MINISTRY OF EDUCATION AND SCIENCE OF REPUBLIC OF KAZAKHSTAN
SULEYMAN DEMIREL UNIVERSITY
ENGINEERING FACULTY

Department of Computer Engineering

UDC 004.352.4.087.5

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SDU-Campus system based on RFID

6M070400– «Computing systems and software» speciality

Kaskelen, 2013

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«__» _____ 2013 year

Master dissertation

SDU – Campus system based on RFID

6M070400– «Computing systems and software» speciality

Master student _____ (signature) Kadyrov Bakhytzhan

Supervisor _____ (signature) Doctor of technical science, Professor Amirgaliyev E.N.

Kaskelen, 2013

Annotation

The main problem that we face in university, especially in canteen and library is a queue. Sometimes, in order to be serviced, you need to wait for your turn, and usually it takes at least 5 minutes. Imagine what can you do if you want to get a bottle of water and you need to wait in line, which consists of 20 students and you have just 10 minutes?

So, I have started to think about the way to get rid of this line and to make efficient way of servicing the people, and moreover, to service people in small amount of time.

The idea of my diploma thesis is to build a system called "SDU Campus system based on RFID technology" for the use in the university. So, the way I am using the RFID- technology is trivial: I have a system, which is used in library and canteen, and for the people, who work and study in our university, we distribute RFID-card, and they can use these cards instead of cash money or credit cards.

This work is done under the supervision of Mr. E.N.Amirgaliev, and results of this thesis will be used for the implementation of this system in our university.

Аннотация

Главной проблемой, с которой мы сталкиваемся в университете, особенно в кантине и библиотеке это очередь. Зачастую чтобы тебя обслужили нужно ждать не менее 5 минут своей очереди. Представьте, вот что вы будете делать, если хотите купить бутылку воды, и вы должны ждать в очереди, которая состоит из 20 студентов и у вас есть только 10 минут?

Итак, я начал думать о том, как избавиться этой очереди и, как можно быстро и эффективно обслуживать людей в короткий промежуток времени.

Идеей моей дипломной работы является построение системы под названием " SDU Campus system based on RFID technology " для использования в университете. И так, как работает RFID-технология: система, которую я придумал, используется в библиотеке и столовой, сотрудникам и учащимся в нашем университете, мы распространяем RFID-карты, и они могут использовать эти карты вместо наличных денег или кредитных карт.

Эта работа велась под руководством Г-на. Е.Н.Амиргалиева, и результаты данной работы будут использованы для внедрения этой системы в нашем университете.

Аңдатпа

Университетімізде кездесетін басты мәселе – асхана және кітапханадағы кезек. Кейде, қызмет көрсетілу үшін кезекте күтуіңізге тура келеді және осыған кем дегенде 5 минут уақыт кетеді. Енді сіз елестетіп көріңіз, сіз сусын алу үшін 20 студент тұрған кезекте тұрсыз, ал сізде 10-ақ минут бар?

Осыған байланысты, бұл мәселені шешу үшін, мен адамдарға қызмет көрсетілуді жеңілдету үшін тиімді жол және уақытты үнемдеу үшін бір әдіс ойладым.

Менің диплом тезисімнің басты идеясы, университетте қолданылатын " SDU Campus system based on RFID technology " жүйесін құрастыру. Мен қолданып жатқан RFID- технологиясы: бұл жүйе кітапханада және асханада қолданылады және университеттегі жұмыс істеп жатқан және оқып жүрген студенттер үшін, біз RFID-картаның қолдану аясын кеңейтеміз, яғни оны адамдар ақша және несие карталарының орнына қолданады.

Бұл жұмыс Е.Н.Амиргалиевтың жетекшілігінде істелінді және бұл тезистің нәтижелері өзіміздің университетте жүзеге асырылады.

CONTENT

Definitions and abbreviations

Definitions and abbreviations

Tag – It is a small chip with antenna. In chip has memory where we can write any data. Through antenna we get signal from RFID reader and send data which RFID-reader need.
Active tag – It is a tag which has small battery. Using energy of this battery tag can send signal.
Passive tag – A tag which do not have a battery lake active tag. It uses energy of RFID-reader to get and send data.
Auto-ID – Automatic Identification. System that helps us to identify any object through waves.
Linear barcode – A one-dimensional, optical bar code. Using this barcode we can get ID of any product
RF – Radio Frequency.
RFID Reader – It is a RFID scanner that helps us to read or scan data from RFID-tag and sends data to host computer which has special software. Also it can write data to RFID-tag.
RFID – Radio Frequency Identification. It is a new technology where uses radio waves to create communication with RFID-tag.
SDU – Suleyman Demirel University. It is university where I am studying and writing new system.
ATM - Automatic teller machine. It is a computer where we can do some operations like send or get money without going anywhere. To use it we have to have card of any Bank.
HOST Computer – It is a computer or mobile phone where we can install any our program which helps us to create communication with RFID reader. In my case I write special software for RFID at JavaFX language.
DBMS – Data Base. To store any data.

1 Introduction

The fast growing technology which we refer to as Radio Frequency Identification (RFID) has large fruitful impacts on various industries. Although RFID is not a new technology, it is becoming more practical in chip manufacturing, especially, in consumer item level tagging. These advancements have the potential to revolutionize supply-chain management, inventory control, and logistics.

At its core, RFID systems consist of small transponders, or *tags*, attached to the objects in nature. We think, these tags are more likely to become widespread microchips. When examined wirelessly by RFID transceivers, or *readers*, tags responses will be according to some identifying information which could be related with some data records. Hence, we can think of RFID systems as a kind of automatic identification system, similar to usual bar codes.

Various applications and settings use different type of RFID systems. Their power sources, operating frequencies, and functionalities vary. RFID manufacturing costs, physical specifications, and performance depend on its specifications and regulations. Examples of some of the most familiar RFID applications are item-level tagging with *electronic product codes*, proximity cards for physical access control, and contact-less payment systems. Lots of other applications are to become useful in the upcoming years.

Our task was to try to solve certain problems of university like queue in canteen and library etc. using RFID card. So we decided to make a "UNI-RFID system". We came up with three applications for canteen, library and ATM to illustrate how they work. RFID card becomes time saving.

Other places where RFID technology might be used include taking attendance, parking cars, opening door etc. But for now we think these three applications are sufficient. We hope to demonstrate other interesting applications after the graduation from master program.

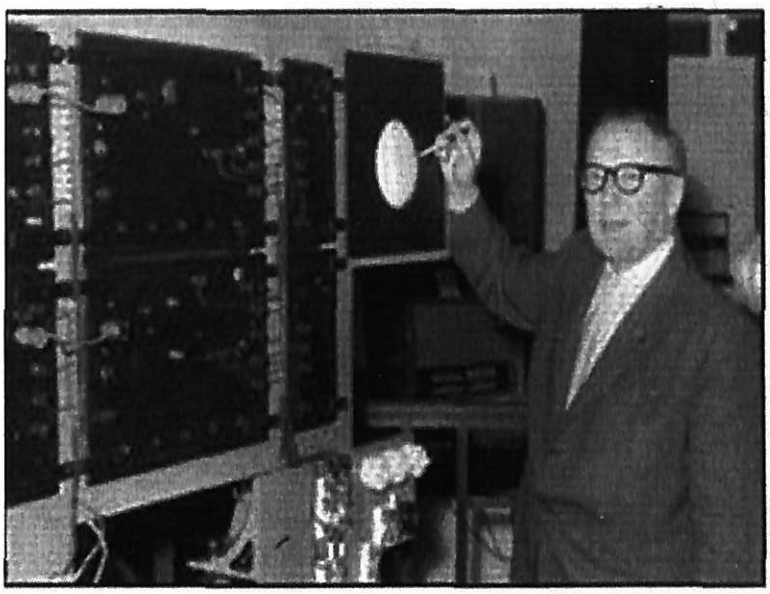
1.1 Some history of RFID

The new technology radio frequency identification was found by people before the World War II. RFID used as radar by British, Americans and the Germans. It was found by Sir Robert Alexander Watson Watt. He was Scottish physicist. The aim of using RFID was to detect planes that flying many miles away. The important thing was to determine is flying aircraft is our or enemies.

First patents for radio frequency identification system was a radio transmitter. Radio transmitter was used to detect object and was designed by John Logie Baird in 1926 [4]. Next patent was Robert Alexander Watson's patent in 1935. It was about "Radio Detection and Ranging" system and it was used as radar. Often in RFID was used the passive communication technology. The first who present it was Henry Stockman. He used it at seminal paper "Communication by Means of Reflected Power" in 1948 [23].

The first passive RFID system was discovered by Germans. If pilot changes way of plane to base, then radio signal was also changed. And it alerted radar which is placed at base and it was meant that it is Germans planes not enemies plane.

The British government enhanced active identity system in the Robert Alexander Watson's project. All British aircraft was able to receive signal sent from RFID transmitter and send signal back to radar which is placed at base. So, using this signal they can understand that it is own aircraft, friends aircraft or enemies aircraft. The RFID system that used now is the same idea. TO send signal and get signal back or read dates from RFID tag.



Picture 1: Watson-Watt with his first radar apparatus

In 1959s and 1960 was improved radar communication system and Radio Frequency. Many scientists started research about RF and found that using RF we can detect or identify object that is placed far away. They were scientists from US, Japan Europe. Many firms started advertising new system. The system was anti-theft system. Using radio waves this system can determine is the product stolen or paid. The idea of system is very easy. RF tag has chip and the memory of this chip is 1 bit. So, we can store there 0 or 1. If buyer paid money this one bit will be 1. It means it paid. But if buyer stole it and goes out of store without paying, the reader which is placed near the door will read it and understand that is not paid and there will be sound of alarm which is says that something stolen in store.

The First RFID Patents

One of the first patent for an active RFID in U.S was in1973 by Mario Cardullo. The active RFID tag was with memory where we can rewrite data. In 1973, capitalist from California who is name is Charles Walton used passive reader and found new system. SO, using this we can open any door without using a key. IN this system we gave RFID-card and RFID reader. When RFID –card near the door RFID reader reads data from tag and compares it with database. If it is the same then the door opens. Walten get license for this new technology.

Scientists from U.S started to work on RFID system about in 1970s. There was many problems and they decided solve them using RFID technology. One of the

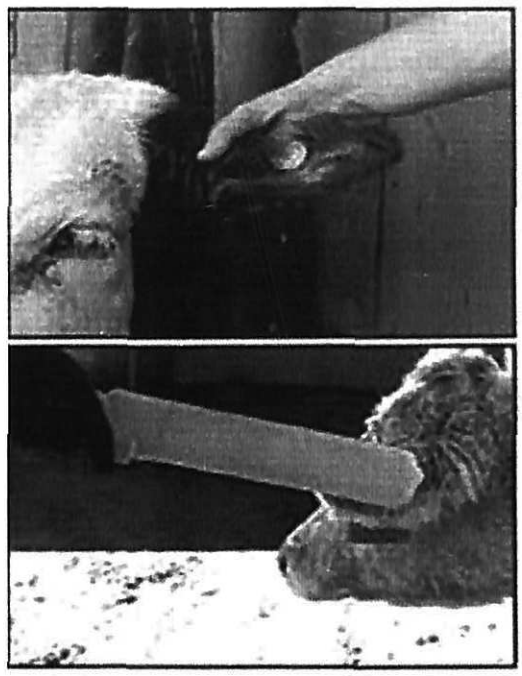
problems was to control pathway of nuclear materials. The National Laboratory on Los Alamos started to work on this project. Some scientist could found very good solution for this problem. They used RFID tag and labeled it to nuclear materials. So, sending signal from base using RFID reader we can control where is our nuclear material. We can write anything in RFID tag. Therefore we can identify our materials from others. In the middle of 1980s many firms started to use it because it was advertised by Los Alamos when scientist who found this system are left laboratory. Nowadays this system is used every especially at tunnels, motorways etc...

Los Alamos built another system using a passive RFID tag. This system used to control cows. When cows become sick we gave them hormones and medicines. But if we give hormones and medicines twice there can be a big problem. For example caw can die. So, scientists are decided to solve it because people can forgot how many times medicine are given. For this scientists are used a passive RFID system. And in this system they used UHF radio waves. IN this system RFID tag gets signal from reader and send signal with data back.

After several years that scientist improved their system. They used low-frequency (125 kHz) and used small transponder. This transponder replaced to under the skin of cows. Nowadays this system is used everywhere. So, anytime and anywhere we can get information about caw because tag is inside caw.

Later scientist started to improve system again. They increased RFID frequency from 125 kHz to 13,5MHz. So, it means we can control our object from far away and the speed became faster. As I said before this system was used to control cows. But after improvement people started to used it for another thing also. Especially in Europe firms started to use it to control containers and so on. Nowadays this system used for others thing also like access and for payment in smart card. Almost all firms use it for anti-theft. If someone stole our object we can determine where our object is now. Also it is placed in keys of cars. When we try to start our car, RFID reader which is replaced in car reads id of key. If they are the same we can start driving. If not the same it means some one wants to steal our car.

In early 1990s, engineers from IBM improved and patented so called Ultra-High Frequency (UHF) RFID system. UHF suggests longer reading scope which is about 20 ft and faster data transferring. When the IBM ran into financial difficulties in the 1990s, they sold their patents to Intermec, which is known as a bar code systems provider. Intermec RFID systems have been installed in various different applications, from warehouse tracking to farming. But this particular technology was very expensive at the time as a result of the lack of sales and the low volume of open, international standards.



Picture 2: Early app: cattle tagging

In 1999 everybody very active, started work on UHF RFID to develop new systems. Especially at the Auto-ID center which is placed at the Massachusetts Institute of Technology. Because firms as Procter & Gamble and Code Council open this center to develop only UHF RFID. David Brock and Sanjay Sarma, two professors from MIT, carried out some research about having low-cost RFID tags on all products made to track them through the supply chain. The brilliant idea was to have a serial number on the tags to keep the cost down. Data related to the serial number on the tag would then be stored in a database which would be reachable from the Internet.

Prof. Sarma and Prof. Brock changed the way people used to think of RFID systems in the supply chain. Before 1999, tags carried a mobile database containg information about the item.What they did was to get RFID into a networking technology by linking objects to the Internet through the tag. For people making businesses, this was a very important achievement since the manufacturer now could simply let their business partners know when a shipment was leaving the dock from the warehouse, the manufacturer would know when the goods has arrived.

Within 4 years, the support for the Auto-ID Center grew very rapidly when over 100 huge companies decided to give the funding. As a result not only in USA but also Europe and Far East there opened new research labs. Auto-ID Center originated two more air interface protocols (Class 1 and Class 0). They were the Electronic Product Code (EPC) numbering scheme, and a network architecture for searching data associated on an RFID tag over the Internet. The licensed of the technology later transfered to the Uniform Code Council in 2003. They later, established EPCglobal, as a joint venture with EAN International, to commercialize EPC technology. In October 2003, The Auto-ID Center shut its doors and its research

continued though Auto-ID Labs.

Some of the biggest distributors in the world such asAlbertsons, Metro, Target, Tesco, Wal-Mart ,and the U.S.A Department of Defense have said they are planning to make use of EPC technology to track products in their provider chain. The pharmaceutical, tire, defense and other industries are also moving to adopt this technology. EPCglobal ratified a second-generation standard during December 2004.

1.2 Identification

For building the trade applications, RFID systems should be considered an example of a wider area of automatic identification (auto-ID) systems. Auto-ID systems attach an identifier name to a physical object so that it can be read automatically. The ways representing the identifier include optical, electromagnetical, or also chemical.

We think that The Universal Product Code (UPC) is one of the best-known auto-ID system in the world. As is well known, the UPC is a one-dimensional, optical barcode which records product and brand information [25]. UPC labels can be found on most consumer products in the United States and worldwide.

The UPC was originally specified by the Uniform Code Council (UCC), a standards body originally formed by members of the grocery manufacturing and food distribution industries. A main body the UCC came together in 1969 to talk about the need for an inter-industry auto- ID system. Aroun 1973, a a linear barcode design was chosen. In 1974, a shop in Ohio, USA scanned the first UPC-labeled good: a package of Wrigley's chewing-gum.

Within a year, the usage of the UPC among the majority of distributors became widespread in USA. Nowadays, about five billion barcodes are scanned around the world per day. 2-dimensional barcodes are used by postal companies such as United Parcel Service, Federal Express, and the United States Postal service, as they are able to carry more data in a smaller surface area .

Clearly, rather than trying to check by hand, Optical barcodes are faster and more convenient. One of the disadventages of optical barcodes is that they need to be in line-of-sight, but sometimes it just might be smudged or obscured by packaging. In most circumstances, optical barcodes still require some human manipulation to align a barcode label with a reader. From ones own experiance sometimes people struggle in scanning an optical barcode.

On the other hand, the Auto-ID systems that transmit data via RFID, do not have these drawbacks as optical systems do. In order to read the data one does not require the line-of-sight and even without human or mechanical intervention it is done automatically. An important benefit of RF-based auto-ID systems is parallelism. Modern RFID systems can read hundreds of items per second.

2 Other Applications

Some of the early trading examples of RFID applications are such as automatic tracking of train cars, shipping containers, and autos. For trackig purposes, the railroad cars were originally labeled with optical bar code. However, from time to

time these labels began to diapear and be obscured by dirt, causing reads to fail. As usual the solution was to tag railcars with RFID devices. Around 1994, these devices were compulsory and almost every railcar in the United States was tagged.

In early 1990s these RFID devices started to be used for automated toll collection. From this date, the electronic toll systems have been started using all around the world. Self-powered RFID devices can be used by electronic toll systems as railway and shipping applications do. Cars, railcars, and shipping containers are all expansive items, with huge physical space that can accommodate more expensive and bulky RFID devices. Compared to simple identification, these kind of tags may offer much more functionality. For instance, shipping containers might have accelerometer sensors, tamper alarms, or satellite tracking integrated into RFID.

Once manifacturing of RFID systems became more efficient and low-cost it started to be used for lower-value goods in industries other than transport. For instance, it started to be used in animal identification of both pets and livestock. Glass-encapsulated RFID devices used in millions of pets throughout the USA. As a consequence, these tags let identify the lost animals and returned to their farm. However, these tags have a very short reading scope.

Devices such as cattle, are usually stamped with an RFID device that is pierced through their ear, attached to a collar. Different from implanted pet tags, these RFID devices are ability to be read from far away. Concerns over Bovine Spongiform Encephalopathy (mad cow) disease have led proposals for universal tracking of devices with such kinds of RFID systems. Like transport applications, animal tracking is still essentially a low-size, expansive market that may justify somehow expensive RFID systems.

Other well known applications of RFID systems are such as contactless payment, access control, or stored-value systems. Since 1997, ExxonMobil gas stations have suggested a system named Speed Pass that let customers to make purchases with an RFID "fob", mostly a keychain-sized [7]. In 2005, American Express announced a credit card that uses RFID letting customers to do purchases without swiping the credit card.

Known as "prox cards", the RFID proximity cards are widely used for entering the building at many firms and universities throughout the world. Similar systems have been used in elevators at ski resorts around the world. In Singapore, they use stored-value RFID proximity cards for subway and bus systems.

There are many applications that use RFID systems as anti-fraud measures. For example, in 2005, the Wynn Casino in Las Vegas first opened and used RFID-integrated gaming tables and gambling tokens. These "chips-in-chips" are designed to prevent theft, detect fraud, and to suggest enhanced games or service. Besides stored-value tokens like casino chips or event tickets, there have also been some offers to tag currency [13]. Around the same year, a proposal to attach tags carrying biometric identification data to United States passports started to be used.

As a result of these applications developers noticed some drawbacks of RFID. To give an example, some RFID technologies do not operate as it should be in proximity to liquids or metals. Certainly, every single technology has its own

advantages and disadvantages, including different in cost, size, power requirements, and environmental limits. There is no "one size fits all" RFID technology. The term itself describes a set of technologies, each of which is applied to different kinds of areas. In Section 3, we discuss these various technologies ne great detail.

Although RFID keeps to lower the costs of tracking high-value items, an untapped market lies in tracking cheap, everyday consumer goods. Companies such as Proctor & Gamble, Tesco, and Wal-Mart have over billions of goods and components in their supply chains. Tracking and managing the flow of products through these supply chains is a complex and expensive attempt.

RFID technology may ease these supply-chain processes and save money. The individual belongings can be traced from manufacturers, through transport, wholesale, and retail into the hands of the consumer where it is sold. It may even be possible to track the used goods when they go for recycling and so on. Yet, this particular ease brings together the privacy concerns and is argued by many people.

In order for the chain management and catalogue control applications to be useful they must be sufficiently cheap. For the cases such as electronic toll systems, animal identification, proximity cards, RFID tags costing about few US dollars might be justified. On the other hand, products in user supply-chain management and catalogue control applications are much economical than in classical settings. One expects that RFID tags in all these applications are to be as economical as in the classical case.

The specifications for low-cost electronic product code (EPC) tags as a replacement for the common UPC was advanced by the RFID standards body, EPCglobal. Before this time, one of the obstacles to RFID adoption was the absance of an open standard. Newly established, the EPC standard and also the ISO-18000 standard [11] are more likely to make it simpler for consumers to integrate the RFID systems.

We think that the ability for EPC is very large. Throughout the world, more than five billion barcode transactions are managed per day. As a result a bit of cost efficiency may impact a large cost savings. The current trade has already started to implement low-cost RFID on a larger scope. Philips Semiconductor, one of the RFID IC manufacturers, has already sent out over billion RFID chips.

Behind RFID embracement we no surprise see the big companies having lots of supply chains. For example, in 2003, Wal-Mart, one of the world's largest retailer, ordered that all providers attach RFID tags to shipping parcels within the three year period [1].Another examples can be seen in the case of The United States Department of Defense [27].

A more detailed instance can be given by the prescription drug industry which requires implementing RFID. The expectation was that the fake drug market to rise to US $75 billion by 2010 [28]. This was a problem for the United States Food and Drug Administration and as a solution they decided to implement RFID pedigrees in their drug shipments. The ultimate aims of doing all these were both testing the authenticity of a drug shipment and detecting the theft.

Some of the companies started implementing RFID earlier. In 2003, razor producer Gillette bought about five hundred million low-cost RFID tags from a producer named Alien Technologies at once [18]. Gillette recyclable razor blade cartridges cost about 1-2 US dollars which is somewhat expansive than the others.

Since these products were tiny, they were more likely get stolen and in fact about 20 percent of Gillette blades were stolen between the producer and the shop. As result, Gillette Company decides to make use of the RFID systems which resulted the decrease in the stolen items.

As an early implementer of RFID we may cite the fashion industry. Many fashion producers such as Ecco shoes, Swatch watch, Prada, and Benetton had the tendency to have RFID labels tagged in their clothing. These tags are typically used for checking the retail stock as the trade clothing stores often face a high level of lost. Besides, buyers are often wants to try on clothing before they buy and this causes a likely displacement of the clothing.

