Developing a Payment System Using Contactless Smart Card

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Master Degree in
Computer Information Systems

by

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April, 2010

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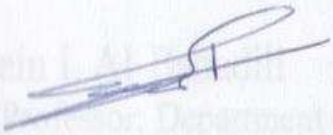
Signature: 

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I do declare hereby that the present research work has been carried out by me under the supervision of Dr. Hazim A. Farhan, and this work has not been submitted elsewhere for any other degree, fellowship or any other similar title.

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DEDICATION

I dedicate this work to my father, my mother, my wife, my children, and my brothers and sister, for their love and support; they were the light in my academic path and without them nothing of this would have been possible.

ACKNOWLEDGMENTS

I would like to express my gratitude to my supervisor, Dr. Hazim A. Farhan, for his expertise, help, and suggestions in addition to his support during the process of this thesis. I also would like to express my thankfulness to all of the Information Technology Faculty members at the Middle East University for Graduate Studies, for supplying me with the necessary information and data to complete this thesis.

Last but not least, big thanks to my family for giving me hope and strength and support through this thesis. This thesis couldn’t have been done without their support.

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ABSTRACT

Contactless smart cards appeared several years ago in the form of electronic tags. Today they are used in the fields of electronic ticketing, transportation and access control. More recently they have started to be used for electronic payment transactions. A contactless smart card is a smart card that can communicate with other devices without any physical connection but by using Radio Frequency Identifier (RFID) technology.

What are the advantages of contactless payments over other methods of payment magnetic stripe cards and cash? Why are traders moving to deploy this new form of payment? Why are consumers willing to change the way they pay? The answer is speed, convenience, and security techniques.

The system that implemented in this thesis used the idea of card based payment systems to bringing a cashless society, this achieved through using the contactless card payment system. As a case study, we implement the system in the Middle East University Cafeteria, and can be extended in future to cover all other payment services. The system is improving the security and will success tackling the problems of fraud, which gives greater confidence for using the system. In addition, it uses biometric techniques (such as fingerprints) to clarifying the candidates and authenticates the user prior to making a purchase.

الخلاصة

البطاقات الذكية اللاسلكية بدأت بالظهور منذ عدة سنوات على شكل بطاقات الكترونية.

في يومنا الحالي، تستخدم البطاقات الذكية لقطع التذاكر الالكترونية، وفي وسائط النقل وتحكم الدخول. وفي الآونة الأخيرة بدأ أستخدامها في عمليات الدفعات المالية.

البطاقات الذكية اللاسلكية هي بطاقات ذكية قادرة على الأتصال بالأجهزة الأخرى بدون أي تماس بل إنها تستخدم تقنية معّرف تردد الراديو.

ما هي مزايا بطاقات الدفع الذكية عن الوسائل الأخرى للدفع كالبطاقات الممغنطة وطريقة الدفع النقدية ؟ لماذا يتحرك التجار لنشر هذا النوع الجديد من طرق الدفع؟ لماذا نجد المستهلكون على استعداد لتغيير الطريقة التي يدفعون بها مشترياتهم؟ الجواب هو السرعة ، والراحة ، والتقنيات الأمنية.

أن النظام المطبق في هذه الأطروحة يعتمد على فكرة أنظمة بطاقة الدفع للوصول الى مجال الدفع غير النقدي، وهذا يتحقق عن طريق أستخدام نظام بطاقات الدفع اللاسلكية (نظام التردد الراديوي).

وتم تطبيق هذا النظام كحالة دراسية في جامعة الشرق الأوسط داخل الكافيتيريا، ومن الممكن تطويره في المستقبل لتغطية جميع خدمات الدفع المختلفة الأخرى وجميع اقسام الجامعة.

أن النظام يعمل على تحسين الوضع الأمني وسينجح بمعالجة المشاكل وكشف الأحتيال، مما سيعطي ثقة أكبر في أستخدام النظام. بالاضافة لذلك تم أستخدم التقنيات الحيوية في النظام (كبصمة الأصبع) للكشف والتأكد من صاحب البطاقة قبل أجراء أية عملية شراء .

Chapter 1
Introduction

1.1 Overview

Contactless smart cards appeared several years ago in the form of electronic tags. Today, they are typically used in the fields of electronic ticketing, transportation and access control. More recently they have started to be used for electronic payment transactions.

The main difference between contact and contactless cards is that the user does not need to insert his contactless card into the slot of a smart card reader.

A contactless smart card is a smart card that can communicate with other devices without any physical connection but by using Radio Frequency Identifier (RFID) technology. The communication takes place via a radio frequency link, over the air, rather than through electrical contacts located on the smart card module. An antenna providing inducted current to the embedded smart card chip powers the whole system, which is normally hidden between the front and the rear of the card body and is thus invisible to the user (Handschuh, 2004).

Contactless smartcards are becoming increasingly popular with applications like: credit-cards, national-ID, passports, and physical access.

Contactless cards are a key technology for improving the consumer experience for retail transactions. Both computational speed and RF sensitivity are factored into the consumer's perceived transaction time (Cook et al., 2007).

Contactless cards will examine rapidly growing market and it will provide an overview of the most recent developments with presentations that spanning the wide range of sectors in which contactless cards and technology are being developed and employed.

The term contactless smart card refers to identification cards (for example, some credit cards) that do not need to make contact either with the reader to be read, or to be swiped in a special slot. The Contactless Smart Card capability is implemented by using a tiny RFID tag in the card; the intent was to provide the user with greater convenience by speeding checkout or authentication processes (Technovelgy, 2005).

RFID is not a new technology as most people think. The first use of RFID system was in the 1940's for distinguishing friendly aircraft from the enemy one, where large powered RFID tags were placed on friendly aircraft, thus these tags would give response to identify the carrying aircraft as 'friendly' when interrogated by a radar signal. The system was called IFF (Identify: Friend or Foe) and the Modern Aviation Traffic Control is still adopting its original concept. (Handschuh, 2004)

After that, the wheels of RFID development were turning. The 1950s were an era of exploration of RFID techniques following technical developments in radio and radar in the 1930s and 1940s. Work such as F. L. Vernon's "Application of the microwave homodyne" and D.B. Harris' "Radio transmission systems with modulatable passive responder" were important for development of RFID. (Cook et al., 2007)

The 1960s were the prelude to the RFID explosion of the 1970s, commercial activities were beginning in the 1960s. Sensormatic and checkpoint were founded in the late 1960s. These companies, with others such as Knogo, developed electronic article surveillance (EAS) equipment to counter theft. EAS is arguably the first and most widespread commercial use of RFID (Cook et al., 2007).

In the 1970s developers, inventors, companies, academic institutions, and government laboratories were actively working on developing RFID.

The 1980s became the decade for full implementation of RFID technology, though interests developed somewhat differently in various parts of the world. The greatest interests in the United States were for transportation, personnel access, and to a lesser extent for animals. In Europe, the greatest interests were for short-range systems for animals, industrial and business applications, though toll roads in Italy, France, Spain, Portugal, and Norway where were equipped with RFID.

The 1990's were a significant decade for RFID since it saw the wide scale deployment of electronic toll collection in the United States. The world's first open highway electronic tolling system opened in Oklahoma in 1991, where vehicles could pass toll collection points at highway speeds, unimpeded by a toll plaza or barriers and with video cameras for enforcement. 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. Interest was also taken for RFID applications in Europe during the 1990s. Both Microwave and inductive technologies were finding use for toll collection, access control and a wide variety of other applications in commerce. (Cook et al., 2007).

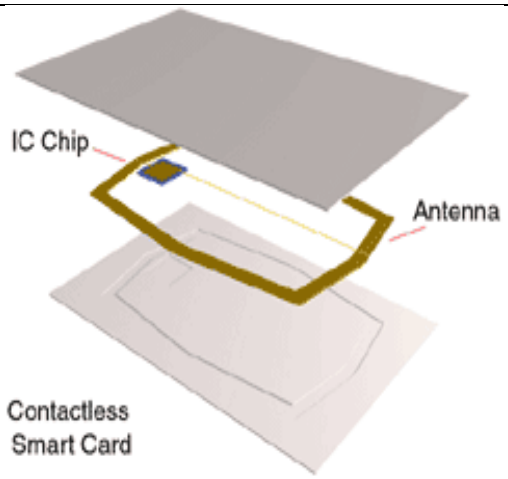
Table 1.1 summarizes the RFID development history.

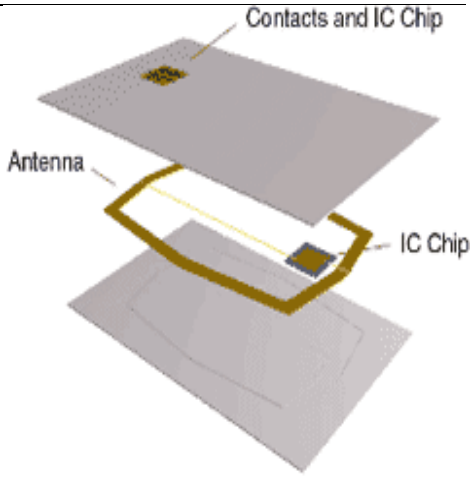
Table 1.1 RFID Development History

Decade	Event
1940 - 1950	Radar refined and used. Major World War II development effort. RFID invented in 1948.
1950 - 1960	Early explorations of RFID technology, laboratory experiments.
1960 - 1970	Development of the theory of RFID. Start of applications field trials.
1970 - 1980	Explosion of RFID development. Tests of RFID accelerate. Very early adopter implementations of RFID.
1980 - 1990	Commercial applications of RFID enter mainstream.
1990 - 2000	Emergence of standards. RFID widely deployed. RFID becomes a part of everyday life.

Nowadays the world of payments and security is changing and new technologies are revolutionizing the way consumers interact with retailers and the way they pay for goods. Also, the rate of change is increasing with recent developments including a new mobile payment service, contactless card trials, and many other innovations.

There are different types of smart cards. They are classified into:
Contact smart cards, contactless smart cards, and hybrid (combined) smart cards as shown in Figure 1.1, Figure 1.2 shows a contactless smart card reader with its computer connection, and Figure 1.3 shows the content of a typical contactless smart card**.**





Contact Smart Cards	Contactless Smart Card	Hybrid (Combine) Smart Cards

Figures 1.1 Types of Smart Cards

Figure 1.2 Contactless Smart Card Reader with its Computer Connection

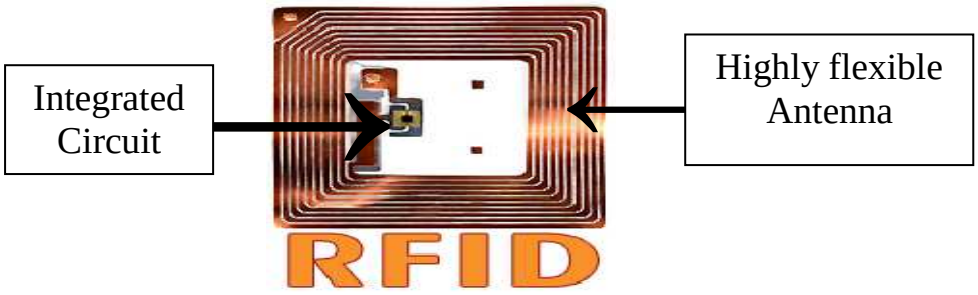


Figure 1.3 Content of a Typical Contactless Smart Card

1.2 Problem Definition

For many years the notion of a cashless society has seemed to be drawing ever closer while around the world coins and banknotes are used as payment in increasingly few transactions as more and more systems present themselves not only as viable, but as potentially better alternatives. A new generation of smart cards is being produced as 'stored value cards' which further reduces the instances in which physical cash is used in making payments.

The change in using this technology shows that stored value card systems can be successfully implemented, and accepted by the public. The advancement of RFID system has seen smart card systems gain popularity in the different services, and it seems perfectly plausible that such schemes will develop in the future to provide multiple functionalities, such that one card can be used to make payments in different services.

There are many perceived advantages to a cashless society, which is likely to cause an increased usage of alternative payment methods in the years to come. Improvements to security techniques may be successful in tackling the problems of fraud, and give greater confidence in such systems. In the future, biometric techniques are a clear candidate to authenticate a user prior to making a purchase.

The developed system tries to implement the usage of the idea of card based payment systems in bringing about the future of a cashless society. This is going to be achieved through using the contactless card payment system, which enables a decline in cash payments.

Today, in Middle East University, they use the cash payment method in every procedure inside the university, where this method has many problems, therefore if we adopt contactless card payments system in converting this method then it's going to be

more useful and effortless in every department, as well as if we compare its benefit with credit cards that need a slot to be swiped in and it is not sufficiently secured. Here are some problems of the two kinds of payment systems, cash payment and credit cards with a slot:

Slowness is one of the problems that make the current payment systems inefficient for example the cash transaction take 34 seconds and the magnetic strip card transaction take 25 seconds (Rankl & Effing, 2003), especially when there are many customers in the market and they are waiting in a casher queue, shall acquire a long time before finalizing their payment.

Also the current payment systems similar to contact credit cards are very risky where the account number can be easily exposed as it is shown in the cover of the card, and the password is required to be entered.

The traditional cash payment is also not secured at all, you cannot carry more cash money with you everywhere you go, there are risks of losing it forever, but if you use the card and the card is stolen you can call the supplier for your card and stop the card immediately in the same time the money will remain in it, and after you make the new card the money is going to transfer to it.

For all the above reasons, we know for sure that the best payments system we can use is the contactless card payments system.

In this thesis, there is an introduction to a new technique added to the system, when the card is stolen or lost you can send a short message service (SMS) from your mobile contains the password of the card, thus the system will block the card immediately. The card will be blocked and no one can use it even if he knows the password. And you can purchase a new card, the new card will contain the same amount of money before the card was stolen or lost.

1.3 Motivation

The growing market and the other requirements of the age, as the consistent speediness, payment protection and other security issues, must get improved. Hence the new payment system is being developed to enhance these issues.

1.4 Thesis Objectives

For many years the notion of a cashless society has seemed to be drawing ever closer. Around the world coins and banknotes are used as payment in increasingly few transactions as more and more systems present themselves not only as viable, but as potentially better alternatives.

This thesis uses a payment automation system, this system provides service-oriented enterprises with many benefits like: simplifies the interaction of users with payment systems, allows the enterprise to customize the types of payment media and adapt them for the different client characteristics, improves fare system by optimizing information flows, increases security and fraud control, and decreases exploitation costs. Contactless smart cards fulfill rather well availability of versatile payment devices, supporting a variety of modes and customization parameters, development of processing and communication mechanisms permitting us to reduce interaction to the minimum, and development of mechanisms guaranteeing data and transactions security (Carmel et al. 2005).

Therefore we use the contactless devices in our thesis and in addition to these benefits the payment system based on contactless devices offer the following properties:

- Scalability: it is the ability to incorporate new payment functionalities means of payment, communication systems, and clients.

- Security: it is the ability to detect wrong transactions, both fraudulent and caused by technical or accidental failures.
- Maintenance easiness: it is the ability to detect and respond to operation failures of its elements. Also, it is the ability of its physical and logical elements to be easily updated.
- Robustness: it is the ability to work in adverse physical conditions, both due to environmental reasons and to a massive and continued use.
- Speed: it is the ability to carry out every transaction that is required in order to provide services access to the users at speeds that do not interfere with productive organization activity.
- Plain interactivity: it is the ability to permit the users to easily employ the means of access to the services.

1.5 Significance of the Study

With recent advances in wireless technologies, RFID becomes an important enabling technology for logistics and supply chain management systems and beyond**.**

What are the advantages of contactless payments over other methods of payment – magnetic stripe cards and cash? Why are traders moving to deploy this new form of payment? Why are consumers willing to change the way they pay? The answer is speed and convenience, as has been substantiated in the early implementations and in recent market research. Consumers no longer have to fumble with cash and change or worry about having enough cash for a purchase - they can place their contactless payment device in close proximity to a reader and go. In most cases, they do not even have to sign a receipt or enter a personal identification number (PIN).

As a result, traders see sales volumes increase and transactions speed up. Chase has reported that time at the POS is reduced 30% to 40% and an American Express study found contactless transactions to be 63% faster than cash and 53% faster than using a traditional credit card.

Research also shows that consumers generally spend more per transaction when they don't use cash – with chase reporting a 20% to 30% increase over cash purchases. Traders also enjoy lower costs, as a result of fewer requirements to handle cash, improve operational efficiencies, and reduce maintenance required by contactless readers. In merchant segments where speed and convenience are key to merchandising and customer service, contactless payments also translate into improved customer acquisition and retention.

By issuing secure contactless payment devices, financial service providers are not only supplying consumers with a more convenient payment mechanism, they are also increasing transaction volumes by replacing cash. In addition, service providers who use this payment system will have a competitive advantage (A Smart Card Alliance Contactless Payments Council, 2006).

On the other hand it gives the traders a pre-money on their pockets, where the consumer will transfer their money to their accounts on the contactless cards which mean cash money on the merchant accounts, so the traders can benefit from that money even before any item sold.

The consumer will also have another advantage from the payment system where he will save his money on an account (contactless smart card), so he will decrease his expenses and keep his money in a safe place.

1.6 Thesis Organization

In addition to this chapter, the thesis includes four other chapters and an appendix, in this section we will describe briefly the contents of thesis, chapters and an appendix.

Chapter 2 devoted to discuss RFID technologies, RFID system's components transaction which consist of Reader and Tag, the advantages of contactless card, the two kinds of payment systems: point of sale with an employee and point of sale without employee and the steps of using this points of sale, then this chapter will describes the communication procedure between the transponder and the reader, what is the RFID transponder and their components, shapes, sizes, power supply for the transponder and their types, operation types. What are the RFID readers and their components, RFID carrier frequencies, the standards that are used in RFID, the end of this chapter will presents the previous systems.

Chapter 3 provides a general description of the procedures, processes and activities of current system that are currently used in the Middle East University (as a case study) in all departments. In addition, depicts and analyze the general description of the developed RFID system in this thesis.

Chapter 4 describes the design steps and implementation of the developed RFID system in detail, including the algorithms, flowcharts, parts of the developed RFID system, and more.

Finally the summary, conclusion and recommended future work are presented in chapter 5.

Our thesis includes also references, glossary of terms and an appendix.

Chapter 2
RFID Technologies and Related Work

2.1 Overview

Radio Frequency Identification (RFID) is an automatic identification technology of the ability of wireless communication (read and write data without direct contact) and without the necessity of line-of-sight.

Contactless cards examine rapidly the growing market and it is able to provide an overview of the most recent developments with presentations spanning the wide range of sectors in which contactless cards and technology are being developed and employed (Market Research, 2006).

The event includes detailed case studies through leading industry players on the latest opportunities, technologies and challenges within the market, including the transport systems, operator networks, payment applications and passports and Identification number (ID).

2.2 RFID System's Components

RFID systems exist in countless variants, produced by many different manufacturers, but RFID system consists mainly of the following components:

2.2.1 Reader (Transceiver)

This device is used to read and/or write data to RFID tags. Antenna could be build inside the reader which is the channel between the tag and the transceiver that control the systems data access and communication.

2.2.2 Tag (Transponder)

Tag is a device that transmits data to reader which is located on the object to be identified. These components communicate via radio signals that carry data either unidirectional or bidirectional.

The integrated circuit contains a microprocessor, memory and a transponder. The microprocessor processes the information coming from the reader. Each tag contains a unique identifier that makes it different from every other tag in a specific set. The antenna is used to communicate with the reader (Jerry et al., 2007) Figure 2.1 shows the RFID System components.

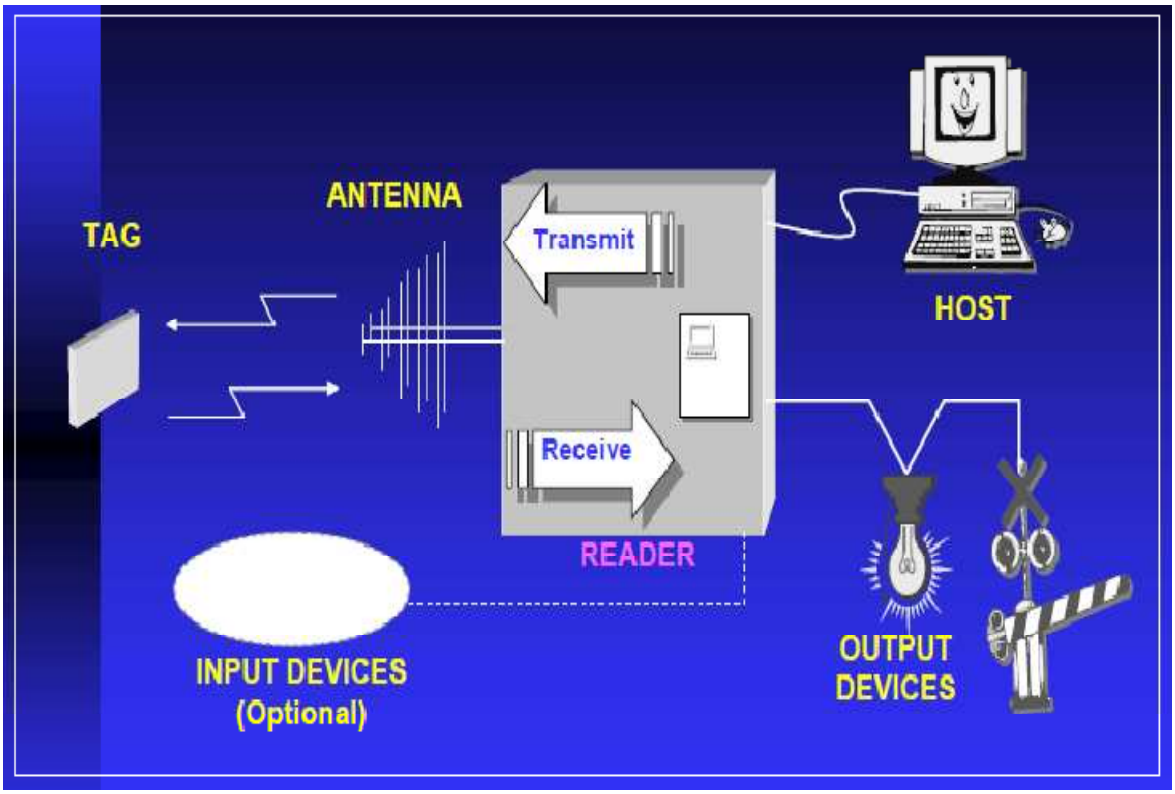


Figure 2.1 RFID System Components (Isao, 2008)

2.3 Transaction Time

From a consumer's point of view the transaction time starts when the card is pulled from the wallet and ends when he/she walks away from the cash register.

Figure 2.2 shows the major elements involved in processing a contactless transaction from the beginning to the end. Each link can be likened to a series of conversations: card and reader, reader and merchant host, host and bank server, etc. Each "conversation" is important to minimize, but a typical consumer will only notice the sum total of the conversation times. (Cook et al., 2007)

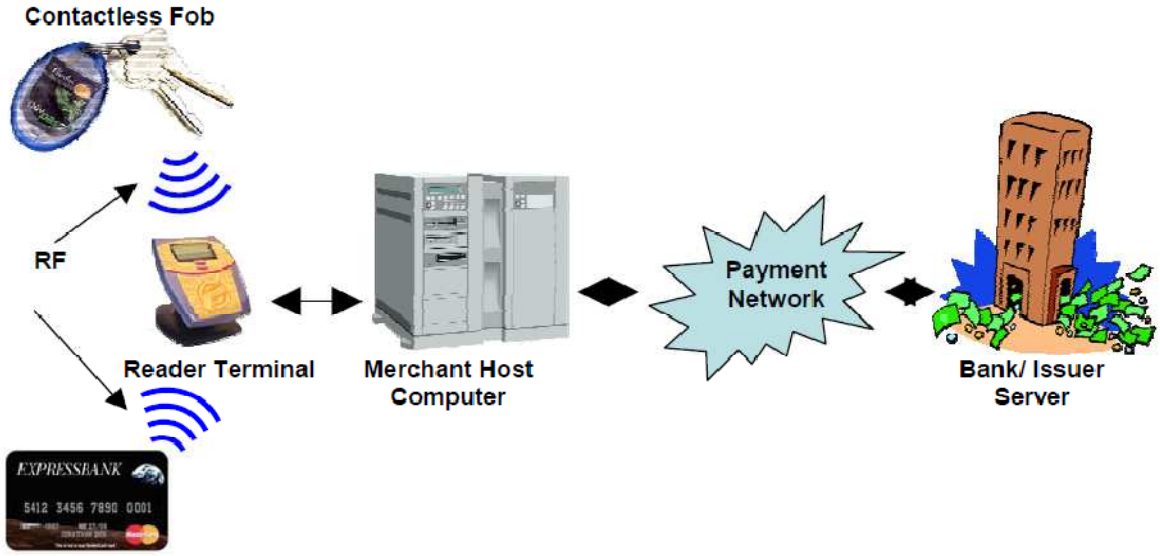


Figure 2.2 Transaction System (Cook et al, 2007)

An integrated circuit (IC) or chip designer's point of view is usually limited to the time it takes for the contactless card to receive, process, and respond to a reader's command set. The time it takes to wave or tap the card and hear the reader's "beep" (positive indication the card was read) should be instantaneous. The "wave to beep" time is influenced by the quality of the RF communication link and the ability of a contactless card to process the series of commands from the reader.

