Ok to login. The following form will appear on the desktop

Note: if you are a new user and you are having problems to login, contact your administrator so that your account can be registered before logging into the CMM 1.0 prototype.

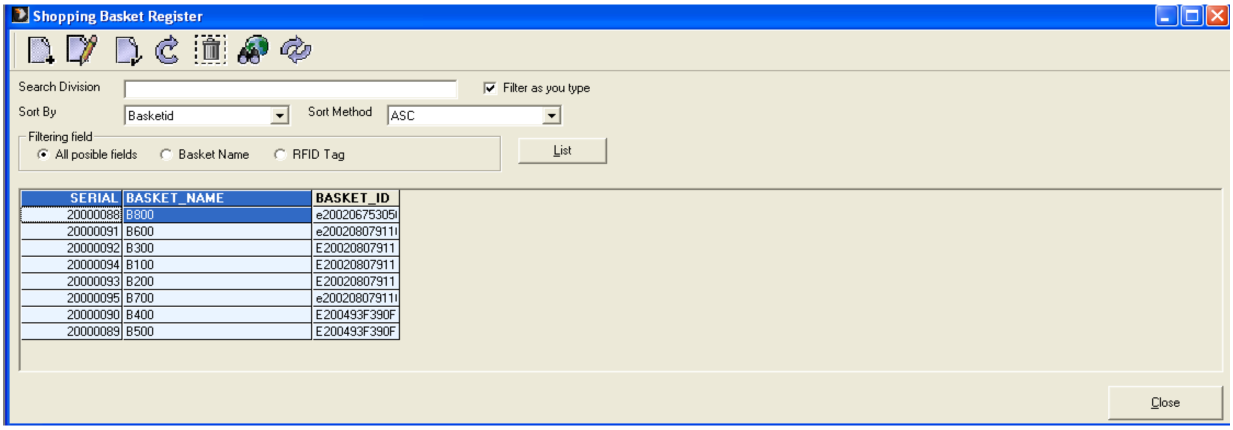
Records management

Registering a new basket

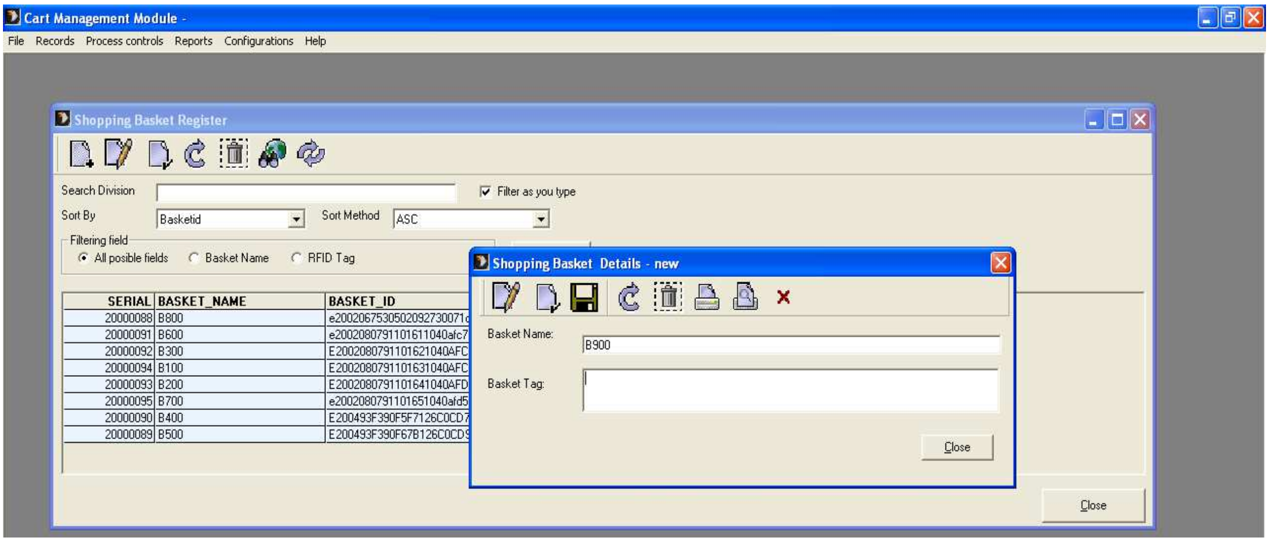
Before a shopping basket is used in this application, it must be registered in the system. Once registered, it can be used as many times as possible. You can register as many baskets as you can.