Another usage of the RFID tags in fashion was to determine the kind of some very expansive fashion products. Also, they were used to help the customers to know more about the products. For instance, Prada's retail shop in New York City uses an RFID-enhanced dressing room which shows product information and offers matching.

The RFID is most suited for clothing as the clothing does not involve metals or liquids that may cause a malfunction of some kinds of RFID systems. Moreover, these shops have no electronic devices like medical equipment which may cause some problems for RFID functioning. Yet, another benefit is that the most clothing are expansive per unit and also RFID may be reused after it has been removed from the clothing. These were the main reasons why the clothing industry started the early implementation of simple EAS systems in the 1960s. So, we think that eventually the clothing industry will be a leader in RFID adoption.

A new suggestion for the clothing to make use of RFID could be to adopt tags directly in the product at the time of manufacture, rather than manually attaching temporary tags. This would significantly reduce the cost. For this method to become widespread the tools at hand should become more economical. One possible suggestion from our side would be to print RFID labels directly into paper products while producing. Clearly, this would greatly reduce the processing costs of adoption of RFID for the products used by the shoppers.

Before we start discussing numerous other RFID technologies in detail, we would like to present some of the RFID applications:

- Tracking and identification:
  - Large items, e.g. railway cars and shipping containers
  - Livestock with rugged tags
  - Pets with tags
  - Provider-chain management with EPC
  - Catalogue control with EPC
  - Trade checkout with EPC
  - Recycling and trash disposal

- Payment and stored-value systems:
  - Electronical toll systems
  - Contactless Credit Cards,
  - Stored-valued systems,
  - Subways and bus passes
  - Gambling tokens and theater tickets
- Access control:
  - Accessing buildings by means of proximity cards
  - Ski-elevator passes
  - Concert tickets
  - Automobile starting systems
- Anti-Theft:
  - Casino tokens,
  - High-value currency notes,
  - Luxury products
  - Prescription medicine

3 Principles

In this section we discuss some basics of RFID systems and will try to classify some of the various kinds of RFID systems. Moreover, without going into detail, we discuss two main RFID standards and their application in real life.

3.1System Essentials

From the above discussion the reader may incline to thing of RFID technology as tag devices but it is more that that. In fact, in addition to containing tags RFID systems have other important main components. In what follows we will consider the main three components:

- RFID tags, also called transponders, have object-identifying data.
- RFID readers, also known as transceivers, write and read tag data.
- Databases correspond anonymous records with tag identifying data.

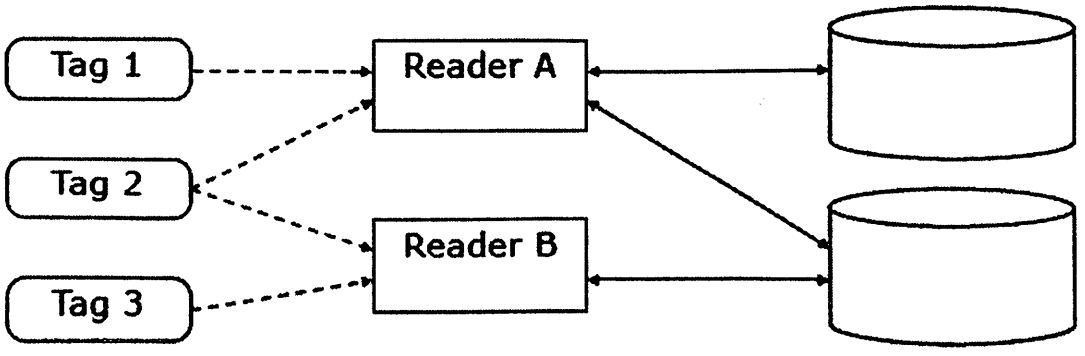


Figure 1: Illustration of RFID System Interaction

In Figure 1, we mention the interaction of these three components as follows. In Figure 1, there are three tags on the left that are readable by one or both of two readers in the middle which are denoted by A and B. For example, as shown in the

figure, tag one is only readable by A, while tag two is readable by both A and B, one reason might be related to controlling restrictions. Once the readers get info from tags they get in touch with databases on the right to relate the info with records at hand so that they may identify the tags. In current situation, two databases both have their own record for tag one.

3.1.1 Tags

Tags are attached to all kinds of materials with the view to be identified in a given RFID system. Usually, tags consist of certain kinds of antennas or coupling elements, and also integrated circuitries. One important difference which we plan to discuss later is the tag's sources of power. Usually, there is no power attached to tags yet they are more likely to get the necessary energy from an RF signal.

The place of use of tags varies. Also, different tags are more likely to have different power sources. Also, the radio frequencies associated to them may be different. As a result, for different applications and purposes one may need a certain kinds of tags and accordingly one expects that the cost varies depending on which tags one need to use.

Current tags inclined to adopt identification functionality on an integrated circuit (IC) that gives computation and storage. In the construction process, the IC is attached or "strapped" to an antenna right before the tags being packed, like a glass capsule or foil inlay, that is related into a final product.

In real life situations, each dealer tend to do each of these manufacturing steps. Some different RFID designs can come "chip less" or have identifying information fixed once for all, that is, they may be called "write-once, read-many" tags.

3.1.2 Readers

RF channel is the way RFID readers get in touch with tags so that they may get information for identification. For certain types of tags the communication may be simple and for other types of tags this communication may become very complex. For systems and products having more than one tags, the related reader might need to do an anti-collision protocol so that there are no mistakes and communication failures. These so called anti-collision protocols allow the reader to quickly communicate with more than one tags in short time in an ordered fashion.

Readers often behave like power sources and deserve the name passive tags through their RD communicating channel. Such kinds of tags have no on board power and only may rely on a reader to function. In particular, these tags have limited ability and hence again in need of a reader even to do certain computations.

There are many types of readers with different shapes and each of which function on many distinct frequencies, and suggest a wide range of functionality. Some of the readers have their own power to do the job and have their own storage capacity in addition to giving some network connectivity. Some readers may have simple way of storing the data by means of local accessibility and some may offer to store the data in an external system.

Nowadays, lots of applications depend on constant devices that do the reading. Before the time of using EPC, some of the very big superstore chains were related to fixed readers into docking-bay entrances. Such kinds of readers can do scanning the tags at the pallet levels once the shipments of products come to the store. In the future, readers might be integrated at a shelf level as a "smart shelf ". This way, these so called the smart shelves would be able to scan the tags at the item level and monitor once they takes their part in a certain shelf.

Another interesting feature of RFID readers is that they may be adapted to a mobile device which makes life easier. As result, just taking these mobile readers with us we may be able to, say, take inventory of a sale house by walking through its aisles. The Nokia whom we are known as a cellular phone maker has started offering RFID-reading functionality in some of their mobile phones [16]. Provided that EPC-like tags become highly fruitful, interesting and attractive then the consumer applications may rise. In this case, RFID reading functionality may become a common specification on all kinds of mobile devices.

3.1.3 Databases

The functionality of RFID databases is related to relating tag-identifying data with some records. For example, such records could contain information about the product, information about sales, tracking information, and date of expirations. Not necessarily related databases can be built throughout a supply chain by independent customer, and sometimes may even be integrated in a centralized database system.

Clearly the secure connections of Databases are crucial for the users and are often the case. Yet, in certain occasions the readers should not be trusted. In this case, it may be a good idea to collapse the notions of reader and database into one entity. For instance, if a certain tag includes some relevant information about the good, then there should be no need to get in touch with an off-site database.

We can think of a federated system of back-end databases, such that each product producer manages their own product search service. In these circumstances, it may be good idea to open an Object Naming Service (ONS) to match the databases associated with the given tag identification value. In this way, the ONS gives an ability to a reader to get a set of databases associated with a particular tag identification value. This is similar to the Internet Domain Naming Service (DNS) which returns addresses of name servers that can translate domain names to numerical IP addresses. As of today, ONS has not yet been used widely in practice.

3.2 Power Sources

As we pointed out earlier, tags have several different ways of getting their power. Clearly, the power source is an essential property associated to a tag, as it will give us an idea as of a tag's potential read range, lifetime, cost, and what sorts of functionalities it could suggest. The power source is also important as it tells us how we should consider the orientation of the tag and how it looks like.

We may classify the types of tag power sources into three categories which we call active, semi-passive, and passive power sources. As you may guess, the active

tags have their own power source, such as a battery, and have ability to start communicating with readers with other active tags. Having its own power sources has an advantage of being much longer operating range compared to passive-tags. Active tags are used for instance in large asset and livestock tracking applications as the items they are attached to such as big containers are high in value and have a large space for bigger tags such as active ones.

The important property of active tags is that they can begin their own communication with readers. Advanced active tags such as "smart dust", can also form ad hoc peer networks with each other. One of the beneficial applications of active tags is in shipping containers, which can fall off the boats over bag weather conditions. These missing containers often are not realized for until well after the ship has docked. However, if it has the active tag attached to it then with a sensor it may be detected when it off containers and broadcast a log of its demise before it sank into the ocean. Active tags could also function as security alarms using the same functionality.

On the other hand, a semi-passive tag has an internal battery, but is *not* able to start the communications. In other words, they become active only if it is initiated by a reader. Clearly, due to being self powered the semi-passive tags do offer a longer reader range than passive tags, but they cost more than the passive tags.

An example application that uses semi-passive tags are the electronic tollbooths. Semi-passive tags are typically attached to the inside of a auto's windshield. When the car passes through a tollbooth, it get initiated to the semi-passive tag and read an account identifier from the tag. Existence of battery lets the tag be read from a considerable distance. But, since the tag only needs to broadcast when queried, it will stay idle most of the time which saves the power. Another usage of the semi-passive tags are when keeping the track parts like automobile parts during manufacture.

Finally, the passive tags have neither their own power, nor the ability to start the communication. Passive tags get their energy by gaining it from an incoming RF communication signal. When the frequencies are low, this energy is typically harvested inductively, while at higher frequencies it is harvested by means of capacitance.

While passive tags have the shortest read range of all three powering types, they have benefit of being the cheapest to manufacture and the easiest to integrate into products. Batteries are relatively expensive and cannot easily be incorporated into some items, like paper packaging. For this reason, passive tags are the most common tags. For instance, the EPC tags are passive.

Absence of the internal power source means less abilities of passive tags. First, as mentioned before without outside power source they cannot function, even though these tags may have an ability to temporarily save some energy in a capacitor. Also, due to their necessarily weak response signal, passive tags are often environmental noise or interference sensitive. In Table 1, we compare various properties of passive, semi-passive, and active tags.

Tag Type	Passive	Semi-Passive	Active
Power Source	Harvesting RF energy	Battery	Battery
Communication	Response only	Response only	Respond or initiate
Max Range	10 M	> 100 M	> 100 M
Relative Cost	Least expensive	More expensive	Most expensive
Example Applications	EPC Proximity cards	Electronic tolls Pallet tracking	Large-asset tracking Livestock tracking

Table 1: Passive, Semi-passive, and Active tag comparison.

3.3 Operating Frequencies

Different RFID systems operate at numerous radio frequencies. Each of the frequency ranges has its own functioning range, necessary power, and ability. Distinct ranges could be subject to different restrictions that limit what applications they can be of use.

The functioning frequency tells us which physical materials propagate RF signals. For practical purposes, the metals and liquids cause a lot of problems. For example, tags functioning in very high frequency (VHF) range do not function properly in close distance to liquids or metals.

Operating frequency is also related in determining the physical dimensions of an RFID tag. Depending on the sizes and shapes of antennae the functioning frequencies changes. The operating frequency also gives us an idea as how the tags interact with each other. To give an example, attaching flat foil inlay tags on top of each other are more likely to obscure tags from reading properly. In Table 2 we lists some of the standard frequencies and their respective passive read distances.

Frequency Range	Frequencies	Passive Read Distance
Low Frequency (LF)	120-140 KHz	10-20 cm
High Frequency (HF)	13.56 MHz	10-20 cm
Ultra-High Frequency (UHF)	868-928 MHz	3 meters
Microwave	2.45 & 5.8 GHz	3 meters
Ultra-Wide Band (UWB)	3.1-10.6 GHz	10 meters

Table 2: Common RFID operating frequencies

3.3.1 Low Frequency (LF)

The range that the low frequency (LF) RFID tags typically function is the 120-140 kilohertz. Most commonly, LF tags are passively powered by means of induction. As a consequence, they often have very short read ranges of 10-20 centimeters.

As discussed, LF tags can be used in rugged environments and can function in existence of metal, liquids, or dirt. This makes them advantageous for applications like implantable pet identification tags or laundry functioning tags. One drawback of

LF tags is they have a very low data read rate compared to other functioning frequencies.

Car immobilization and access control systems mostly make use of LF tags. In these systems, an automobile starts only if an LF tag which is attached to the ignition key is nearby the ignition. This takes advantage of LF's short read range and is more secure.

In 2006, LF passive tags were purchased in bulk for US$1 per tag or less. Two main producers of LF tags at that time were Texas Instruments and Phillips Semiconductor. The ISO 18000-2 standard suggests specifications for LF RFID tags [9].

3.3.2 High Frequency (HF)

High frequency (HF) RFID tags function at the 13.56 megahertz frequency. HF tags are often packaged in a foil inlay or debit card form. This makes HF tags beneficial for building access control, contact-less credit cards, and ID badges. Again, the short read range of HF is a benefit in all these settings.

HF tags are also used in many item-tracking applications. Bookstores and libraries usually use HF foil inlays to track books. Some airports have started using HF RFID luggage tags for baggage handling applications.

HF tags have higher data reading rate compared to LF tags, but do not function as nice as LF tags in nearby metals or liquids. Yet, still HF tags suggest better performance near metals and liquids than UHF tags do.

The range of the HF frequency tags lie on a mostly regulated part of the radio spectrum. However, the signals broadcast by readers should function in a narrow frequency band. This is a problem for environments with sensitive electronics such as medical equipments that function in the proximity of frequencies. As a result, this makes HF tags not adequate for environments like hospitals.

In 2006, the price of HF passive tags was about US$0.50 or less per tag in quantity. Texas Instruments and Phillips both manufacture HF tag lines, although there are many lesser and focused manufacturers or integrators in the HF space.

International Standards Organization (ISO) specifications for HF RFID tags are specified by the ISO 18000-3 standard. Also, the specifications for HF contactless smart cards and proximity cards appear in ISO standards 14443 [9] and 15693 [10].

3.3.3 Ultra-High Frequency (UHF)

Finally, Ultra-high frequency (UHF) RFID tags function within the ranges of 868-928 megahertz. The tags in Europe usually function in the 868-870 MHz range, while in the United States and Canada they function in 902-928 MHz.

As we mention earlier, the UHF tags are very usually used for product tracking and supply-chain operation applications. The main reason is that they give a longer reading range and are cheap to produce in bulk than LF or HF tags. The very first EPC tags function at UHF frequencies.

One of the main obstacles of UHF tags is that they have a problem of interference in proximity to liquids or metals. For the kind of applications such as

metal container tracking, animal tracking, or even some access control systems are inconsistent with UHF tags. Some materials have been constructed so that they may protect UHF tags from metal-related distortion, but such things may be cost for the practical use. UHF readers may also interact with sensitive electronics similar to medical equipments.

Compared to LF and HF tags the UHF tags are a relatively newer and reader prices are typically higher than the lower LF readers. In 2006, UHF tags were purchased in quantities for under US$0.15 per passive tag. UHF tags costing as low US$0.05 are most likely to come onto the market in coming years. Properties for RFID tags functioning at UHF frequencies are defined by both the ISO 18000-6 [11] standard and the EPCglobal standard [6].

3.3.4 Microwave

Other kinds of tags are so called Microwave tags which function at 2.45 and 5.8 gigahertz. We call this frequency range is as the super-high frequencies (SHF). Microwave RFID technology has become very attractive and is fast increasing. Microwave tags used in practice are usually semi passive or active, however they may also be in passive form. The semi-passive ones are mostly used for purposes such as flight identification and electronic toll applications.

A microwave system has higher reading rates than UHF and also passive read ranges. Compared to UHF the reading ranges of microwave semi-passive and active tags are higher. However, some microwave active tags can be read from ranges about 30 meters, which is less than UHF counteracts. We note however that physical adaptations of microwave RFID tags could be much smaller and compact than lower frequency RFID tags.

There are some drawbacks of microwave tags. One disadvantage is that they spend comparatively more energy than their lower-frequency counterparts. Also, the microwave tags are often more expensive compared to UHF tags. Available active tags in the marked were priced about $25 per tag as of 2006.

To mention another shortcoming of them is that the wireless 802.11b/g (Wi-Fi) networks are more likely to conflict with microwave RFID systems. The upcoming ZigBee 802.15 wireless standard using products could also potentially interfere with microwave RFID devices as well.

The ISO 18000-4 and the rejected ISO 18000-5[11] standards suggest respective specifications for 2.45 and 5.8 gigahertz RFID tags.

3.3.5 Ultra-Wideband (UWB)

Ultra-wideband (UWB) technology applied to RFID has been started using very recently. Instead of referring a strong signal on a given frequency, UWB uses low-power signals on a very broad scope of frequencies. The signal on a particular frequency used by UWB is very weak; however, communication is quite robust. In real life, some UWB tags are used from 3.1 to 10.6 GHz.

UWB are very beneficial in the that it has a relatively long scope of reading range, maybe 200 meters in some vases. Metal or liquids are not a problem with UWBs. When the signal on some frequency is weaker, UWB does not interact with sensitive equipment. Hence, it can also be used in hospitals.

On the other hand, a drawback of nowadays adaptations of UWB is that it cannot be a passive tag. Though, they not need power a lot as they function in very weak signals. As of 2006, it is not certain if the companies can construct passive UWB tags.

UWB RFID technology is in its young ages and there are not many commercial items obtainable. It is expected to have a price of US$5 per tag in reasonable time.

3.4 Functionality

The very important and main RFID functionality is identification. After getting communicated by a reader, the tags return identifier that can be used to recover other data records. Moreover, tags can have much other productivity useful in numerous applications. The necessary principles and technologies of all the different kinds of tags are so closely related to strict RFID tags, which they often collectively referred to as "RFID". We now mention some main classes of RFID-related devices.

We divide RFID-style tags into five broad classes: EAS, read-only EPC, EPC, sensor tags, and motes. We will be referring them as classes A from E. EPCglobal also suggests five alike classes of tag depending on functionality dubbed Class 0 through Class 4. Although, the EPCglobal classes closely align with ours, but differ somewhat. These five classes are summarized in Table 3.

Class	Name	Memory	Power Source	Features
A	EAS	None	Passive	Article Surveillance
B	Read-only EPC	Read-Only	Passive	Identification Only
C	EPC	Read/Write	Passive	Data Logging
D	Sensor Tags	Read/Write	Semi-Passive	Environmental Sensors
E	Motes	Read/Write	Active	Ad Hoc Networking

Table 3: Tag Functionality Classes

Class B and class C devices encounter some economical problems and alo technical ones. EAS tags have very limited action and very very cheap to produce. On the other hand, class D and E devices suggest sufficient functionality to justify higher production costs and may suggest relatively ample resources. The challenge "sweet spot" lies in class B and class C devices, as they are parts of certain crucial systems, but are still subject to tight resource and cost constraints.

3.4.1 Electronic Article Surveillance (EAS)

EAS tags are the most basic RFID-type tag and have been in market for about 40 years now. EAS tags are not really RFID tags as they do *not* contain unique identifying information. Yet, they just announce their existence to the reader. That is to say, EAS tags broadcast a one bit of information – "Someone is here".

In real life examples, EAS tags are mostly passive and are usually added to things like clothing products, compact discs, and books in retail locations. EAS tags could be active or semi-passive, but then they get more expansive Because of their limited activity, EAS tags are the very simple and cheap to produce.

3.4.2 Read-only EPC

EPC tags differ from EAS tags, in that they contain some identifying information. EPCglobal call these tags as class B tags. The information could be an item code or a unique identifier. Read-only EPC tags have a single identifier that is written once when a tag is produced. Thus, class B tags offer strict RFID functionality. Class B tags are more likely to be passive. Even though there may be semi-passive or active, once again the price of a battery would be higher.

As it is clear from its name, the essential purpose of EPC tags are to track items. In addition, there are lots of other interesting applications of tags, such as smart cards or proximity cards, are using tags with read-only memory that suggest easy identification. As the read-only EPC tags are very simple and are sometimes "chipless", they are relatively cheap.

3.4.3 EPC

As far as Class C concerned, they are simple identification tags offering write-once, read-many or re-writable memory. Instead of having an identifier set by the producer, identifiers can be set by the last user. In case an EPC tag has re-writable memory, this means that its identifier can be changed on several occasions. Class C tags suggest strictly RFID functionality.

Class C EPC tags may be used for logging purposes and might be compared to Class B read-only EPC tags. In practice, class B EPC tags might be passive, semi-passive, or active. Strict RFID functionality contains class B tags. If one wants to add writable memory it puts the complexity to class B tags. As a result, they are more likely to be more expensive than read-only EPC or EAS tags.

3.4.4 Sensor Tags

Sensor tags might have environmental sensors attached, and can log and store data without the reader's help. For such kinds of tags we call them as class D tags. Sensor tags have more than strict RFID functionality, and are mostly not thought of as RFID.

Lots of sensor tags can group a "sensor net" that monitors a physical area's environmental features. As such, it can admit temperature changes, changes in orientation, rapid acceleration, vibrations, the presence of biological or chemical agents, light, sound, etc. Due to the fact that they function without the help of a

reader, sensor tags has to be semi-passive or active. An attached power source and sensor functionality comes at a much higher production price.

3.4.5 Motes

Class E tags known as "smart dust" motes [17], are able to ignite communication with other devices, and form impromptu networks. Motes are importantly general widespread computing devices and are much more complex compared to simple EPC-style RFID. Because they can originate their own communication, mote devices have to be active. Motes in market are available from Crossbow Technology. Ongoing research into smart dust and motes is being carried out at the University of California, Berkeley and Intel.

3.5 Standards

The International Organization for Standardization's ISO/IEC 18000 standard [11] and EPCglobal's standards are the two major relevant RFID standards. These standards are not competing, and it is more likely that EPCglobal'sx standard may be implemented into an ISO standard.

EPCglobal defines specifications for EPC-type tags functioning in the UHF range.

The ISO 18000 standard has 6 parts addressing different frequency ranges:

- Part 1 – General standards
- Part 2 - LF
- Part 3 - HF
- Part 4 – Microwave, 2.45 GHz
- Part 5 – Microwave, 5.8 GHz (withdrawn)
- Part 6 - UHF

Two other ISO standards, ISO/IEC 14443 [9] and ISO/IEC 15693 [10] are related to smart card and proximity card interfaces functioning in the HF range.

4 Challenges

4.1 Technical

There are many technical challenges and obstacles that RFID encounter in practice. The main concern is just having RFID systems work in practical environments. In a Lab the systems may be working great while the same situation may ne happen especially facing with the environmental noise and human elements.