2.4 Advantages of Contactless Card

By issuing secure contactless payment devices, financial service providers are not just supplying consumers with a more convenient payment mechanism; they are also increasing transaction volumes by replacing cash traditional way of payment. In addition, service providers who use this payment system will have a competitive advantage (A Smart Card Alliance Contactless Payments Council, 2006).

In another hand, it gives the merchants a pre-money on their pockets, where the consumer will transfer their money to their accounts on the contactless cards which mean cash money on the merchant accounts, so the merchants can benefit from that money even before any item sold. The consumer will also have another advantage from the payment system where he will save his money on an account (contactless smart card) and thus he decreases his expenses and keeps his money on a save place.

The reports for the credit card companies show that they are claiming the following advantages for contactless credit cards:

Contactless Cards are Fast and Easy to Use

To make a purchase, the card owner just waves his card over the RFID reader, waits for the acceptance indicator- and goes on his way. American Express, Visa and Master Card have all agreed to waive the signature requirement for contactless credit card transactions.

If you want to look at the numbers, here is where this technology is taking us in our need for speed (average transaction speeds):

A. Contactless credit card transaction: 15 seconds.

B. Magnetic strip card transaction: 25 seconds.

C. Cash transaction: 34 seconds. (Carolyn, 2006)

Contactless Cards Use Highly Secured Data Transmission Standards

Contactless cards make use of the most secured encryption standards practical with current technology. 128-bit and triple DES encryption make it nearly impossible for thieves to steal your data (Technovelgy, 2005).

Contactless Card Never Transmits your Card Number

Instead, the RFID chip within the card creates a unique number for the transaction; if a criminal intercepted the number, then it would be useless even if successfully decrypted.

Contactless Cards Probably Use Other Measures

Although this is just speculation, there are certainly other ways to secure the data on the card. For example, the RFID reader that sits on the merchant's counter may use some sort of special signal, or offer a special set of frequencies, that would be difficult for a thief with an off-the-shelf reader to duplicate.

More Memory and Higher Security

The contactless cards have internal RAM and there are many kinds of cards, such as: 1KB RAM card, 4KB RAM card, and 16KB RAM card etc. and for that reason it has a wider memory to store and higher security**.**

Provides Expanded Flexibility Over Magnetic Cards

2.5 Contactless Smart Cards and Payment Systems

In this thesis, the MIFARE contactless smart card and MIFARE card reader/writer were discussed. It was developed to handle payment transactions for public payment systems.

Although contact smart cards could also do the job, but by comparing the contactless readers we find that they are faster and easier to use, and there is virtually no maintenance on the readers, or wear and tear on the cards. MIFARE technology is owned by Philips Electronics where they do not make cards or readers, but they make and sell the card and reader chips in the open market.

In this thesis, we designed and implemented an essayer payment system that requires minimal spare of efforts; the payment system will have two kinds of selling and registering points.

1. Point of Sale with an employee.
2. Point of Sale without an employee.

2.5.1 Point of Sale with an Employee

This kind of point of sale use an employee, for helping the user paying for the first time cost of the contactless card and the fee of registration and add credit.

2.5.2 Point of Sale without an Employee

These points of sale are going to consist of a touch screen only (no employee required) that the user can:

1. Add credit.
2. Pay for a service.
3. Checking his/her account details and updating his/her file.

All customer information will be halted in a main server in the head of above figure and the data of the user will be incepted by using the algorithm encryption technique and connecting all the points of sale we can use either VLAN (virtual LAN which is a local area network by using the Internet) or by using leas liens that will cost more. Figure 2.3 shows the whole diagram of the point of sale and registration.

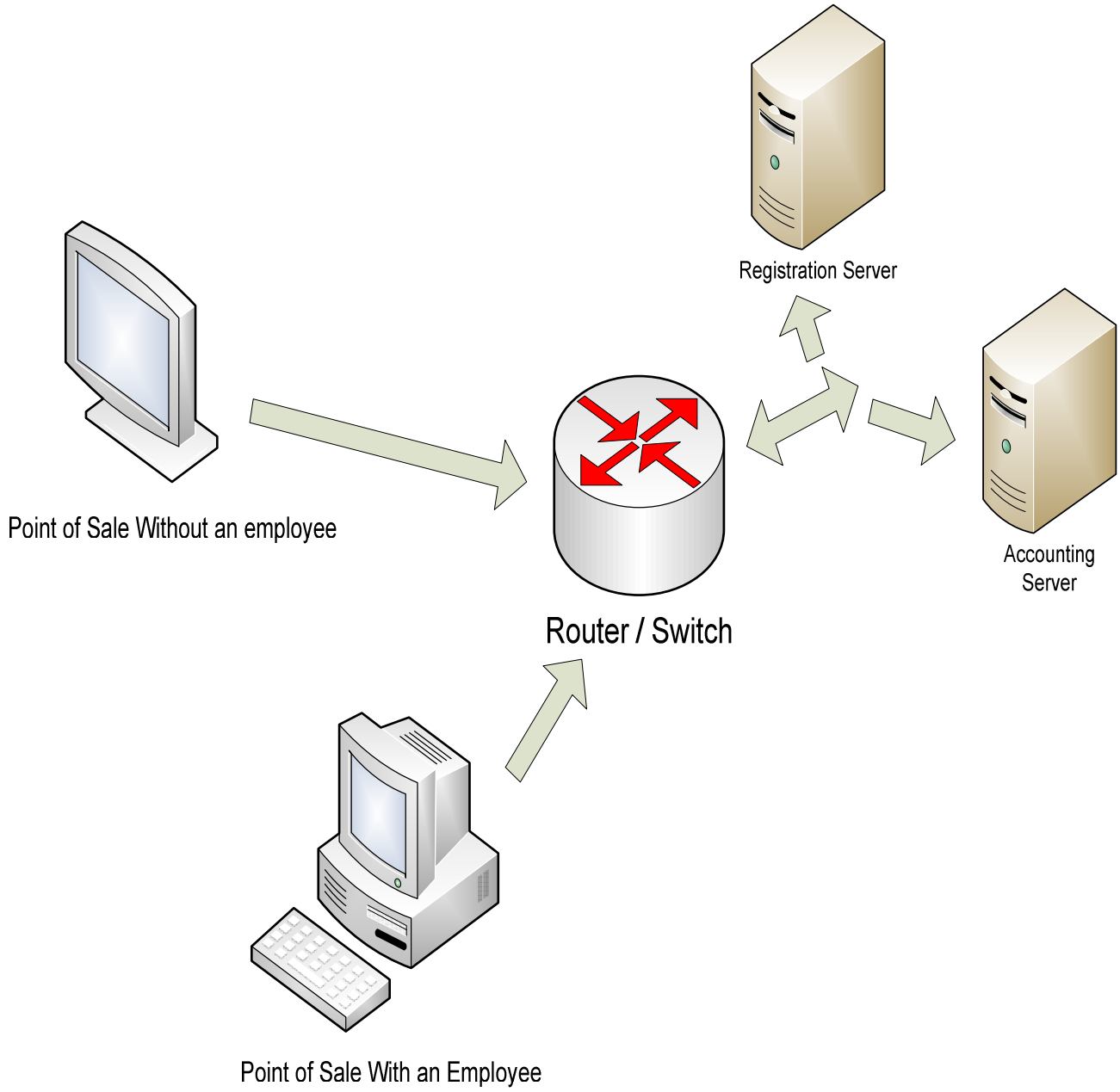


Figure 2.3 Point of Sale and Registration

2.6 Steps of Using Points of Sale

There are two steps as described below:

2.6.1 Point of Sale with an Employee

It is done like any old system, the user approaches to the point of sale and requests from the employee what he wants. The employee will press the request for the user and after the user will finish what they need, the employee will give him a print documentation paper for all the user processes.

2.6.2 Point of Sale without an Employee

When the customer approaches to the point of sale device and the contactless card is in range a welcome screen will appear requesting from the user a pin code. The user inserts his information and then the user can use the system.

2.7 System Communication

Typical communication procedure between the transponder and the reader can be highlighted as follows:

2.7.1 Handshake

1. The interrogator sends a command to start communication with transponder in the interrogator field and also to power it (passive transponders).
2. Once the tag has received sufficient energy and command from the reader, it replies with its ID for acknowledgment.
3. The reader now knows which tag is in the field and sends a command to the identified tag for instructions either for processing (read or write) or sleep.

2.7.2 Data Exchange

1. If the tag receives processing and reading commands, it transmits a specified block data and waits for the next command.
2. If the tag receives processing and writing commands along with block data, it writes the block data into the specified memory block, and transmits the written block data for verification.

2.7.3 Termination

1. After the processing, the interrogator sends an End command to send the tag into the Sleep (“silent”) mode.
2. If the device receives an End command after processing, it sends an acknowledgement (8-bit preamble) and stays in Sleep mode. During the Sleep mode, the device remains in non-modulating (detuned) condition as long as it remains in the power-up (Rao, et al., 2009).

2.8 RFID Transponder

A transponder is a small electronic device that will transmit information upon request from the reader. Transponders are the data carrier in the RFID system.

There are more than 100 suppliers of RFID tags, ranging from large semiconductor companies like TI, Motorola, and Philips down to one-man entrepreneurial businesses

Figure 2.4 RFID Transponder

2.8.1 Transponder Components

Basically, RFID transponders (tags) consist of an integrated circuit (IC) or a chip attached to an antenna as shown in Figure 2.4.

Information about the physical object of the tag is stored on the IC/chip, while antenna is responsible for receiving and transmitting data and recharging the transponder (passive tags). Typically, these components are printed or encased on a thin plastic sheet (Al-Mousawi, 2004).

2.8.2 Shapes and Sizes

RFID transponder comes in different construction formats, such as label-type, card-type, coin-type, stick-type and many other types depending upon the application and environment that will be used on. It can be as small as the head of a pin and as flat as a sheet of paper.

2.8.3 Power Supply

Powering the RFID transponders is important to any RFID system. There are two types of transponders which can be summarized as follows:

2.8.3.1 Active Transponders

These kinds of transponders have no need to be powered by the reader. Active transponders have an integrated battery which supplies all or part of the needed power. When the communication between the reader and the transponder starts, signals from the reader will put the transponder in “wake up” mode. After completing the transaction with the reader, the transponder will then return to the power saving “sleep” or “stand-by” mode.

2.8.3.2 Passive Transponders

Passive transponders do not have any integrated power source and therefore are totally dependent on reader's (magnetic/electrical) field to get the needed power supply. The transponder collects part of the energizing field via its antenna. Typically, passive transponders are smaller and lighter than active ones, and less expensive. They are maintenance free and will last almost indefinitely. In my thesis application program, I will use this kind of transponders (passive transponders).

2.8.3.3 Active Verses Passive Transponders

Table 2.1 shows the main differences between the active & passive RFID transponders.

Table 2.1 Active and Passive RFID Transponders

	Active	**Passive**
Power	Battery powered	Powered by electromagnetic signals
Reading distance	Long	Short
Size	Large device	Small device
Life time	Limited	Unlimited
Cost	Expensive	Inexpensive
Working environment	Sensitive to harsh Environment	Withstands harsh environment
Weight	Heavy	Light

2.8.4 Operation Type

RFID systems operate according to one of two basic procedures, Full Duplex (FDX), Half Duplex (HDX) systems or sequential systems (SEQ).

In full\half duplex systems, the transponder's response is broadcast when the reader's radio frequency field is switched on. The transponder's signal to the reader can be extremely weak compared to the signal from the reader itself. Because of that transmission procedures must be employed to differentiate the transponder's signal from the reader (Finkenzeller, 2004).

This means, in practice, that data exchange from transponder to reader using load modulation, but also sub harmonics technique may be used for the reader's transmission frequency.

Sequential systems employ a system whereby the field from the reader is switched off briefly at regular intervals. These gaps are recognized by the transponder and used for sending data to the reader. The disadvantage of using this procedure is the power loss to the transponder during the transmission break, which must be smoothed out by the provision of sufficient auxiliary capacitors or batteries.

2.8.5 Data Quantity

The normal range for the data capacity of RFID transponders vary from few bytes to several kilobytes. The only exception is so-called 1-bit transponders. 1-bit of data is enough to describe the situation for the reader: "transponder in the field" or "no transponder in the field". These kinds of transponders are very cheap because there is no need for electronic chip and for this reason enormous number are used in Electronic Article Surveillance (EAS) to protect goods in shops and businesses (Al-Mousawi, 2004).

2.8.6 Data Carrier's Memory Access

According to memory accessibility, there are two types of transponders:

2.8.6.1 Read-Only Transponders

These transponders are programmed only once by the manufacturer. The information in the memory (transponder ID) cannot be changed by any command once it has been written. This kind of transponders has small memory and is not expensive.

2.8.6.2 Read/Write Transponders

On the other hand, read/write transponders can be reprogrammed by reader's commands. These transponders have large memory and more expensive than the Read-Only transponders. Read/write transponders have three main procedures for storing and managing the data.

- **EEPROM** (Electrically Erasable Programmable Read-Only Memory):

This procedure is dominant in many RFID systems. However, this has the disadvantages of high power consumption during the writing operation and a limited number of write cycles.

- **FRAM** (Ferromagnetic Random Access Memory):

FRAM are more used in isolated cases. FRAM's read power consumption is lower than the EEPROM by a factor of 100 and the writing time is 1000 times lower. Manufacturing problems have hindered its widespread introduction onto the market.

- **SRAM** (Static Random Access Memory):

SRAM are used for data storage in microwave system which facilitate very fast write cycles. The disadvantage of this procedure is that the data requires an uninterruptible power supply from an auxiliary battery (active transponder).

2.9 RFID Reader

RFID reader has the responsibility to read, write and retransmit data to RFID transponders (tags) without direct contact and in some cases powering when the transponders are passive. Reading and writing operations to tags are based on master-slave principle. Reader's role could be master or slave, which depends on whom the reader are communicating with.

As showed in Figure 2.5, the application software (end-user) is controlling and activating the reader by sending write or read commands.

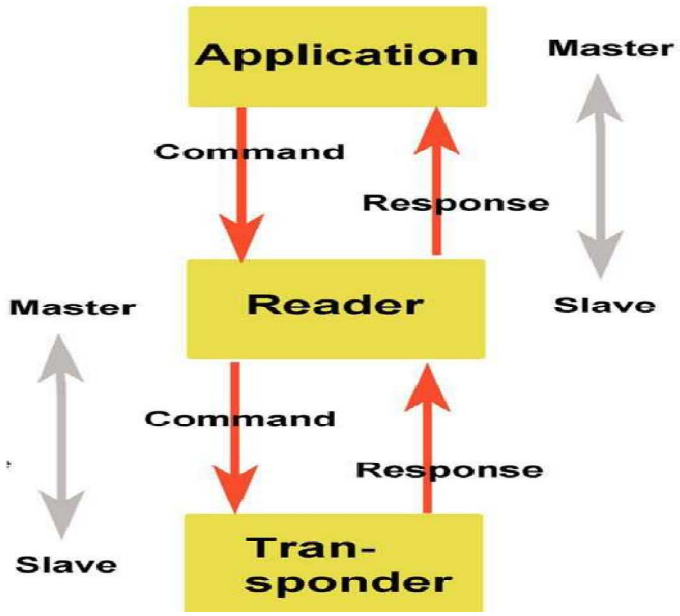


Figure 2.5 RFID Reader's Master-Slave Role

In this case the reader is slave for the application program. On the other side, the reader starts the communication, which is originally an order from the application software, with RFID transponder in the interrogation zone. The RFID reader here takes the master role.

2.9.1 Reader's Components

Generally, readers in all systems consist of two fundamental functional blocks as shown in figure 2.6:

2.9.1.1. HF Interface

The master part of the reader which has these functions:

- Supplying RFID transponders with power by generating high frequency power.
- Modulation of the signal to the transponder
- Reception and demodulation of signals from the transponders.

2.9.1.2 Control Unit

The slave part of the reader performs the following functionalities:

- Communication and executing the application software's commands.
- Signal coding and decoding.
- Communication control with a transponder.

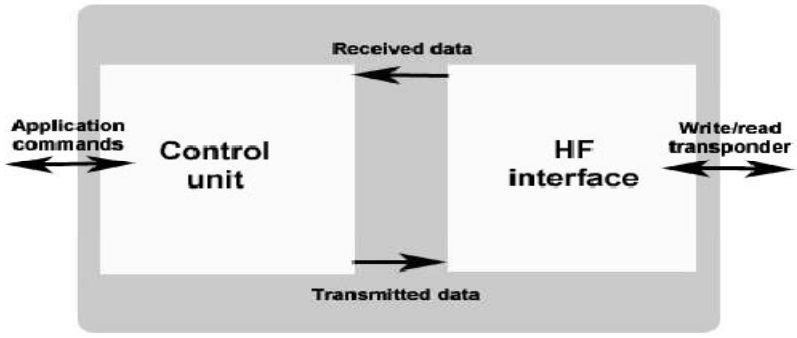


Figure 2.6: RFID Reader's Master-Slave Role

Other RFID system operates with addition functions like anti-collision algorithm, encryption and decryption of transferred data, and transponder-reader authentication.

2.9.2 Data Transfer to Transponder

There are many types as follows:

2.9.2.1 Amplitude Shift Keying (ASK)

In amplitude modulation, high envelope is a ‘1’ and a low is a ‘0’. Amplitude modulation can provide a high data rate but with low noise immunity.

2.9.2.2 Frequency Shift Keying (FSK)

This form of modulation uses two different frequencies for data transfer. FSK allows for a simple reader design, provides very strong noise immunity, but suffers from a lower data rate than some other forms of data modulation.

2.9.2.3. Phase Shift Keying (PSK)

This method of data modulation is similar to FSK except that only one frequency can be used, and the shift between 1’s and 0’s is accomplished by shifting the phase of the backscatter clock by 180 degrees. PSK provides fairly good noise immunity, a moderately simple reader design, and a faster data rate than FSK. Because of the simplicity of demodulation, the majority of RFID systems use ASK modulation (Pete 2002).

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2.9.3 Types of Readers

Different applications have different requirements from each other, which results to different designs of readers. Generally, readers are classified into the following three types:

OEM Readers

OEM (Original Equipment Manufacturers) readers are mostly used for data capture systems, access control systems, robots, etc.

Industrial Use Readers

Industrial readers are used in assembly and manufacturing plant.

Portable Readers

These readers are more mobile than the other readers which are supported with a LCD display and keypad. Animal identification, device control and asset management are some of uses for this kind of readers.

2.10 RFID Carrier Frequencies

RFID operates in several frequency bands. The RFID frequency for each country is controlled by The Radio Regularity.

Most of the RFID frequencies that are used now are frequencies that have been served specifically for industrial, scientific or medical application known as ISM frequency ranges. RFID frequencies can be divided into the following three basic ranges:

2.10.1 Low Frequency

The range of the low frequency RFID fluctuates a lot from a product to other because the RFID producers do not have a standard. The range will find a place between 30 and 500 kHz. 134.2 kHz is the most ordinary used frequency that has been used for the low frequency tags and readers.

Low frequency systems have short reading ranges and lower system costs. The vast majority of the low frequency systems operate without the need of integrated battery in their tags. They are most commonly used in security access, asset tracking and animal identification applications. They are not too sensitive to metal, water and electrical noise.

2.10.2 High Frequency

High frequency systems operate between 10 – 15 MHz, but a range of high frequency RFID tags and readers operating mostly at 13.56 MHz (ISM frequency).

High frequency systems have longer read ranges and higher reading speeds than the low frequency systems. The cost of this system is inexpensive, but higher than the low frequency system. These systems are used in access control and smart cards.

2.10.3 Ultra High Frequency

An ultra high frequency system operates between 400 MHz to 1000 MHz and 2.4 GHz to 2.5 GHz. This technology is very expensive compared to the systems above. This frequency range has a very long read range and a high reading speed. Unlike the other systems, line of sight is required for the communication between RFID readers and transponders. Ultra high frequency systems are used for such applications as railroad car tracking and automated toll collection(Al-Mousawi, 2004)

2.10.4 Frequency Comparison

Table 2.2 shows the RFID frequencies and their properties.

Table 2.2 Frequencies Used in RFID

Frequency	Common Name
125 KHz	Low frequency(LF)
13.56 MHz	High frequency (HF)
303 MHz	Ultra-high frequency (UHF)
433 MHz	Ultra-high frequency (UHF)
915 MHz	Ultra-high frequency (UHF)
868 MHz	Ultra-high frequency (UHF)
2.45 GHz	Microwave

Table 2.3 shows the differences between RFID frequency categories and their applications.

Table 2.3 RFID Frequency Categories and their Applications

Frequency Band	Reading Range	System Characteristic	Typical Use
Low 100- 500 kHz	3 cm – 2 meter	- Short read range - Inexpensive - High reading speed	-Access control - Animal id
High 10 – 15 MHz	5 cm – 5 meter	- Medium read range - Medium reading speed	- Access control - Smart cards
Ultra High 850 -950 MHz , 2.4 – 5.0 GHz	Average of 30 meter	- Long read range - High reading speed - Expensive - LoS Required	- Vehicle id. - Toll collection systems

Finally, it is important to ensure that RFID systems do not interfere with or jam radio and television, mobile radio services, marine and aeronautical radio services and mobile telephones.

2.11 RFID Standards

There are a number of ISO standards – and subsets of those standards – for contactless smart card technologies. The most prevalent are ISO15693 and ISO14443.

Each ISO standard has a unique advantage. ISO15693 provides the option of longer read ranges than ISO14443. While this is not important to some users, it can be very important to users that have become accustomed to the longer read ranges provided by traditional, mid-range 125 KHz proximity readers/cards. On the other hand, ISO14443 provides much higher data rates than ISO15693.

While this may not be important to customers using access control cards as traditional ID-only badges, it is very important when employing data intensive applications (such as biometrics).

These tradeoffs should be weighed carefully when selecting a smart card technology. Ideally, a contactless platform that supports both ISO standards would be preferred.

As well as, it is important to know the standardization of the Contactless Smart Card readers, such as the frequency used for reader devices.

2.11.1 The ISO 14443

ISO 14443 is a four-part international standard for contactless smart cards operating at 13.56 MHz in close proximity with a reader antenna. This ISO standard sets communication standards and transmission protocols between card and reader to create interoperability for contactless smart card products.

PICCs (Proximity Integrated Circuits Cards) are intended to operate within up to 10cm of the reader antenna at a frequency of 13.56 MHz. The 13.56 MHz frequency was

chosen for various technical reasons (e.g. suitability for efficient proximity compliance and low absorption by human tissues.

Two main communication protocols are supported under the ISO 14443 standard series Type A and Type B.

The ISO 14443 series define an “envelope protocol” that supports reliable, error-free data transmission with multiple cards, but do not define the contents of the data. ISO 14443 supports the exchange of standard ISO 7816 data packets, thus preserving the industry investment in contact smart cards by allowing almost transparent and painless application migration between contact to contactless environments.

As mentioned before, the ISO 14443 consists of the following parts:

Part 1: Physical characteristics

Part 2: Radio frequency power and signal interface

Part 3: Initialization and anti-collision

Part 4: Transmission protocols

The main key features of ISO 14443 can be summarized in the following points:

1- Operating frequency : Which is 13.56 MHz.

2- Read/write range : Up to 4 inches (10cm). Note: this figure is generally accepted but it is not stated in the standard.