1. To register a new basket, on the menu, click on records then click on Basket Register

The following form will appear



2. Click on this button on the tool bar to add a new shopping basket. The following form will appear

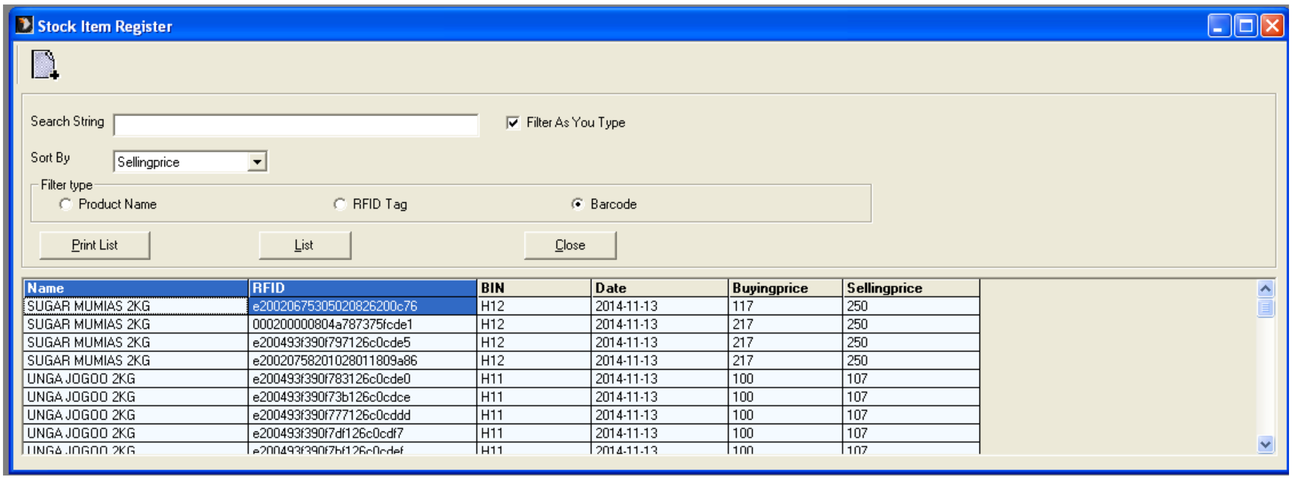


3. Input the Basket name then Scan the RFID label on the basket and click on this button to save.

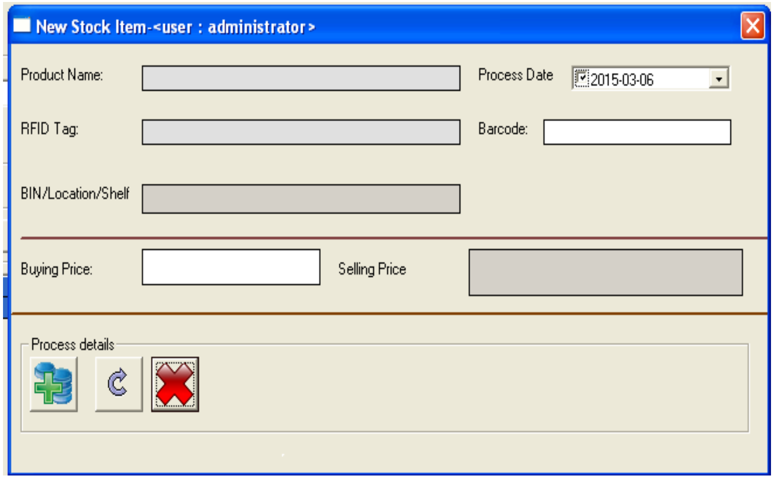
Registering Stock Items

In the CMM each and every tock item must be registered individually and a unique RFID label attached to it.