To give an example, around 2005, RFID pallet-level tracking was tested by a big seller chain in their shipping and receiving cargo bays. The seller then got into problems in achieving near 100% reading rates and unanticipated, ordinary technical concerns. On the other hand, these problems are expected to be resolved once the implementation becomes more frequent.

Sometimes, readers and tags experience interference due to other wireless systems. Such interventions are not systematic but mostly follow from the surrounding environments. In order to resolve these problems one needs trial and

error, and practical experience to recognize what the problem due. For instance, changing the locations or alignments might resolve the problems in many cases.

Software that support RFID tags are yet in their young stages. Getting spread out the database look-ups to work in practice is a complex mission which requires a lot of work and is usually hided in RFID literature. For instance, key operation and network connectivity problems are usually not focused well. Many retailers currently offer RFID software solutions. However, in future it is probable that the industry will split onto several standardized software interfaces.

The reason why we discussing this point is to point out that like many information technology systems, RFID systems needs some practical expertise to install, function, and configure. The owners could expect to experience certian common technical issues related to using RFID. Inspite the marketing says the converse, RFID is not a "magic tool" which is easy to implement out of the box.

4.2 Moneywise

The main obstacle which still stays in RFID systems is their pricing. Especially EPC item-level tagging are a bit coasty. So called the economic price is US$0.05 per UHF tag.

As of 2006, such 5 cent tags went extinct. However, without packaging Tag ICs alone cost about US$0.08, although such tags are sold as a loss leader. We should wait for couple more years when tags are more likely to be available at the 5-cent price, and those will only be in huge quantities. However, this may be an artificial breakpoint. Many applications could very well take use from more expensive tags.

Another issue is the price door readers; again, especially UHF readers, which are sold in 2006 for over US$1,000. For such a price, many companies may only support a small number of readers in loading retailers. "Smart shelves" that incorporate readers throughout a retail or warehouse environment could be too expensive for most applications.

With the growing market, RFID costs will drop and hopefully some innovative applications should become cheaper, especially as more investment is made into back-end architectures. However, for the coming decade, the price for many planned applications, particularly for EPC tags, are simply not cheap enough.

4.3 Security and Privacy

A lot of worries have been pointed out relating the security and privacy old RFID systems. Old fashion applications such as large-asset tracking were usually closed systems in the sense that they have sensitive information. Tags on railway autos included the same information painted on the side of the autos themselves. On the other hand, once there are many applications improved security, and especially privacy, would become important issues.

Lots of work has recently emphasized on security and privacy problems of RFID. Gildas Avoine wrote a comprehensive knowledge of RFID security and privacy papers. Ari Juels suggests a survey of RFID security and privacy concerns

[12]. Interested readers are encouraged to refer to these references for a more comprehensive analysis.

4.3.1 Eavesdropping

One of the biggest security issues in RFID systems are espionage and privacy threats. As companies start implementing and integrating RFID into their supply chain, more and more important data will be added on RFID tags. As these tags helplessly end up in consumer hands, they could leak sensitive data for tracking individuals.

An attacker who is able to eavesdrop from a long range may want to spy on a passive RFID system. Although the passive tags have a short operating range, a quality reader might be used to monitor from a long distance. This is because the reader signal actually carries the tag's power.

As a result, a reader connected with a passive tag in, for example, a UHF setting could be monitored from a range up to 100-1000 meters. Although this is just one side of the story, some older protocols may in fact broadcast sensitive tag data over the forward channel. Newer specifications, like the EPCglobal class-1 generation-2, can be used to avoid this.

In spite of the fact that a short-range eavesdropping requires close physical access, it can still be a threat for lots of occasions. For instance, a spy may be carrying a monitoring device while a the store conducts its daily inventory.

Espionage is not necessarily passive. Attackers may actively question tags for their contents. Rather than waiting to eavesdrop on some readers, an active attacker could simply direct tag read operations by itself. Active attackers could be easy to detect in a closed retail or warehouse environment, but may be difficult to detect when it is open.

Personal privacies become under threats by eavesdropping. As mentioned, RFID tags can be embedded in clothes, shoes, books, key cards, prescription bottles can have RFID tags attached to them. In all these cases the buyer is not even aware of this. If not secured properly, an outsider may access to your belongings and know which drugs you have, which books you are reading, perhaps even what kind of underwear you prefer.

A lot of people are very concerned on RFID. In 2003, clothing maker company Benetton intended to label clothing with RFID and was boycotted by several groups at once. Hence, for companies RFID implementation might be a serious drawback.

Not only outsider may get to know about the sensitive data but also may be tracking where you are heading. No doubt those mobile phones may already track people. However, cell phones can only be tracked by the producer and for RFID tags it is really anyone with bad intention may be able to track you. Besides, the readers will become cheap sooner or later so that many can have them.

Once the outsiders gets the unique identifying numbers from tags you carry it they can track you in no time. A unique fashion love may let people physically track you through an area by your set of favorite brands.

We refer the reader to Juels' survey [12] and Avoine's bibliography [1] about how some privacy countermeasures can be taken to decrease the current threads.

4.3.2 Falsification

Instead of trying to gather data from legitimate tags, commercialists may try to imitate tags to readers. This causes a risk to RFID systems that are now being used for access control and payment systems. While someone can physical obtain a tag may also copy it. The main risk is somebody can copy the tags wirelessly and get information which may then be used to produce forgeries.

Forgery is clearly a main concern in RFID systems used specifically as an anti-counterfeiting device. For instance, Food and Drug Administration (FDA) in USA proposed attaching RFID tags to prescription drug bottles as identification [8]. If somebody only steels the tag information we may be seeing lots of fake drugs around with legitimate tags.

To give an example put the ExxonMobil Speed Pass, which uses an RFID keychain fob which lets their customers to buy at ExxonMobil gas stations [6]. A group of scientists from Johns Hopkins University and RSA Security broke the security in Speed Pass and generate forgeries that could be used to do shopping at retail places [5].

Luckily, cheap security countermeasures have recently been developed which allow readers to verify tags. For instance, Juels and Weis suggest a cheap way of authenticating protocol based on a hard learning issue which is efficient to adapt in tags [14]. However, as of 2006, these protocols are not yet available commercial products.

4.3.3 Denial of Service

The attackers who were not able to accomplish the espionage could still be able to sabotage RFID systems. They may simply prevent the communication channels and block the readers from identifying tags. An outsider may also extract a physical space with "chaff " tags intended to confuse legitimate readers. Locating and removing chaff tags are usually difficult in practice.

Some electromagnetic signals which are very powerful may physically destroy RF systems in a destructive denial of service attack. Luckily, from longe scope, attempting these attacks requires so much power that it will affect other electronic components and can be detected.

While these denials of service and sabotage attacks seem to be not very important, they may bring some very serious risks. This is indeed the case for defense or medical applications. For instance, the United States Department of Defense is inclined towards RFID-based logistics control. A possible attack on the RFID infrastructure may delay important shipments of war materiel amy may slow down troop deployments.

4.3.4 Viruses

In 2006, researchers illustrated an RFID virus based on an SQL injection attack [21]. The virus payload was an SQL database query that could overwrite the current RFID identifiers in the database with the virus payload. Once the tags were updated from the infection, the virus would be propagated.

This virus has RFID essential contents "executed" without any validation. It may also block the future reads as an infected system can overwrite tag contents, this is not usually the case in practice. In deed, nothing about the virus was specific to RFID systems. Inputing from any place, whether a network connection, USB port, or keyboard, could spread viruses when executed insecurely.

5 Future Technologies

The Two printed circuits and organic components seem to be technological developments related to RFID are [24] [26]. Such technologies may in the future decrease the prices for production and to manufacture RFID tags made of flexible plastic materials.

In the long term, big packaging producers may print RFID tags directly into paper or plastic as getting done. Item makers would not use this RFID enhanced packaging material as they often do. One benefit in the sense of privacy is that RFID tags could only be attached to product packaging instead of the product itself.

It will take some years until this technology becomes economic and there are lots of issues needs to be addressed. At present, circuits printed by an inkjet offer a very low resolution; circuit gates take much more surface area than traditionally fabricated circuits. Technologies similar to gravure printing also manufacture large circuit surface areas.

Anyway, a lot of research is being emphasized on organic components for purposes such as flexible displays. Such developments would be useful for RFID, potentially opening the door to many inexpensive and interesting future applications.

6 Used Technology

6.1 List of used programming Language

6 MySQL
7 Java
8 JavaFX

6.1.1 MySQL

MySQL("My Sequel") is a programming language. This language helps us to work with DBMS. In DBMS we store our data. There can be any data. For example: String, number, picture etc... When we work on any program we have to always get data and save data. In such situations we use MySQL language. Using this language many users can get any data from server simultaneously. MySQL developed by Micheal Widenius. The phrase SQL means Structured Query Language.

MySQL is free language. So, everybody can download and use it. When this language is found it belong to Swedish company, but later Oracle Corporation owned it. But not all MySQL is free. If we pay money we can use extra features of MySQL. Now all programmers use MySQL. Especially those who write web applications. Nowadays big companies as Google, Facebook and Wiki also use MySql.

The applications which use MySql are php, Joomla and Drupal.

MySQL is a database management system. Nowadays it is most used language to manage DBMS. Most of people choose this language because it is very secure. It is very important for DBMS because we store data. For example our login and password. So, only we have to know about it. If someone can get my password we can use my email and it is very big problem especially for big companies. Therefore security is very important.

The next advantage of MySql is we can work with one server and with many servers simultaneously and we can store many data. It can be more than gigabyte.

```
public var driverName: String;
public var jdbcUrl   : String;
public var user      : String;
public var password  : String;
public var driver    : Driver;
public var conn      : Connection = null;

public function connect() {
Class.forName(this.driverName);
this.conn = DriverManager.getConnection(this.jdbcUrl, this.user, this.password);
}
```

Above you can see example of source code. First, to create connection with DBMS, we have to upload "mysql-connector-java-5.0.8-bin.jar" file. Because NetBeans cannot create connection with DBMS itself. Then if we have connection we have to check it and write username and password etc... Above you can see source code where we get connection. To get connection with DBMS I used java file and there get connection.

```
var rs:ResultSet;
var stmt:Statement = null;
var db = Database{
        driverName: 'com.mysql.jdbc.Driver'
        jdbcUrl   : 'jdbc:mysql://localhost/bakhytzhan'
        user      : 'root'
        password  : ''
}
```

Above you can see another part of code. It is not a java language. It is a JavaFX language. In JavaFX file to do some functions I have to create connection

with DBMS using java file where I get connection with DBMS. Now everything is ready and I have to just start connection then I can do everything what I want to do.

```
try{

        db.connect();
        stmt = db.conn.createStatement();
        rs = stmt.executeQuery("SELECT * FROM studentinfo WHERE
      `login`='bakitcan32'");
          while(rs.next()){
                  label2.text="Name: {rs.getString("name")}";
                   welcome.text="Surname: {rs.getString("surname")}";
                   studentid.text="ID: {rs.getString("studentid")}";
                  group.text="Group: {rs.getString("group")}";
                  password="{rs.getString("password")}";
                 }
    }catch(e:Exception){e.printStackTrace();}
```

Above I start connection and using keyword "SELECT" I get all information of student whose login is "bakitcan32" from table the "studentinfo". Then using I showed these information's at my software.

6.1.2 Java

Java is a one of the most used programming language in our days. Developer of this language is James Gosling. He worked at Sun Microsystems and developed Java platform in 1995. Java language's syntax is the same as C and C++ but Java is improved version and there is many advantages. One of the big difference of Java then C and C++ is Java object-oriented language. It means we can write one function and use it anywhere. Java runs at any computer where has Java Virtual Machine(JVM). Most of firm and companies started to develop applications or web applications at java language. Because it is better than other languages, more secure, many features and more reliable.

It is free language. So, everybody can download and use it. WE have to just download compiler for java and use it.

The First developers of Java are Mike Sheridan and Patrick Naughton. It was in 1991. The idea was to develop new language for interactive television. In 1991 everybody call this language Oak then it was changed to Green. Later developers decided rename it again and chose one word randomly from list. It was the word "Java".

The first version of Java 1.0 was developed in 1995. Everybody started to call this language "Write once, run anywhere". Later version was improved. Developers added applets. So, programmers can use it at web applications. In 1998-1999 was developed Java 2 version with many features. Later, developed version J2ME. It is needed to develop application for mobile phones. Another version is J2SE to develop

standard applications. Nowadays developed J2EE Enterprise edition and all companies started to use this version because there is many advantages and easy to develop any application.

One of reasons why I chose java language is it is more secure and it is easy to write software. These two things are very important for me because in my project I use my RFID-card as Bank card therefore for me security is very important and my project is very big project but developer is only me. To finish project at short time I chose Java because as I said before at Java language we can write one function and use it anywhere where we want.

```
public void getInfo(){
    File file = new File("D:\\[Dissertation]\\SOFT\\log.txt");

     try {
         BufferedReader reader = new BufferedReader(new FileReader(file));
         text = null;
             while ((text = reader.readLine()) != null) {
             break;
             }
          }
        catch (FileNotFoundException e) {
         e.printStackTrace();
         }
```

Above you can see example of java source code. I created a function named "getInfo" to get info from txt file. So, first I opened my "log.txt" file using keyword "File". Then using keyword "BufferedReader" I read all info from txt file and save it as text in my software to use it later.

6.1.3 JavaFX

JavaFX is a one of the programming language. It is developed in 2010. This language developed for Web applications, blue-ray players and desktop applications. It is similar to Java language. Inside JavaFX we can use Java language and it work everywhere where works Java or where we have Java platform. One of the big disadvantage of java is we can't create application with good design. But at JavaFX we can create software with good design because one of the reasons of developing JavaFX was for good design. At JavaFX it is very easy to create any design and also using timelines we can create any animation that we want. I chose JavaFX because my applications are desktop applications. So, design must be good because thousand students will use it. But there are one disadvantage of JavaFX. To create desktop application with animations the computer must be with good characteristics. But I think it is not big problem.

```
static var readDateCounter = Timeline {
        repeatCount: Timeline.INDEFINITE
        keyFrames : [
          KeyFrame {
            time : 0.5s
            action: function() {
                  get.getID();
                  }
             }
          }
        ]
    }
```

Above you can see example of JavaFX source ocde. Here i created timeline. Using function timeline we can do some action at every time. Here we can set time. İ set time "0,5s" and i have a function. İnside function get ID of user from function getID(). So, i have to check ID of user always because it changes everytime. For such kind of situatiuns it is very good to use timeline and it is very easy. At java language we use it as "timer" .

```
var background = Timeline {
       repeatCount: 1
       keyFrames: [
              at (0s) {main.layoutX => 620.0}
              at (0.5s) {main.layoutX => 10.0 tween Interpolator.LINEAR}
       ];
}
```

Above you can see another part of code of JavaFX. İt is also timeline but here i used it to create animation. İt is very big advantage of JavaFX. At another languages we cannot do it or to do it we have to write at least 200 rows of code. But at JavaFX as you can see to create animation is very easy. Using keyword "repeatCount" we can say how many times our animation is have to work. My animation starts from pixel 620. Then at 0.5s it changes layout to 10. So, my main page comes from right to left. One of the reason why i choos JavaFX is timeline. I can create it very fast and it will not take my time. Using this timeline i can create project with good design and with effects.

6.2 List of used program

1. NetBeans IDE 6.9
2. XAMPP 6.3a

6.2.1 NetBeans IDE

NetBenas IDE is framework for programming languages. Using NetBenas IDE we can develop project with Java, C, C#,C++,JavaScript and Ruby etc...

NetBenas IDE works at any computer with operating system as Window, Linux, Mac OS where works java language and where installed JVM.

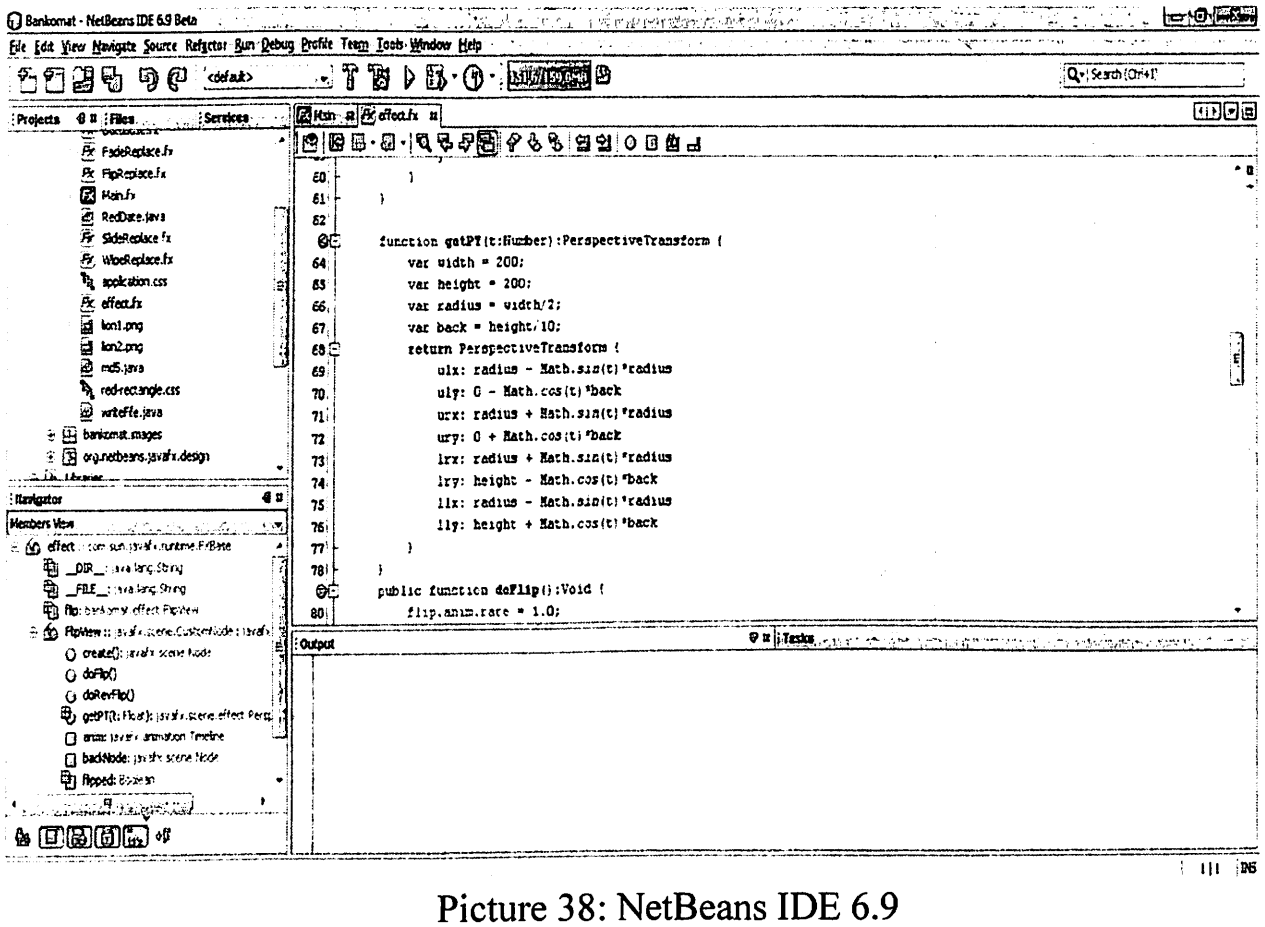
Most of programmers uses NetBenas IDE because there are very easy to create project. In NetBenas IDE has ready modules and we can use them. We do not need to create many folders and files. By clicking one button "Create project" everything creates automatically.

Programmers at Charles University in Prague started to develop NetBenas IDE in 1996. In 1997 they decided to develop market version. But in 1999 Sun Microsystems bought NetBenas IDE software.

At NetBenas IDE if we want to use any language we have to just download SDK and add to NetBenas IDE and there are also many advantages. For example there are designer so, to create design we do not need to write code. Using Designer we can do it much faster and without writing any code.

We have other frameworks like eclipse but I decided to use NetBenas IDE because I use Java and JavaFX.

When we write software we have to always check error compiling. But at NetBenas IDE we don't need to do it. NetBenas IDE checks when we write soft automatically and shows errors. It saves our time.



Picture 38: NetBeans IDE 6.9

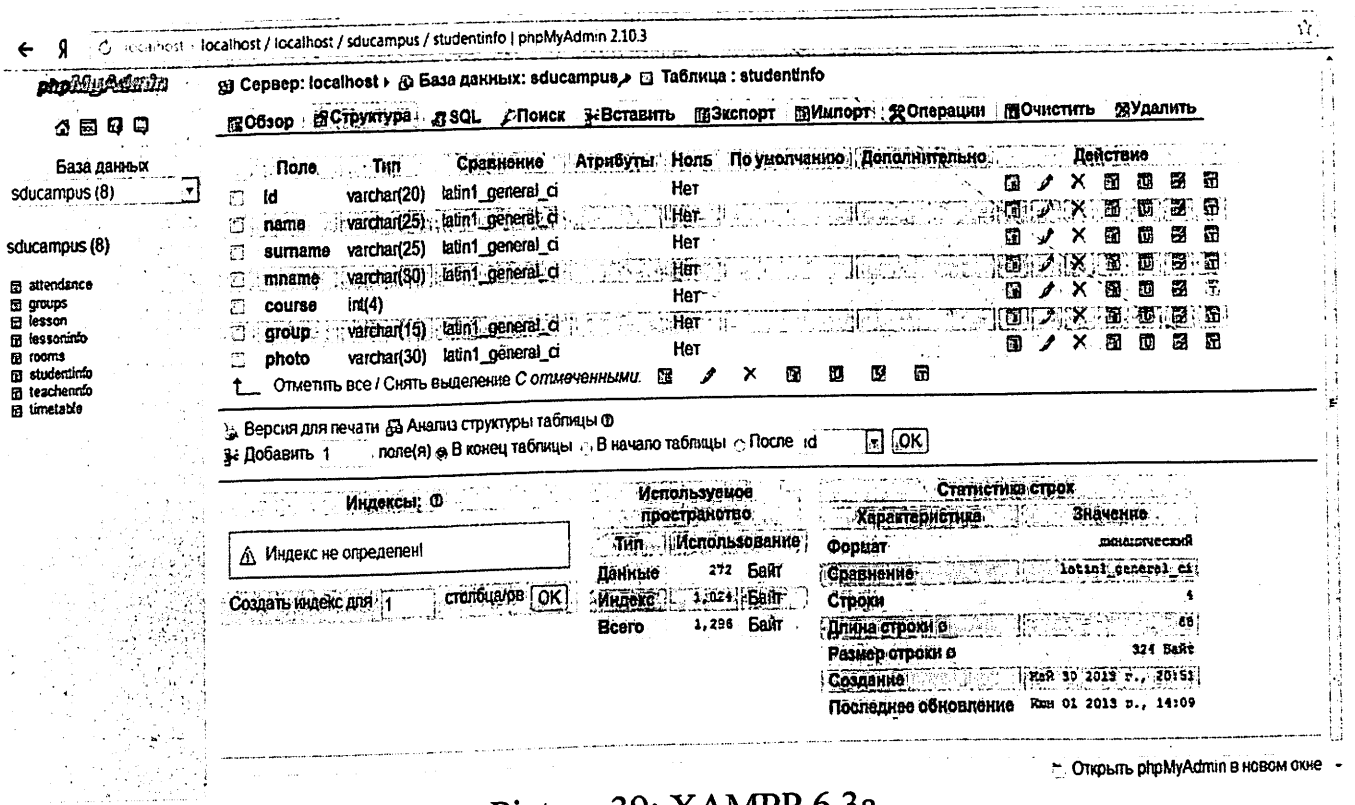
At the picture 38 you can see NetBeans. At the left side opened my projects that I created. At the bottom of the left side you can see keyword that I used at my project.