3- Speed **:** The ISO standard specifies a default speed of 106 Kbps, which is mandatory for anti-collision stage. Higher communication, such as 212 Kbps and higher, are allowed as an option.

4- Security

A. Wired logic cards: authentication mechanisms are available.

B. Microprocessor cards: security mechanisms available in contact smart cards are also available for both ISO 14443 Type A and Type B.

C. Crypto coprocessors, such as 3DES, ECC and RSA, can be used, but they are not defined in the ISO standard.

D. The close proximity of the card to the reader helps limit unintended communication.

5- Interoperability **:** Supported through full definition of commands in ISO 14443 Part 4.

Currently, there are several enhancements to ISO 14443

1. Increased transaction speed: ISO 14443 standard already cater for optional higher data rates of maximum theoretical speed of 847KBps. Type A, as is, is not suitable for such higher data rates, so a mixed type A and B scenario has been proposed and is debated by the ISO committee.

2. Testing: With each published standard ISO must also publish a standard set of minimal test procedures that ensure the minimum accepted interoperability. For the ISO 14443 series, ISO is now developing ISO 10373 Part 6 that includes a set of test procedures.

2.11.1.1 The Purpose of ISO 14443 Part 1

ISO 14443-1 was published as an international standard on April 15, 2000. The standard defines the following:

- Card dimensions, referring to ISO 7810 standards for contact card size.
- Surface quality for printing.
- Mechanical resistance.
- UV and X-ray resistance.
- Sensitivity to surrounding magnetic fields.
- PICC: Proximity integrated circuit(s) card.
- PCD: Proximity coupling device (the card reader or terminal).

Part 1 defines the size and physical characteristics of the card. It also lists several environmental stresses that the card must be capable of withstanding without permanent damage to the functionality:

- Ultra-violet light.
- X-rays
- Dynamic bending and torsion stress
- Alternating magnetic and electric fields
- Static electricity and magnetic fields

The operating temperature range of the card is specified in Part 1 as an ambient temperature range of 0°C to 50°C.

2.11.1.2 The Purpose of ISO 14443 Part 2

ISO 14443-2 was published on July 1, 2001. This standard describes the characteristics of power transfer (based on inductive coupling) and communication

between the PICC and PCD. Power is transferred to the card using a frequency modulated field at 13.56 MHz +/- 7 kHz.

Two different types of communication signal interfaces (bit modulation and coding) are specified: Type A and Type B. The bit protocol timings are defined and the default data transmission rate is defined at 106 K baud. Here are Some abbreviations used in this standard are:

- ASK Amplitude Shift Keying.
- BPSK Binary Phase Shift Keying.
- NRZ Non-Return to Zero.

Part 2 defines the RF power and signal interface. Two signaling schemes, Type A and Type B are defined in part 2. Both communication schemes are half duplex with a default 106 kbps data rate in each direction. Data transmitted from the card to the reader is achieved by utilizing load modulated with an 847.5 kHz sub carrier. The card is powered by the RF field and no battery is required.

Differences between Type A and Type B include the modulation of the magnetic field used for coupling, the bit and byte coding format and the anti-collision method (i.e., how the cards and readers respond when more than one card responds at the same time to a reader's request for data). Type A has an ASK of 100% Reader to Card modulation index, meaning that data is coded with short pauses in the transmission. During these pauses no power is transmitted to the card. This dictates special requirements to the chip in the card. Type A uses Modified Miller bit coding. Type B, however, has an ASK of 10% Reader to Card modulation index, meaning that data is coded with only minor reduction of its normal amplitude, enabling both card and reader to maintain power throughout the communication process. This provides major advantages compared with Type A. Type B uses NRZ bit coding.

2.11.1.3 The Purpose of ISO 14443 Part 3

ISO 14443-3 was published as an international standard on February 1, 2001. This part of ISO 14443 describes:

- Polling for PICCs entering the field of a PCD (i.e., the terminal talks first).
- Byte format, command frames and timing.
- Request (REQ) and Answer To Request (ATQ) commands.
- Anti-collision methods to detect and communicate with one particular card when several cards are presented to the same reader.

Anti-collision methods rely on a unique ID per card:

1. Type A: Binary search method referring to the unique identifier (UID) of the card.
2. Type B: Slotted Aloha method with special slot markers.

The initialization and anti-collision protocols for Type A and Type B. The anti-collision commands, responses, data frame, and timing are defined in Part 3.

The initialization and anti-collision scheme is designed to permit the construction of readers capable of communication with several cards of the same type, powered simultaneously. Both card types wait silently in the field for a polling command. A multi-protocol reader would poll one type, complete any transactions with cards responding and then poll for the other type and transact with them. It is not assumed that both types can be powered at the same time.

2.11.1.4 The Purpose of ISO 14443 Part 4

ISO 14443-4 was published as an international standard on February 1, 2001. This standard specifies a half-duplex block transmission protocol (T = CL).This standard, showing how this common transmission protocol can be used. The standard also defines the transparent exchange of data, independent of the lower layers.

Part 4 defines the high-level data transmission protocols for Type A and Type B. The protocols described in Part 4 are optional elements of the standard.

Part 4 deals mostly with the band rate negotiation between the card and the reader, data encapsulation n block format, chaining (breaking a long block into smaller ones) and error handling and recovery scenarios.

2.11.2 The MIFARE Standard

The MIFARE name covers two different kind of contactless cards:

1. MIFARE Classic and MIFARE Ultra Light Cards Standard.

2. MIFARE ProX, and SmartMX Cards Standard

2.11.2.1 MIFARE Classic and MIFARE Ultra Light Cards Standard

MIFARE Classic or Standards employ a proprietary high-level protocol instead of ISO 14443-4, with a Philips proprietary security protocol for authentication and ciphering. MIFARE UltraLight Cards employ the same protocol, but without the security part.

The MIFARE Classic and MIFARE Ultra Light Cards are fundamentally just memory storage devices, they are ASIC based and therefore have limited computational power. Thanks to their low cost and reliability, those cards are widely used for electronic wallet, access control, corporate ID cards, transportation or stadium ticketing.

The MIFARE Standard 1k offers about 768 bytes of data storage, split into 16 *sectors*; each sector is protected by two different keys, called A and B. They can be

programmed for operations like reading, writing, increasing value blocks, etc. MIFARE Standard 4k offers 3 kb split into 64 sectors.

The MIFARE Ultra Light has only 512 bits of memory (i.e. 64 bytes), without security. This card is so inexpensive, it is often used for disposable tickets.

2.11.2.2 MIFARE ProX, and SmartMX Cards Standard

MIFARE ProX and SmartMX, are NXP Semiconductors brand names for smart cards that comply to ISO 14443-4. They are microprocessor based cards. The hardware does nothing on its own, it has to be programmed with dedicated software in the operating system. Most of the time, the microprocessor is coupled to a co-processor dedicated to fast cryptographic computations (e.g., Triple DES, AES, RSA, etc.). These Cards are capable to execute complex operations as secure and fast as known from contact based cards, which includes Java based operating systems such as JCOP.

Depending on the installed software, the card can be used for almost any kind of application. This kind of card is mostly used where a high level of security is required (e.g., secure travel documents, electronic passports, payment card, etc.)

The MIFARE DESFire is a special release of Philips SmartMX platform. It is already sold and programmed with a general purpose software (the DESFire operating system) that offers more or less the same functions as MIFARE Standard (4kB data storage split into 16 areas) but with higher flexibility, stronger triple-DES security, and faster communication.

The typical read/write distance between card and reader is 10 cm (4 inches), but actual distance depends on the field power generated by the reader and its antenna size.

2.12 Previous Systems

In this section, we will review a previous systems related to the problem of this thesis. Here we identify and evalute current and past approches. Reviewing the successes and/or limitations of the related work is important to avoid past mistakes, taking advantages of previous successes, and most importantly, improving the solution when applied. It also motivates interest in the work by demonstrating its relevance and importance. Therefore, discussing the related work is a best way to compare our system with other systems.

There is a lot of related work that discussed how contactless smart cards are working, showing its security level and its method of payment. Also there are special kinds of payment systems which are sold (ready to use), these kinds are designed for a special purpose, e.g. the bus card used in Amman Transit Authorities fare cards, where you can find a card reader machine inside the bus for one function only which is deducting a certain amount in each process.

In the last decade, smart cards evolved from basic memory cards to complex systems on chips with expanding processing power. This has opened the path to many applications such as financial transactions, e-commerce, physical access control, health, and transportation services (Dhem, 2001).

Education industry is one of the growing industries that have adopted smart cards system where many universities are successfully facilitate the usage of it. Among the most reputable universities that use smart card are: University of Cambridge, University of Nottingham, University of Chicago and University of Exeter. In the following, we will give a brief description for each of them, showing the strength and weakness points:

The University of Cambridge Card

The University Card looks like a credit card containing the cardholder's name and photo, college scarf (students, fellows and college members only), date of birth (undergraduates only) plus a barcode that is primarily used for University Library borrowing. Since June 2003, the Card Office has issued two types of University cards. They look identical but one contains a TDSi strip and the other contains both the TDSi strip and smart chip. These technologies can be used for a number of purposes including access to buildings, use of catering services, PC and web access or use of photocopying facilities. The TDSi card was successfully phased out in July 2009 and is no longer active in the University buildings access system. The card in circulation is the contactless chip card, where the chip is not visible. Figure 2.7 shows the University of Cambridge card.

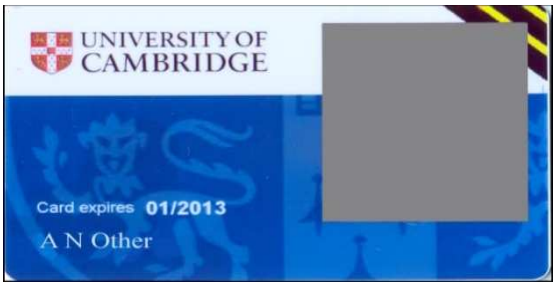

Figure 2.7 University of Cambridge Card (Cambridge University, 2003)

Replacements

If your card is stolen, lost or damaged, always contact your card representative to arrange for a replacement, and to see if there is a temporary card to use. A replacement for a stolen or lost card will be issued 2 days after being reported, this is to allow time for the cards if found or recovered to reach the card office (Cambridge University, 2003).

The University of Nottingham Card

The University Card or 'Uni Card' is a multi-function state of the art card that can be issued to all students and staff. This card is specific to the University of Nottingham and contains a combination of Mifare proximity chip, magstripe and barcode technologies. The student and staff cards vary in layout slightly, but both contain key information that is utilized by a number of systems around the University, such as: cardholders name, photograph, group type (i.e. student or staff), library category, library card number and student number / start date (for students) or issue date (for staff). Figure 2.8 shows the University of Nottingham card (Nottingham University, 2006).

Figure 2.8 University of Nottingham Card (Nottingham University, 2006)

The University of Chicago Card

The new Chicago Card coming shortly to the University offers new features and functionality. The card's redesign and its new features are part of an effort by IT Services and the University to streamline University systems while making access to the campus' various resources faster and easier for all members of the University community.

The main new feature is that the new card contains a RFID (easier access). In the near future, the primary use of this new capability is going to improve access controls to University buildings. This RFID feature is currently used by the Dean of Students in the University office to allow students with disabilities to open doors and use elevators. The technology does not require the cardholder to swipe the card through a reader. Instead, the cardholder holds the card within some proximity of a reader. The distance is ordinarily measured in inches.

Once new readers are installed, the new card will allow faster movement through entry gates because the proximity readers have a higher "first read" reliability. The current Chicago identification card uses a magnetic stripe to hold and transmit data. This requires swipe readers. The readers sometimes require multiple swipes to get a good read. If the magnetic stripe reader is for an outside door, the elements, cold, dust, humidity or rain, can prevent the swipe reader from reading the card. The new card allows for readers with enclosed electronics. (Chicago University, 2008) Figure 2.9 shows the University of Chicago card.

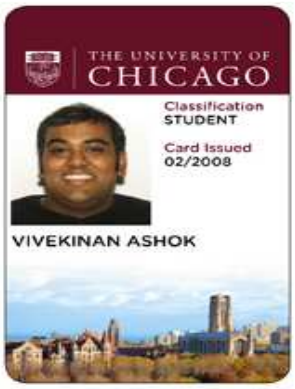

Figure 2.9 University of Chicago Card (Chicago University, 2008)

The University of Exeter Card

The UniCard is issued to all staff and students. The UniCard serves as your Library card, identifies you as a member of the University and allows you appropriate access to its services and facilities. Entitlement to University facilities varies according to your University status. UniCards bear the user's name and photo, expiry date and a barcode with a number underneath it. The barcode/number is encoded on the reverse of the card and this magnetic strip is used for building access control. The Unicard also carries the University of Exeter logo. Lost, stolen or damaged cards: If your UniCard is lost or stolen, please notify the card office immediately (Exeter University, 2008).

Chapter 3
Analysis of the Developed System

3.1 Overview

System analysis is the process of examining a business situation for the purpose of developing a system solution to a problem or devising improvements to such a situation. In order to develop any system, the first essential step is to make a comprehensive and detailed analysis of the current system to develop a quality and new information system.

Therefore, this chapter provides general descriptions of the procedures, processes and activities of the current system which is currently used in the Middle East University (MEU) as a case study in all departments. Besides, depicts and analyzes a general description of the developed RFID system in this thesis.

3.2 Analysis of Current System in the MEU

This section will describe, in detail, the processes and procedures that are currently used in MEU. MEU has many departments, each department consists of one or more branches, these branches require information about each and every students belongs to it.

When a new student wants to register in the university, at the beginning he/she goes to the Financial Department and pay the required fees for registration (determined from the financial department) and take the student number which is unique and use it as a primary key in the current university database.

The Financial Department currently uses the traditional cash payment, and when a new student wants to register for the new course, the procedure is going to be as follows:

When the student wants to register for a new course, his first step must be visiting the Admission and Registration Administrative (ARD), and take the registration form No. 2, then write the desired subject, after that he/she must pay the fees in the Financial Department (Cash Money) and stamp the registration form No. 2. The next step must be visiting head of the department to sign the registration form and return back again to the Admission and Registration Administrative (ARD) to complete the registration process.

After finishing the registration, the student will take a letter from the Financial Department as a proof for fulfilling his payment and a letter from the Admission and Registration Administrative (ARD) contains the subjects that he/she registers for in the coming course.

Figure 3.1 shows that the current cash payment system for the registration of a new student or an old student requires joining and registering for a new course.

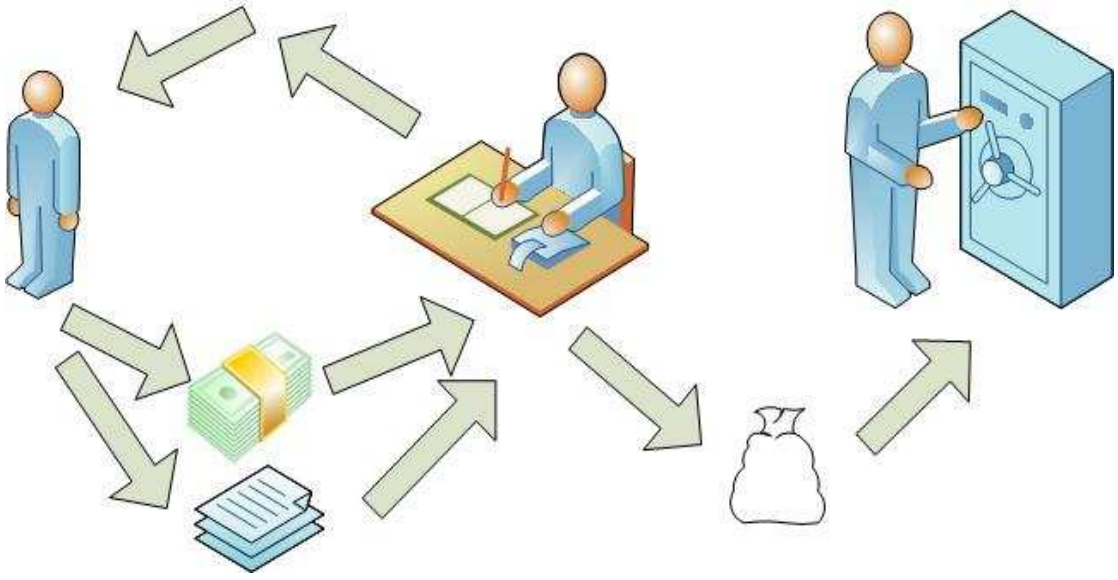

Figure 3.1 Traditional Cash Payment

Currently, all payments activities in the university is done manually such as:

1- Making a student ID card.

2- Buy a badge for the car to enter the university garage.

3- Rent out books from the library.

4- Dealing with the university cafeteria and supermarket.

All the above mentioned activities and other additional long procedure can be solved by taking one step which is using the developed system only.

3.3 The System Development Life Cycle

There are many ways for developing an information system such a prototyping and Systems Development Life Cycle (SDLC); both users and managers should know what they want from the system. This means, the software requirements should be clearly understood. We must develop our system using the SDLC, which consists of the following phases/steps:

- Identification and Selection
- Initiation and Planning
- Analysis
- Design
- Implementation
- Maintenance.

3.3.1 Identification and Selection

3.3.1.1 Studying Existing System

After analyzing and studying the current system at the university and gathering information from the specialists, we found many problems and weakness points in the current used system processes. Therefore, we are obliged to overcome these problems in the new developed system.

3.3.1.2 Studying the New System

The new developed RFID system is meant to overcome the problems arising by the current running system, and working through developing a RFID system, which increases the efficiency, security, reliability, etc…, and making sure of its usefulness for all members in the university (student, employees, professors, etc..).

3.3.2 Initiation and Information System Planning

Mission Statement

Facilitating the everyday commonplace routine, where the student, the member of the staff, and the management can perform every and any process in the university simply, quickly, securely, and most of all efficiently.

Functions: Update system or make a new system.
Student register for a new course, print the schedule for the course, add credit to the contactless card, etc….
Training and maintenance.

Data Entities: Students, faculty staff, employees, managers, server computers, LAN, monitors.

Information Systems: Search system, lending system, calculation processing, retrieve system.

3.3.3 Analysis

3.3.3.1 Feasibility Study

Tangible benefits worksheet: Networked RFID information system intends to help us increasing system transparency, error reduction, increase speed of operation and activities, new technology like search remotely, and many other benefits.

Intangible benefits worksheet: Networked RFID information system is helpful in increasing employee morale, more rapidity information, improves statistical information and charts that assist in decision-making, improve system security, and ability to recover system.

One–time cost worksheet: At start of year 0 we are going to need a new hardware, employees training, application software.

Recurring cost worksheet: In year 1 to 2 we are going to need application software maintenance and new hardware.

3.3.3.2 Developed System Requirements

User's requirements (person who uses the system): the user wants to do all the processes in the university in an easy, secured, and speedy way. In addition, enabling the user to get the best use of the system by building the system posses user friendly interface.

The system should have a kind of validating through helping the user to discover and correct most of the errors that will happen when they use the system. Finally, the system should make all the necessary calculation for the user, with an easy and clear interface.

Manager requirements: system must have a good security for all peoples that use the system, this done by enabling each group to access data that is needed for them and hiding the data and interfaces for others.

Hardware and software resource requirements: the system requires a fast processor computer, to get high performance, LAN network and server. The current software requirements are VB.net, SQL server, and WIN XP operating system.

In this thesis, we intend to create a complete RFID system at MEU. Everyone at the university who has a RFID card (contactless card) a student, as a case study, who have a card. The card contains many details as show in Figure 3.2.

The contactless card must be charged by amount of money from the Financial Department before using it. This amount of money is not fixed, it is different from one student to another. It must hold a minimum of 1200 JD for the new student (including the first semester courses registration fee) and the remainder of the money can be used in different activities at the university, for example to pay for the car badge, for the cafeteria, and for the registration in every new course.

Figure 3.2 Contactless Student ID Card

This contactless card can always recharged by adding new amount of money from the Financial Department. The following sections show how the RFID system is easy to use by the students. The RFID card contains student number which is unique for each and every student in addition to the amount of money. When a student wants to use the card, he/she can use it in two different methods of POS, these are:

1- Using POS RFID System with an Employee

The first method is, when the student go to the POS and put the contactless card near the RFID reader, then the system will open the details of the card and the employee can see all details and the student photo stored in the card (each student have a photo in the database for more security reasons). If the student photo does not match the card holder, the employee asks the student to enter the password, if the password does not match in three trails, the employee will end the registration and blocks the card. If the photo is the same or the password matches then the employee will continue the procedure for the student.

Finally, the student orders will respond and a list can be printed-out showing the details of the order and how many discounted from the card and the remaining amount. Figure 3.3 shows the developed RFID system which depicts the above process.

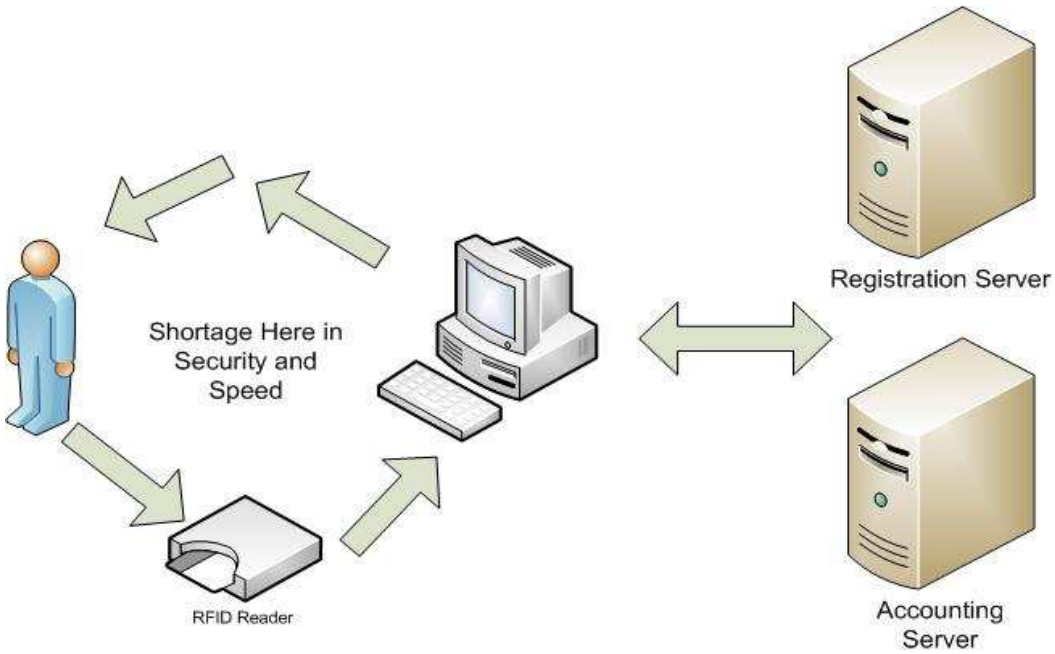

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Figure 3.3 Developed RFID System with an Employee

2 - Using POS RFID System without an Employee

The second method, is when the student himself uses the POS, the student puts the card near the card reader, the computer will open a welcome screen and ask to put his/her finger in the finger print device. The finger print device is added to the system for every card user to enhance security. Then the system will check the finger print of the student in the database, if it does not match, it will cancel everything and end the process. If it matches, the system will move to another screen which helps in completing the required activity. Figure 3.4 shows the developed RFID system for the second method.