1. To register a new stock item, on the menu click on records then click on Stock Register. The following form will appear;



2. To register a product, click on this button on the tool bar. The following form will appear



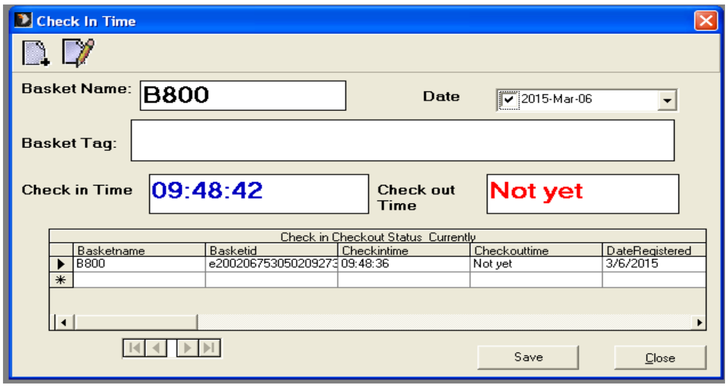
3. Input the Product name, Scan the RFID label to be attached to this product, bin/location/shelf, Barcode, buying price and selling price. The barcode is not mandatory.
4. Click on this button to add the product to your stock list.
5. Attach the RFID label to the stock item. Repeat the same for all stock items on after the other

Shopping Process

The shopping process has three main stages which are check in, RFID Scanning and checkout.

Check In Process

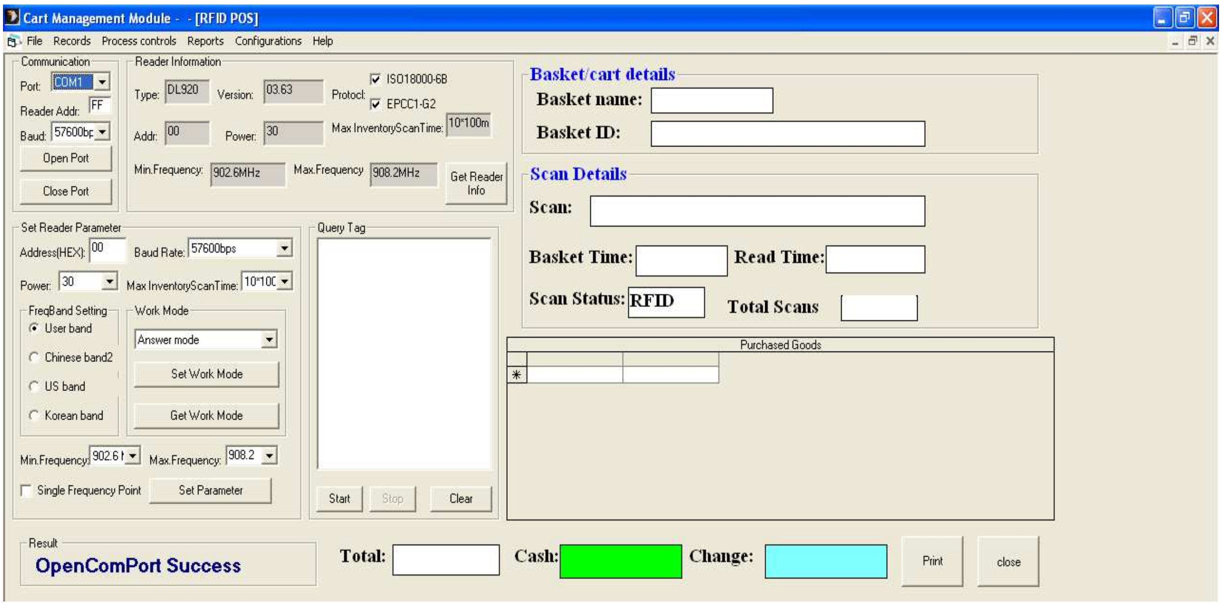
1. To begin this process, the customer must check in and pick the RFID basket.
2. On the menu click on process control then click on check in. the following form appears:



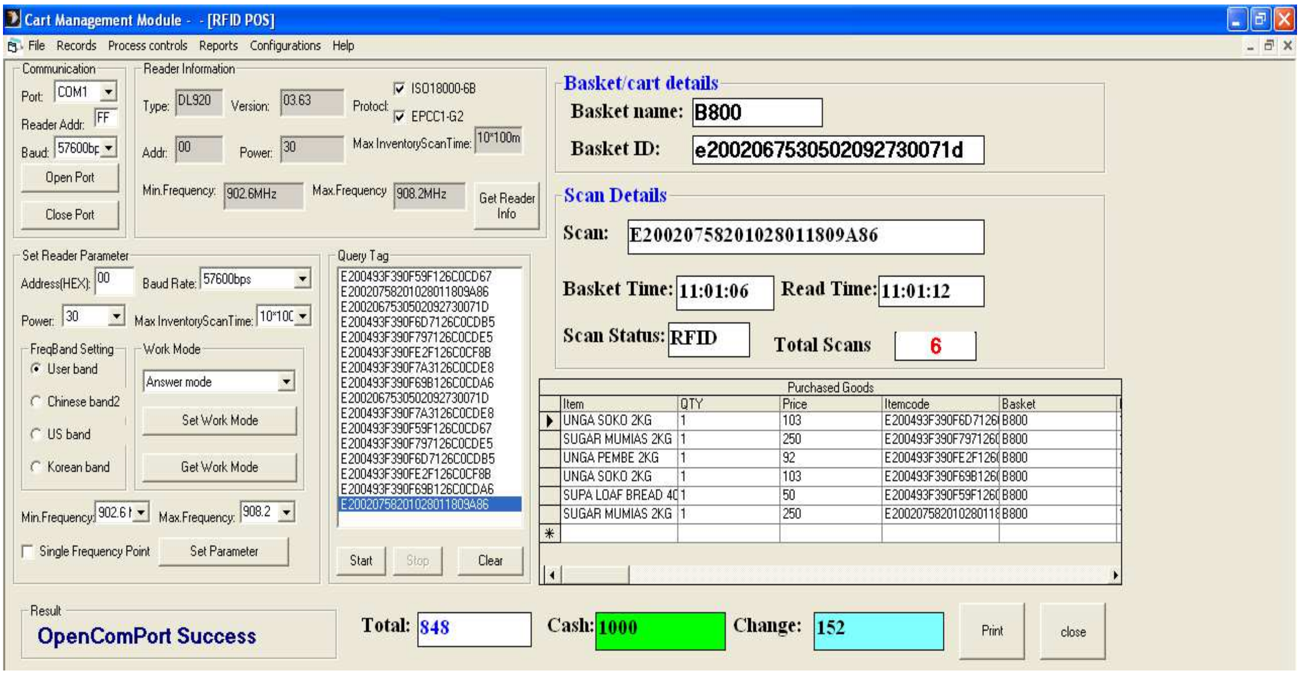
3. Let the customer to pass close to the check in reader, the CMM will scan the basket automatically and save the basket details. The form should be left open always as long as the supermarket is open for business.
4. To exit from this form click the close button.

RFID Scanning Process

1. The scanning process begins when the basket is placed on the RFID till.
2. On the menu, click on process control then click on RFID scanning. The following form will open:



6. Place the RFID basket around the till.
7. Click on start button to scan the stock items on the basket. As the content of the basket is scanned, the scanned tags will appear under query tag list view. The found stock items will appear in the purchased goods grid. The cost of the goods purchased will appear under total. Your form should now look like the one below:

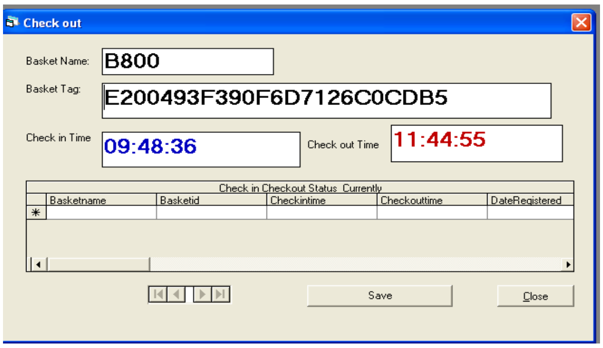


8. Input the amount paid by the customer in the cash text box and the balance will appear automatically in the change text box.
9. Click on print button to print the receipt.
10. To exit from this form click the close button.

Checkout Process

The checkout process begins once the purchased goods have been packed, the customer is leaving the supermarket and the RFID basket is returned at the initial collection point. The process is carried out by one of the attendants as the customer is leaving. In order for the customer to be checked out, the checkout form must be left open always.

1. To open the checkout form, on the menu, click on process controls the click on checkout. The following form will open;



2. Once the basket is within the range of the checkout reader, the basket will be checkout automatically.

3. To exit from this form click the close button.