At the center you can see opened JavaFX file. There I write code to do some actions. Using button F5 I can compile my project and see what I did. One of advantages of NetBeans is if I write something wrong it shows it immediately without compiling. Before NetBeans I used software JCreator but there it showed errors after compiling and it showed just line of error. But NetBeans show where exactly error is happened.

6.2.2 XAMPP 6.3a

XAMPP is free software for web servers. It consist MySQL database, compiler for PHP and Apache HTTP Server.

After installing if we write localhost at any browser we can see site of XAMPP. Through this site we can control our DBMS and create or delete rows. So, using MySQL we can save or get data from DBMS and also we can create or delete rows. But to do all these processes through software it is very hard. Using XAMPP we can easily control all processes that is happing on DBMS and check them. And one of advantages of XAMPP we can fill our DBMS through Localhost.



Picture 39: XAMPP 6.3a

At the picture 39 you can see web site XAMPP and it is phpMyadmin. At the left side you can see I opened my DBMS sducampus. And there is I have 8 tables. At the right side you can see rows of one of my tables. If we click the button "Обзор" we can see data of the table. Using button "SQL" we can write query's and see result. If the result is true then we can copy it and use in our project. Also we can export our DBMS and import it at any computer to continue developing the project.

7 Where to use RFID in the University

Above I explained everything about RFID. How it works, how we can use it, types of RFID, benefits of using RFID technology etc... As you understood it is a very useful technology with many advantages. Now I want to explain where we can use RFID technology in Suleyman Demirel University.

Before the Suleyman Demirel University was one of the smaller universities of the Kazakhstan. But now the University of Suleyman Demirel is one of the biggest universities of Kazakhstan. Because administration built a new building for SDU. Now SDU is not just university it became Campus. At the pictures 3 you can see the old buildings of SDU and at picture 4 you can see the new building of SDU.

Picture 3: Old building of SDU

Picture 4: New building of SDU

But there is we have one big problem. The system of old SDU is not changed and at the system of old SDU many disadvantages. One of the big disadvantages is everything done by manually. For example: If we have to fill something we have to do it using pen, if we have to send something we have go there and leave it etc... So, it is very big disadvantage and it takes very long time to do something. Therefore we have always queue at canteen or library. I know all of these problems because I am studying here at SDU. So, I decided to do research and create new system for Campus of SDU to increase all disadvantages of old system and do everything automatically. First I decided to consult it with my supervisor. He recommended me to use RFID technology for the new system. He knows many things about RFID technology because his thesis was about advantages of using RFID. After, I decided to do research about RFID. I found much information and read all of them. At the end I understood that I have to use RFID technology to improve the old system. Because there is many advantages and it is what I need.

When I found all information about RFID I decided to do research about where I can use it and where it uses nowadays. I found many software where was used RFID technology. But it was just part of my new system. Below you can see where RFID technology used at universities nowadays.

1. Malaysia Pahang University (MPU) – uses RFID technology to control is student come to lesson or not.
2. Maryland University (MU) – uses RFID technology manage medicines in laboratory
3. Northem Arizona University (NAU) – uses RFID technology to take attendance from students. For this they used RFID-card. It is similar to my RFID-card but without card of Bank.
4. SCSF College – uses RFID technology to enter territory of college from main gate. For this they used RFID-cards. In my project it is similar to parking system.
5. Whitcliffe Mount University (WMU) – uses RFID technology to give permission to staff to enter or go out from building. For this they used RFID-cards. So, when staff comes to work RFID-reader checks ID of staff.

Unfortunately I could not find much software about RFID. Only at 3-4 universities uses FRID technology. But they uses only for one thing not for all the university. It means that if I will create system with RFID for university I will be first student who did it in the world. If we can get license for the new system of university by using RFID we can sold it for other universities. Other universities will see that there is many disadvantages and they will want to buy and use at own university. It

means we can earn many and SDU will be very famous university in Kazakhstan and may be in the world.

I also decided to use RFID at ATMs. It means we don't have to create new card of bank. For this we went to KazKom bank. We chose this bank because it is very good and secure bank in Kazakhstan. We negotiated about creating new KazKom cards. But our card will be different than current KazKom cards. Our card will be KazKom card plus RFID card together.

Picture 5: KAZKOM card

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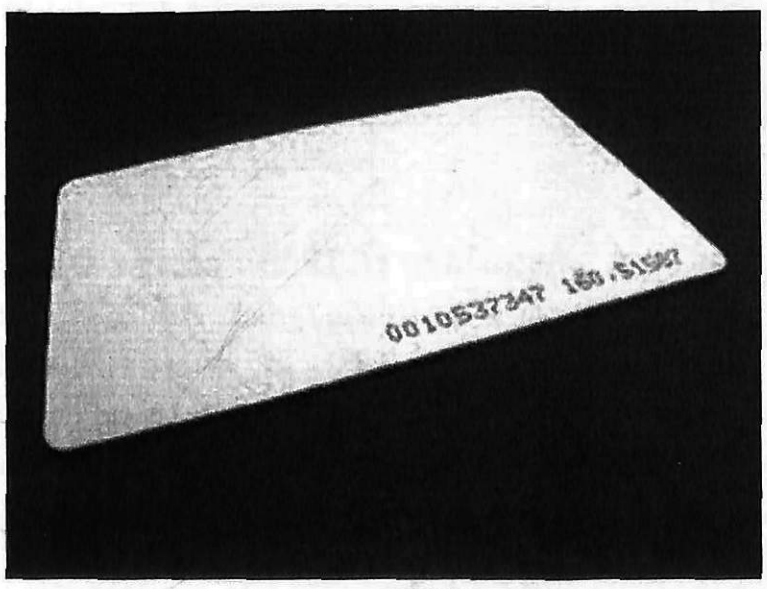

Picture 6: RFID card

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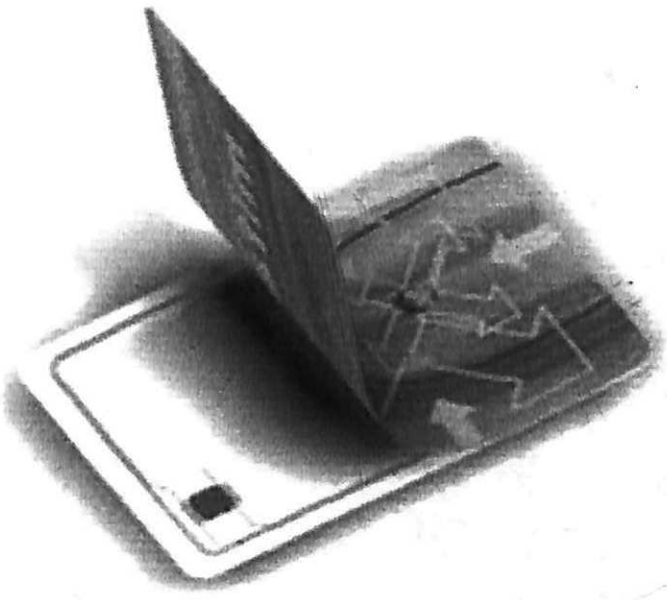


Picture 7: New RFID card

So, we can use this card as normal KazKom card and do all processes which are possible and also we can use it as RFID card. It is very big advantage of my new system. Because it means we can use our RFID card not only in Suleyman Demirel University, also we can use it everywhere even in other countries. For example: to send money, get money or for payment if we buy something etc.

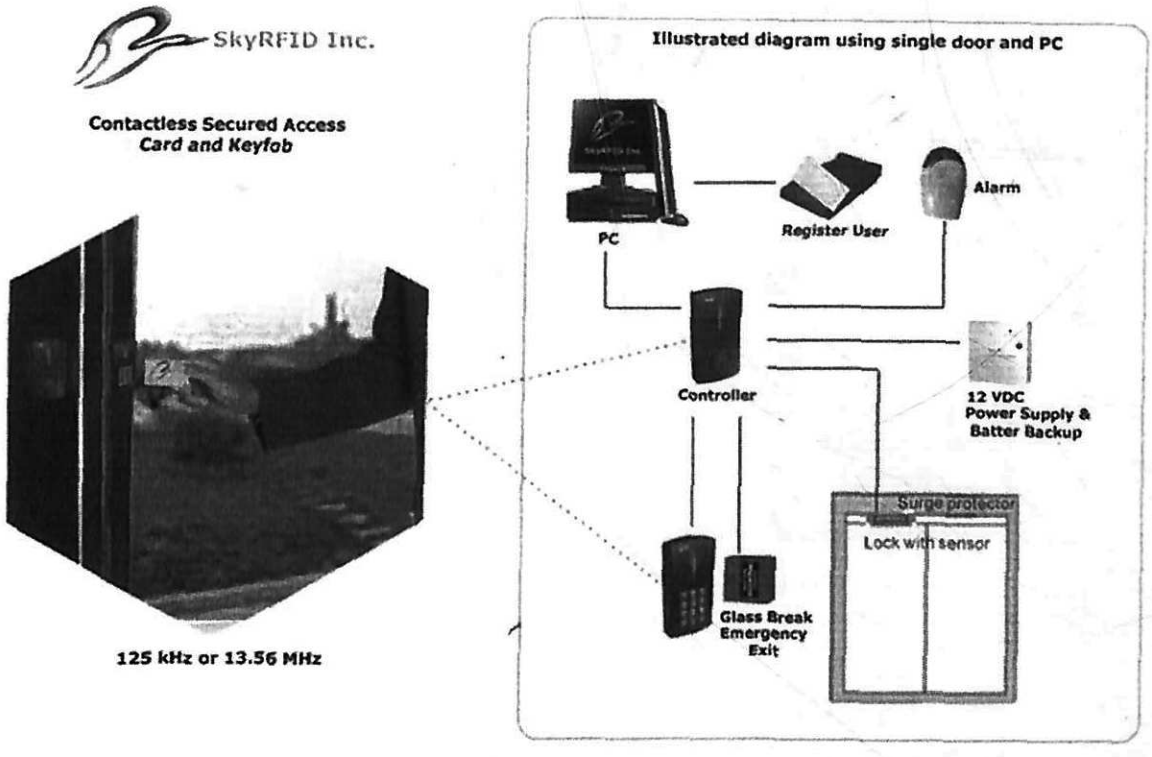
Now below you can see where we can use RFID in our University

1. Open\Close door
2. Parking
3. Student check
4. Attendance of teachers
5. Attendance Control system
6. Payment
7. Canteen
8. Library

At these eight places we can use RFID technology. At current system we do all these manually and there are many problems and disadvantages. I am going to explain all these problems below. Now for open/close door we use key, for parking we use special id written to paper, for student check we use student id card, for attendance of teachers we use paper which teachers have to fill, for attendance control system we use student id card, for payment we use KazKom banks card, for canteen we use money and for library we use library id card. As you see for all these 8 things we use 7 different ID cards. It means we have to always care them with us which is not comfortable and problem. But if we use RFID we will have to care with as just one thing and it is RFID card. We can do all these procedures using only one

RFID card and special software. Below I explained how we can do all procedures using only one card and advantages of using it.

7.1 Use RFID for access to room



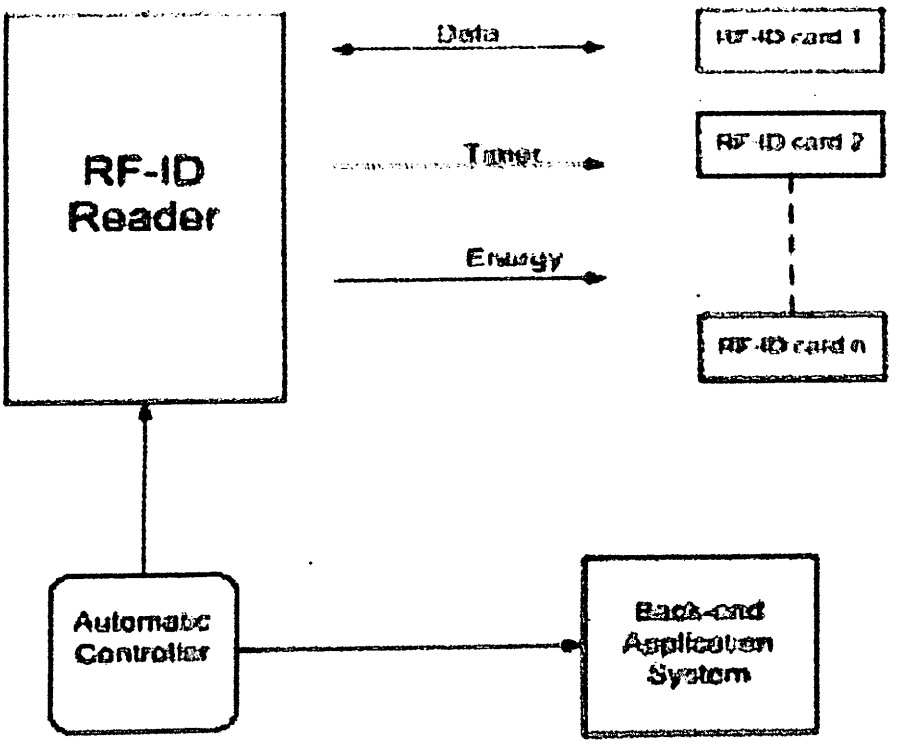
Picture 8: Scheme of RFID controller

We cam use RFID technology for access to room. Now to open door we use key that made by metal. To carry many such keys with us is problem. Because, it is not heavy. But if we use RFID-cards to open door it will be much better. Card made by plastic so, to carry it is not problem and to open door is much faster than key. Using RFID-card is more secure than using key. Because, some different keys may open the same door. But if we use RFID –card it is impossible. Because their ID are different and they cannot be the same.

There is one more advantage of using RFID – cards. RFID –cards are more cheaper then keys and if we lost our key we have to crash our door. So, it is big problem because to crash and buy new door takes much money and time. But if we use RFID –card we can just go to administrain with ID and get another RFID-card to open the door. It will cost maximum 200tg.

At the picture 8 you can see how work system of accessing to room. When anyone comes near the door with RFID-card readers reads ID of RFID-card and checks it with ID's in DBMS. If there is exists such ID door will be opened. If does not exist then door will not be opened.

For such kind of system we need computer where we have special software which can get ID from RFID reader and compare it with ID's in DBMS. If it is big company where we have many doors then we have to have Server where we will save ID's of doors. At the picture 9 you can see architecture of this system.



Picture 9: Scheme of RFID reader

7.1.1 A typical RFID system

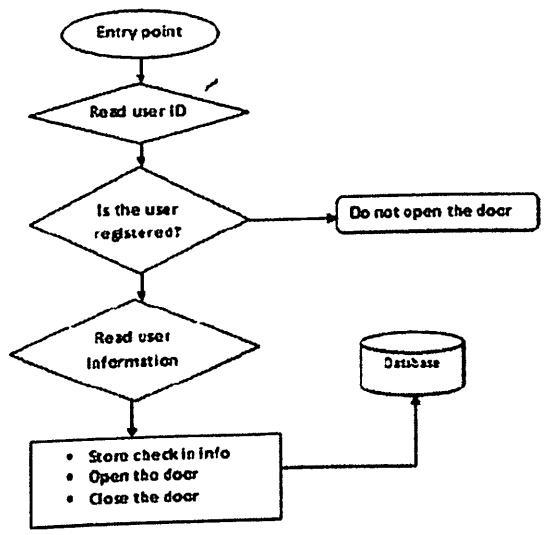
We adopt the system using passive tags. The RFID tag is detected when it is touched or when getting within the range of few millimeters from reader. The tag is automatically detected by RFID reader in every mille second and reader sent the information containing by tag to the central control through serial port. The central control has the information of different users registered with the system. The signal information gotten from RFID reader is matched with the stored information in local as well as central control. Once the information is matched with the stored information, system displays the information. The information contains details of the user by their name, id no, category, check-in time, check-out time, date and possibly photo as well. All the coming information of RFID tag gets stored by central control server. System can also generate report of a single user as well as multiple users according to the time and date. Once the tag user authentication is performed, system generates a control signal through a particular parallel port. This control signal goes to the control circuit.

RFID reader can be connected to the system through USB port to provide communication between system and RFID reader. The output control signal is generated by system by means of parallel port which controls the opening and closing of door through steeper motor. The technical specifications of the RFID are as follows:

- Power: DC6V, 4 standard AA alkaline batteries
- Read speed: 0.5 ~ 1.0 second
- Capacity: 100 different cards
- Maximum reading rang: RFID card: less than 30mm
- Card format: For ID card EM.125K

- Door Lock: Motor driven locks and unlock
- Battery life: More than 4,000 times open/close of door
- Low voltage warning: When CPU working voltage is less 4.8V, the lock can still be opened 200 times before the batteries are replaced
- Door thickness request: 32mm ~ 45mm

The system stores all the needed information about the user. When a new user is registered for the first time with the system and the corresponding information is burn in RFID tag. This RFID tag will be accessible through the system. When a registered user comes to the entry point, and lets the tag be read by the reader, the system checks whether it is registered user or outsider. If the user is a registered one then the tab information is matched with the user information stored in system. The door is then opened to let user in after successful authentication and closes momentarily by itself after a short specified time interval. The check-in information is also stored in the database with date and time. A log is also generated by the system according to check-in information.



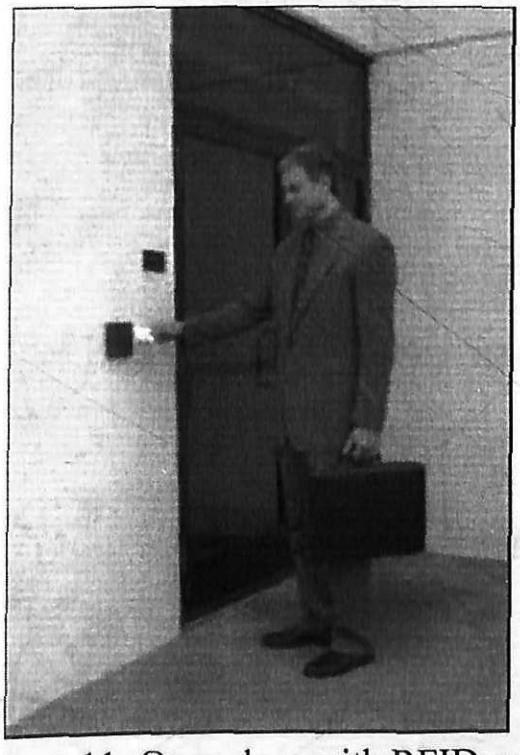
Picture 10: User check-in process

The system has a controller PC which contains the record of the check-in and check-out of the user. User must have RFID tag which contains the personal information of that particular user. A door along with locking system is driven by stepper motor. Stepper motor acts as actuator, which is able to open and close the door in real-time. The RFID Reader detects tag in real-time and open door automatically and closes it again in a specific time interval. In this application, user authentication information is searched on the database first. If the user does not have any previous record registered to the database, the door will not be open thus unauthorized entries will not be allowed.

The system is also able to maintain the record of a user such as how many time and when the user check-in and to which area. All the databases are stored in database server as well as local server. Administrator can access database server remotely through internet or intranet and can see all the records.

Using RFID card for opening the door is prefered to using a pin code. This is so, as anybody who knows our pin code can enter inside but if we use RFID card nobody can enter without RFID card and it also saves time for opening the door.

Now in our university to open or close the door we use key. It means we always have to care key with us. In some classes has PC especially in labs. So, we have to close these rooms after lesson and open at the beginning of the lesson. Otherwise bad guys can steal something and always to do it we will use key. But if we use RFID we can solve this problem. We just need device like RFID reader which can read id of RFID and which can check it with information in DBMS. If id exists the door opens or closes if opened. Actually such system exists. So, we can buy it and use. But RFID card will be our own RFID card.



Picture 11: Open door with RFID card

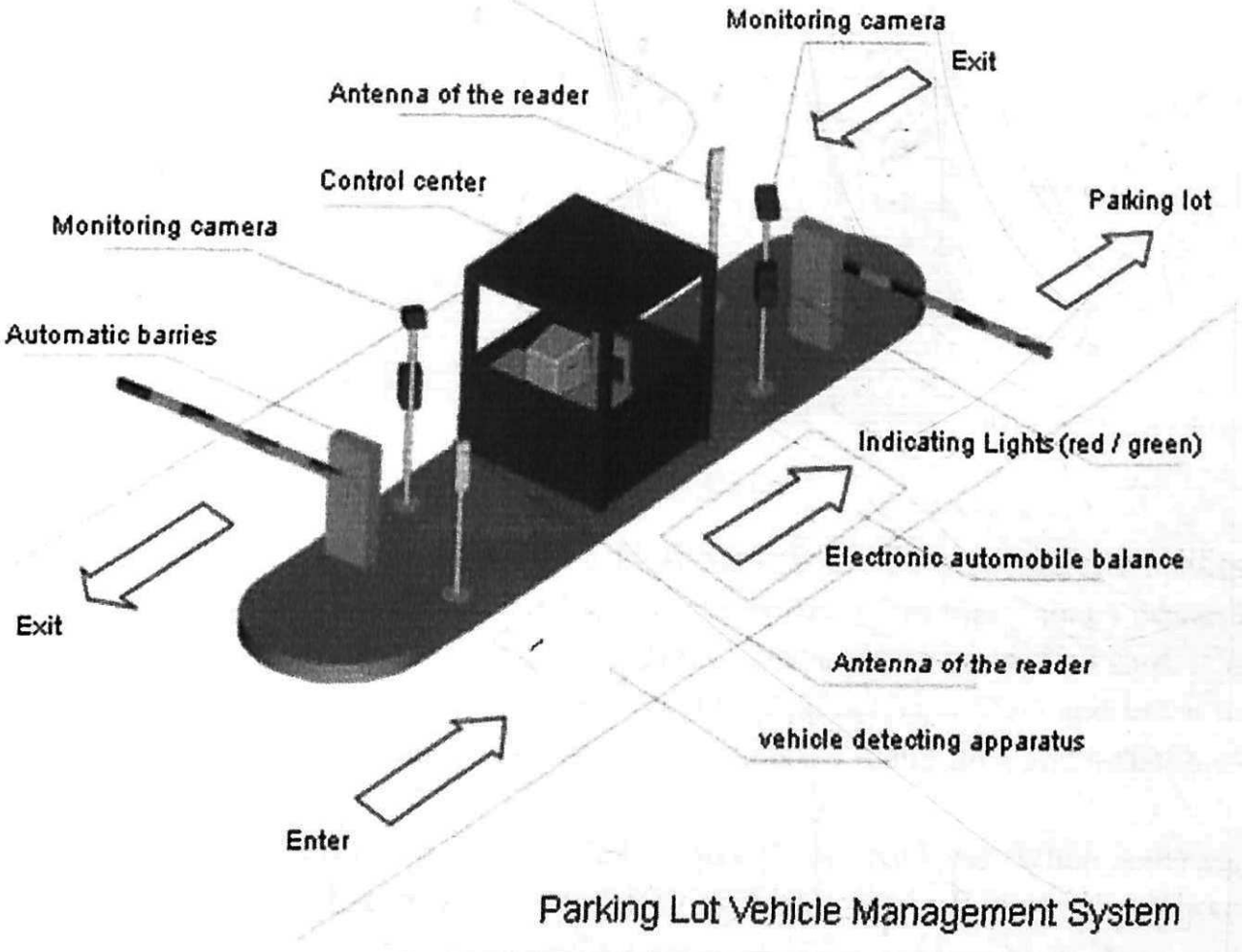
At the picture 11 you can see the example of such system. Our system will be the same. The advantage of this system is we will not need to carry key with us anymore.