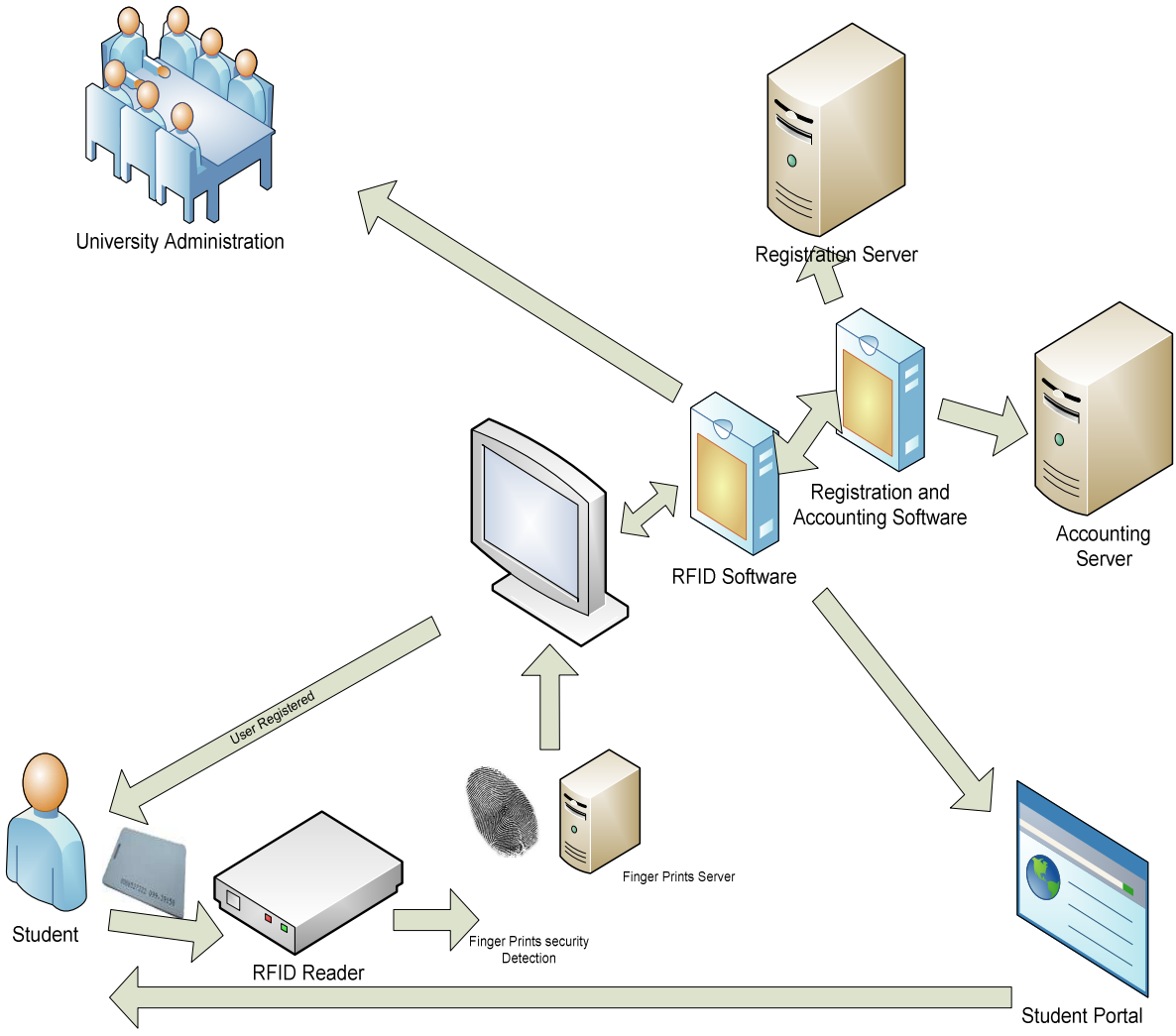


Figure 3.4 Developed RFID System without an Employee

Figure 3.4 shows a step-by-step usage of the developed RFID system. When the student put the card nearest the card reader and puts its finger on the finger print device, then the student can chose what they want from the system using the RFID software. The RFID software will save all the activities of the registration in the server of the registration department, or in the accounting server for the Financial Department. The University administration has full authority to enter the database and see all these procedures in event viewer.

For example, if the students require registration for a new course, the system will complete the registration for the subjects, by guiding the student using a special user friendly software and easy to use (wizard). The student can print out a bill before completing and confirming the procedure (by click the confirm bottom) the system will discount the money from the card and send the transaction to the financial department server. Besides, it gives the student a printable report that contain the whole activities that the student made for this process, like the amount of the money paid, the remaining money in the card, the subjects that have registered for this course, the schedule, and all other details.

3.3.3.4 The Users of the Developed RFID System

The developed system is very useful, and may be used by different members in the MEU, these may be included in Figure 3.5.

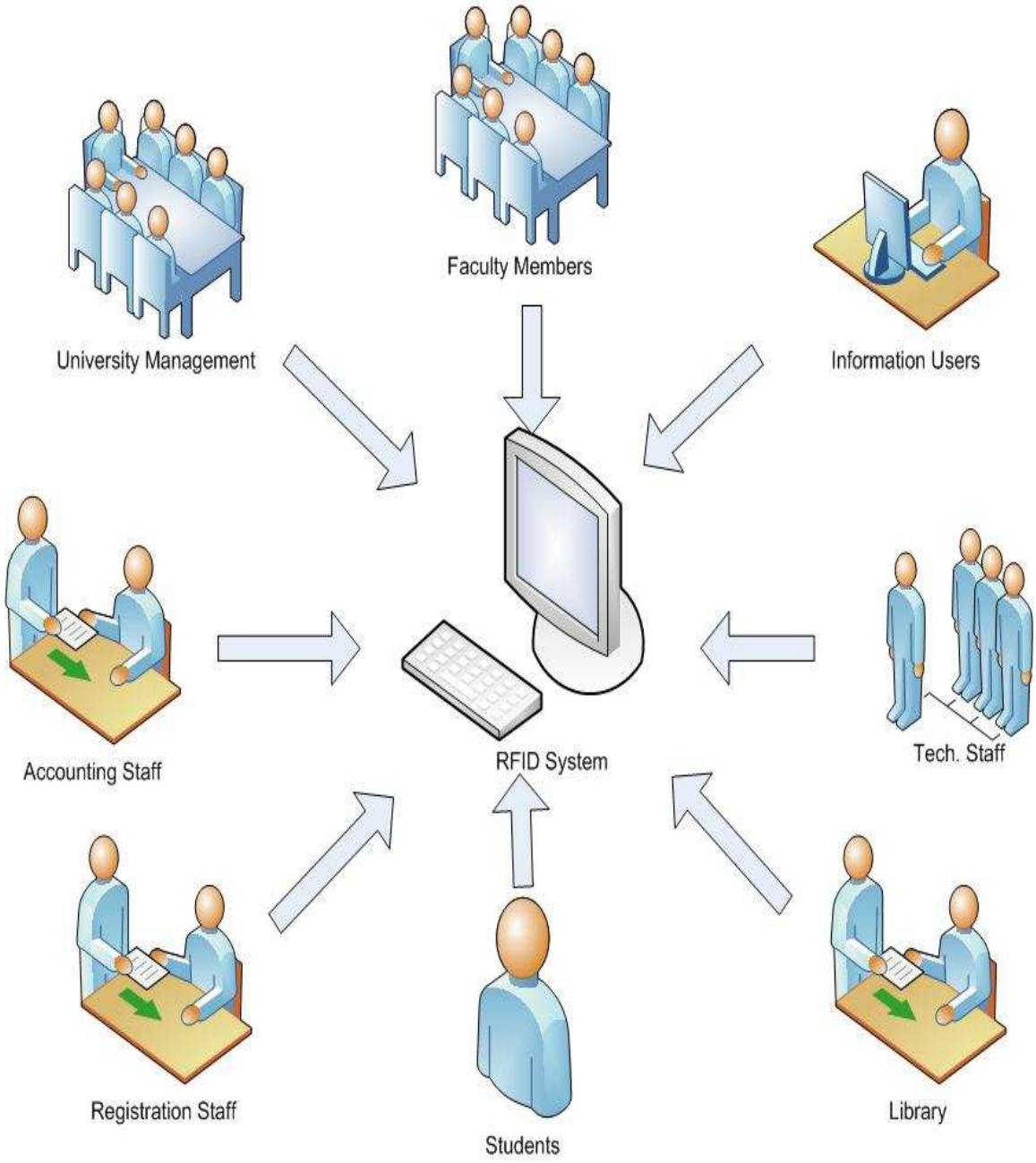


Figure 3.5 Users of the Developed System

In the following, we can explain the parts of the above figure:

The University management will use the system to know all details about the users and to know the benefits from this system. They can generate full reports for all process in the University and these reports will help the managers to take their plans, to

organize the university to meet these plans, direct them to execute the plan, and control the resources.

The accounting staff will use this system to help them in the accounting department; they can get full details about all the accounting activities at the University.

The registration staff uses this system to do all the registration process and to have full details about the registration forms for all students.

The student is the most users who benefits from using the system.

The library department will use the system to manage all activities in the library; they can get full details about all books that are borrowed.

The technical staff will support the system every time and will be ready at any time if any problem happens.

The information users will always check their accounts and their activates in the university.

The faculty members will also use this system and help them in their work when they want to use the library, to use the cafeteria, or to enter the university

The users can access to the system via Internet anywhere, as shown in Figure 3.6.

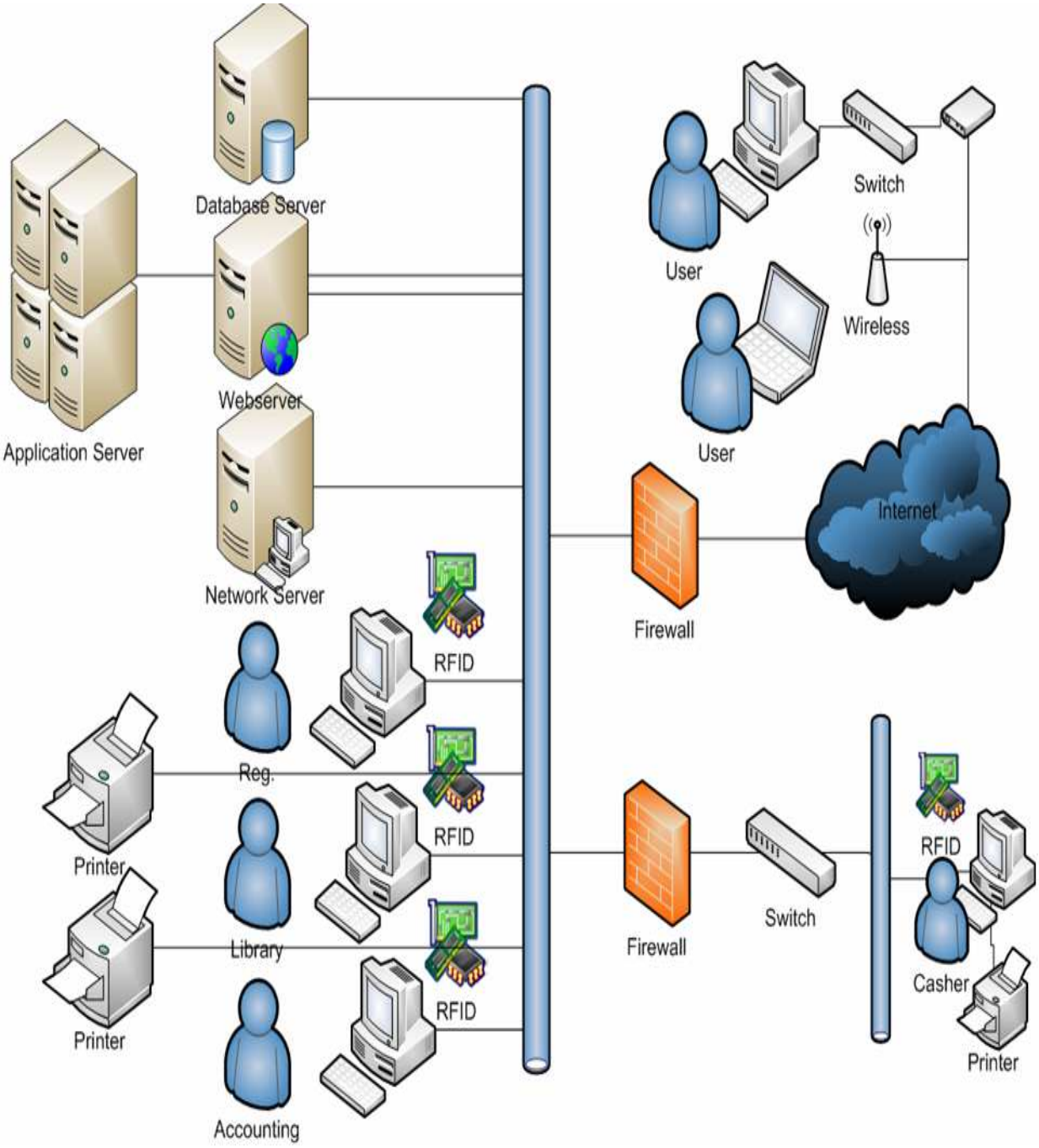


Figure 3.6 Developed RFID System Linked to the Internet

As shown in the Figure 3.6, the whole developed RFID system can be linked to the Internet. In this case, a proposed network design may read through many servers (Database server, Application server, Web server, Network server) and firewalls for optimum performance and security reasons.

Chapter 4
Design and Implementation of the Developed System

4.1 Overview

This chapter explains, in detail, the design and implementation processes of the developed system. This will be done through design and implementation of the pilot system (which applied only in the Middle East University cafeteria) where we take the pilot system as a case study in order to demonstrate the effectiveness of applying this system. Furthermore, we can apply the same technology and components to provide solutions for different applications in the other remaining University Departments such as (Library, Registration Department, Financial Department …etc), as well as it can be used, in general, at many other different public departments.

4.2 Developed System Design

System design is the process of defining the components, modules, interference, architecture, and data for a system to satisfy specified requirements. In the following subsection we will demonstrate the system design through different perspectives.

4.2.1 Flowchart of the Developed System

To understand how the system works precisely, we need to go through the following diagram and track it from the start point that leads to the success or failure of the process using the developed system. Figure 4.1 shows the flowchart of the developed system.

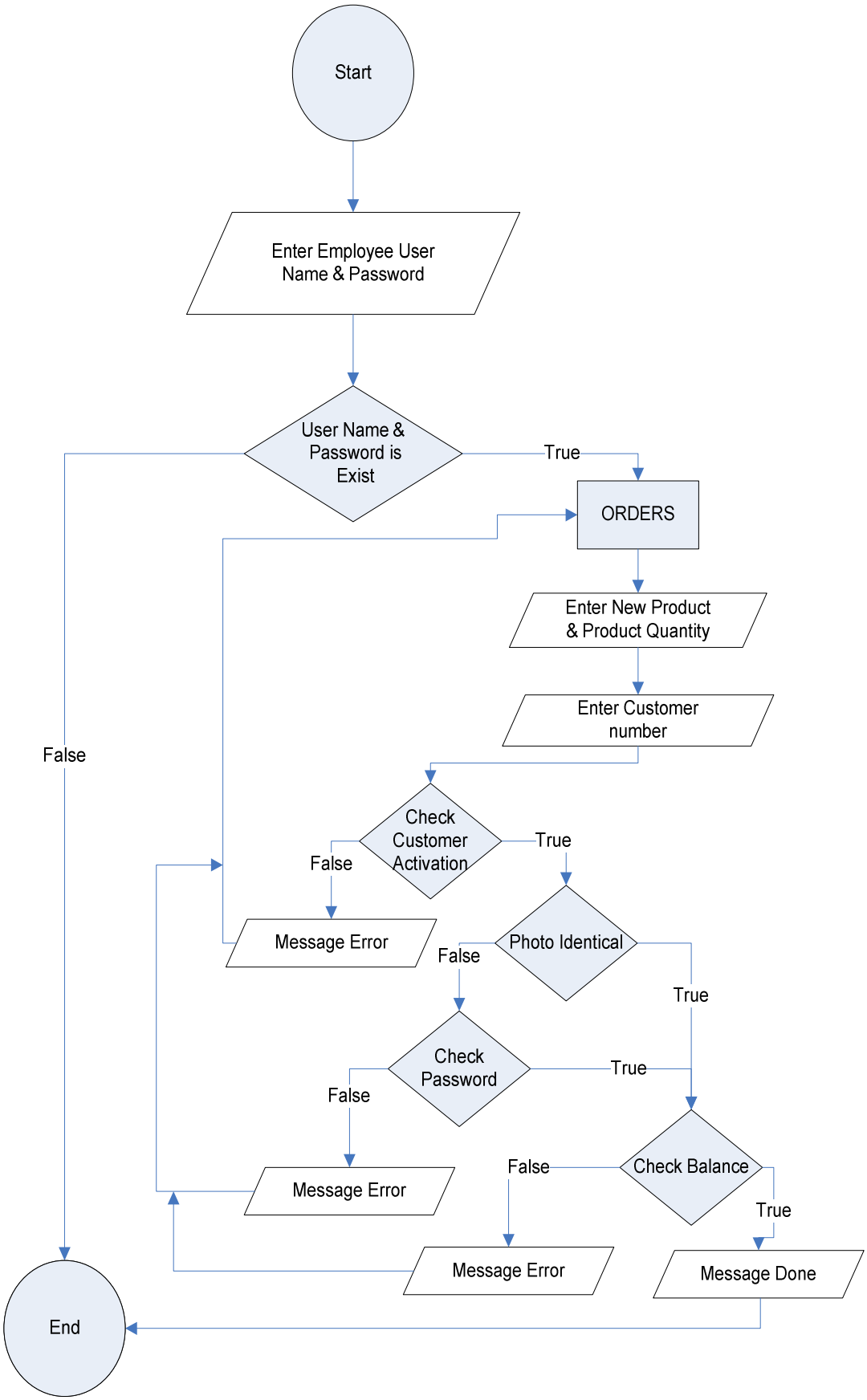


Figure 4.1 Flowchart of the Developed System

4.2.2 Data Flow Diagram of the Developed RFID System

A Data-flow diagram (DFD) is a graphical representation of the "flow" of data through an information system (Wikipedia, 2010). DFDs can also be used for the visualization of data processing (structured design). Figure 4.2 shows the DFD of the developed RFID system.

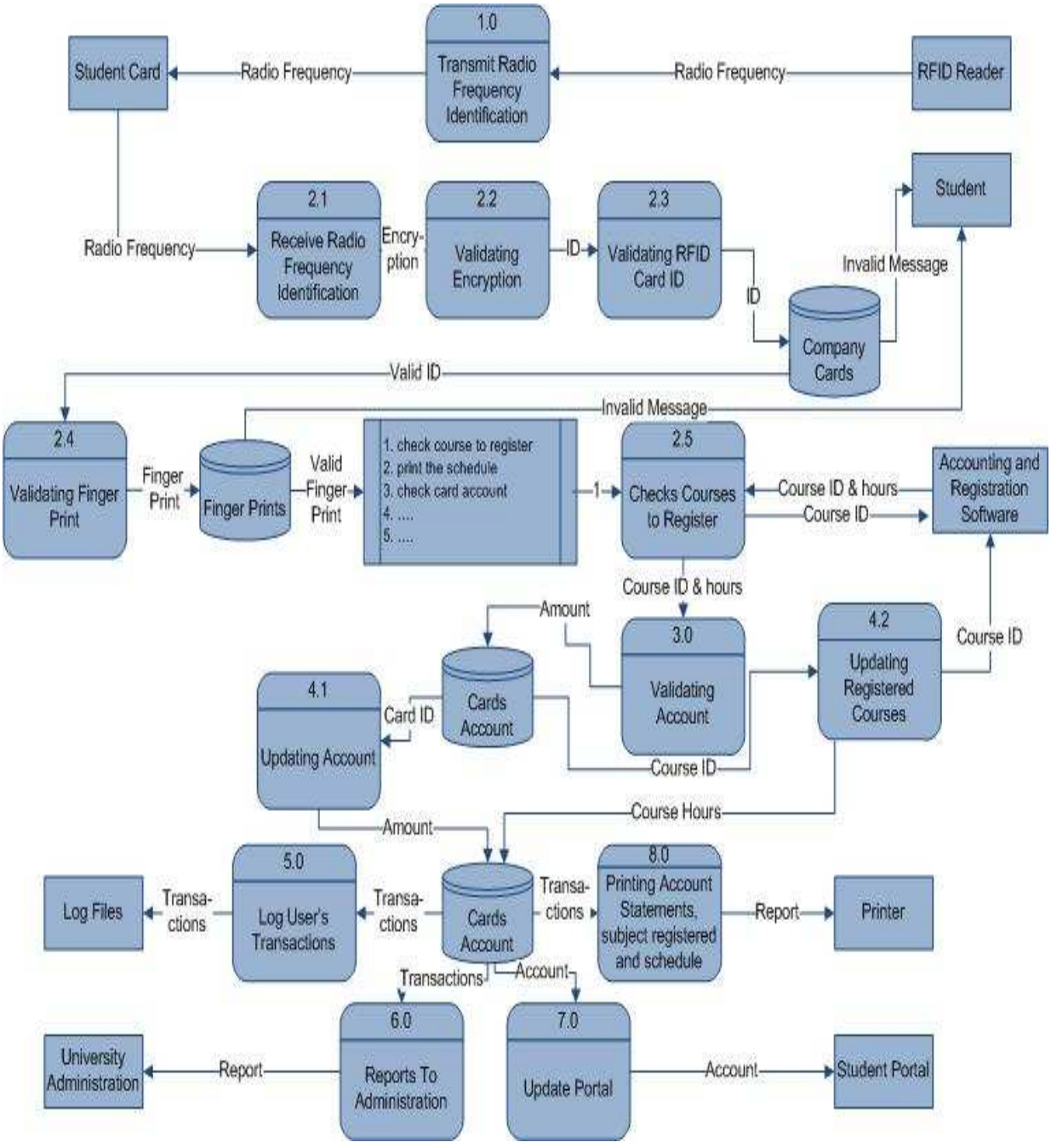


Figure 4.2 Data Flow Diagram for the Developed RFID System

Follows a description is given for the definition of each process:

Process No. 1.0: When the student wants to use the system, then the card must be closely facing the card reader, then the card reader will transmit a radio frequency for identification.

Process No. 2.1: This will be the power for the contactless card and it will be received from the contactless card and send the signal to the reader.

Process No. 2.2: The reader will validate the encryption used with the card reader software.

Process No. 2.3: the card reader then will take the ID card number from the contactless card and check it with the company cards database that was made for the program.

Process No. 2.3: If the card ID is not matched with the company cards database then the system will end the procedure and send error message, but if it matches then the system will check the finger print authentication.

Process No. 2.4: by using the finger print device (the student put his finger in finger print device scanner), if the authentication does not match then the system will end the procedure and send error message but if it matches then the system will open a new window contain multiple option to chose from, the student will chose what process they want. And for example here the student chose no. 1 which is check course to register

Process No. 2.5: the student then will chose what the subjects that they want from the accounting and registration software, and the software will send the course ID & hours to the student and when the student agrees for these hours and subjects.

Process No. 3.0: the system will check the account for the student and is it valid from the cards account

Process No. 4.1: updating the account after the system will take the total price for the procedure from the student account.

Process No. 4.2: updating the registered courses

Process No. 5.0: save the transaction in the log files

Process No. 6.0: send reports to University administration.

Process No. 7.0: updating the student portal.

Process No. 8.0: printing account statement, subject registered, and schedule reports.

4.2.3 Fingerprint Identification Flow Chart

Figure 4.3 shows the finger print identifications flow chart

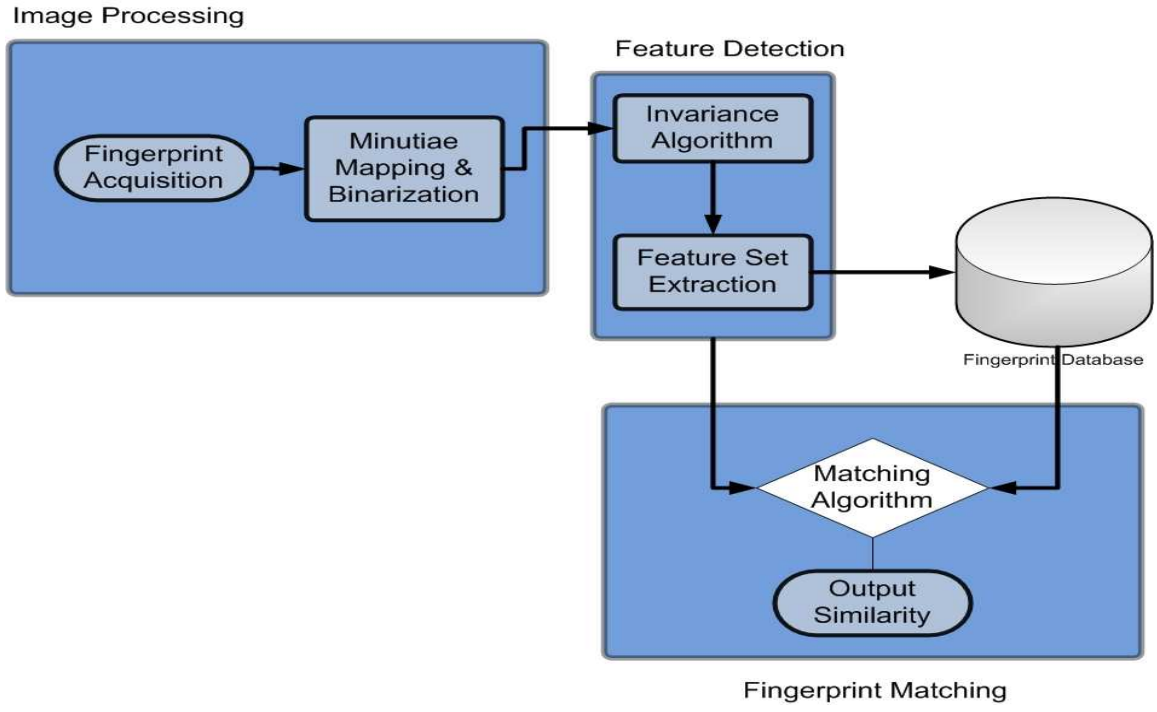


Figure 4.3 Finger Print Identifications Flow Chart

4.3 Developed System Implementation

This section will describe the implementation of the developed system through explaining the tools required to build its components.

This developed system is implemented by using Visual Basic.Net programming language and SQL Server for its consistent, which provides the developer with power of many good features like user friendly interface and easy deployment and integrated with other applications.

❖ **Developed System Database**

The developed system uses seven different tables which described as follows:

- Cards (Id, CardNo, RealCardNo)
- Customers(Id,CustNo, Name, Attachement, Active, Balance, StudentNo, Mobile)
- Employee(Id, Name, Username, Password, Group_Num, Address, Attachment)
- GeneraldailyOrder (Id,GNumber, InvoiceNo, TotalPrice, CustNo)
- HistoryProduct(Id, Gnumber, ProdNo, CustNo, Qty, Mdate)
- Orders(Id, OrderNo, ProdNo, Gnumber, Qty)
- Product(Id, ProdNo, ProdName, ActualPrice, Price, Qty, SoldQty)

Figure 4.4 illustrates the developed system class diagram and its properties and operations.

❖ Relationship Between Developed System Tables

In this paragraph, we will describe the relationship between different tables, the relationship between Cards and Customers Tables is one to one, for each CardNo there are one Customer, CardNo is primary key in Cards table and foreign key in Customers table.

The Relationship between Customers and GeneralDailyOrders table 1 to many and also the relation between Customers and HistoryProduct is the same,CustNo is primary key in Customers table and foreign key in GeneralDailyOrders and HistoryProduct, the relationship between Product and HistoryProduct is 1 to many and also the relation between Products and orders is the same, ProdNo is primary key in Products and foreign key in HistoryProducts and orders. The relationship between GeneralDailyOrders and Orders is 1 to many, GNumber is primary key in GeneralDailyOrders and foreign key in Orders

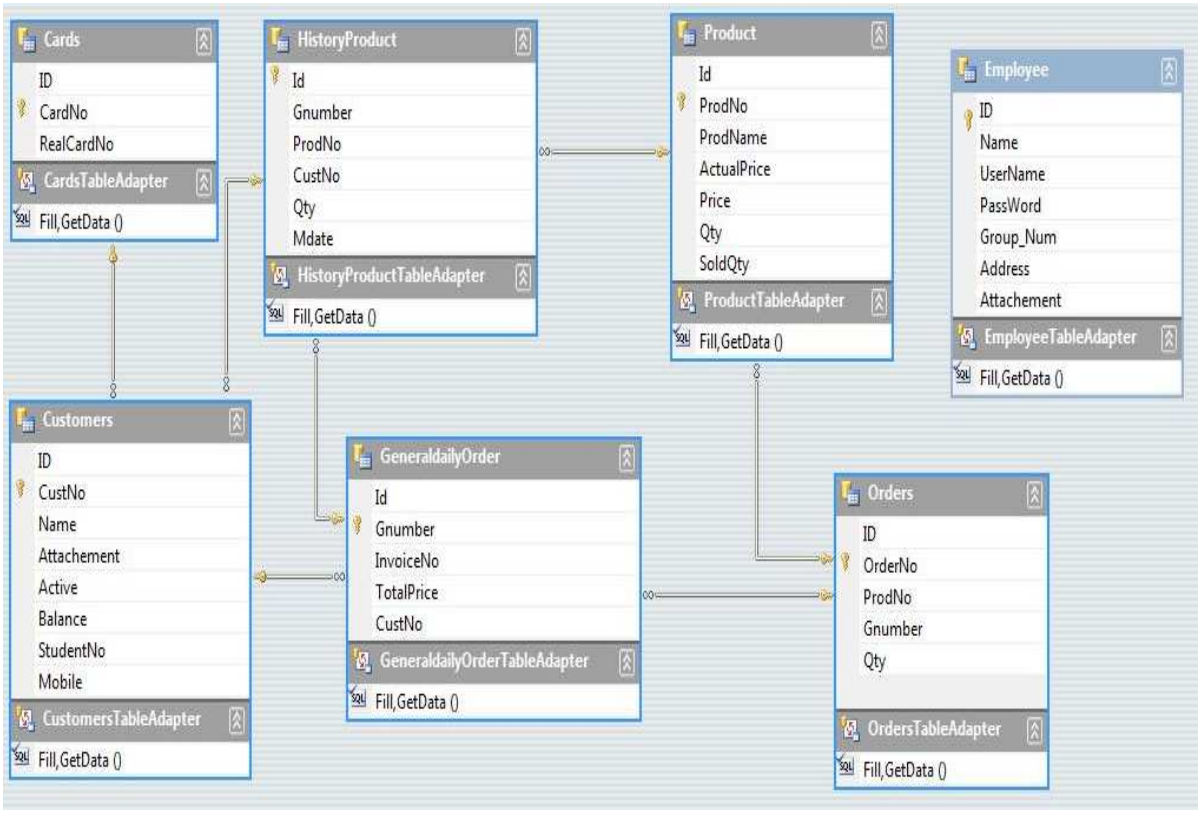


Figure 4.4 Developed System Class Diagram

❖ The User Interface of the Developed System

There are many Form/Screens which represent the different processes and functions in the system. The first form appears in the system is the User Login Form (Figure 4.5). After entering the user name and password, the system will check its validity against that stored in the database. If the user is authorized, Figure 4.6 main form will appear.

Figure 4.5 User Login Form

Figure 4.6 Main Form

As shown in Figure 4.6 (main form), all primary functions/activities of the system are appeared such as New Order, Products, Customers, and Employee (Figure 4.7).

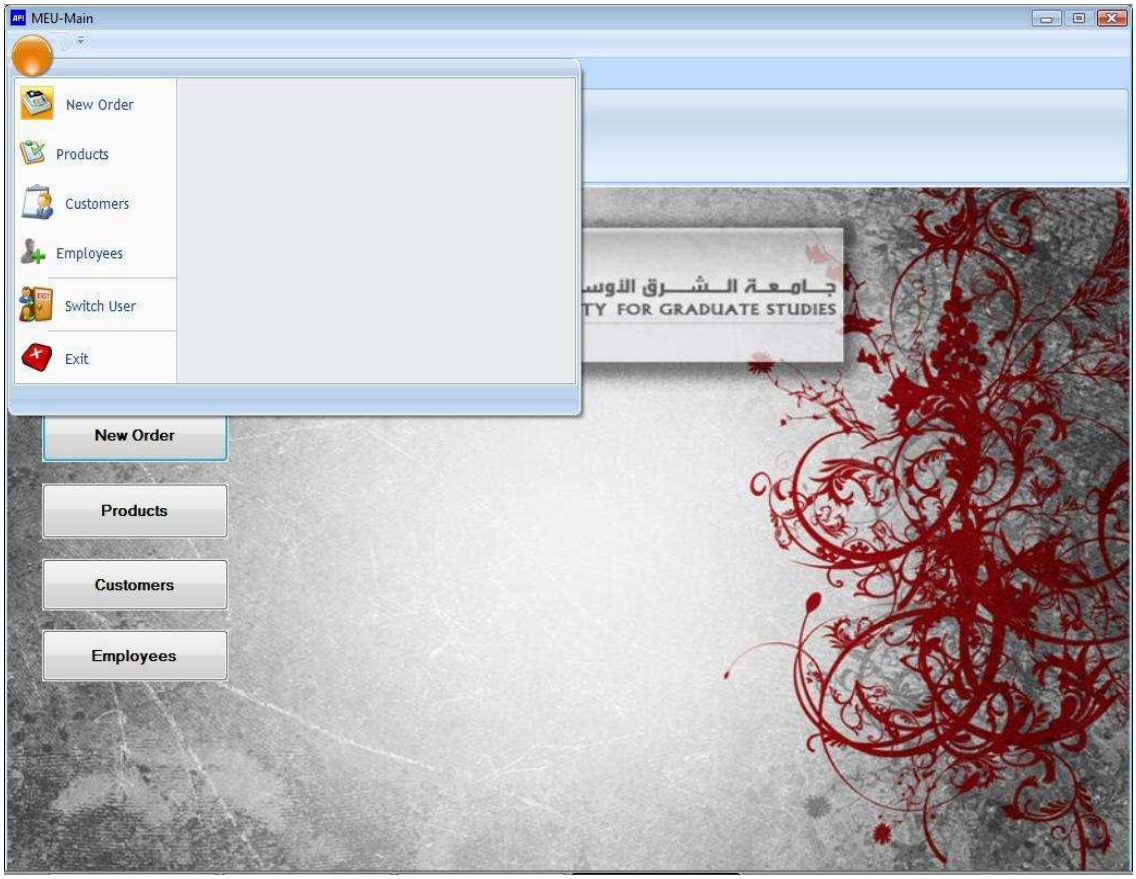


Figure 4.7 Main Form with Functions

In the following, we are going to explain all forms that are used in the developed system:

- **New Order Option**

When clicking the New Order Button:

1- In this option, the employee should enter product number of the item to be sold to the student and its quantity and then click (Add).

2- After finishing all the products that are sold to the student (Figure 4.8), the employee click on Save button (it is used to store the sales process).

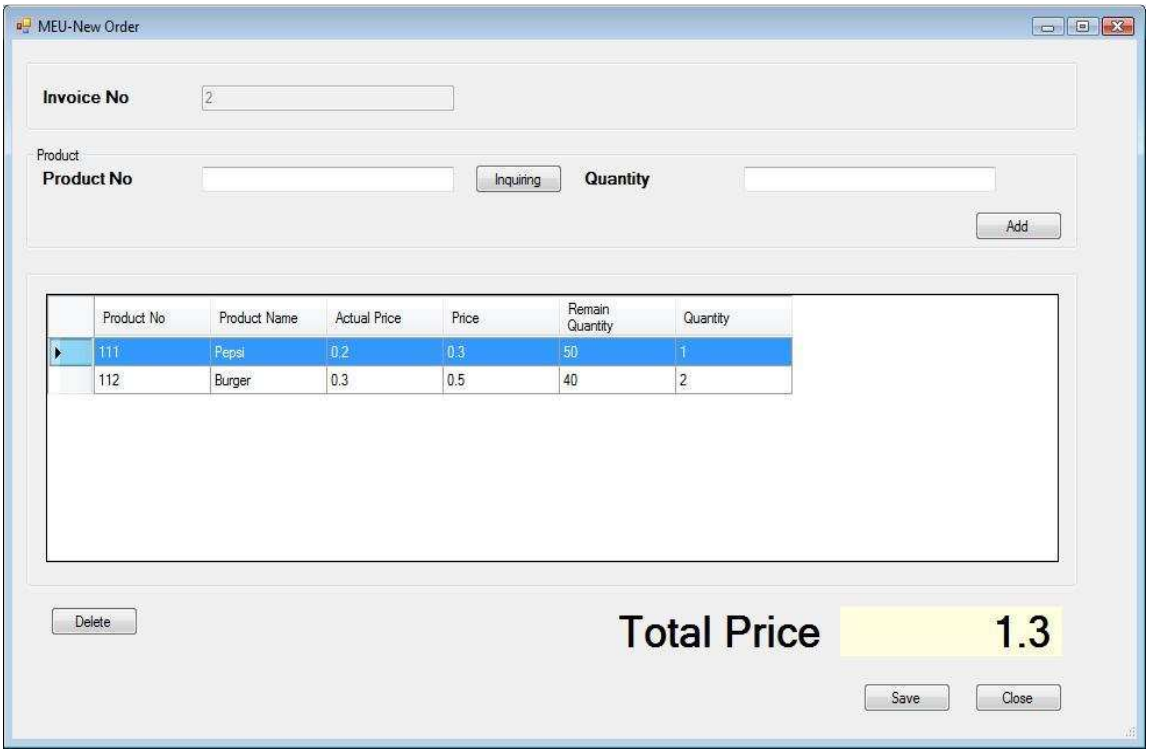


Figure 4.8 Orders Form

3- After the employee click Save button, pay form is opening. In this form, the student must face the card in front of the card reader devise, then the student information (name, picture, balance) will come out, which is stored in the database. Now, if the picture is not clear, the employee can check customer password and customer number by click on (Check) button. If customer balance is less than Total Price, the system will stop the saving process and return to (Orders) form (Figure 4.9).

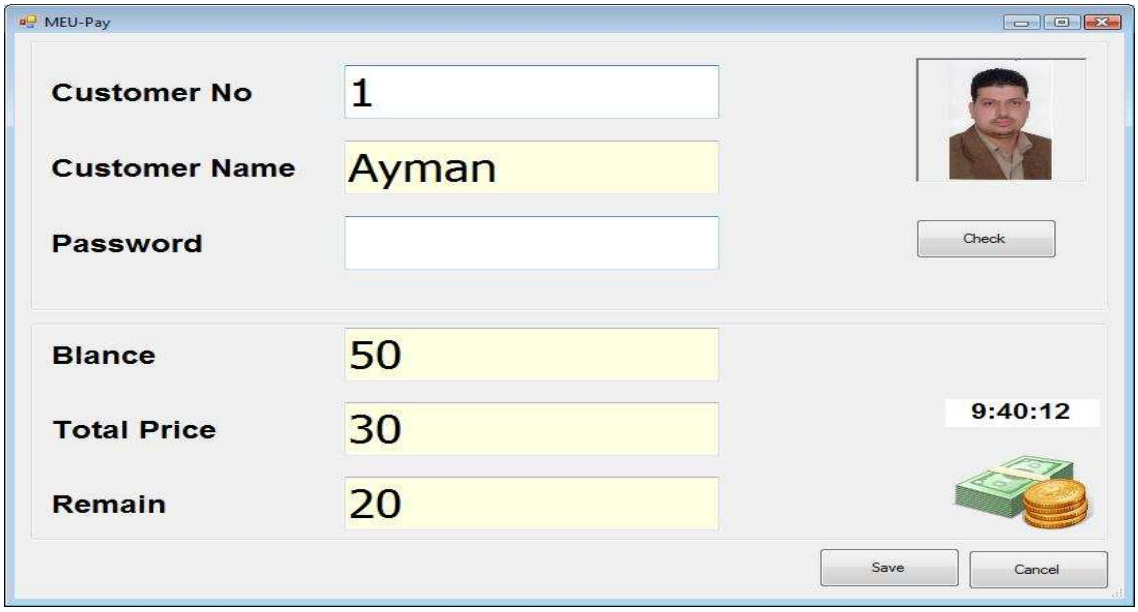


Figure 4.9 Pay Form

- **Products Options**

This option contains four secondary buttons (Figure 4.10), which are:

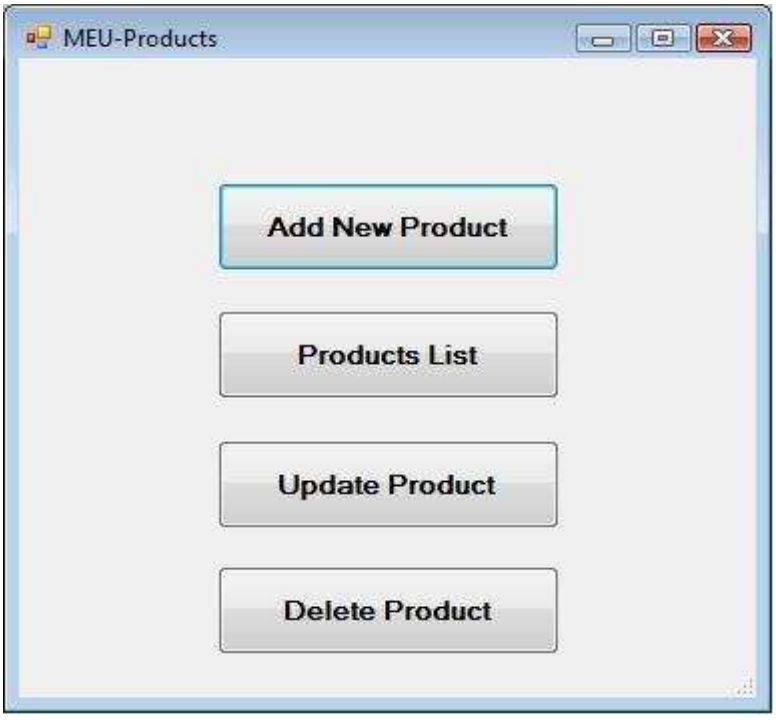


Figure 4.10 Products Form

1- Add New Product Button: this button allows us to add new product, we can also add new product by clicking on add in (Products List) form. Figure 4.11 shows the Add New Product Form.

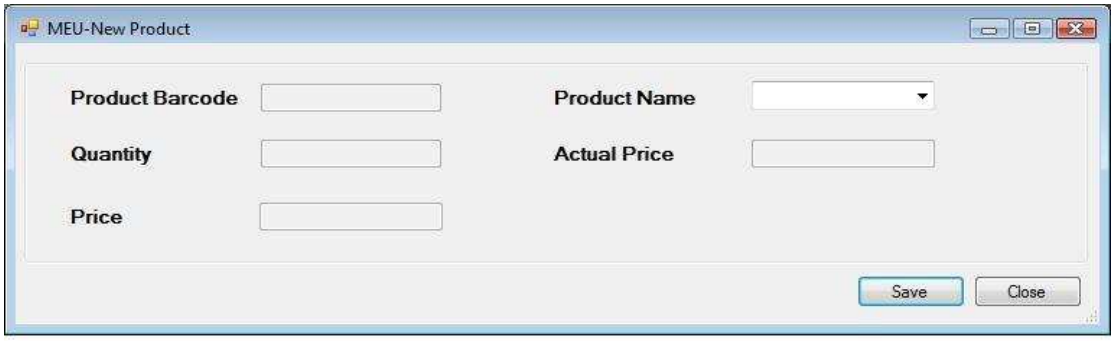


Figure 4.11 Add New Product Form

2- Products List button: this button lists all products that require data in the database system (Figure 4.12).

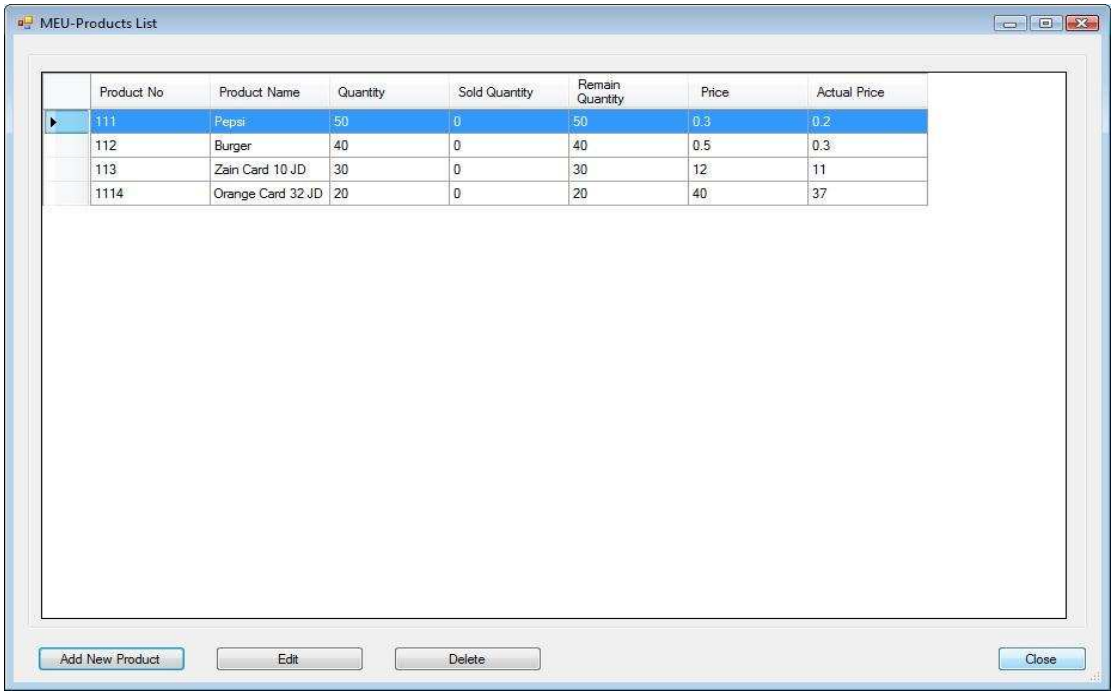


Figure 4.12 Products List Form

3- Update Products: this button allows us to update products information that is stored in the database, we can also update or edit customer information by clicking on Edit in (Products List). Figure 4.13 shows the update Products Form.

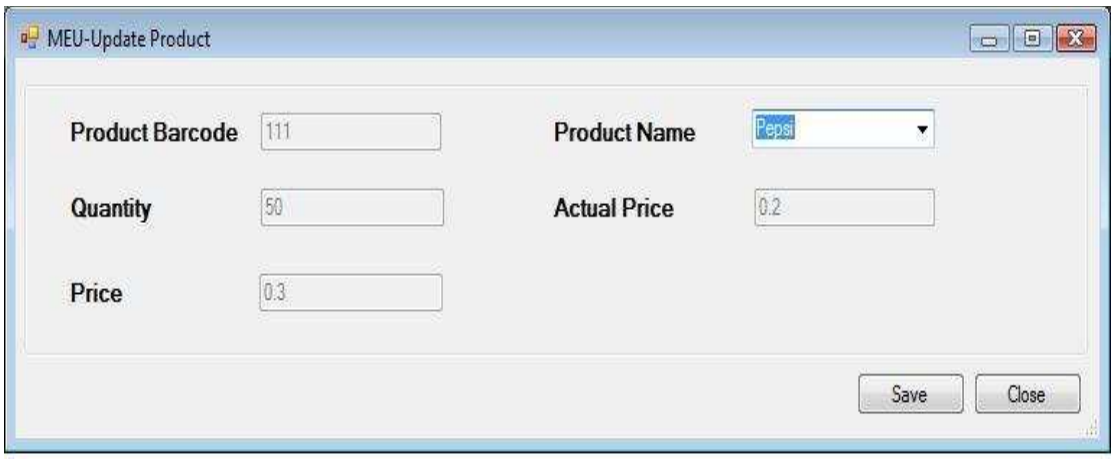


Figure 4.13 Update Products Form

4- Delete Product: this button allows us to delete customer information that is stored in the database. Figure 4.14 shows the Delete Product Form.

Figure 4.14 Delete Product Form

- **Customers Options**

This option contains four secondary buttons (Figure 4.15), which are:

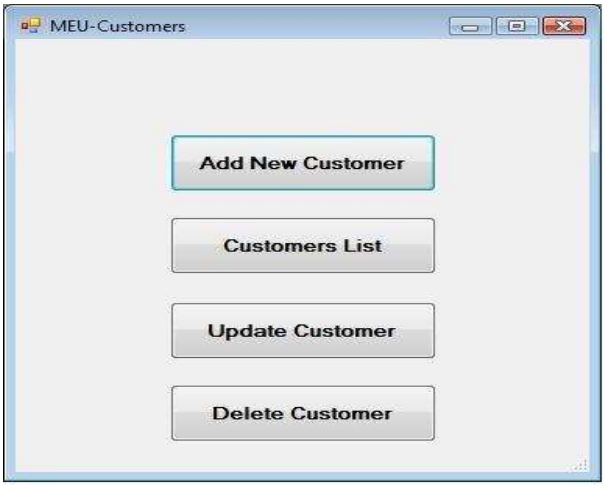


Figure 4.15 Customers Form

1- Add New Customer button: this button allows us to add new customers, we can also add new customer by clicking on add in (Customers List) form. Figure 4.16 shows the Add New Customer Form.