Also we can do it without connecting to any DBMS. We will just save id's of people who has permission in RFID reader. It is easier.

7.2 Use RFID for Automated Parking Access Control Systems

It is very useful to use RFID at Car parking System. It can be at universities or building. If car came near the door for parking RFID reader reads data from tag and checks is it our parks car or not and it will automatically count how many cars are in the park. TO count is very easy. When the car go out we decrement the number of

cars and when comes we increment number if cars. This system is very important for security because other cars cannot enter to park. This process happens very fast.



Picture 12: Parking system

Nowadays parking system is not good. First we have to check is it park's car or not and we do it manually. Drivers have to show an admission. Then we have to check it. If everything is true, only then we open the door of park. All these processes we have to do manually and they take much time. If we have many cars at park it will be problem to us.. But if we use RFID technology as I explain above it will very easy do it all processes and everything will be done automatically. So, there will not be a queue.

7.3 Student check

At any university when someone enters to the university, security guard has to check them one by one is he (or she) studies here or not. It is very important otherwise there can be problem. For example: When I studied at 3course some bad guys enter to our university and stolen the computer of my friend. So, to avoid such problems we have to check all who enters to the university one by one.

At current system security guard checks by Student card. At picture 13 you can see example of current student card.

Picture 13: Student ID card

But, there are many problems and disadvantages. In SDU works and studies about more than 2500 people. To check them one by one takes many times because security guard have to compare student with photo, this is placed in student card. It is needed because some bad guys can stole student card of students SDU and use it to enter to university. But to check one by one by photo takes many time and sometimes it cause of queue.

But if we use RFID card we can easily solve these problems. When someone comes to SDU RFID reader reads id from RFID card and shows us his (or her) photo and we can compare them. So, it means we don't have get student card, check and give it back. We save time and there are will not be queues.

7.4 Attendance of teachers

All teachers and other workers of university have to come about 08:30 in the morning and they have to be there till 18:00 evening. It is the rule of universities. Students need help of teachers about lesson. Therefore teachers always must be there. But our university is too big and it is impossible to control is the worker or teacher is at the university or has gone and it is disadvantage of our university. So, I decided to solve this problem and write special program which controls it. We need just RFID reader. But there must be many RFID readers. For each faculty one RFID reader and several RFID readers for other workers of university. It depends on number of workers. When teacher or worker comes to university or goes out RFID reader reads id and writes the date and time on DBMS. So, administrator can get data from DBMS and see who came late and went out earlier and give them punishment. The program is very easy.

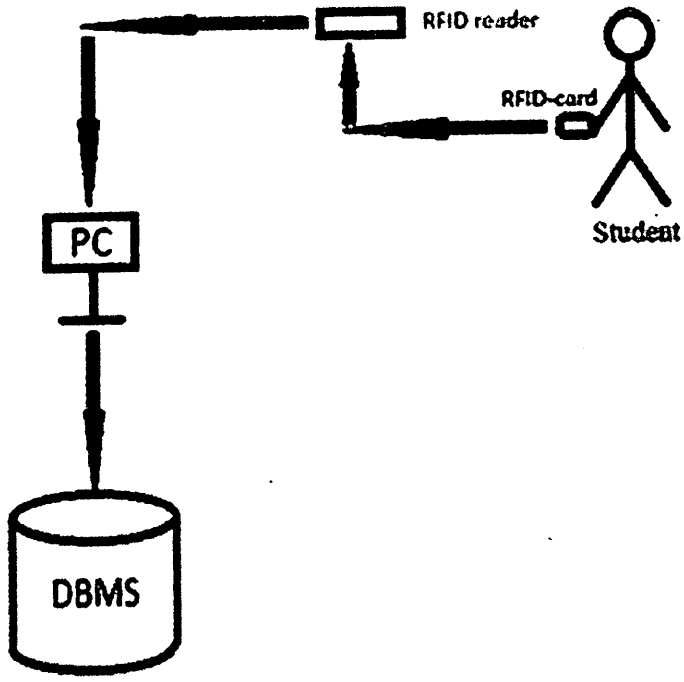
7.5 Attendance Control System

One of the big problems of our university is taking attendance of students. Because it takes very long time. Especially at lectures when in one class sits about 85 students together. It is about 3-4 groups. So, I decided to solve this problem. My aim is to safe time as it possible. Because, time is very important for students and for teachers also. Some teachers did not have time to explain all what he/she wants and one of reasons of it is taking attendance.

First I want to explain the old system of University of Suleyman Demirel and then explain my own new system and compare it to show how much it is better. At old system all teachers have to carry registration form with them. First when lesson is begins teacher says name and surname of each students and checks is he/she at class or not. If he/she at class teachers writes "+" If not writes "a". So, teacher has to say all names and surnames of students one by one to control who came and who did not come. But at lecture time 3 or 4 group's sits together and it is about 85 students. To check each student and fill the registration form takes about 5 second and to check all students it takes about 7-8 minute. But it is very long time for teachers. At university of Suleyman Demirel each lesson last 50 minute. It means to take attendance it takes about 16% of lesson. Also teacher has to take attendance each lesson because some students who came to first lesson may not come to second lesson. Therefore teachers have to take attendance at each lesson. At the end of semester teachers have to calculate how much time the student came and put point and put retake who misses 20% percent of all lessons. One of the big disadvantage of this system is teachers have to do all these operations manually. This system is used at many universities not only at University of Suleyman Demirel.

So, my task was to create new system to save time and do all these operations automatically. I had many ideas how to solve this problem and at the end I chose the idea with RFID (Radio Frequency Identification) card. Using RFID we can solve this problem. This system does not take any time of students and teacher to take attendance and system calculates point automatically.

First we need special soft to do all of these operations automatically.

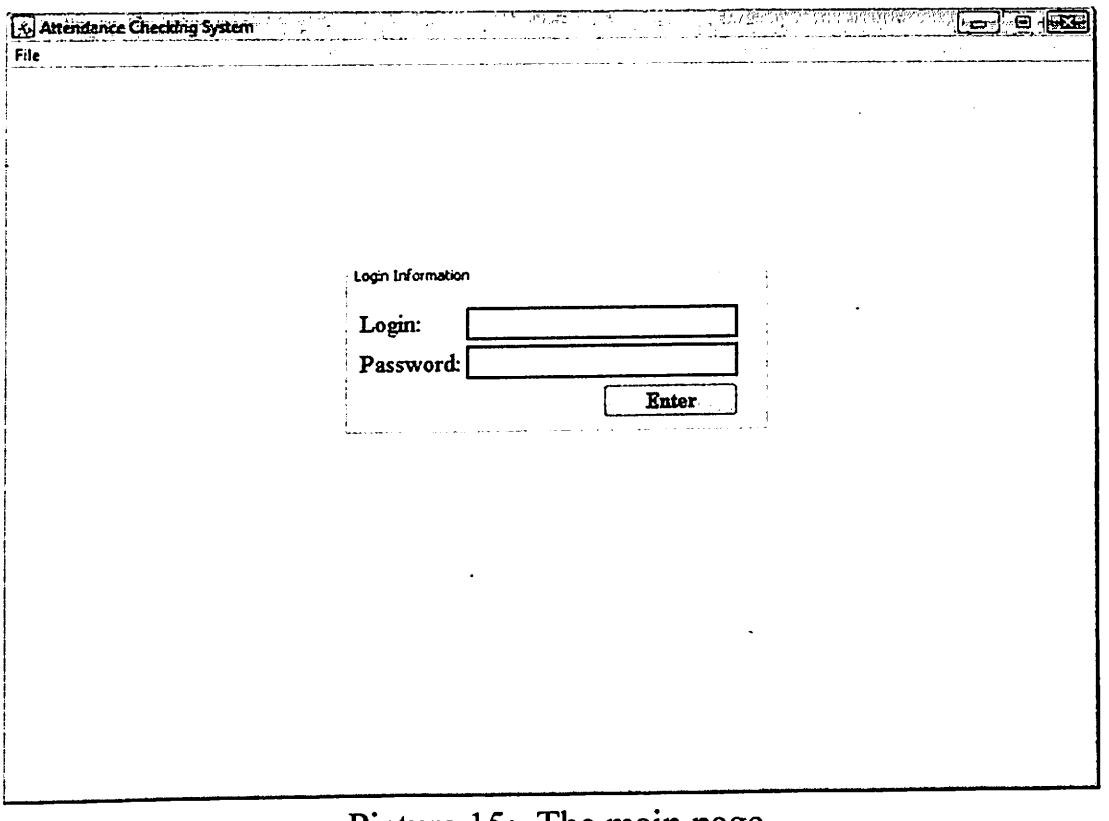


Picture 14: Architecture of attendance control system.

At picture 14 you can see the architecture of my attendance control system. System is very easy. When a student enters class, the RFID reader reads his/her student ID card from RFID card and sends information to the PC. When everybody enters to class teacher submits all data for storage in a data base. Below I will explain all system detailed.

We also can create another system for attendance taking but I chose system with RFID because I am going to use RFID not only in this system. I will use it everywhere where it is possible in our University.

For this system we need RFID reader, PC in each class and all students have to have RFID card. So, all these components are cheap for university. It means all the universities can use this system. Here I use only ID of RFID card. The soft gets other data from database. It is needed for security. Nobody can change ID of RFID card but other data can be changed.

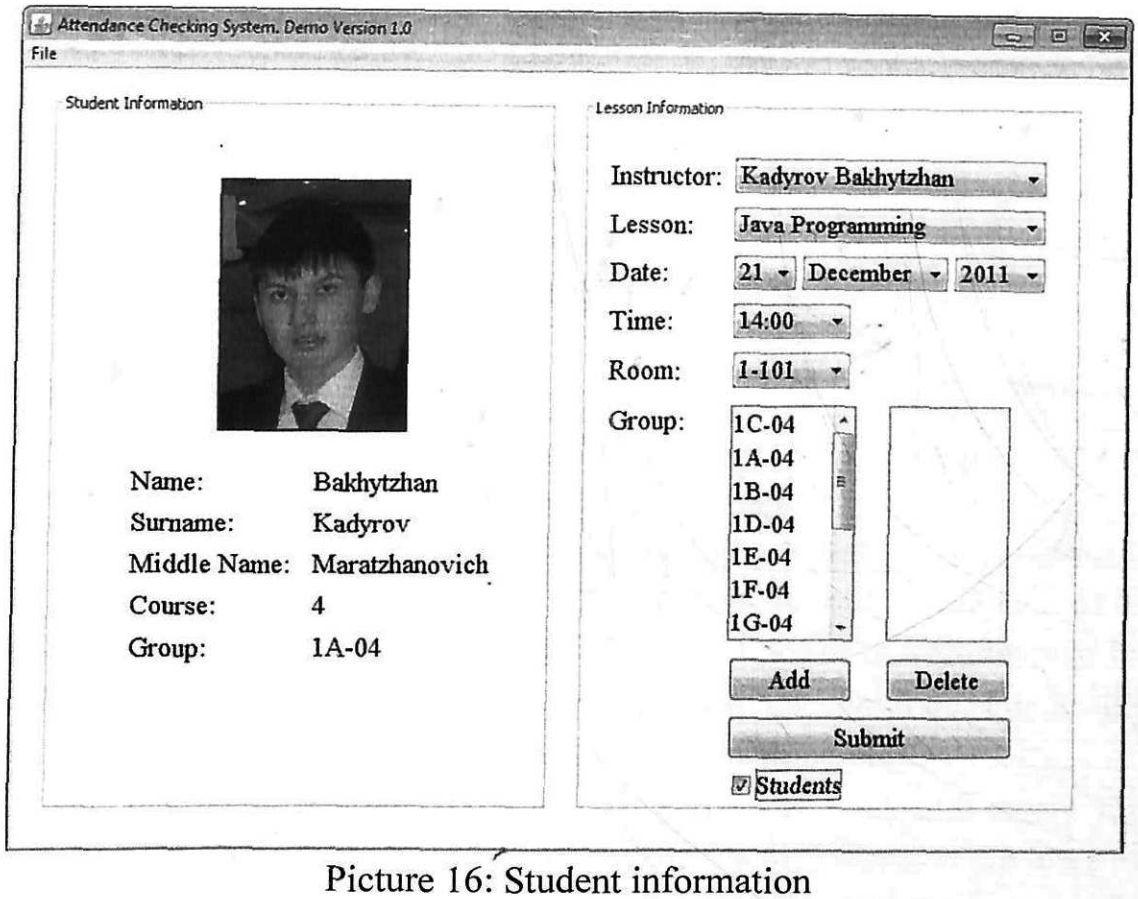


Picture 15: The main page

When the teacher arrives in class, s/he logs in and submits a password on the PC to a special program, which checks student RFID-card (See picture 15). The soft starts when teacher logs in. So, it means RFID reader also starts to read RFID cards.

RFID reader must be placed near the teacher to see students. Otherwise student can bring RFID card of other student who did not come to the lesson and RFID scans both RFID cards. So, it means in database will be stored as both of them came. But it is not true. Therefore it must be placed near the teacher and teacher can see who came and who did not come.

RRID reader reads very fast so it means there will not be queue. It does not take 1 second. There is many types of RFID readers. Some RFID readers can read data from RFID card from about 10-15 cm. But there is another RFID reader which can read ID of RFID card from 90-100 cm. We can use both of them. I think if we use second RFID reader we can scan RFID card faster.



Picture 16: Student information

Above (See Picture 16) you can see main page of Attendance taking system. When teacher logs in opens main page of Attendance taking system. After teacher have to fill right side of page. There is name of instruction, name of lesson, date, time, room and groups. We can fill all of this automatically if we store timetable in Database. Soft will take all this information's from Database automatically and teacher will just check is everything true or not. If not teacher can change it. But it will be hard to create such system therefore I will do such soft after. At the right side you can see photo, name, surname, middle name, course and group of student.

We can see this information's when RIFD reader reads ID of RFID card. FRID reader reads only ID of RFID card. Soft gets other information's from Database according ID and shows as. The photo of student is very important for us. Because at lecture many groups sits together and it is hard to remember face of all students.

So, some students can give RFID card to others students. But in Database it will be saved as she/he came. But it is not true. So, looking to picture teacher can recognize student is it his/her RFID card or not.

After 5 minute teacher presses button submit and all data will be stored in Database. Students who come late will be absent. It will be punishment for them.

At the end of semester point for attendance will be calculated automatically and who misses 20% of lesson will get fail.

So, as you see the system is very easy to use, cheap and secure. Everything is thought out to avoid disadvantages. In the future to improve this system. In that system everything will be filled automatically and there will be web camera to take photo of student who came to lesson. It is needed for security. The soft will read ID of RFID card and takes photo of student simultaneously. Then it compares this photo with the photo in Database to check is he/she the same student.

7.6 Using RFID card at ATMs

We can also use our RFID card at ATM and we don't have to create new card of bank.

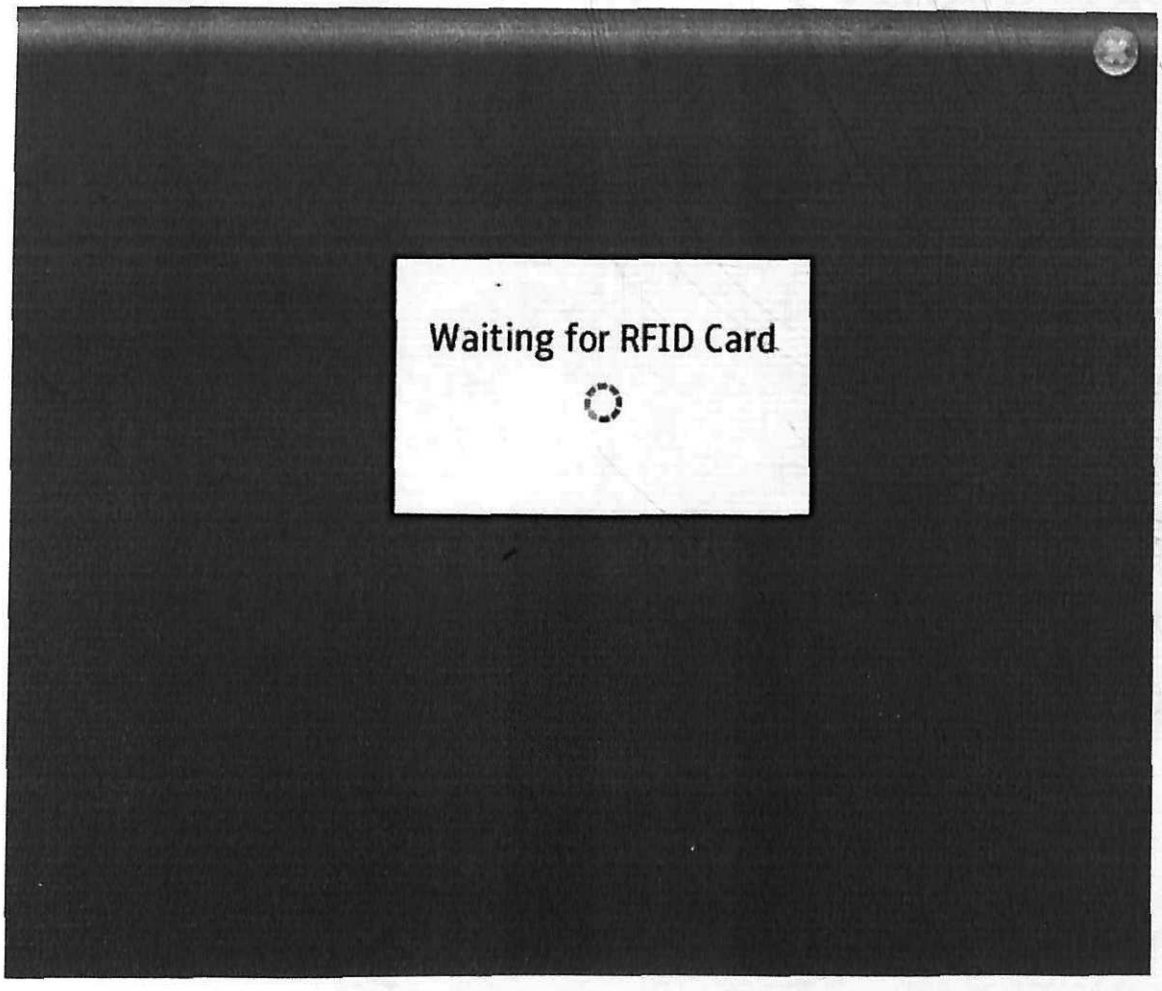
So, we can use this card as normal KazKom card and do all processes which are possible and also we can use it as RFID card. It is very big advantage of my new system. Because it means we can use our RFID card not only in Suleyman Demirel University, also we can use it everywhere even in other countries. For example: to send money, get money or for payment if we buy something etc.

At old system of our university we have to go to bank and create KazKom card. It means the student card and KazKom card are different and we have to carry both of them. But at new system these two cards are together in one card. Using this card we can do many things. One of them is ATM. We can use this card at any KazKom's automatic cash terminal and also we can create our own automatic cash terminal. Because at KazKom's automatic cash terminal we cannot do all process that we needed. It is assigned for all people not for universities. There are some processes like payment for retake or tuition that does not exists at KazKom's automatic cash terminal.

So, I decided to create new automatic cash terminal for our University of Suleyman Demirel with the functions that we need and which we can do not going to accounting department. Below you can see SDU's automatic cash terminal with new system.

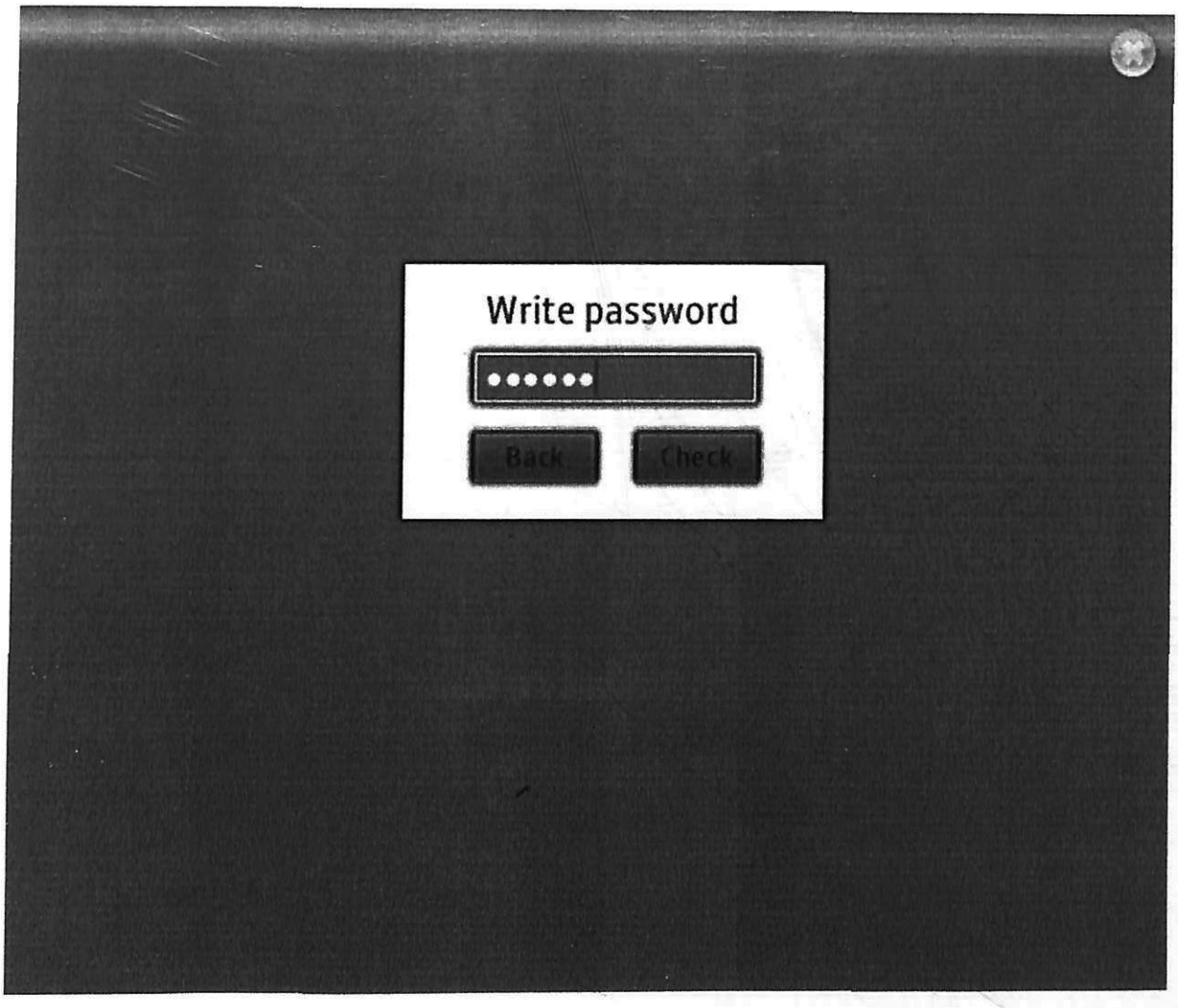
Picture 17: ATM

For this system I used JavaFx and Java. Because there is we will work with money. So, it means our soft must be very secure. Design also must be good because all the students will use it. Therefore I used JavaFx for design because this language assigned to design.



Picture 18: Main page

First of all, my program checks the RFID card then user must write password with 6 letters. I used password for security because anyone can stole our RFID card and get money from ATM without our permission. I used hash algorithm when I save password in the server. There are many advantages of hash algorithm. And I used 6 letters for password because it is hard to break or find password randomly. If user writes wrong password three times the RFID card will be blocked because it may mean that RFID card is stolen.



Picture 19: Enter password

A hash Function

A hash function H is a cryptographic algorithm that takes input string with size a and returns output string with size y, we call it the hash value h. There is many advantages of hash algorithm especially at our situation. If we use normal cryptographic algorithm anyone who has access to DBMS can learn our password and use it. But if we use hash algorithm even who has access to DBMS cannot learn our password because there we will save only changed part of our password.

To use Hash algorithm we have to have these 5 thing:

- the size of input can be of any length,
- the output will string with fixed size,
- H(x) is very easy to use for any string ,
- From result we cannot get password,
- At hush algorithm the different strings can get the same result.

We said one-way hash function H if it is hard to get the first string using result. So, it means it is impossible get the first word using output string because result is part of result.

But Hash algorithm has one small disadvantage. Sometimes we can find such two string that result of both of them the same. H(String1)=H(String 2) and string != string 2. We call such Hash weak collusion free.

Now we have many types of Hash algorithm. Most of programmers uses SHA and MD5.

n the program I used hash algorithm named "NG". It is my own hash algorithm. In my algorithm I used MD5 and one key to do it more secure. This is very important as in our RFID card we keep our money. If somebody hacks our password he may steal our money.

Example of my hash algorithm:

Password is: Diplom

Let us encrypt it using "NG' algorithm.

First we have to encrypt using MD5 algorithm

MD5 returns: a90d326a1354a45605470b26db875792

Then I used a key to change result of MD5

Key is: bh34ba86jer784jkkje70asebj4

I append it between the result of MD5

```
for(int k=0;k<27;k++){
        result=result+""+md5_redult.charAt(k)+""+key.charAt(k);
    }
```

Result is : ab9h03d43b2a68a61j3e5r47a8445j6k0k5j4e7700ba2s6edbbj84

Then I get reverse of the result

```
for(int k=53;k>=0;k--){
        reverse_of_result= reverse_of_result +""+result.charAt(k);
    }
```

Result is: 48jbbde6s2ab0077e4j5k0k6j5448a74r5e3j16a86a2b34d30h9ba

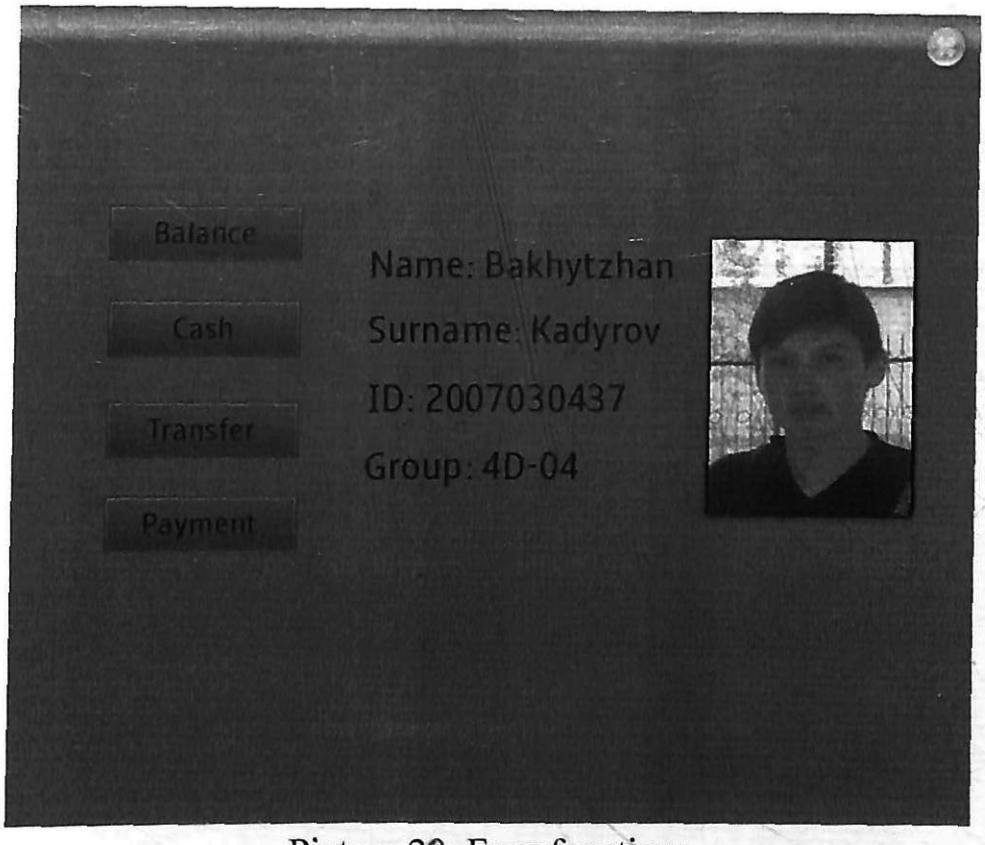
Then I get third letters

```
for(int k=0;k<54;k+=3){
        hash=hash+""+reverse.charAt(k);
    }
```

So the result will be: 4be207j0j475jaa339. And I store it in the server.

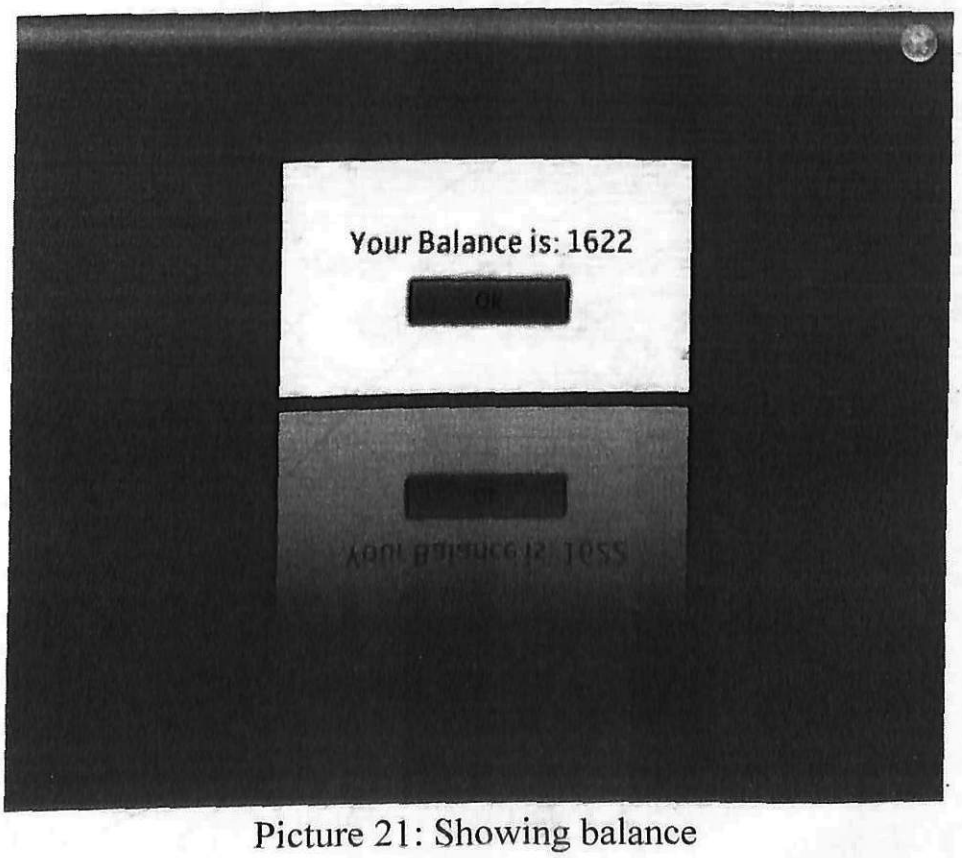
I used hash algorithm because to obtain the password from the result is almost impossible. To get the password hacker must know algorithm of MD5, my key and my algorithm. Therefore, I think it is impossible as the information is in a secure place and private. Even if he knows my algorithm I think it is impossible to break.

If the password is true then we can enter inside the program.



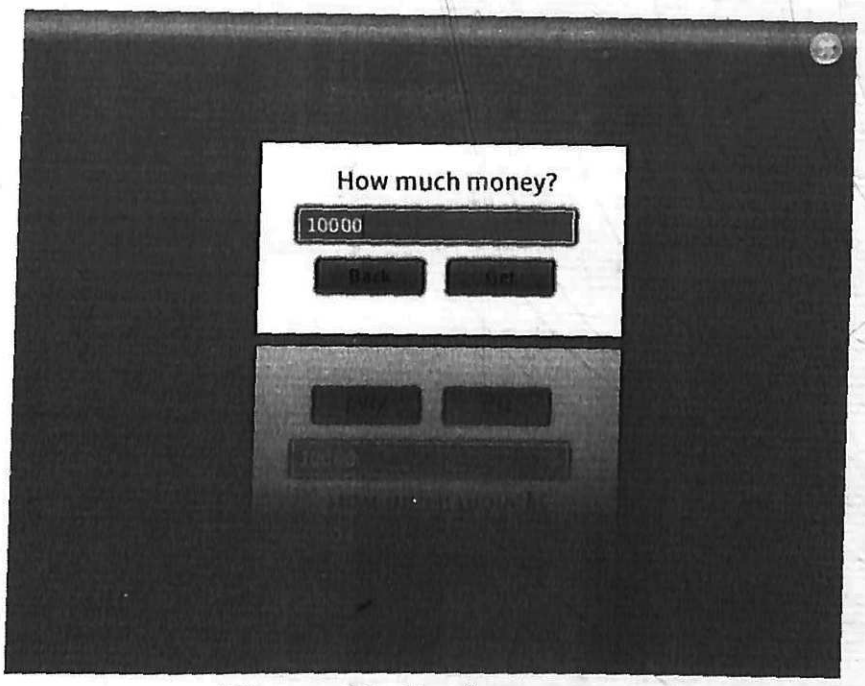
Picture 20: Four functions

As you see at picture 20 we have four functions. ATMs have many functions but for us these four functions are sufficient to show where exactly we can use RFID card. These functions are: Balance, Cash, Transfer, and Payment.



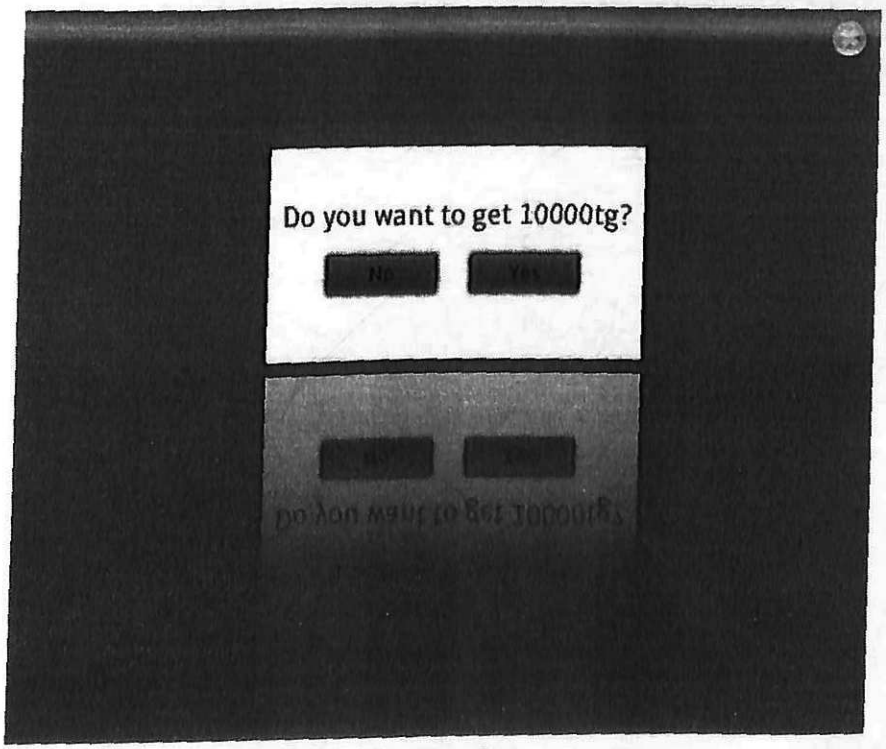
Picture 21: Showing balance

If we press the button "Balance" we can see how much money we have in the RFID card. Using our unique ID, the program gets the information about the balance from the server.



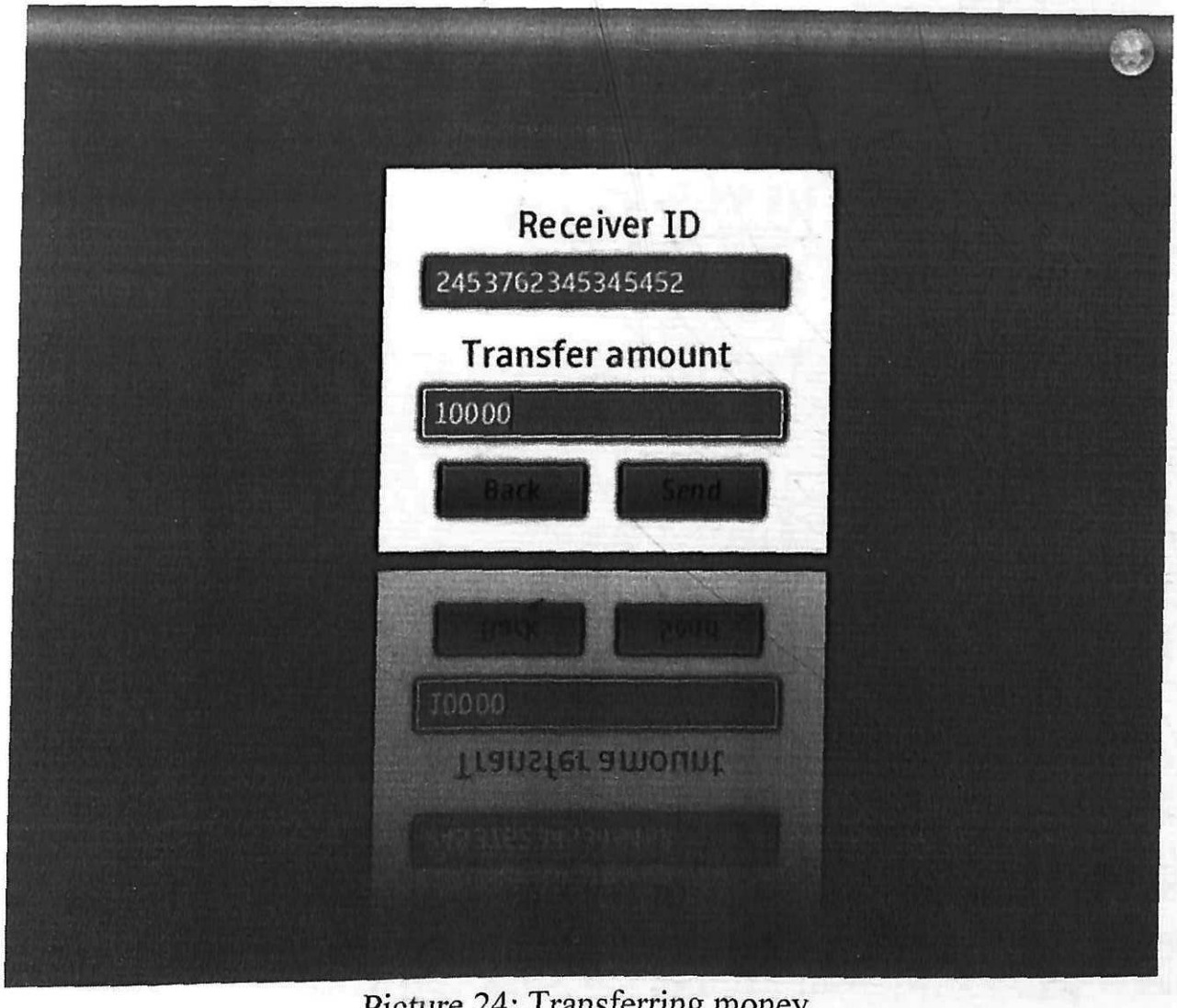
Picture 22: Getting money

To get money we have to press button "Cash" then as you see in the picture below program asks how much do we want to get.



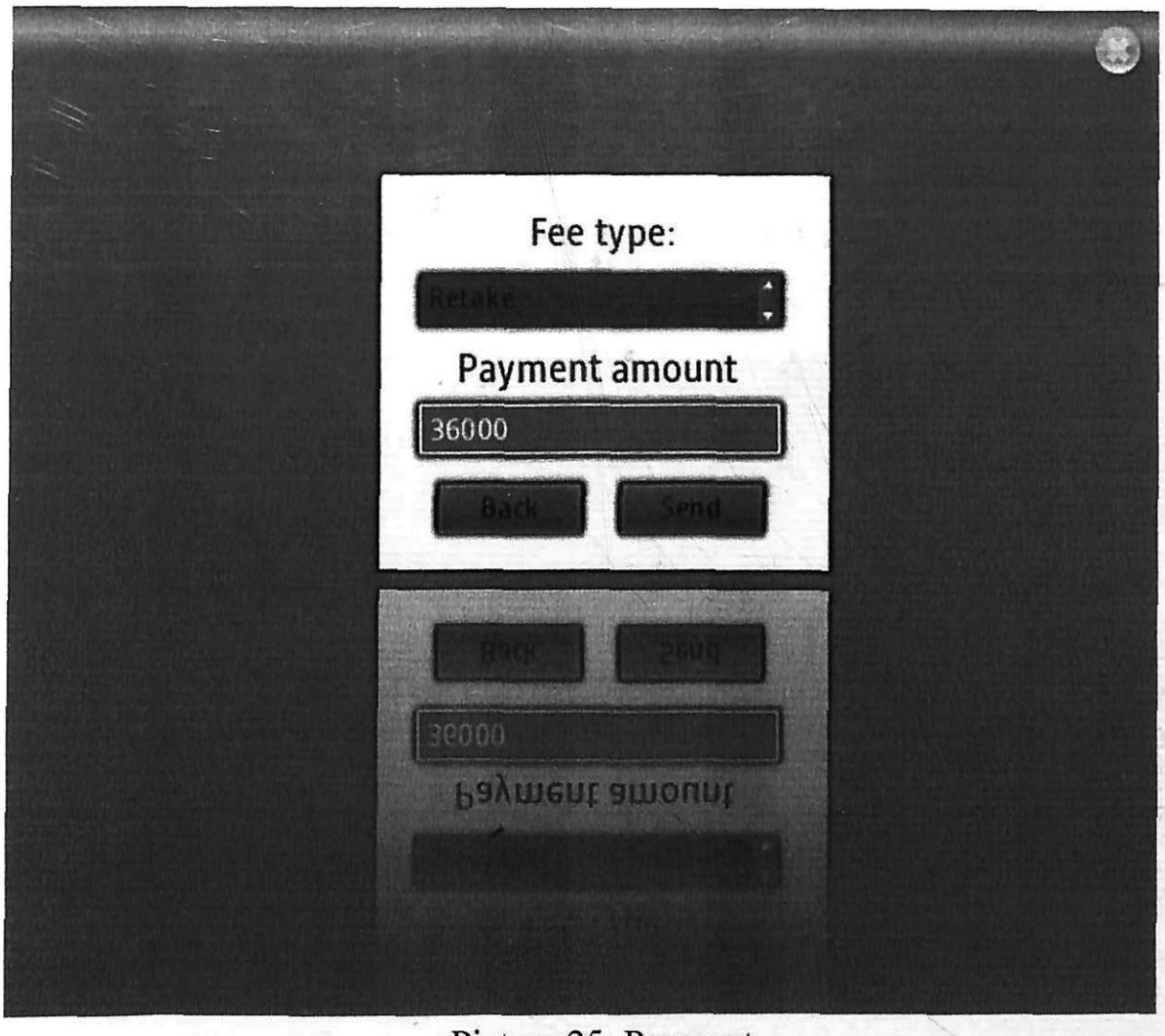
Picture 23: Getting money

Then program asks "Do you want to get 10000tg?" - To be sure. But if we don't have enough money the program says "You don't have enough money".



Picture 24: Transferring money

To transfer money to other cards we have to press button "Transfer". Then we have to write how much we want to transfer and write ID of the receiver. Then program asks if we are sure to send or not. If the id if Receiver is wrong or if we don't have enough money the program says it and we have to correct it.



Picture 25: Payment

We also have the payment function to pay for retake and tuition, so we do not need to go to accountant, wait in queue and fill in some forms. This will save us lots of time. Everybody knows the haw much we have to pay for retake or tuition. At this situation the program check do we have enough money or not.

All these processes are saved in DBMS. So we can see when and how much money we get, how much we send or how much salary is come to our card etc.

So, as you see using this new ATM system it will be very easy to do all payments and we will save our time.