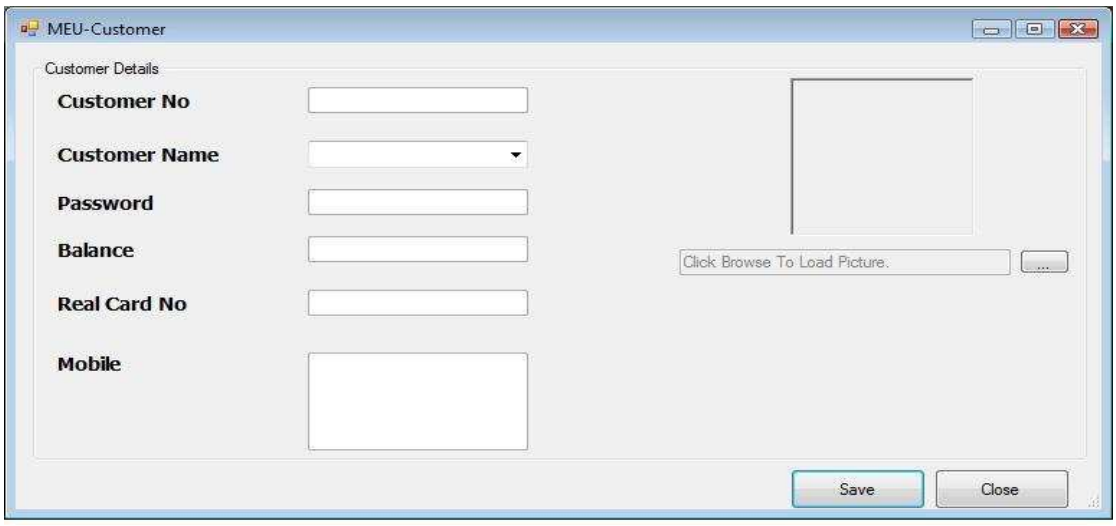


Figure 4.16 Add New Customer Form

2- Customers List button: this button lists all customers that require data in the database system. Figure 4.17 shows the Customers List Form.

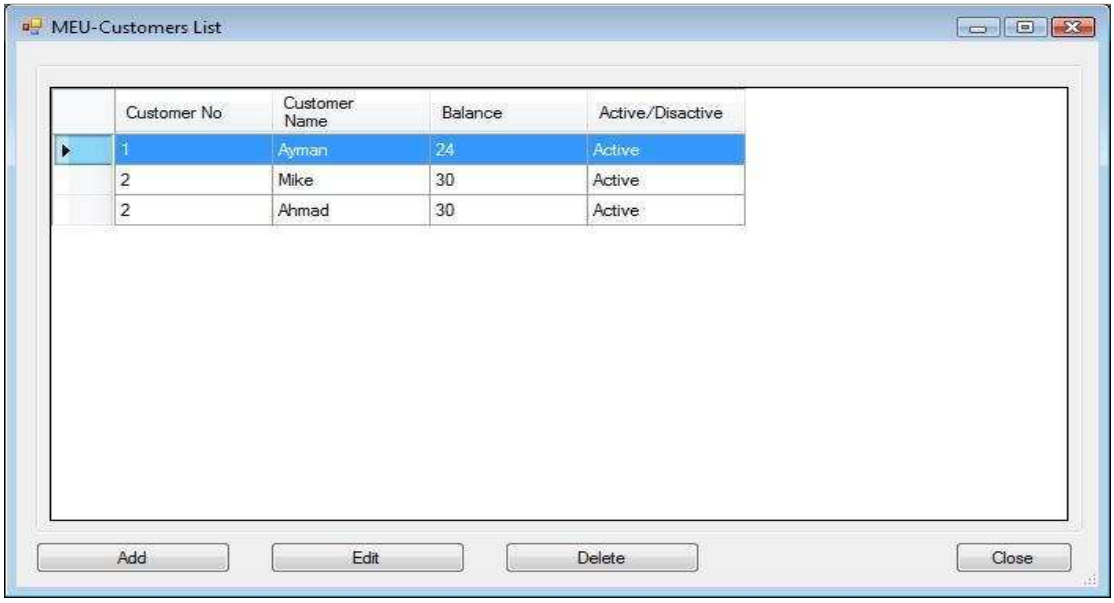


Figure 4.17 Customers List Form

3- Update Customer: this button allows us to update customer information that is stored in the database (for example add a new mobile number or edit the number), we can also edit customer information by clicking on Edit or Update in (Customers List). Figure 4.18 shows the Update Customer Form.

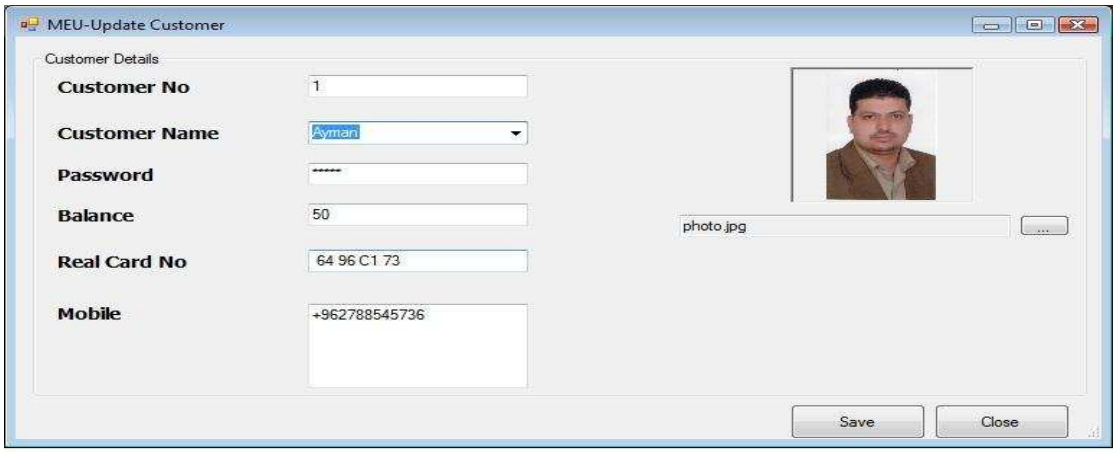


Figure 4.18 Update Customer Form

4- Delete Customer: this button allows us to delete customer information that is stored in the database, we can also delete customer information by clicking on delete in (Customers List). Figure 4.19 shows the Delete Customer Form.

Figure 4.19 Delete Customer Form

- **Employees Option**

This option contains four secondary buttons (Figure 4.20), which are:

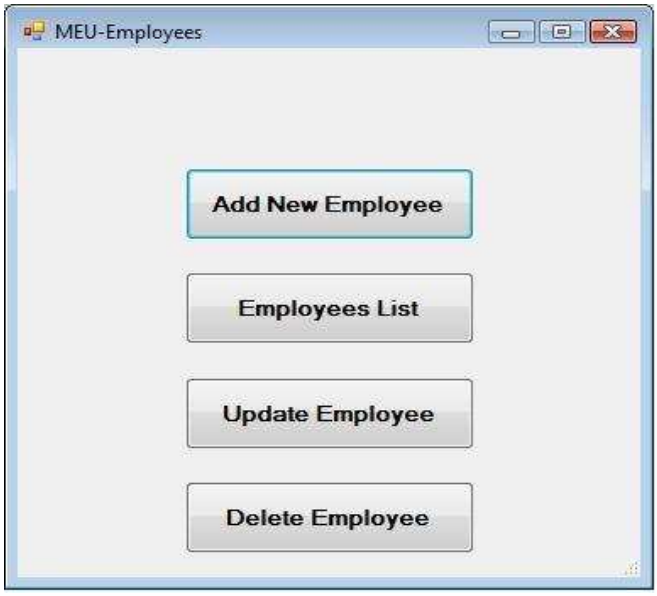


Figure 4.20 Employees Form

1- Add New Employee button: this button allows us to add new employee, we can also add new employee by clicking on add in (Employees List) Figure 4.21 shows the Add New Employee Form.

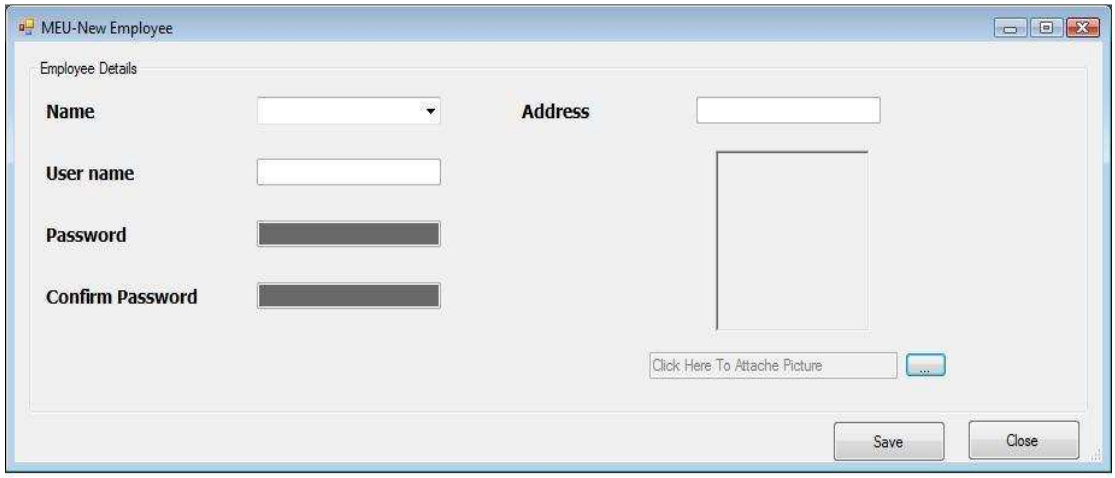


Figure 4.21 Add New Employee Form

2- Employees List button: this button lists all employees that are stored in the database system, Figure 4.22 shows the Employee List Form.

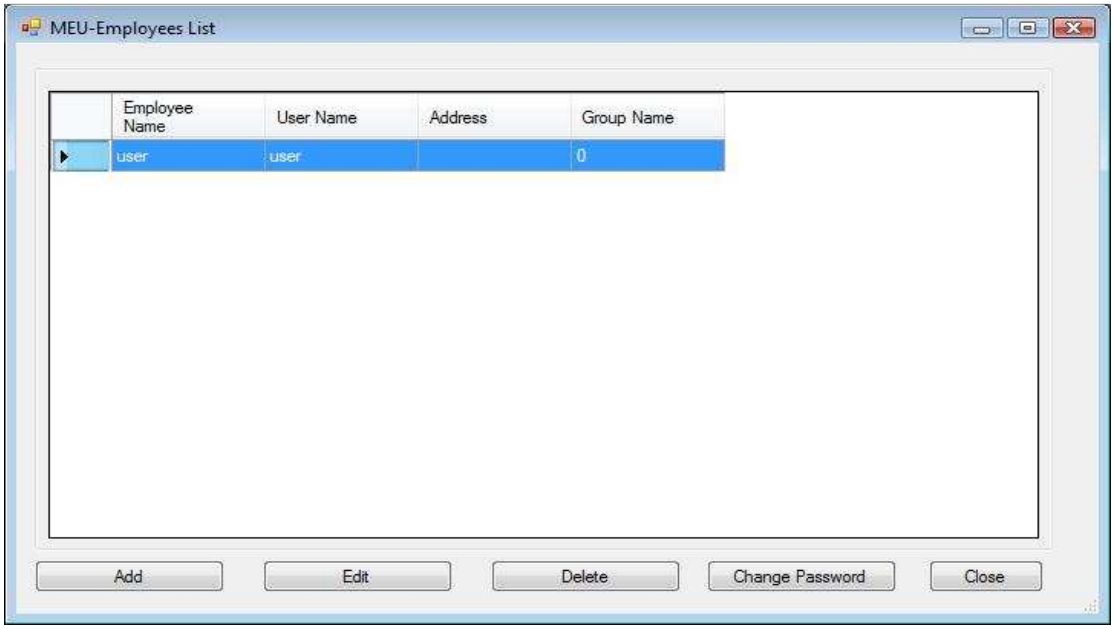


Figure 4.22 Employees List Form

3- Update Employee: this button allows us to update employee information that is stored in the database, we can also update employee information by clicking on Edit in (Employees List). Figure 4.23 shows the Change Employee Password Form.

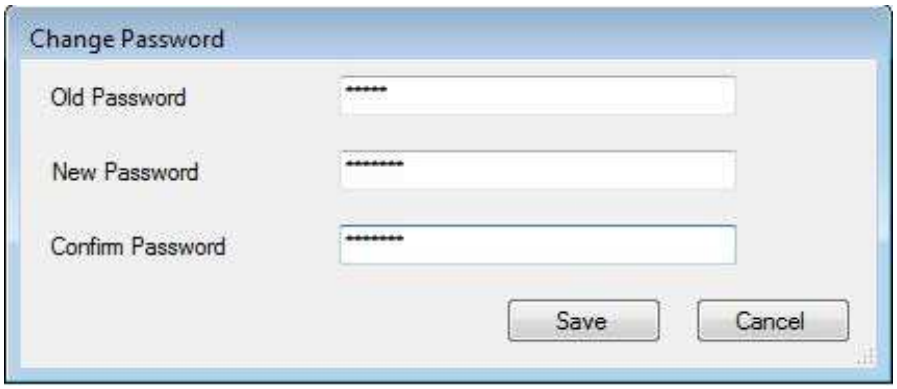


Figure 4.23 Change Employee Password Form

4- Delete Employee: this button allows us to delete employee information that is stored in the database, we can also delete employee information by clicking on delete in (Employees List). Figure 4.24 shows the Delete Employee Form.

Figure 4.24 Delete Employee Form

❖ **Blocking the Card Using SMS**

This service is added to the developed RFID system and to the pilot system as well. This service is very useful due to its high level of security providing to the system.

When the new student wants to register in the University, the employee enters the information of the student to the system. It includes student mobile number which is very important and has many benefits. Some of these benefits are: system can block the card automatically, sending messages, exams dates, results and other matters of interest to the students.

When any card holder looses his/her card, he/she can send right away an SMS from his/her own personal mobile number (which is stored in the RFID system database). The SMS must contain the password of the card in order to the system to stop the card immediately.

Afterward, he/she can purchase a new card, which will contain the same amount of money before the card was stolen or lost.

The mechanism to blocking the card will be as follows:

1- The student sends a message containing the password of his/her card (which is given to the student) to the system mobile number.
2- There will be a connection between Nokia mobile (system mobile number) and the server (which contains the system) so that the Nokia device is connected via a USB. Then the Nokia device is connected simultaneously; so that the process would verify that there is a message in every minute.

3- When any message comes to the system, the system analyzes the message and saves the card number and password's card, so the card number and password as inputs to the system and the output action is to block the student's card who sent the message

4- Within the system, the program receives input from mobile, the program will search in the database through an specific algorithm and matching card number with student's number that is stored in the database, if the card number and the password is the same as the sent password, then the program blocks the card, so anyone cannot use this card again.

5- Then the software deletes the message automatically, and will be ready to accept any other message.

This thesis use the PC connectivity to connect the mobile with the PC. PC connectivity enables synchronizing of a user's personal information data, such as contacts and calendar entries, installing applications, performing backup and restore, and transferring data (images, video, music, etc.) between the user's mobile device and a PC using short-range protocols such as Bluetooth, infrared, serial port, and USB.

The PC Suite API is available for application developers and ISVs. The API is an integrated part of the Nokia PC Suite and it takes advantage of the suite's existing capabilities. It has been designed to free the user from the complexity of the connectivity and transmission protocols and mobile phone system architecture, thus enables faster PC connectivity application development.

Figure 4.25, shows the flowchart of blocking the card using SMS in thesis developed system.

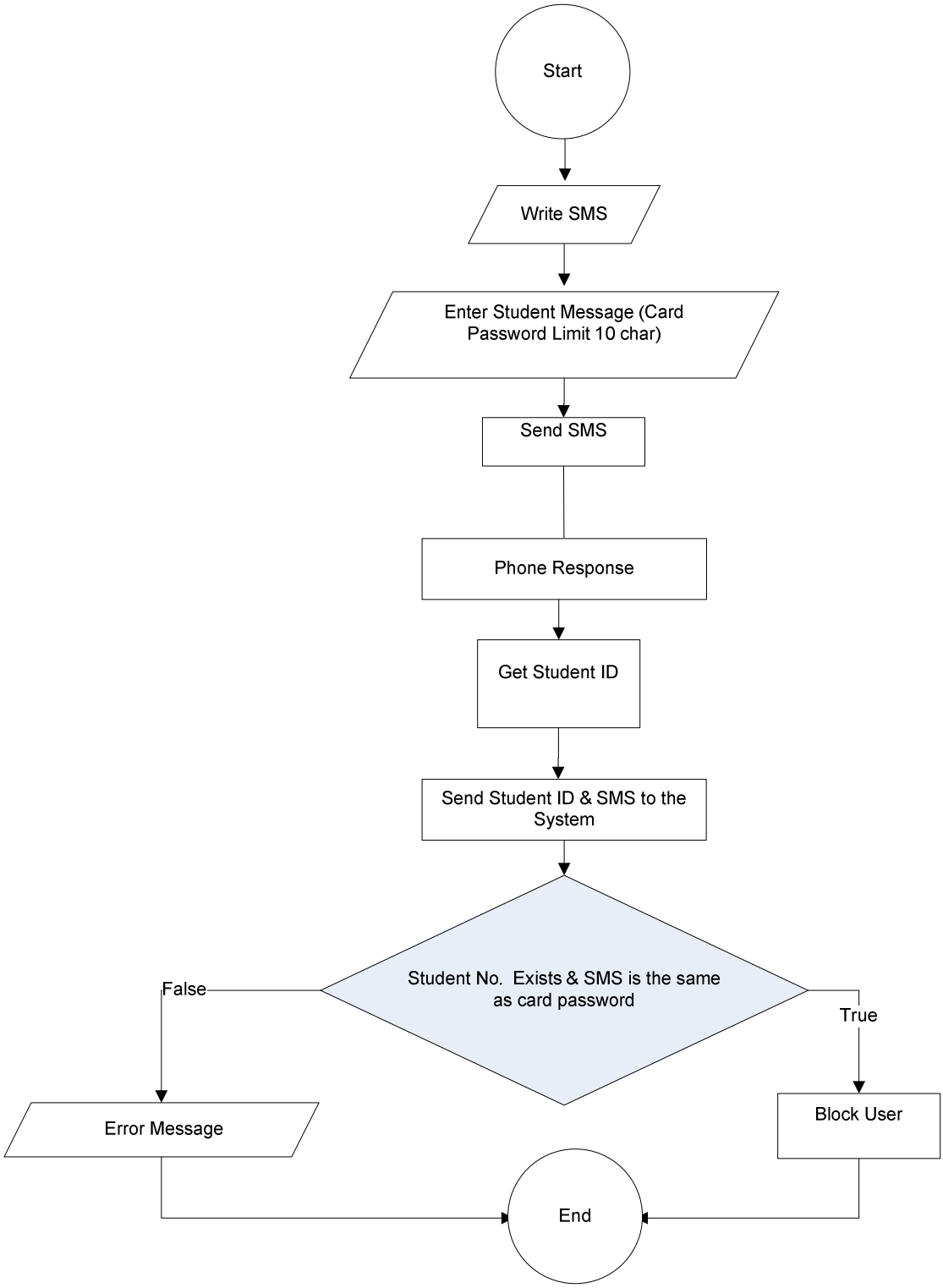


Figure 4.25 Flowchart Diagram for Blocking the Card Using SMS

❖ Comparison Between the Developed System and the Other Systems

Table 4.1 summarizes the main features which help to comparing the developed system with the other systems.

Table 4.1 Comparison Between the Developed System and the Other Systems

University Name	Multi-Used Card	Ways for blocking the card	Blocking Using SMS	Using Finger-Print
University of Exeter	Yes	Notify Card Office	NO	NO
University of Cambridge	Yes	Notify Card Office	NO	NO
University of Nottingham	Yes	Notify Card Office	NO	NO
University of Chicago	Yes	Notify Card Office	NO	NO
Middle East University	Yes	Send SMS to the Card Office or Notify Card Office	Yes	Yes

The above table shows the comparison between the universities that use smart cards. We find that our RFID developed system is more secure card system by using the finger-print authentication in addition to the password.

Moreover, our RFID system uses the ability of blocking the card immediately after its losing. This is done directly by sending one SMS to the system, which is not available in all the other universities systems.

Chapter 5
Conclusions and Future Work

5.1 Conclusions

In this section, we summarize the conclusions of our thesis, these are:

1- The developed system using the contactless cards in MEU and this system is a universal cost-effective identification solution addressing a wide range of applications in the university.

2- The anti-collision capability in the developed system and its ability to be read or written without a slot, a direct line of sight (like contact credit cards) make this technology more efficient in comparison with currently used systems.

3- Since no item can pass by a transponder reader without being scanned and/or updated, human intervention and its associated costs are significantly reduced.

4- Using smartcards developed system in MEU ‘stored value cards’ reduce the instances in which physical cash is used in making payments.

5- The developed system contains improvements in security techniques. These improvements will success tackling the problems of fraud, and give greater confidence in such systems.

5.2 Future Work

In order to extend the system that is developed in this thesis, we suggest several recommendations for future work, these are:

1- Making the contactless card the only card you will carry in your wallet at the university (All money transactions are made by the card).

2- Adding more security through enhancing the point of sales, by adding a finger print authentication device to recognize the user, and validate encryption of database by using special software.

3- For every student, an SMS could be used (of the same mobile number stored in the student database) to contact the student whenever is needed and to inform the student of any new action in the University.

   For example, when the student finishes his registration, he/she will receive an SMS to confirm his precise date of starting the course, to inform him about his/ her results for every subject, and to inform him about the due date of returning the books he had borrowed from the library.

4- This card system provides a highly secure level; it will decrease the use of the security staff in the entrance of the University and will monitor the coming and leaving of everyone, in addition to that this card system contain the event viewer software, this event viewer software will enable us to monitor any student and employee’s exact date and time of any action taken by everyone in the University.

References

Al-Mousawi, Hussain 2004,' Performance and Reliability of Radio Frequency Identification(RFID)' Master Thesis, Agder University College, Norway Available at:<http://student.grm.hia.no/master/ikt04/ikt6400/g28/Document/Master_Thesis.pdf> [Viewed 05 April 2010]

A Smart Card Alliance Contactless Payments Council 2006, 'The What, Who and Why of Contactless Payments', CPC-06002, *Smart Card Alliance* , Available at: < http://www.smartcardalliance.org/resources/pdf/CP_What_Who_Why_Final.pdf > [Viewed 12 April 2010]

Bill, Glover & Himanshu, Bhatt 2006, *RFID Essentials*, 1st edn, O'Reilly Media, Inc. USA. Cambridge University (2003), University Cambridge Smart Card [online]. Available at: < http://www.admin.cam.ac.uk/offices/misd/univcard/ > [Viewed 3 March 2010]

Carmelo, R. García, Ricardo, Pérez, Joaquín, Caraballo, Francisco, Alayón & Gabino, Padrón 2005, 'A Proposal for a Payment System for Public Transport Based on the Ubiquitous Paradigm' Available at: < http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-208/paper30.pdf > [Viewed 12 April 2010]

Carolyn, S. 2006 'If You Really Hate to Wait', San Francisco Chronicle 17 Feb. 2006. Available at:<http://www.sfgate.com/cgi- bin/ article.cgi?file= /c/a/2006/02/17/ CONTACTLESS.TMP&nl=top > [Viewed 10 April 2010]

Casset L., Lanet J. L. (2002). Increasing Smart Card Dependability. *ACM SIGOPS European workshop* [online], Available at: < http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.10.1795 > [Viewed 27 March 2010]

Chicago University (2008). Identifications Smart Card [online]. Available at: < http://nsit.uchicago.edu/services/chicagocard/ > [Viewed 12 April 2010]

Chris, Cook, Konstantin, Aslanidis & Helfried, Vollbrecht 2007, 'Improving Consumers' Contactless Payment Experience' Texas Instruments, Inc. Available at: <http://www.ti.com/rfid/docs/manuals/whtPapers/wp-improving_payment_experience .pdf > [Viewed 12 April 2010]

Dennis, Brown 2007, *RFID Implementation*, McGraw-Hill Companies, USA.