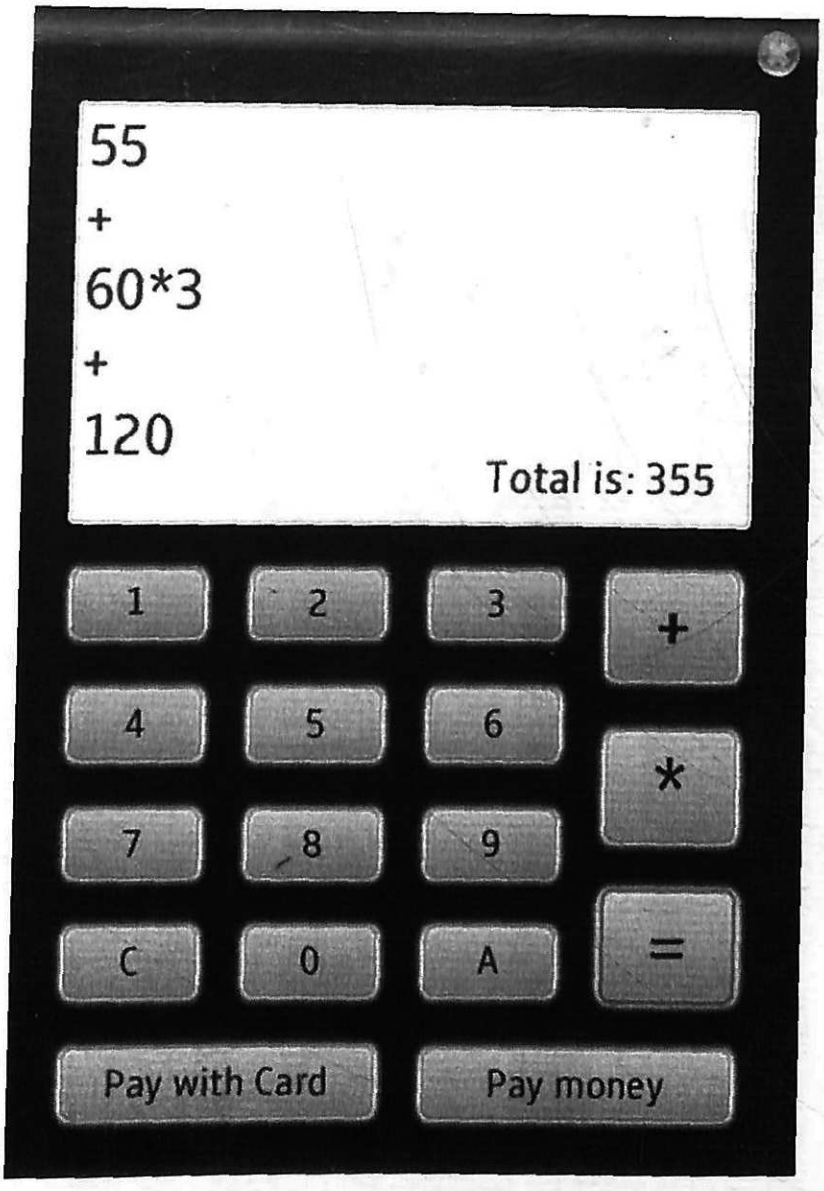
7.7 Use of RFID in Canteen and dining rooms

As we all know, we always have queues in our university canteen and dining rooms especially at lunch time. Because at the moment in SDU studies more than 2500 students, teachers and workers. Almost everybody eats lunch every day. But the break time is too short. It is about 50 minute. So, it means people who wants eat are a lot but the break time is too short. Therefore some students cannot be in time at lesson or does not eat lunch to not miss the lesson. So, it is one of the big

disadvantages of our university. The reason of all this is the old system of our university. Because it takes some time to get money from a student and to return the change. Probably it takes about 30 seconds to serve each student. But if we will use RFID card we can do it faster because we will pay using card and we do not need to pay money and wait for the change. Thus, it will be easier and faster and we can write program which will do all current operations automatically. Below you can see the queue in our university at lunch time.

Picture 26: Canteen in SDU

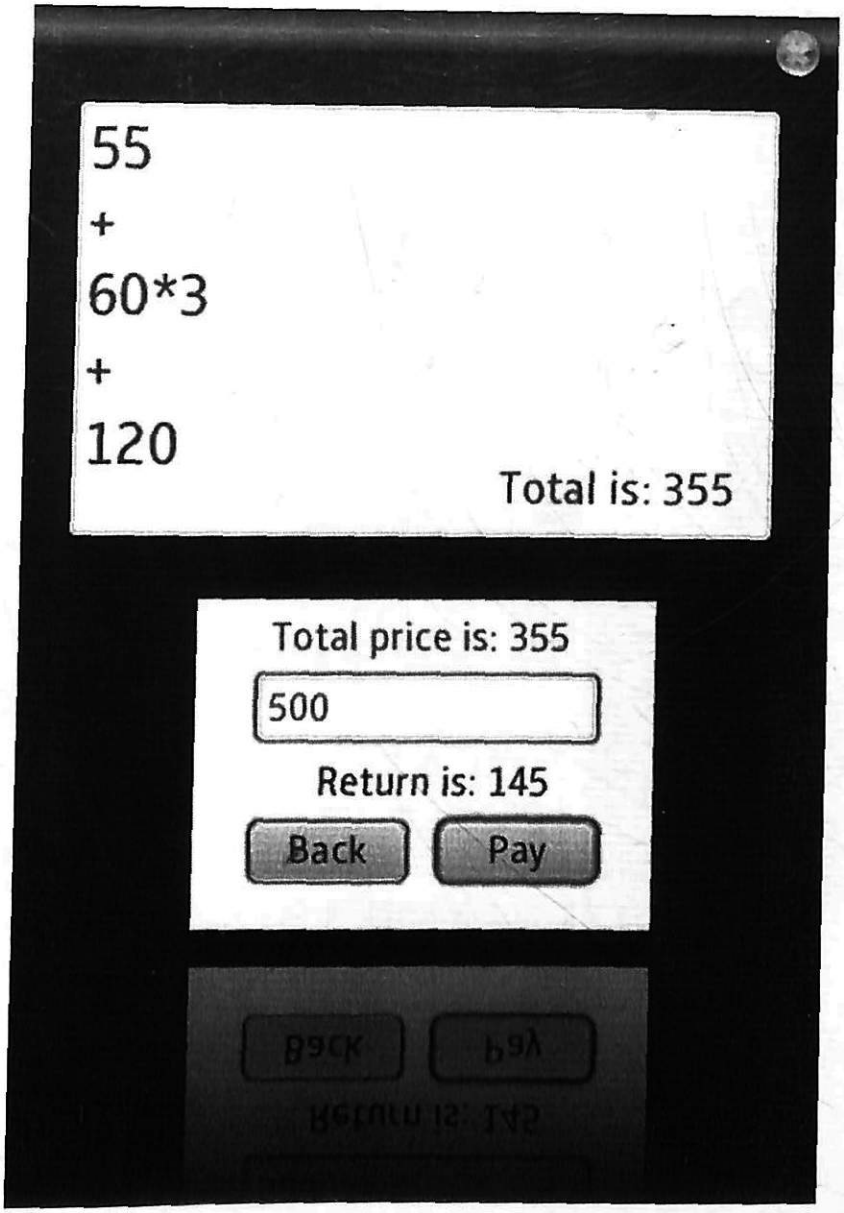
We also can use it at canteen or shop to buy something in our university. The program will be same everywhere. Because, it just calculates. Below you can see new program for canteen, shop and dining room that I write.



Picture 27: Special calculator

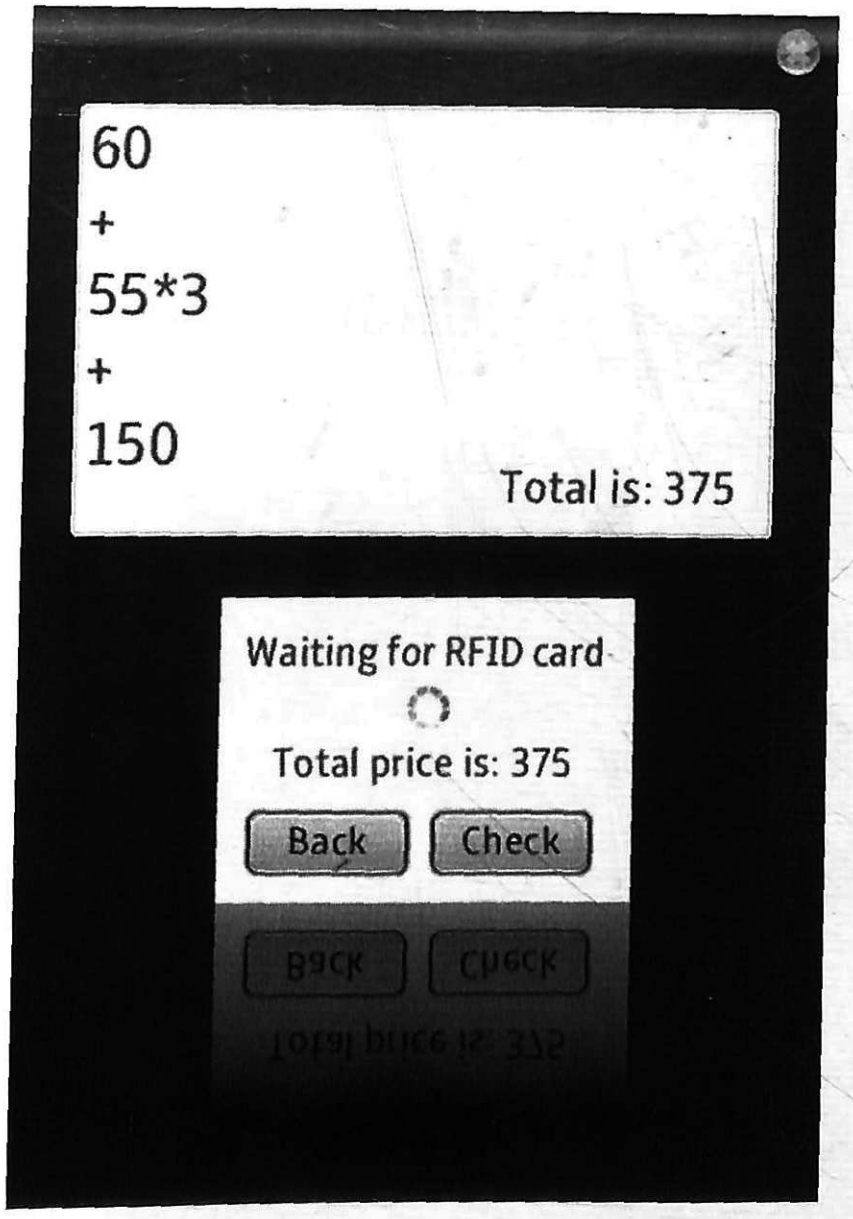
At picture 27, the seller can calculate what student bought easily. If student bought many things, the seller can calculate using '+' button. If student bought many the same things the seller do not need to calculate each of them separately. He can calculate it just using '*' button. When he calculates everything he presses the button '=' and the program calculates the total amount. You can see it in the picture above.

As you see in the picture above, there is two more buttons. 'Pay with card' and 'Pay money'. These two buttons are very important for us and it is advantage of my new system. To pay easily, faster and to not wait return the change we can pay using RFID card but if we do not have enough money in RFID card then we can pay by cash.



Picture 28: Paying by money

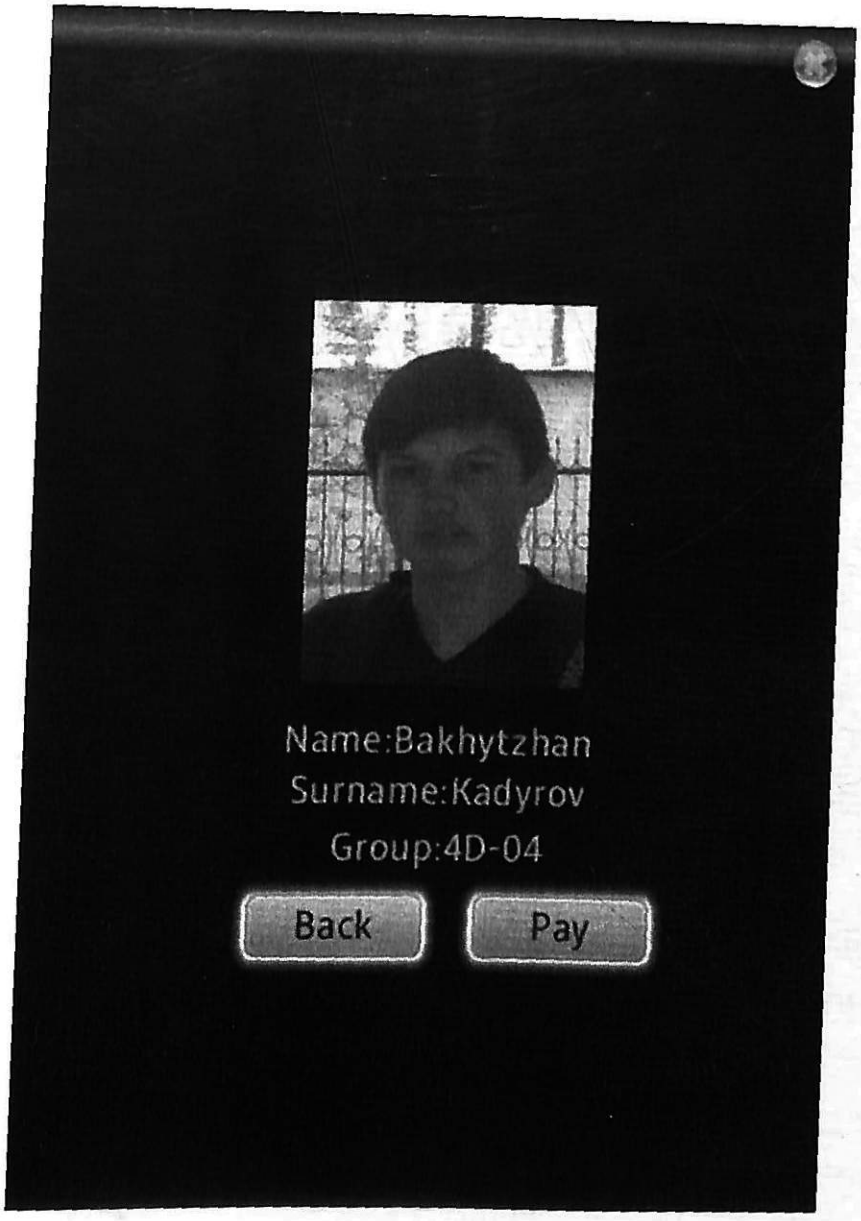
If we want to pay by cash the seller presses the button 'Pay money'. At picture 28 the student bought something for 355tg and gave 500tg to the seller. When the seller presses the button Pay, he or she can see the change he or she needs to return. In this process we do need to use a calculator. We can do it using our program. And to serve next student seller have to press back. As you see everything is very easy and we don't need to use calculator and calculate everything manually. So, it saves our time and decreases the length of queue.



Picture 29: Paying by RFID card

If we want to pay by RFID card the seller presses the button 'Pay money'. As you see at picture 29 the soft will wait RFID card. Then it checks if the student has sufficient money to pay. If he has no sufficient money it will say "You don't have enough money" then we can pay by cash. If we have enough money we can pay with card. As you see in the picture below seller can see the student's name, surname, group, and photo. We need the photo to identify if this RFID card belongs to the buyer. It may be stolen RFID card. This improves the security of RFID card. We get photo from Database of the server so that nobody can change the photo.

At the end the seller presses the button 'Pay' and the program will wait next buyer. As you see we do not need to give money and wait return of change. So, it decreases the length of queue.



Picture 30: Checking student

At the picture 30 you can see data about student. Especially for us is important photo of student. Without it I can stole RFID-card of other students and use it to bye something. But using photo we can check the student.

7.8 Library System using RFID

We can use an RFID card in the library when we get books and when we return them back. The current procedure is that when we borrow a book from a library first we need to find the book. To find a book we have to go and search from library. So, it takes very long time. Then if we found, to get the book we need to write down our names, surnames, date, deadline and ISBN of the book on a notebook and sign it and leave our student card, library card or ID and when we return it we have to find our names from notebook. Then librarian check is it the same book according to ISBN

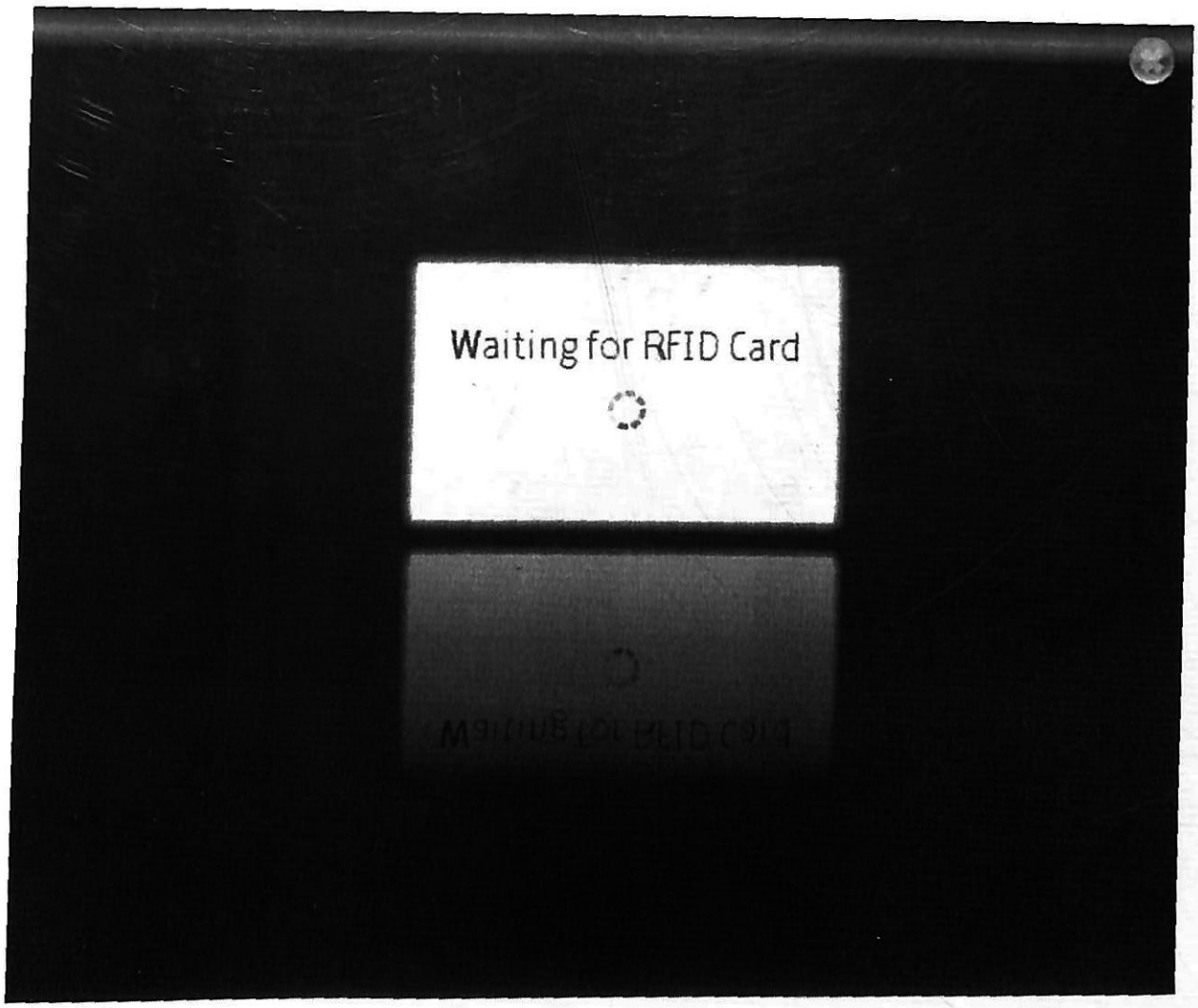
and also check deadline. If I return book later I have to pay money for each day about 50tg. It is like punishment. If everything is correct only then I can erase information's about me from notebook.

This is one of the big problems of our university. There are many disadvantages of current system:

1. It takes very long time to do all processes of taking and returning the book. Therefore sometimes there are queue. But students have only 10 minute at break time to get or return book. Because of it some students go to lesson late and get lower point for attendance. This is one of the big disadvantages of the current system.
2. Some students can change the deadline to not pay punishment for each day.
3. If someone lost the book he can bring another book and change the ISBN from notebook etc…

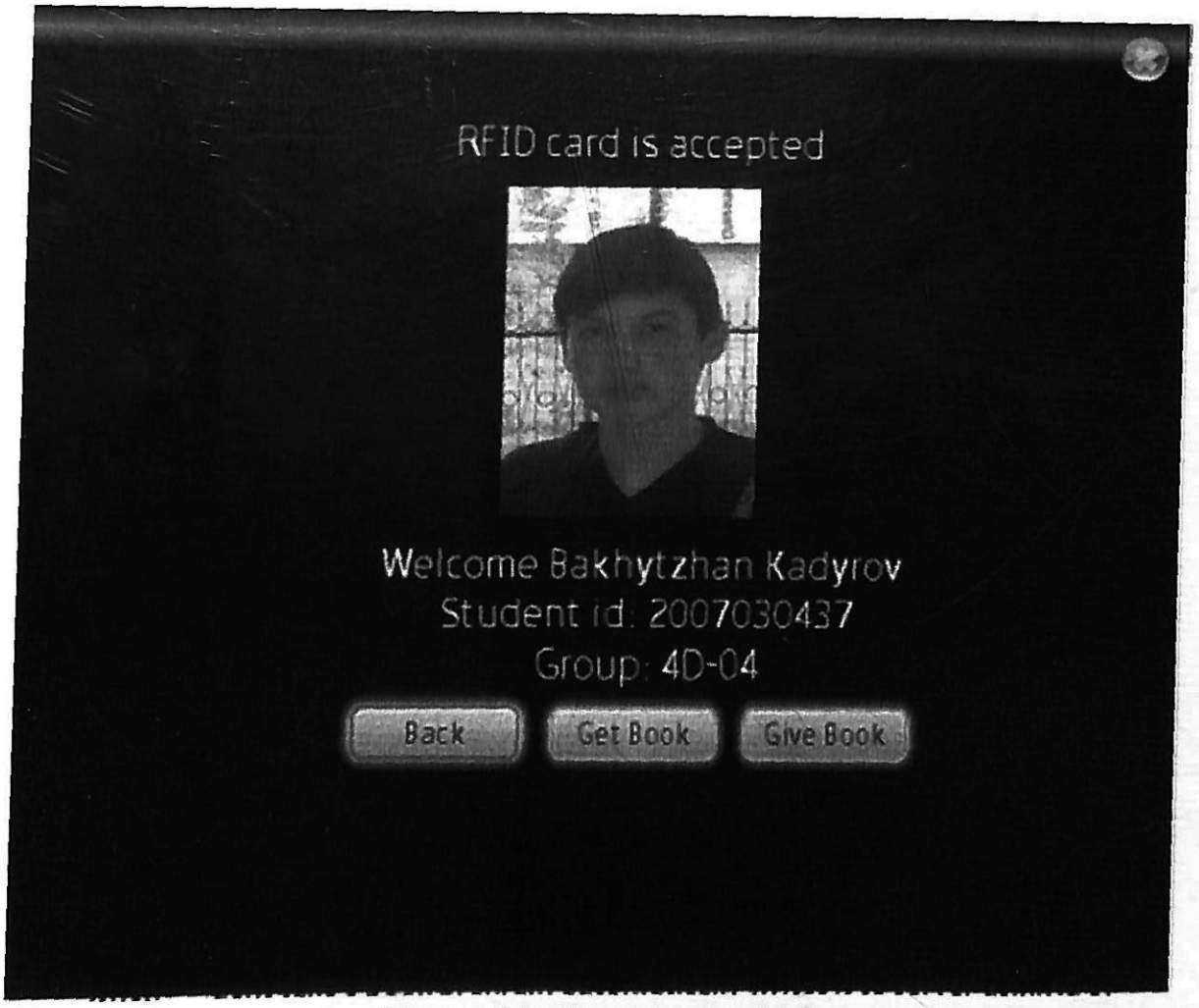
However, if we use an RFID card we can do it much faster and solve all these disadvantages. We do not need to fill some blanks or erase and leave any ID cards. The procedure will be done by a computer program automatically. So we can save from time. Moreover, there will be no queue and students can be at lesson on time.

To solve problem I wrote special program using RFID technology. I have used JavaFX programming language for good design. So, there will be one computer and two displays like at cinema. Librarian will use PC to do all procedures of taking and returning the book. Second display is for student to control procedures. For example: Which book he wants to take or give etc…



Picture 31: Waiting RFID card

First program waits RFID card to identify students. We need this because when student takes book program automatically writes it to the server using ID of the student. So, it means we do not need to leave any ID cards to identify student. This is one of the advantages of new system.

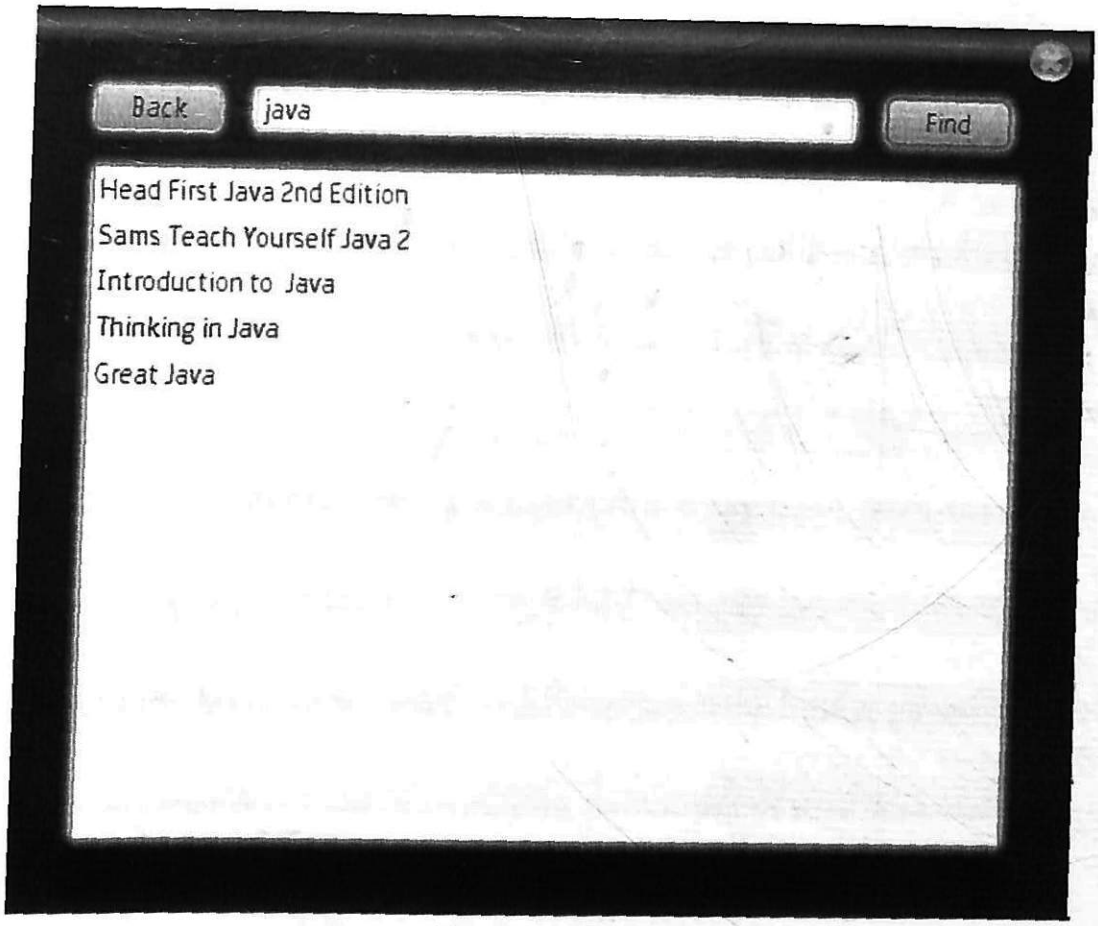


Picture 32: Checking student

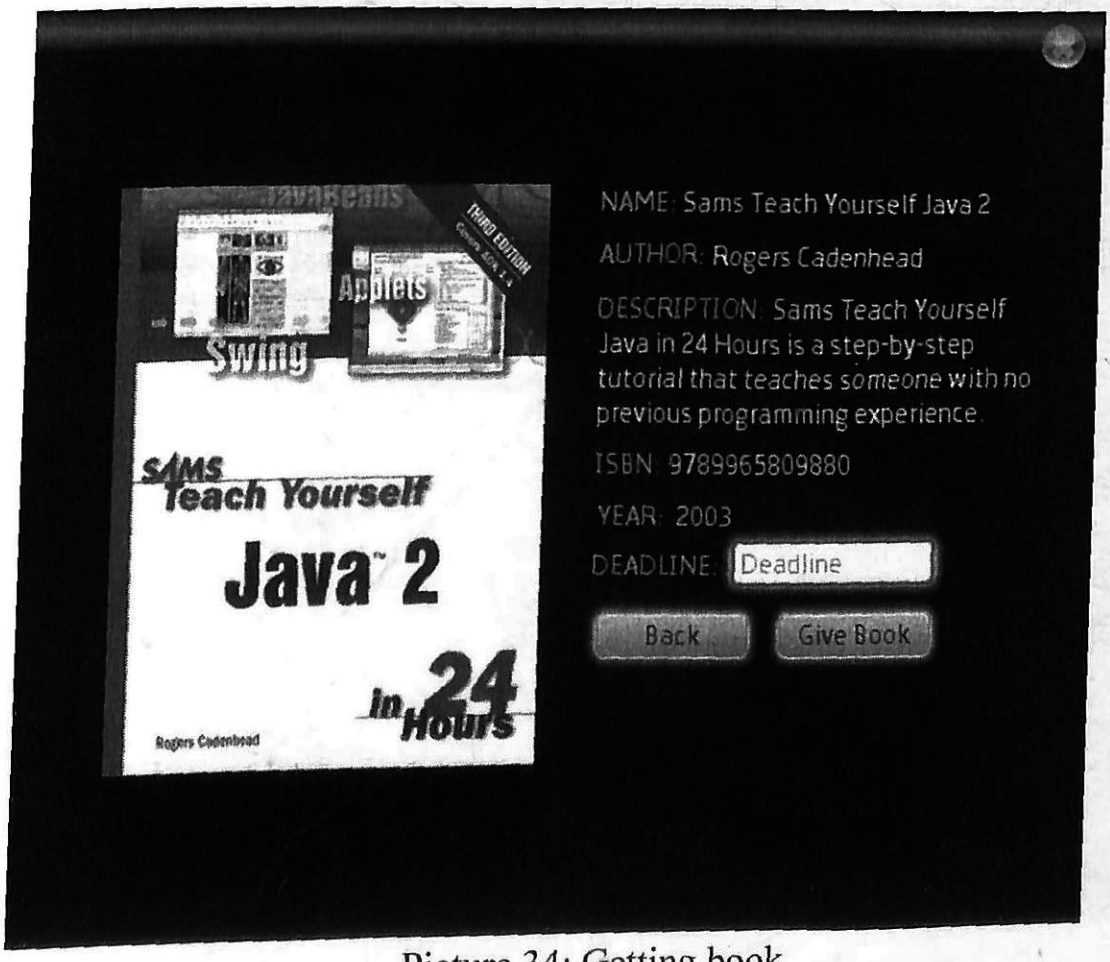
As you see at picture 32 we have two functions: getting a book and giving it. In a library system we have many functions. However, I only considered two of them as my task is not to set up all university system. My task is to show where an RFID card can be used and to show the benefits of using it. Considering only two functions should be sufficient to point out the importance of using the RFID cards.

To borrow a book we have to press button "Get Book". Inside Get Book we have a text field to search the book we want to borrow. We can search by name or by author of the book. We can see the results of the search in the list view. In my case I decided to find book about java programming. So, I wrote 'java' and press the button find and the program found me all the books about java programming which exists in library.

To get more information about a particular book we have to press twice on the name of the book. So, we don't need to search from library as it was before and almost it doesn't take any time.



Picture 33: Found Java books

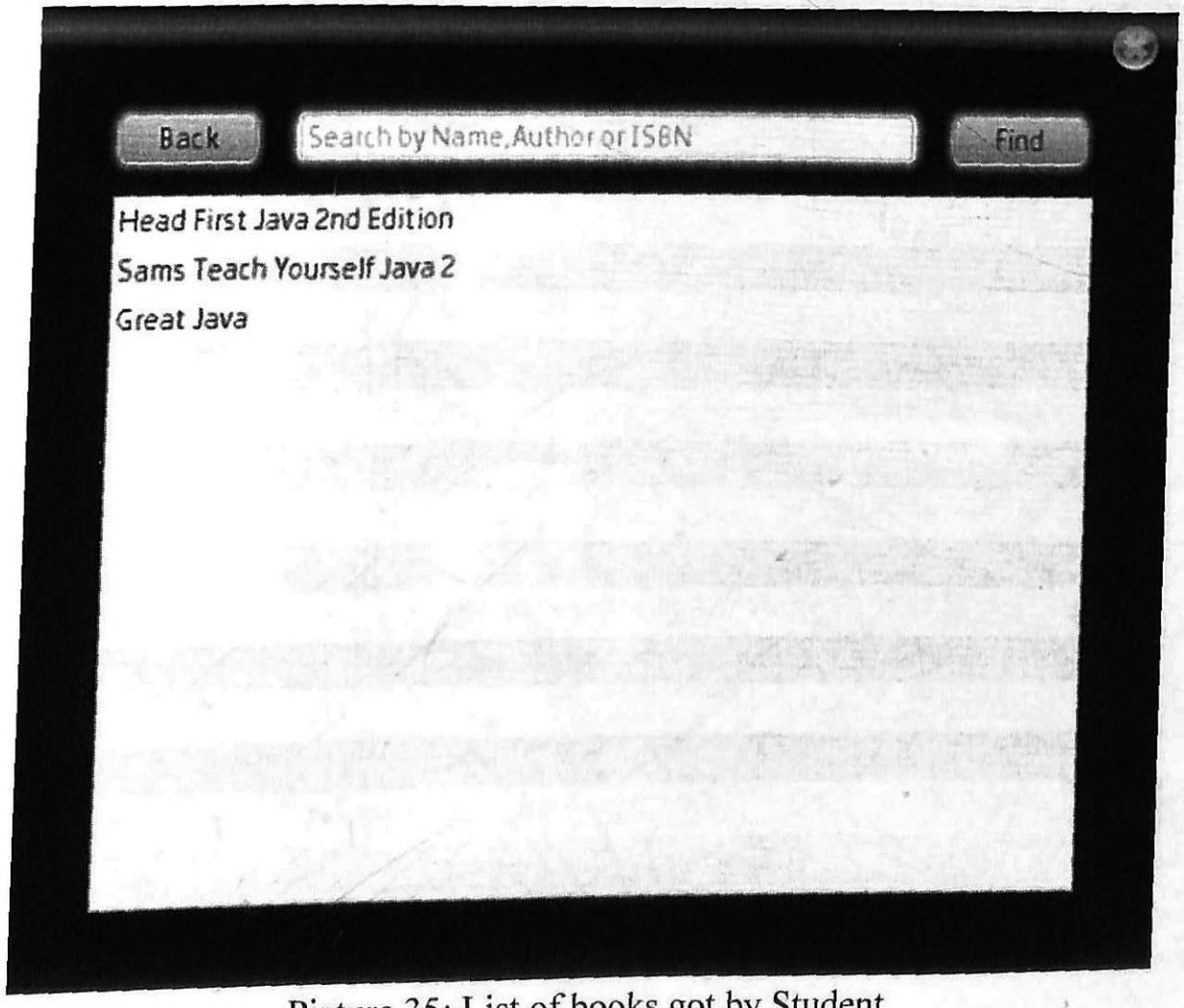


Picture 34: Getting book

We can see name, author, description, ISBN and year of the book. Also we have text filed named "deadline" to write down the deadline. Student must return book back by the deadline as otherwise he (or she) will be charged late fees of 50tg per day. It is a rule set up by the library administrator. This is somewhat necessary as other students may be waiting to borrow the same book and since in many cases there are no sufficient books for each student. Without deadline student may want to keep the book and return it at the end of semester when he or she does not need it anymore. On the other hand, other some students will be left without book all semester. Therefore it is very important to have a deadline and expect from students to return the books by the deadline.

So, just pressing the button "Give Book" we can get the book and we do not need to fill anything on notebook.

To return the book all we need to do is to press the button named "Give Book". In this way, without trying to search we can see which books we borrowed. In this case, we have another text field to search for books and to find them faster. Again, we can search books by their names or by their authors.



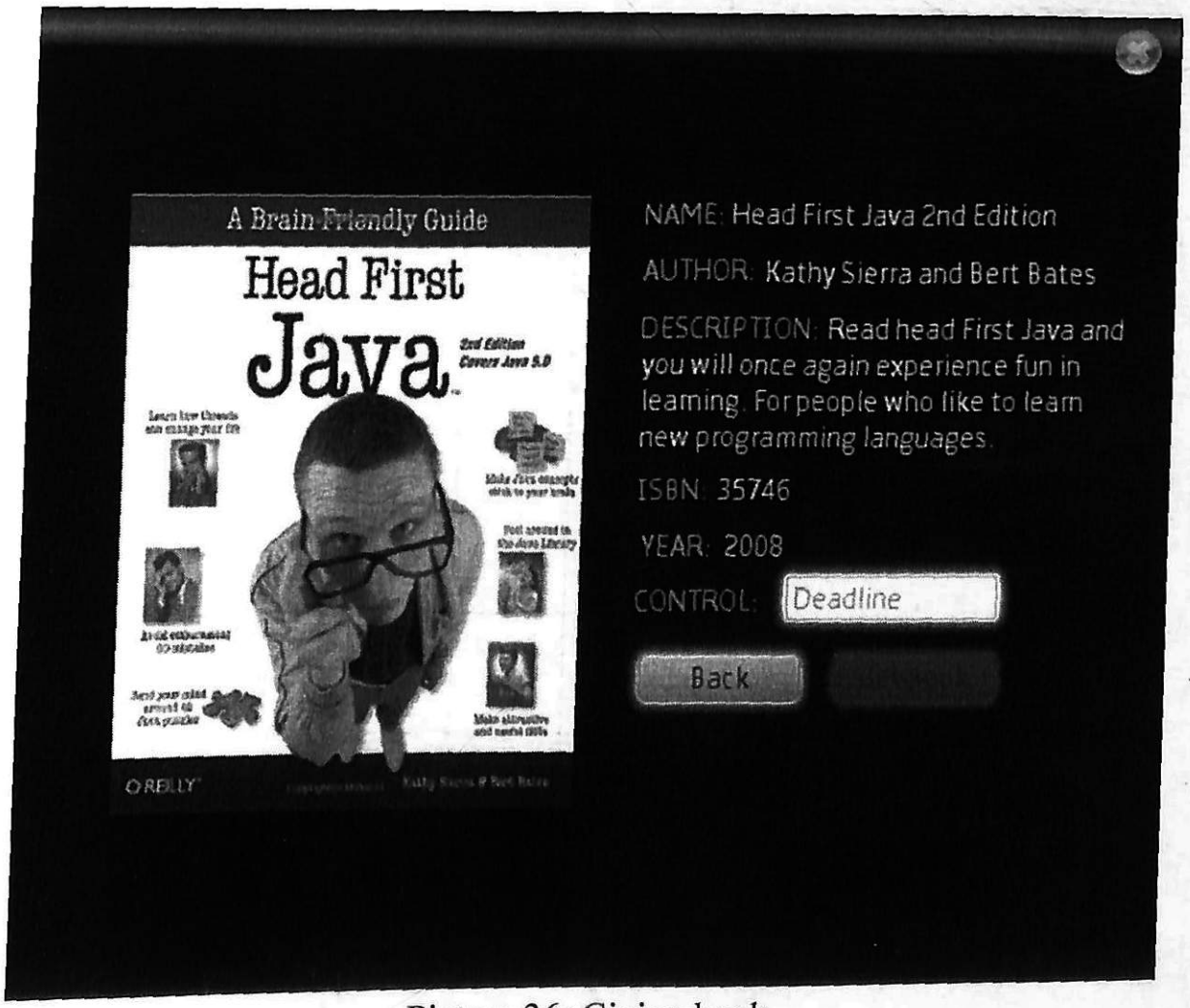
Picture 35: List of books got by Student

Here I borrowed three books. We have to click twice on the name of the book which we want to return to the library.

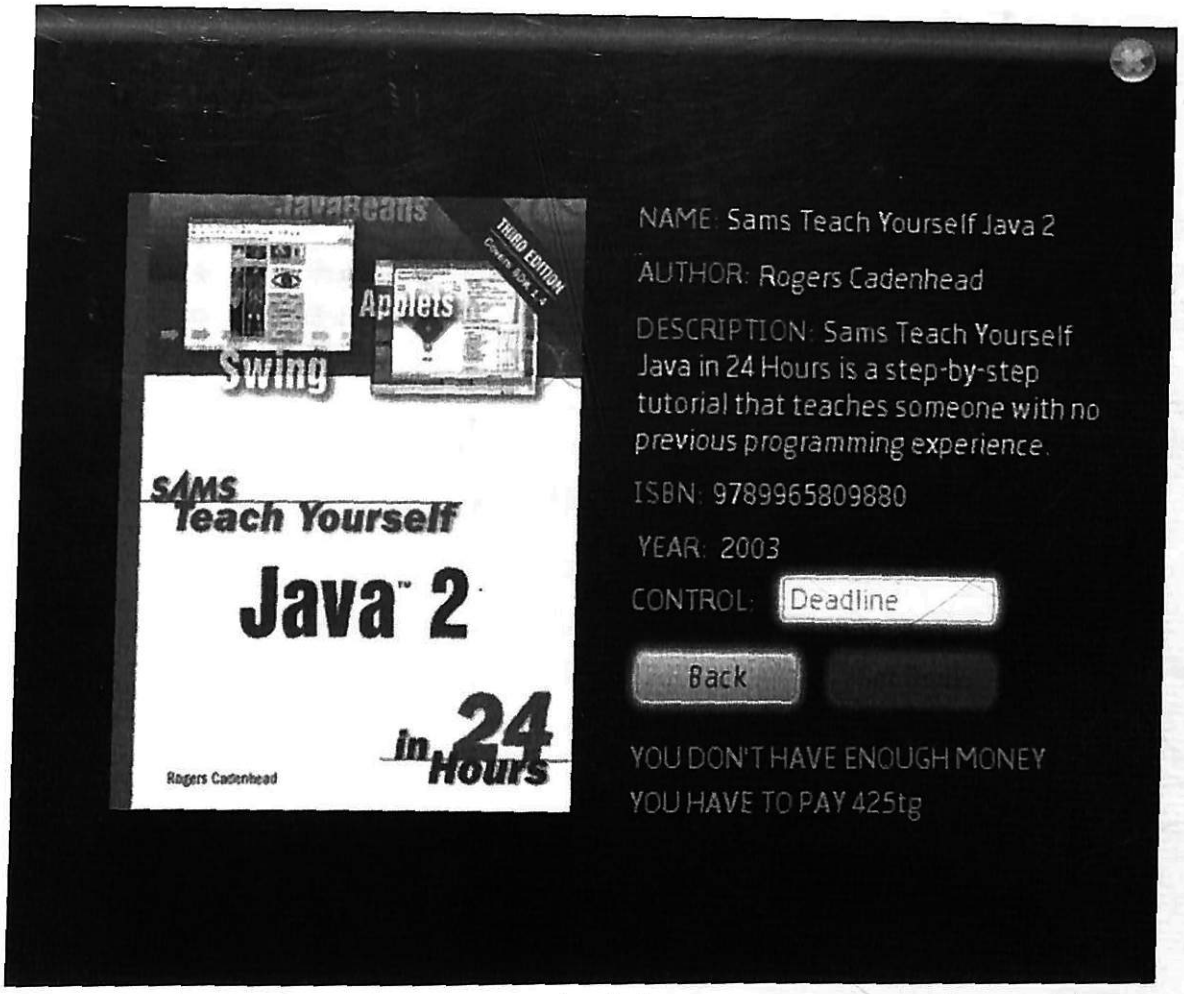
In the picture below we can see information about a book. The name, author, description, ISBN and year of book are shown. Also there we have text field named "CONTROL". This text field is very important for us as in the library there are lots of other copies of the same book. We can distinguish them only by their ISBN.

To check ISBN I used bar code. Using bar code we can check ISBN faster. If it is not the right book we are looking, the program will warn us. If it is the same book program will say so and the student can return the book back.

Also program checks whether the deadline passed or not. If the student missed the deadline then he (or she) must pay 50tg per day for each day after the deadline. If the RFID card has not got enough money, the program will say how much money student must pay. You can see it at the picture below.



Picture 36: Giving book



Picture 37: Soft shows that student don't have money to pay for punishment

At the picture you can see that we do not have enough money to pay with card and we have to pay 425tg.

Conclusion

By the end of this project we have shown the system that can be built with the use of RFID technology. This system is flexible, which means that we can extend our system by adding more modules. Cards that have been used for this specific system are RFID- cards, and algorithms we have implemented has shown stable and reliable results, and moreover have secured our important data that we have stored in these cards.

We can use these cards in our university, and it is believed that we can replace student's id-cards with these cards. Our personnel and students can use these cards in many places within the university as it was shown in this project.

For the future, we can extend the work by adding the more functionality for this system, and by adding more security for cards.

RFID- technology will continue its development and we have to use its functionality. The main aim of this research is to show the possible use of RFID-technology and to build a system with the RFID-technology deployment.

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