Dhem Jean-Francois and Nathalie Feyt,. IEEE Micro, Vol:21, issue:6, Nov 2001, p.14-25.

Jean-Francois and Nathalie Feyt, Hardware and Software Symbiosis Helps Smart Card Evolution.IEEE Micro, Vol:21, issue:6, Nov-Dec 2001,p.14-25. Available at: <http:// portal.acm.org/citation.cfm?id=359340.359342&coll=portal&dl=ACM&idx=35>[12April 2010]

Exeter University (2008). Smart Card [online]. Available at:
< http://as.exeter.ac.uk/support/admin/taught/unicard/> [Viewed 12 April 2010]

Finkenzeller, Klaus 2004, *RFID Handbook Fundamentals and applications in Contactless Smart Cards and Identification*, 2nd edn, Carl Hanser Verlag, Munich/FRG. Germany.

Jerry, Banks, David, Hanny, Manuel, A. Pachano & Les ,G. Thompson 2007, *RFID Applied*, John Wiley and Sons, USA.

Handschuh, H 2004, 'Contactless Technology Security Issues', *Information security Bulletin 9,* Information security Bulletin, *Gemplus,* p.95 Available at:< http://www. chi-publishing. com/samples/ISB0903HH.pdf > [Viewed 12 April 2010]

International Organization for Standardization 2005, Available at:
< http://www.iso.org/iso/home.htm > [02 MArch 2010]
Isao Shirakawa, 2008, art of RFID Tags and Their Applications

Market research, 2006, *Conference Documentation: Contactless Cards*, Available at:
< http://www.marketresearch.com/product/display.asp >[10 February 2010]

Nottingham University (2008). Smart Card [online]. Available at:
< http://www.nottingham.ac.uk/smartcard/> [Viewed 12 April 2010]

NXP 2006, *NXP Semiconductor,,* Available at: < www.semiconductors.philips.com > [Viewed 12 April 2010]

Ottawa University (2008). University of Ottawa Implements Smart Card [online]. Available at: < http://www.secureidnews.com/news/2002/01/14/university-of-ottawaimplements-smart-card/> [Viewed 12 April 2010]

Pete, Sorrells 2002, *Passive RFID Basics,* AN680, Microchip Technology Inc., Available at:<http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE& nodeId =1824&appnote=en011768 > [Viewed 12 April 2010]

Philips 2008, *Philips Datasheet,* Available at:
< http://www.datasheetcatalog.com/philips/1/ > [Viewed 12 April 2010]

Srinivasa, S, Rajan, G & Lalkishore, K 2009 'Human Activity Tracking Using RFID Tags', *IJCSNS International Journal of Computer Science and Network Security*, VOL.9, No.1 , January 2009 Available at:
< http://paper.ijcsns.org/07_book/200901/20090154.pdf > [Viewed 12 April 2010]

Technovelgy 2005, *Contactless Smart Card,* Available at: < http://www.technovelgy. com /ct/Technology-Article.asp?ArtNum=27 > [Viewed 12 April 2010]

Technovelgy 2005, *Contactless Credit Card Advantages,* Available at:
< http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=62 > [Viewed 12 April 2010]

Wikipedia , Available at: < http://en.wikipedia.org/wiki/Data_flow_diagram> [Viewed 10 April 2010]

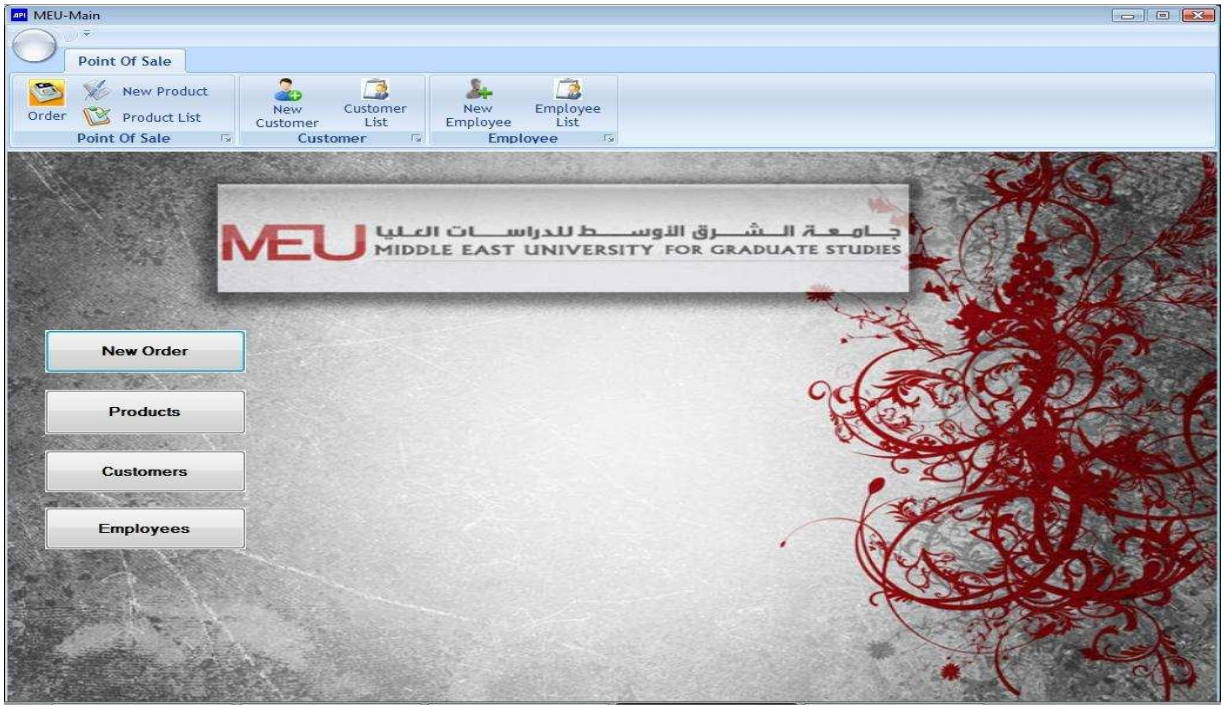
Wolfgang, Rankl & Wolfgang, Effing 2003, *Smart Card Handbook* , 3rd edn, Carl Hanser Verlag, Munich/FRG. Germany.

Appendix

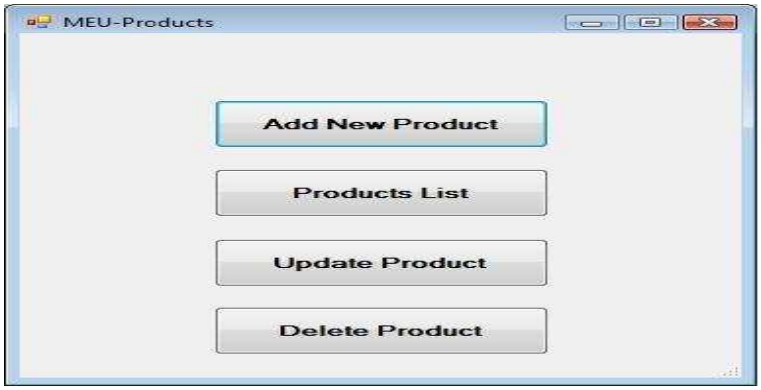
Demonstration of the Stimulation Process

In this appendix, we will give an example to illustrate how the system is used. The first step in the system is by entering the username and password for the employee in the Login Form.

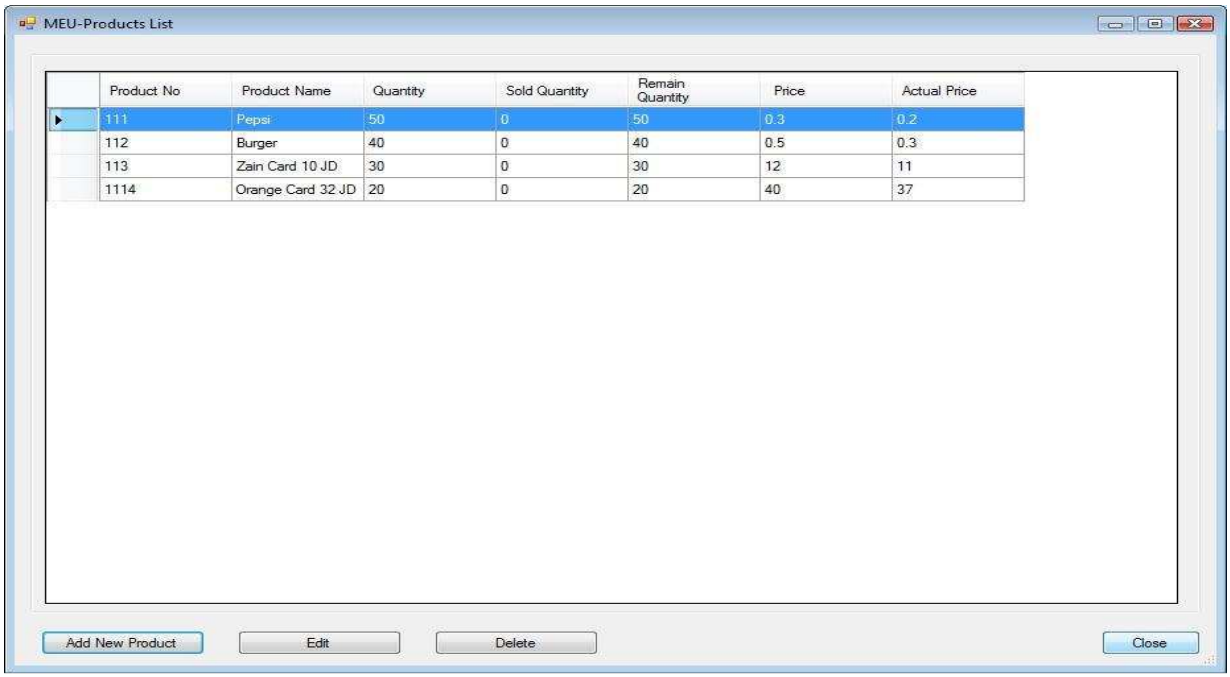
Then the Main Form appears, where it shows the program content, if the employee wants to check the Products List then he/she must click on the Products Tab.



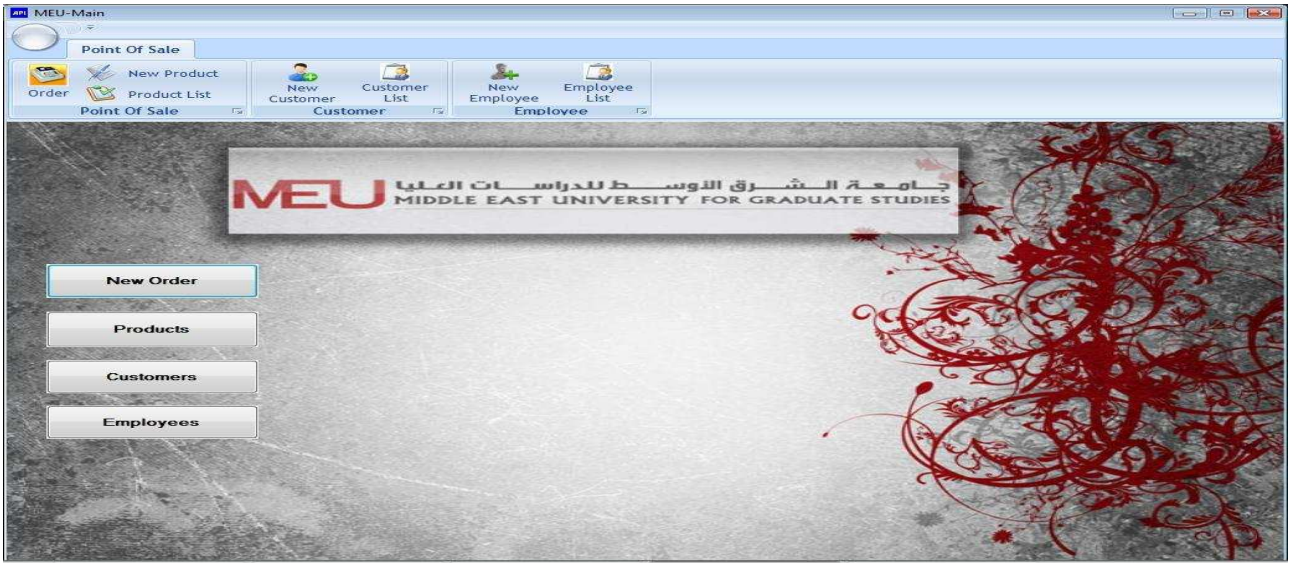
Then the Product Options appears showing the four alternatives to chose from.



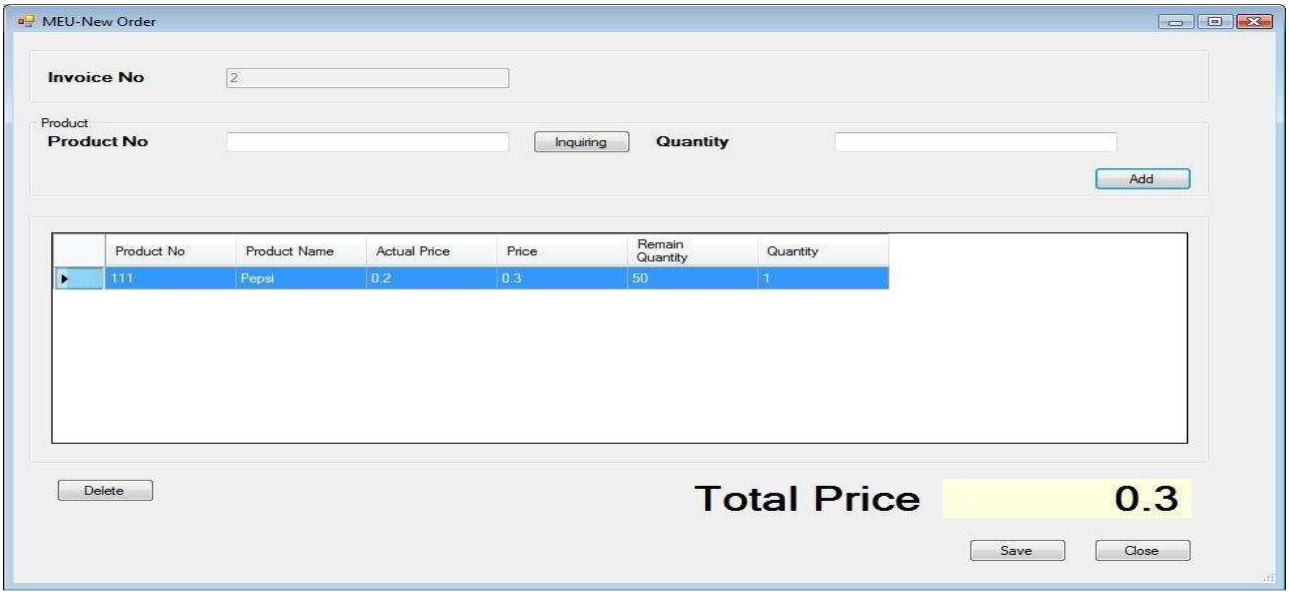
When the employee chose the Products List in order to check the goods availability then a window of the Products List Form will appear.



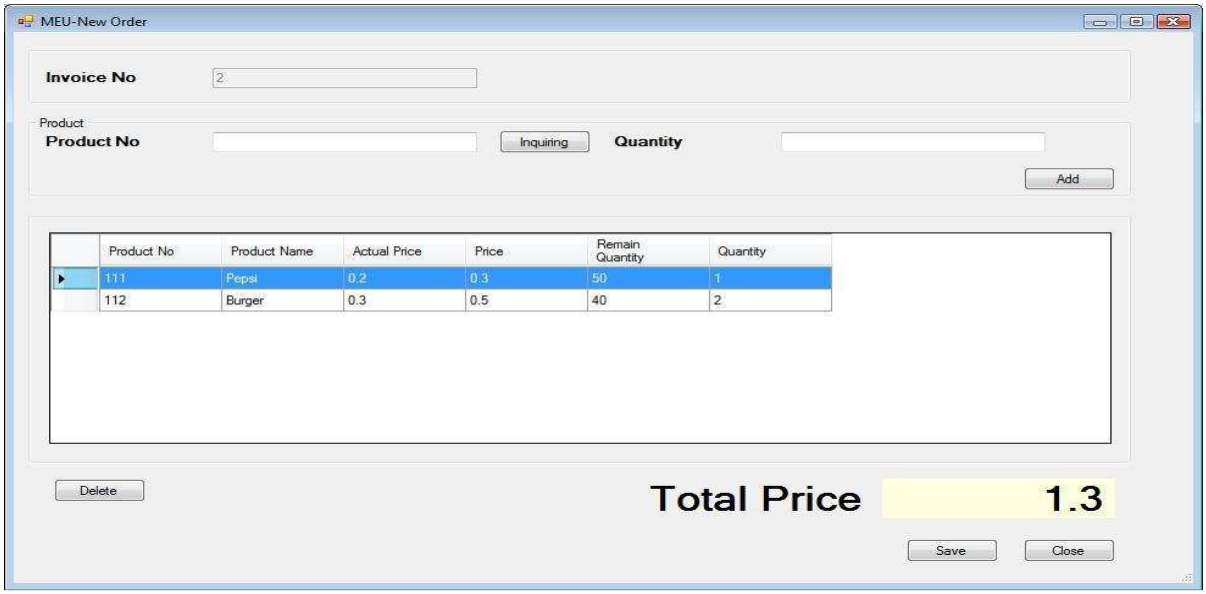
After finishing checking the Products List, then the employee closes the window to return to the Main Form again.



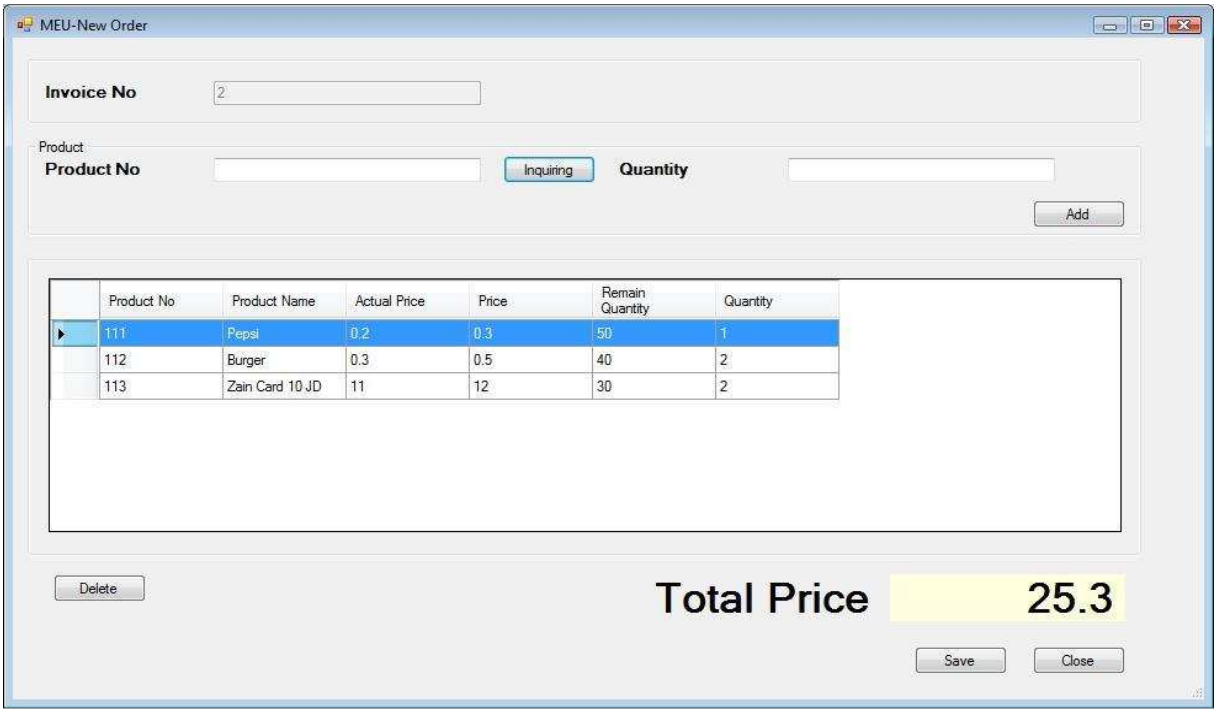
In case there is a customer wants to purchase something, then the employee will click on the New Order button, then a New Order Form will appear.



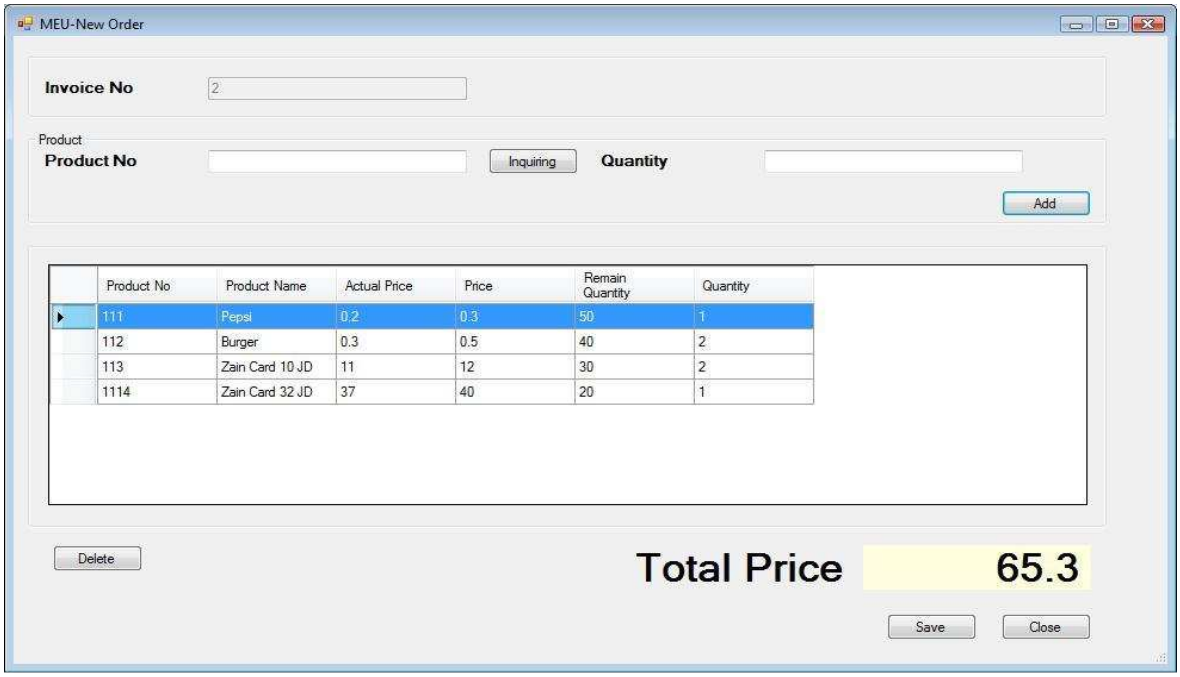
starting to add the materials, one after one, with its quantity.



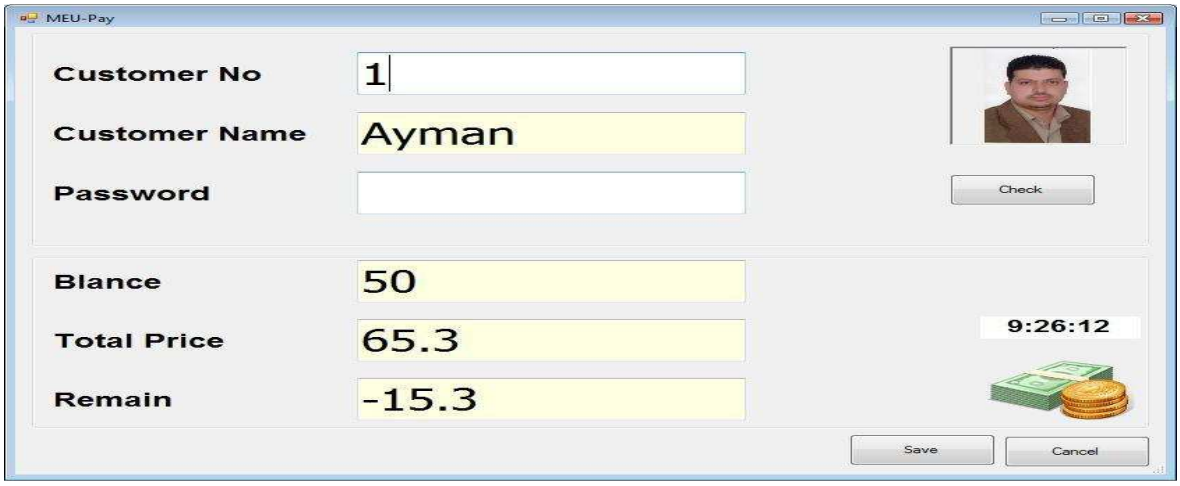
Another material is added to the menu.



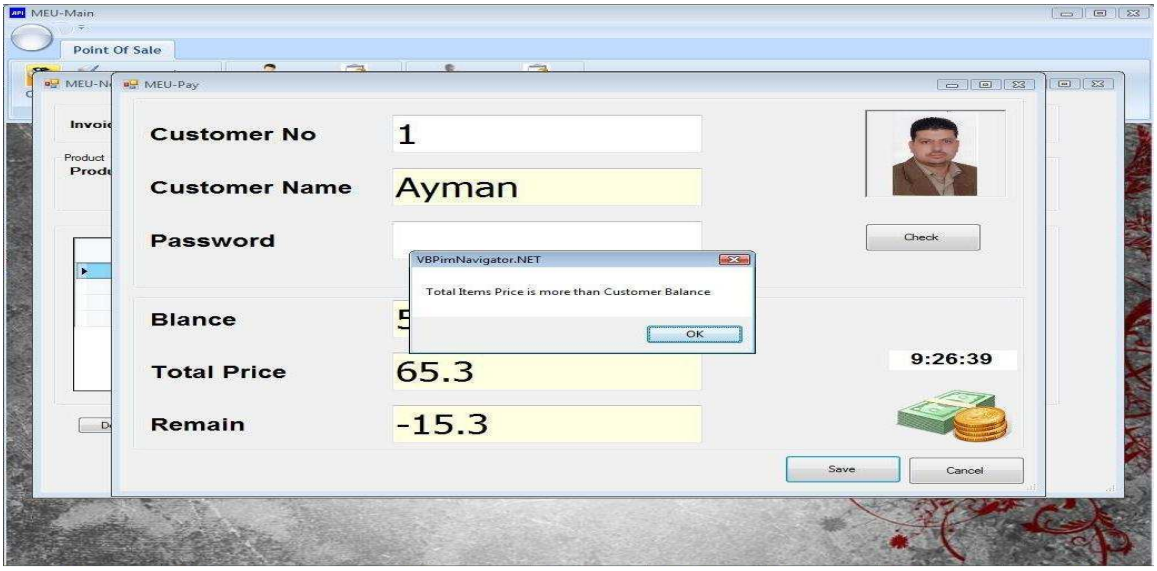
And another one.



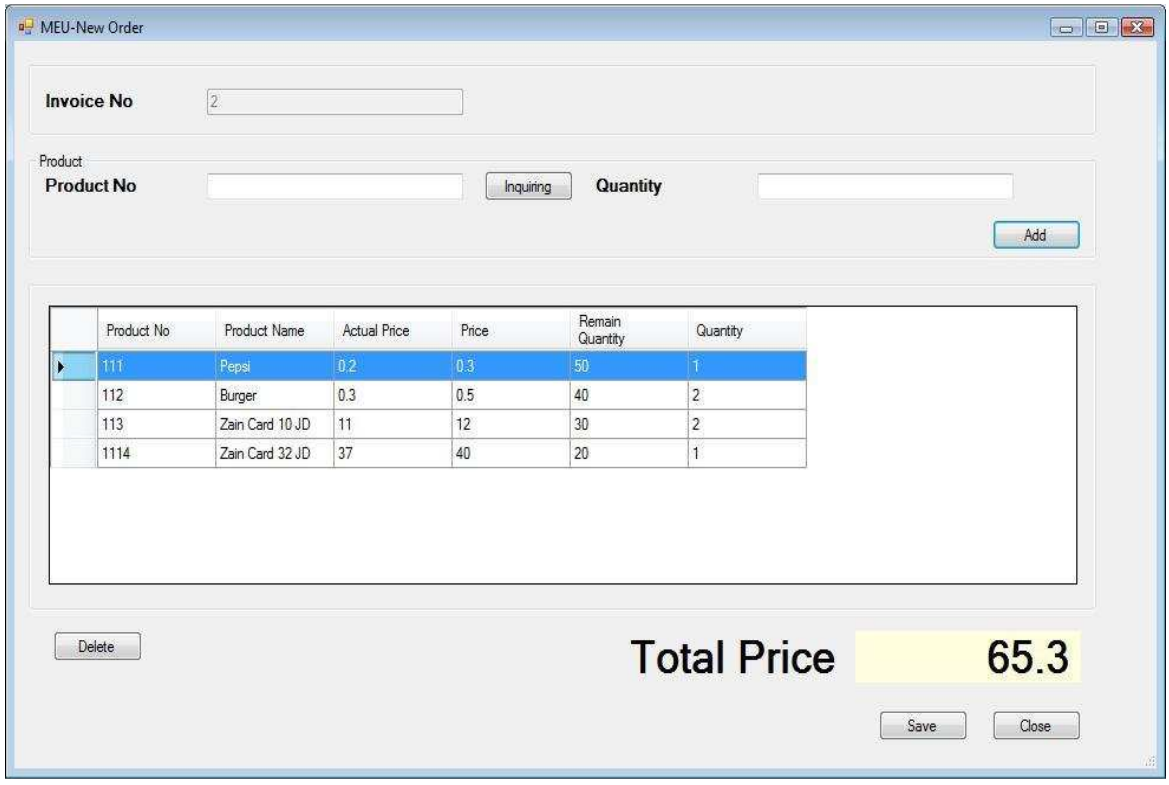
At the end of the adding, the employee save the form, and thus the Pay form appears.



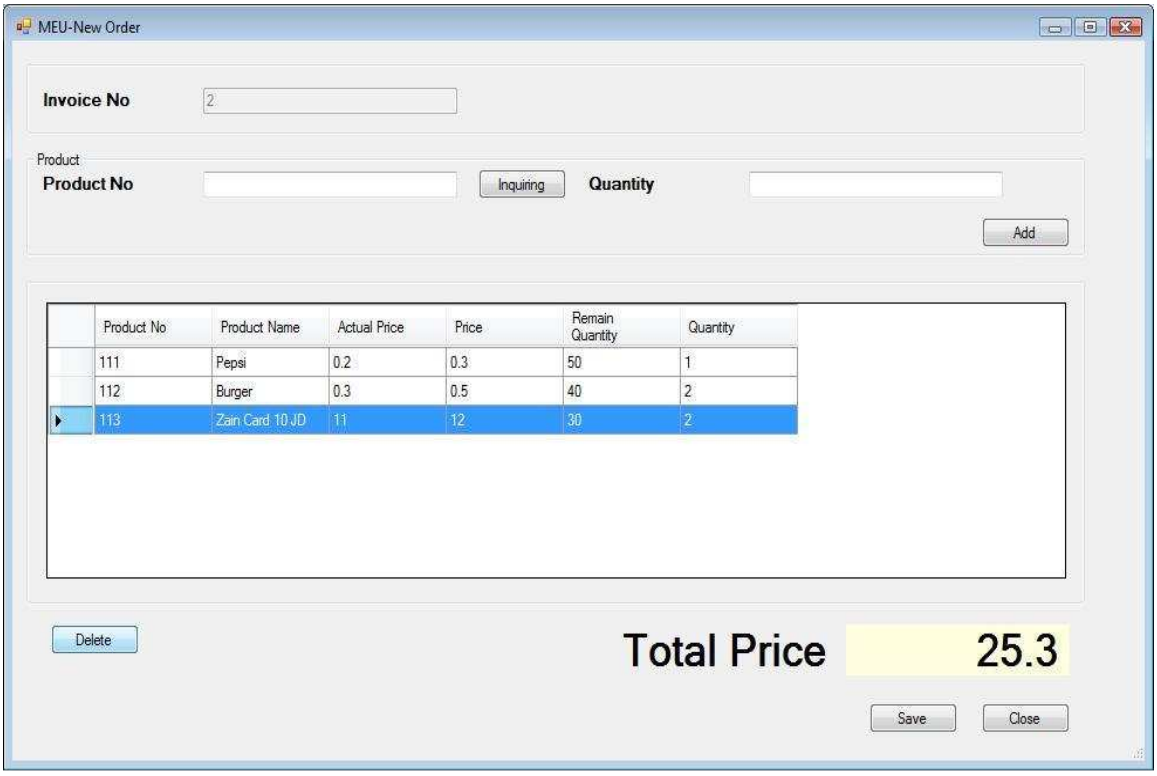
The Pay form shows the balance of the customer and makes the required financial transaction, and if the balance does not cover the total price, then an error window will warn the employee, stating that the total items price is more than customer balance.



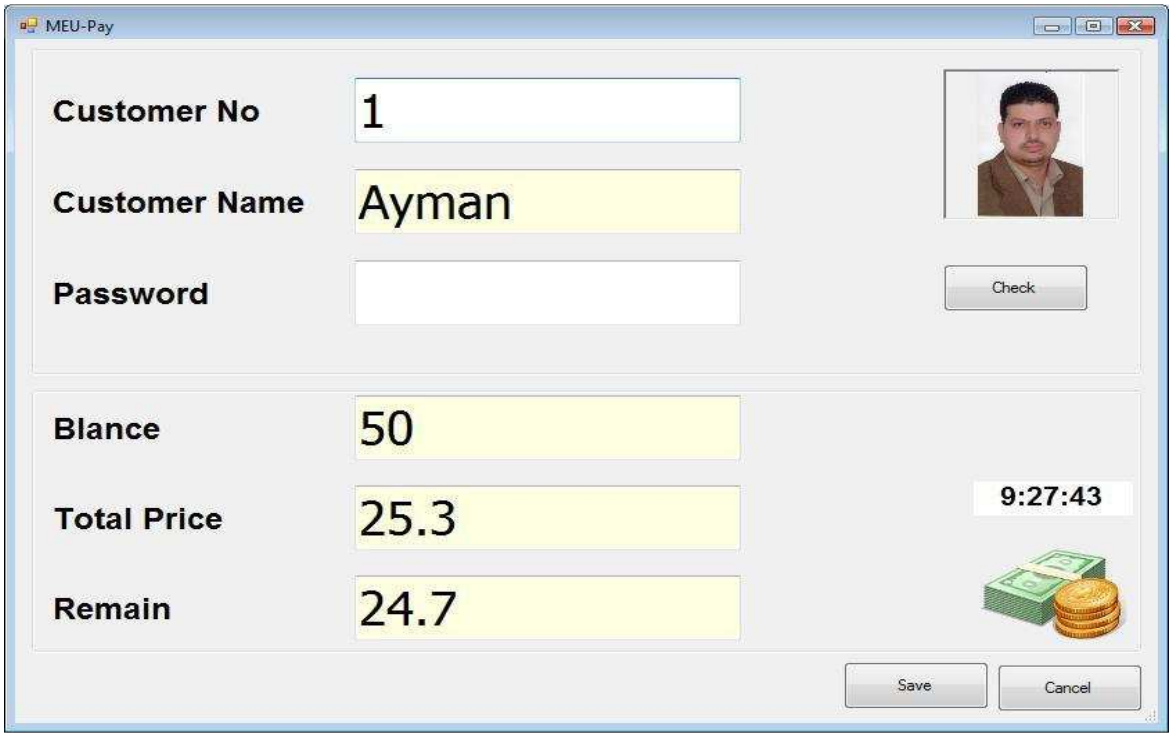
by clicking OK, the employee returns to the New Order form.



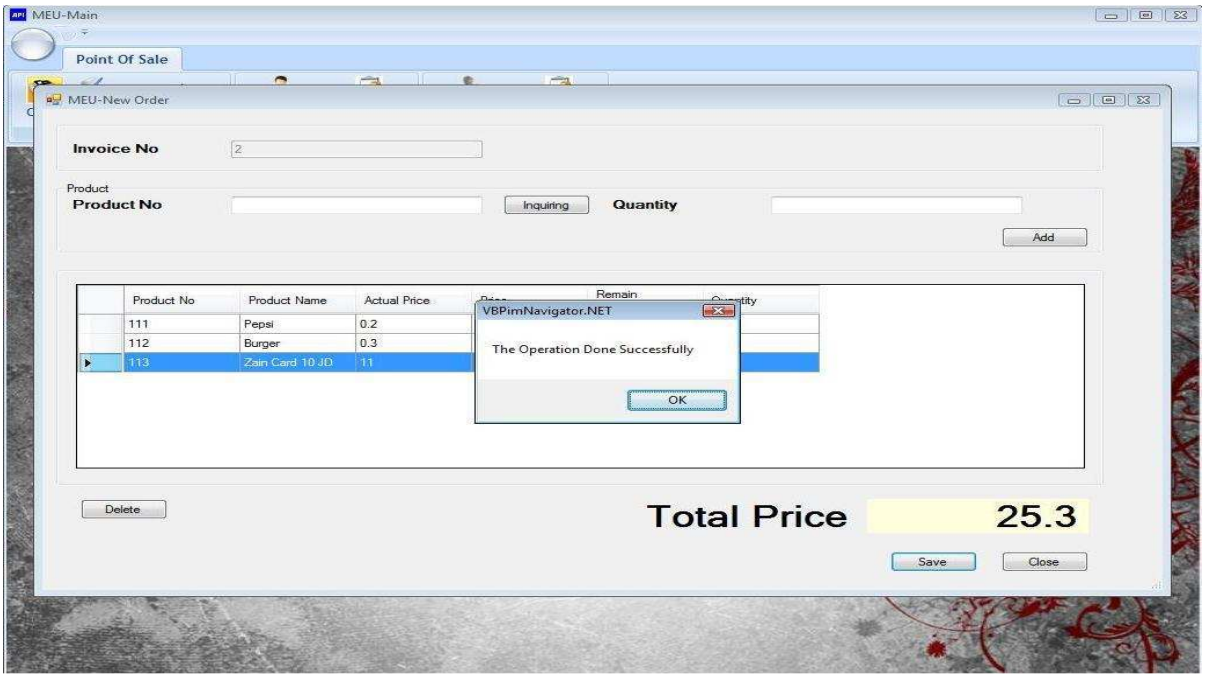
The customer will omit some items.



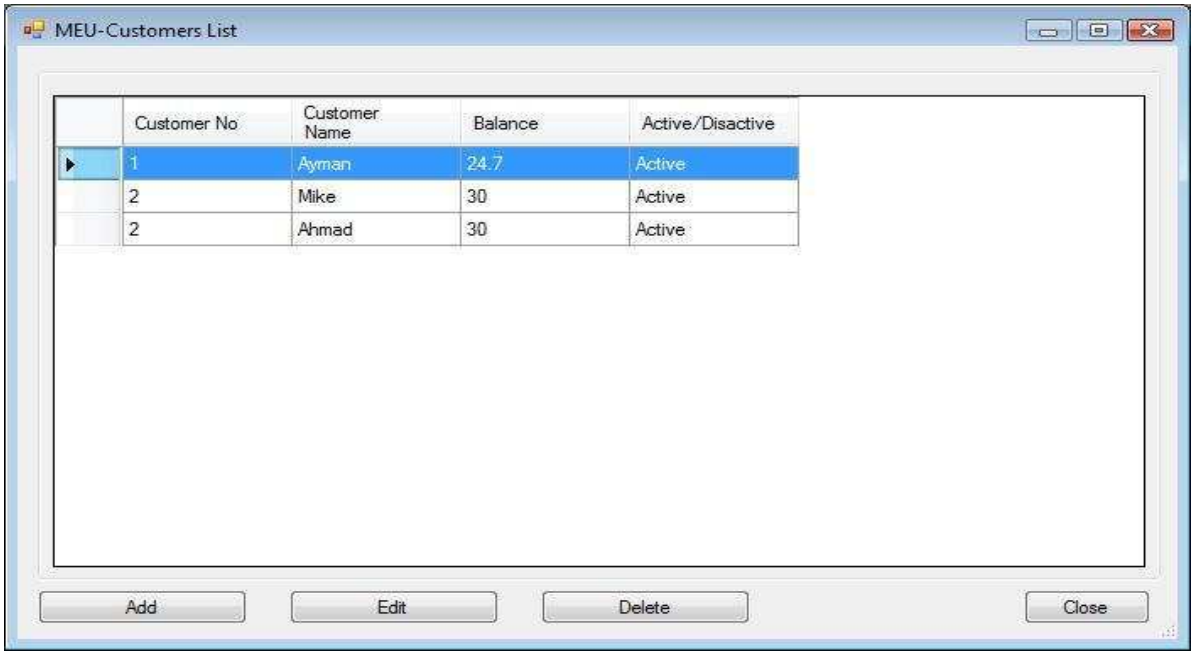
And the employee save the form again, so the Pay form will appear all over again.



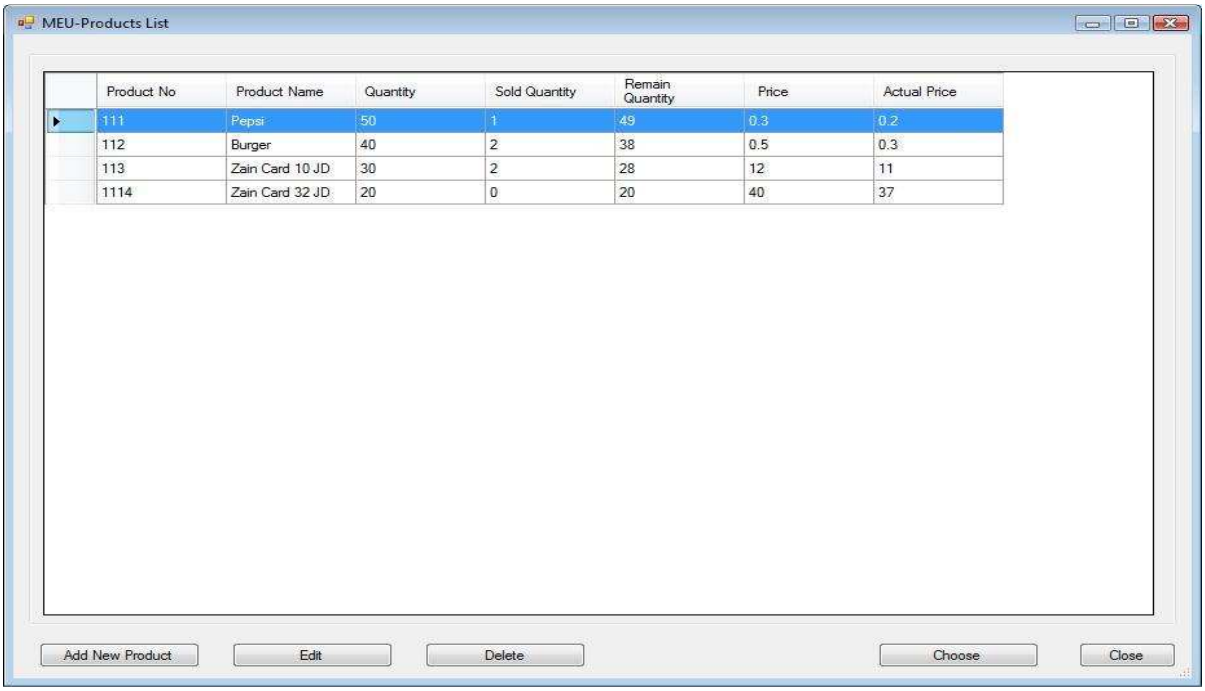
The required comparison will occur and a warning window will show telling that the operation is done successfully.



If the employee wants to check the Customers list after the last process and see the balance of the Customer No 1.



And if the employee wants to check the remaining product quantity after the last process, the Product List form will show that (Here we can see that the Remain Quantity is different from the beginning before of the new order process).



And the same process as in the above will repeat again.

Glossary of Terms

⌂ **Contactless smart chip:** An integrated circuit (IC) that includes a secure microcontroller or equivalent intelligence and internal memory, and communicates with a reader through a radio frequency (RF) interface. Contactless smart chip technology, a form of proven smart card technology, is used increasingly in applications that must protect personal information and/or deliver fast and secure transactions. Leveraging many years of smart card security developments, contactless smart chips have the ability to store, protect, manage, and provide access to secure data and to support the security protocols and algorithms required by an application. In addition, contactless smart chip technology delivers the convenience, durability, and reliability required by applications that must support fast transaction throughout in demanding environments. The contactless interface provides users with the convenience of allowing the contactless device to be read at short distances with fast transfer of data.

Contactless smart chip technology is available in a variety of forms – plastic cards, watches, key fobs, documents, and other handheld devices such as mobile phones.

⌂ **Dual-interface smart chip:** A single smart chip that has two interfaces – contact and contactless – and shares memory and chip resources. A payment card with a dual-interface smart chip can be used with either a contact reader (where the card is inserted into the reader) or with a contactless reader (where the card is tapped on or waved close to the reader).

⌂ **Encryption:** The process of translating information into a code that can only be read if the reader has access to the key that was used to encrypt it. There are two main types of encryption – asymmetric (or public key) and symmetric (or secret key).

⌂ **Form factor:** The physical device that contains the contactless smart chip and antenna and that is used by the consumer for payment. Contactless payment devices can come in a variety of form factors, including plastic cards, key fobs, wristbands, wristwatches, personal digital assistant (PDAs), and mobile phones.

⌂ **ISO/IEC 14443:** The international standard for contactless smart chips and cards that operate (i.e., can be read from or written to) at a distance of less than 10 centimeters (4 inches). American Express, Master Card, and Visa contactless payment devices are based on this standard.

⌂ **Microcontroller:** A highly integrated computer chip that contains all the components comprising a controller. Typically, this includes a central processing unit (CPU), random access memory (RAM), some form of read-only memory (ROM), input/output ports, and timers. Unlike a general purpose computer, a microcontroller is designed to operate in a restricted environment.

⌂ **Near Field Communication (NFC):** A short-range wireless standard (ISO/IEC 18092) that uses magnetic field induction to enable communication between devices when they are brought close together (within 10-20 centimeters or 4-8 inches). NFC technology is compatible with ISO/IEC 14443-based technology.

⌂ **Range:** The distance from which a contactless payment device can be read. American Express, MasterCard and Visa contactless payment devices are designed to comply with the international standard, ISO/IEC 14443, that restricts the device range to less than 4 inches (10 centimeters).

⌂ **Reader:** The electronic device that connects to, provides power to and communicates with a contact or contactless smart card. Contactless readers generate in electromagnetic field. When a contactless device is brought into the reader's electromagnetic field, the contactless smart chip is powered on, a wireless communication protocol is established between the card and reader, and data can then be exchanged. For contactless payments, contactless readers used at merchant locations integrate with point-of-sale terminals and comply with the ISO/IEC 14443 international standard.

⌂ **Radio frequency (RF):** Any frequency within the electromagnetic spectrum associated with radio wave propagation. Many wireless communications technologies are based on RF, including radio, television, mobile phones, wireless networks and contactless payment cards and devices.

⌂ **Radio Frequency Identification (RFID) Tag:** Simple, low-cost and disposable electronic devices that are used to identify animals, track goods logistically and replace printed bar codes at retailers. RFID tags include an integrated circuit that typically stores a static number (an ID) and an antenna that enables the chip to transmit the stored number to a reader. When the tag comes within the range of the appropriate RF reader, the tag is powered by the reader's RF field and transmits its ID to the reader. There is little to know security on the RFID tag or during communication with the reader. Typical RFID tags can be easily read from distances of several inches (centimeters) to several yards (meters) to allow easy tracking of goods.

⌂ **Smart card:** A device that includes an embedded integrated circuit that can be either a secure microcontroller or equivalent intelligence with internal memory or a memory chip alone. The card connects to a reader with direct physical contact or with a remote contactless RF interface. With an embedded microcontroller, smart cards have the unique ability to store large amounts of data, carry out their own on-card functions (e.g., encryption and digital signatures) and interact intelligently with a smart card reader. Smart cards are available in a variety of form factors, including plastic cards, Subscriber Identification Modules (SIMs) used in GSM mobile phones, and USB-based tokens.

⌂ **Transponder:** A wireless communications device that detects and responds to an RF signal.